Paraspinal Thermography in Chiropractic Practice

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Thermography

Review of Literature

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Reviews of the Literature

Skin Temperature Assessment for Neuromusculoskeletal Abnormalities of the Spinal Column

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ABSTRACT

Objective: A qualitative review of the scientific literature on thermographic instrumentation for detecting neuromusculoskeletal abnormalities of the spinal column was made. Electronic infrared instrumentation (telethermography), liquid crystal thermography and various hand-held devices were scrutinized in terms of reliability and comparison with other diagnostic tests (e.g., computed tomography, myelography, electromyography, magnetic resonance imaging).

Data Sources: A *Medline* literature search was performed from 1966 through 1990. English language material was retrieved using the following key words: thermography and spine, spinal injuries, cervical vertebrae, thoracic vertebrae, lumbar vertebrae, sacroiliac joint, lumbosacral region, back or neck. The *Index to Chiropractic Literature* was also reviewed. The categories of skin temperature and thermography were scrutinized. Chapters of texts and nonpublished works were not incorporated.

Study Selection: Studies involving the comparison of thermographic findings with those of other tests were the primary focus of the review. Case reports, as well as the use of thermography as an outcome measure, were also studied. Interexaminer reliability studies are reported.

Data Extraction: The study populations are characterized as well as blinding procedures, if any. The authors' statistical work, if applicable, is presented and criticized.

Data Synthesis: Relatively few reliability studies exist for thermography. Emphasis has been on validity studies that compare the results of the thermogram with other reference tests. There has been a general lack of high-quality research design (e.g., blinding) throughout the thermographic literature base. The sensitivity of the various thermographic instrumentation has shown encouraging results, although this must be tempered with the generally poor design of many studies. Specificity, in contrast, has shown mixed results. The review indicated telethermography to be a sensitive diagnostic procedure for detecting abnormalities, such as disc protrusion, of the lumbar and cervical spine. Liquid crystal thermography effectiveness is difficult to determine due to the paucity of blinded investigations, although normative data for the cervical spine and upper extremities is present. Literature on the various hand-held instruments has revealed moderate levels of examiner reliability for infrared devices, with less information available for thermocouple instruments. Normative data for hand-held instruments is absent.

Conclusion: Continued investigation is needed in the area of thermographic research in light of the paucity of blinded and/or controlled investigations. More sensitive neurophysiological and anatomical measures must be used when comparing the results from thermography. The lack of an available gold standard for comparing thermographic findings has been problematic. Future research should focus on thermography as a noninvasive outcome measure and interpreter reliability. (J Manipulative Physiol Ther 1992; 15:365–381).

Key Indexing Terms: Chiropractic, Spine, Thermography.

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INTRODUCTION

The purpose of this article is to review the scientific and clinical research on thermographic examinations of the spinal column and pelvis. There are many excellent reviews of the thermographic literature (1, 2). The focus of this article is to review the most current literature on the subject as well as older investigations, but more importantly, to scrutinize the designs of the various studies.

Thermography is a test of physiology. It complements studies that determine anatomic abnormalities, such as computed tomography (CT), magnetic resonance imaging (MRI) and plain X ray. Electromyography (EMG) is another test of physiology. A complete review of the proposed mechanisms of underlying thermal dysfunction has been presented by Hamilton (3). The basis of extremity and trunk thermography and its relationship to disorders of the spinal column is that thermography can detect thermal manifestations of sympathetic dermatomes and increased heat from biochemical components (e.g., substance P) of the inflammatory process.

Sympathetic modulation is one of the more popular theoretical mechanisms of thermal dysfunction. Traditionally, preganglionic cell bodies are thought to be confined to the thoracic and upper lumbar levels (4). Mitchell (5), however, has identified preganglionic sympathetic cell bodies at all levels of the spinal cord. Randall (6) has confirmed these observations by finding preganglionic neurons at the lower lumbar levels. His work is further supported by Richter and Woodruff (7), who mapped the lumbar sympathetic dermatomes through operations on the various lumbar ganglia.

An investigation by Ash et al. (8) concluded that infrared thermographic imaging of the sensory dermatomes is not plausible. They based this upon the unpredictability of sympathetic dermatomes due to crossover in anatomy. In their study of 31 normal subjects and 87 patients with neurological deficits (undefined), temperature analysis was made with a Diatech 500, a YSI Telethermometer Series 43A and a Series 396 Atkins 39658-J thermocouple digital thermometer. How the authors concluded that the patients had definite neurological deficits is unknown, and no blinding procedures are reported. Temperatures of the back and limbs were recorded. These are not the typical instruments used for thermographic evaluation. The women in the group wore gowns during the examination and the men wore shorts. This is not typical thermographic protocol. Usually, patients are completely disrobed. Their equilibration time of 10–15 min is lower than what is customarily used (i.e., 20 min). Statistical analysis was not performed because, in the author's words, ". . . there was nothing to analyze." Because of problems in the design of this interesting study, the author's conclusions that thermography should not be used in the evaluation of painful conditions of the back, neck and limbs is suspect.

The recurrent meningeal (sinuvertebral) nerve (mixed sensory, sympathetic) innervates the articular capsule, posterior longitudinal ligament and annulus, and when stimulated may give rise to pain or thermal manifestations. Stimulation of the dorsal root ganglion can raise skin temperature from antidromic (propagation of an impulse in a reversed direction) stimulation (9–11). This has been termed the cutaneous axon reflex. It is possible that many different neural and myofascial mechanisms are involved in thermoregulation. Ultimately more research is needed in this area.

The skin temperature is due to the blood flow of underlying arteriolar and deep venous plexuses. The temperature is a function of activity 1.0–1.8 mm beneath the skin surface (12). Cutaneous, subcutaneous and myofascial inflammation create underlying temperature increases that elevate the skin temperature from unknown depths. It is unlikely that skin temperature is a function of direct inflammatory heat from the posterior or central joints. Thermocouple and other contact instrumentation measure the temperature of the skin to a depth of not more than a few millimeters unless severe pressure is applied.

DISCUSSION

Thermographic Instruments

One of the benefits of thermography is its noninvasiveness. Telethermography (electronic) is based on the emission of infrared radiation from the body. Electronic sensors convert the thermal radiation into a video or graphic display, which can then be interpreted by the human eye. Computer-assisted images provide a more quantitative analysis of the thermogram. Besides the relative noninvasiveness of all thermography, telethermography has as its advantage the capability to scan large areas of the body with the elimination of skin contact.

In liquid crystal thermography (LCT), elastomeric sheets embedded with liquid crystals are placed in contact with the skin. These cholesterol derivatives selectively reflect polarized light, which results in specific color-temperature responses. Advantages of LCT include its low price, distinct color contrast and simplicity.

A thermocouple instrument consists of thermal sensors composed of two dissimilar metal wires spot welded at their ends. When the ends are at different temperatures, the voltage generated between them is roughly proportional to the difference in temperature due to the thermoelectric effect involving the drifting of free electrons in a metal from the hot junction to the cold junction (13). The low-impedance thermocouple can then be connected in series with a microameter to provide a differential measurement of temperature.

The thermister method of thermography (13) us in sensors that have semiconductor properties that lower the electrical resistance as temperature is in-eased. This method corresponds well with other eans of measurement (i.e., telethermography, LCT, thermocouple), but is rarely cited in thermography literature on the spinal column.

Study Designs

Most studies of thermography have been performed comparing it to other diagnostic tests. The clinical amination (with or without a pain drawing), EMG, myelography, CT and MRI are the most commonly mpared examinations. The results of the comparison tween these tests are then placed in a 2 × 2 table (Table 1). When one examination agrees with another, the literature on thermography often describes this as a rrelation (14). Here, the term "correlation" is used osely in the statistical sense. In fact, the comparisons can be described more accurately as percent agree-ents. Correlation coefficients such as Pearson's or the traclass correlation coefficient (ICC) (one-way analysis of variance) are described when they have been used analyze continuous data from a particular study.

Often, the thermogram is compared with a surgeon's overall opinion or findings at surgery. The surgical findings are then used as the gold standard. Comparing ermography or other physiological tests to surgical dings may not be valid. Thermography is a test of nerve physiology that may not always correspond to normalities detected visually at operation. Findings surgery are usually described in terms of an anatomic abnormality such as a herniated intervertebral disc.

There is an extremely low incidence of negative rgical explorations. It seems that just about everyone e spine surgeon operates on has a lesion. Usually the number of patients who eventually undergo operation is small. Thus, the surgical data represent a small subset of the original study example. The diagnostic effectiveness of a test is more difficult to determine when there may not be an appropriate gold standard or reference test for comparison.

The clinician needs to know how much validity he or she can place on a diagnostic test. Sensitivity is the most useful parameter for evaluating the efficacy of an imaging method or comparing it to alternative methods. It is the basic term stating the effectiveness of an examination in detecting lesions (15, 16). Sensitivity is defined as follows: sensitivity = true positives/(true positives + false negatives); sensitivity = percentage of existing lesions detected.

Specificity is another useful term for the clinician. It quantifies the ability of an examination to identify normal cases. It is defined as follows: specificity = true negatives/(true negatives + false positives); specificity = percentage of normal cases identified.

A relative abundance of studies exists for neuromusculoskeletal thermography of the spine. However, controlled and/or blinded studies are relatively few in number. There are also few reliability experiments on examiner interpretation.

The literature search for this review was performed on *Medline* using the following key words: thermography and spine, spinal injuries, cervical vertebrae, thoracic vertebrae, lumbar vertebrae, sacroiliac joint, lumbosacral region, back or neck. The *Index to Chiropractic Literature* was also reviewed. Searches were performed using the categories of skin temperature and thermography. English abstracts or summaries of foreign language material with sufficient detail to invite analysis are included. Chapters of texts and nonpublished works were not reviewed.

BLE 1.

		Reference Test or Gold Standard	
		Present	Absent
Thermography Results	Positive	True Positive	False Positive
	Negative	False Negative	True Negative

Normal Skin Temperature

Chang et al. (13) used telethermography, a thermocouple, thermister and LCT to investigate normal temperature variation of the posterior trunk. All four thermal sensors demonstrated a temperature increase over the midline (spinous processes) with a relative temperature decrease over the paramedian areas. Thirty subjects were evaluated in this experiment. Thirteen subjects were pain-free and the remainder had headache disorders. The assumption that headache patients will not have abnormal temperature variations remains untested and may be suspect. Other authors (17–19) have described this relative temperature increase over the midline area of the spinal column as a normal variation. However, the patients used in these investigations could not be considered truly normal. Their infirmities ranged from herniated lumbar discs and coarctation of the aorta to leprosy.

In a small study (10 subjects) by Silberstein et al. (20), it was concluded that temperature symmetry of the anterior chest, abdomen and back of the human male is relatively constant. They recommended temperature asymmetries greater than 1° C as having clinical significance.

Feldman and Nickolog (21) used LCT of the cervical spine and upper extremities to arrive at normal thermographic standards for those regions. Their population consisted of 100 relatively asymptomatic actively employed factory workers. Exact thermographic symmetry (<0.3° C) was found in 82% of the subjects. Asymmetric thermograms between 0.3 and 0.6° C were obtained in 4% of the subjects. A thermal difference of less than 1.0° C was found in 94% of the subjects. They concluded that a thermal asymmetry of 0.62° C is a presumptive indication of an abnormality. A 1.0° C thermal asymmetry was regarded as definitely abnormal.

In contrast, Gratt et al. (22) found that thermal asymmetry (telethermography) (>1.0° C) of the posterior neck was present in 44% of the subjects tested. Their pilot study of 12 men and 8 women did not identify subjects who may have had a history of cervical trauma.

Goodman et al. (23) used computer-assisted telethermography to determine the normal temperature symmetry of the back and extremities. They used a strict protocol to determine normalcy for the subjects. This included laboratory tests, physical examination (including anthropometric data and body composition) and psychological evaluation. In general, normal temperature variation was greater in the extremities than in the posterior trunk or cervical spine. Ninety-nine percent confidence limits of normal body surface thermal asymmetries were determined (Table 2).

Uematsu (24) used telethermography on 90 pain-free subjects in an attempt to determine the normal v tion of skin temperature. As seen in previous v the mean temperature difference of the toes and fi (e.g., fourth toe, 0.67 ± 0.41° C) varied more corresponding areas of the trunk (e.g., posterior cal, 0.23 ± 0.16° C) (Table 2). These values were s to those found in previous studies (25, 26).

TABLE 2. Normal asymmetry of skin temperature (° C) for selected areas of the human

Region	Uematsu (1988)[a]	Goodman (1986)[b]
Posterior cervical	0.23 ± 0.16° C	N/A
Posterior thoracic	0.20 ± 0.17	0.4
Posterior lumbar	0.22 ± 0.19	0.2
Posterior thigh	0.23 ± 0.18	0.7–0.9
Posterior leg	0.29 ± 0.21	0.6
Posterior forearm	0.31 ± 0.22	1.2–1.4

[a] Mean (SD) of thermal difference between the right and left sides.
[b] Ninety-nine percent confidence limits of normal body surface thermal asymmetry.

Telethermography

Green et al. (27) conducted a thermographic ana of 50 asymptomatic volunteers with no history of or neck pain. Fifty cervical thermograms and 50 lu examinations were performed on the subjects. T thermograms were then grouped with 10 cervical 10 lumbar thermograms of 10 symptomatic indivi with cervical or lumbar radiculopathies. Three ex enced clinical thermologists served as examiners fo experiment. They were blinded to the sympto profile of the patients. Using previously agreed criteria, the clinicians correctly identified all the sy tomatic patients (sensitivity of 100%). There were asymptomatic subjects who were identified as the graphically abnormal, which yielded a specificit 95%. This study supports the effectiveness of telet mography as a diagnostic test.

CT, EMG and Myelography

Chafetz et al. (14) evaluated 19 patients who ha confirmed disc bulges. Patients had to have greater t a moderate displacement to be included in the sam These patients then had thermography perfor which was interpreted in a blinded fashion. All o patients with disc protrusion had positive thermogr (sensitivity of 100%). A control group of 15 asym matic volunteers showed that six were interprete positive by thermography. The specificity was de mined to be 71%.

In a study to test the validity of telethermograph Uricchio and Walbroel (28), blinded reading was formed on 24 thermograms of 22 patients who also CT or myelography. Three thermograms were o cervical region and the remaining 21 were of the l bosacral area. The blinded thermographic evaluat detected every one of the 14 clinically significant normalities as evaluated by either CT scan or mye raphy (sensitivity of 100%). The spinal abnormal included disc protrusions, spinal stenosis and spor losis. There were no false negative thermogram r ings. Myelography is an invasive procedure with kn complications. Side effects can include pain, infec and arachnoiditis.

Green et al. (29), under blinded conditions, compared the results of telethermography and myelography. An abnormal thermogram was correlated with a positive myelogram in 91% of the patients (10 out of 11). There was negative agreement in 17 of the 19 patients (91%). Thirty age-matched controls were analyzed with thermography. None of these thermograms were classified as abnormal (specificity of 100%).

Hubbard and Hoyt (30) compared the results (unblinded) from telethermographic, electromyographic and myelographic examinations on 805 patients from a large neurology group practice. Using a strict protocol for the thermographic examination and interpretation, they found that thermography agreed well (94%) with the pain diagram drawn by the patients. In the lumbar spine, the agreement with the myelogram was 95%, with 80% concordance for CT scanning and 68% for the EMG.

Uematsu et al. (31) reviewed the thermographic and clinical findings of 803 patients from a pain clinic. They concluded that when the thermogram was normal, the chance of nerve injury was 11%. When an afflicted limb is more than 1.0° C colder, the EMG and nerve conduction tests will show abnormalities in 50% of the cases. If the area of pain shows a decrease in temperature of more than 2.0° C, then one should suspect an organic cause in 66% of patients. No blinding procedures were reported in this retrospective analysis.

In a retrospective unblinded study by Weinstein and Weinstein (32) comparing telethermography (back and extremities) with EMG, CT, myelography and surgical exploration, a positive thermogram yielded an overall agreement rate of 94% when compared with the other tests. Of the 500 patients evaluated with thermography, 308 (62%) were regarded as positive. A negative thermogram was nearly 100% sensitive (one false negative) in documenting the absence of any nerve root irritation as demonstrated by the other modes of assessment.

Harway (33), in a retrospective unblinded analysis of 66 patients with lumbar pain evaluated with telethermography, CT and myelography, found that the thermogram agreed well with the results of the other tests. Thermography agreed with CT scanning in 59 (90%) of the patients and in 60 (91%) who had positive myelograms. Harway concluded that thermography is a highly sensitive and accurate test, which shows at least a 90% agreement with CT scanning and myelography.

Meek (34) reports on 12 patients that were conservatively managed (low back) using telethermographic results. Comparisons were made between CT evaluation and the thermogram. It was concluded that if the thermogram was negative, it was unlikely that the patient had significant disc disease. Meek and Gilbert (35) used electronic thermography of the lower extremities to assess 200 patients from an orthopedic clinic. Thermographic results were compared with the CT scan and response to cryoanalgesia treatment. No statistics or blinding procedures were reported. Of the 200 patients, 60% had abnormal thermograms. Fifty-eight patients also had CT scans. The thermogram appeared to agree well with CT evaluations. The authors speculated that if the thermogram was normal, it was unlikely that laminectomy or chemonucleolysis would be required. Meek (36) continued with these investigations and arrived at similar conclusions in a later paper, following the evaluation of 250 lumbar thermograms. Again, no blinding procedures were reported.

Hubbard and Hoyt (37) evaluated the results from 495 consecutive thermographic examinations of the lumbar ($n = 208$), cervical ($n = 245$), thoracic ($n = 34$) and facial ($n = 8$) regions. The patients ranged in age from 26 to 55 yr and had symptoms of radiculopathy, low back and neck pain and trunk pain. Sixty-seven percent of the lumbar and 32% of the cervical studies were considered abnormal. A control group of relatively pain-free medical students (age: 21–29 yr) were evaluated with telethermography. Blinding procedures, if there were any, were not reported. The lumbar spine was normal in 87% if these subjects. Eighty-two percent of the subjects had normal extremity temperature. For the cervical region, 87% had a symmetric temperature distribution. Follow-up evaluations of those control subjects with abnormal temperature variations revealed that all but two had a history of trauma to the abnormal region. An 84% agreement was observed with the lumbar thermogram and the dermatomal distribution of the complaint in the trunk or the afflicted extremity. For the cervical area, an 81% agreement was obtained with the radicular complaints. The thermogram and lumbar CT ($n = 29$) had a concordance of 76%. For the cervical region ($n = 51$), it was 84%. Electromyographic concordance was somewhat lower, ranging from 57 (lumbar) to 71% (cervical). For lumbar patients ($n = 15$), the thermographic agreement with the myelogram was 93%. In the cervical region ($n = 18$), it was 84%.

Ching and Wexler (38) report on selected cases with abnormal thermograms. Increased heat was generally observed in the lumbar spine, characterized by a linear area of heat emission radiating laterally (heat stripe). In this unblinded review of four cases, they conclude that lumbar thermography is complementary to lumbar myelography. They emphasize that interpretation should be done in the context of correlating the thermographic information with the patient clinical history and complaints and results of other tests. They speculate that when many of these variables correlate or agree, there is a high likelihood that an abnormal disc is present.

Wexler (39) compared the results of 86 consecutive orthopedic patients who had electronic thermography of either the cervical or lumbar spines (and related dermatomes) with the results of objective clinical findings and EMG. The thermogram agreed (positive or negative) with the EMG in 76% of the cases. It agreed with the clinical exam in 92% of the cases. The sensitivity of thermography was reported to be 100% and the specificity 85%. No blinding procedures were reported in this investigation.

Uricchio (40) observed agreement between telethermography and myelography in 89% of 63 patients with lumbar spine radiculopathies. In a later study (41), he compared telethermography to myelography in 195 patients. Ninety percent of the patients with a positive myelogram had thermographic alterations.

Raskin et al. (42), in a series of 38 patients, found myelography to be superior to telethermography in predicting disc lesions at L5-S1. Equal agreement was noted for the L4-L5 level. The authors concluded that when the thermogram was positive for an abnormality, the probability of a normal myelogram was small. However, the findings of myelography could not be predicted by a negative thermogram.

Fischer et al. (43) compared telethermography to the EMG and clinical assessment in 114 patients with low back pain and 76 patients with neck pain. Blinding procedures were not reported in the authors' abstract. They concluded that thermography was more sensitive than EMG for lumbosacral radiculopathies. EMG was found to be more sensitive than thermography for cervical radiculopathies. When both examinations were performed, there was agreement with the clinical evaluation in 96% of the lumbar cases and 97% of the cervical patients.

Uematsu (44), using computer-assisted telethermography, analyzed 144 patients with low back pain and sciatica. One hundred eighteen of these patients had previous spinal surgery. Skin temperature differences greater than 2 SD from the mean of a control group were defined as abnormal. Sensitivity of 92% was yielded when comparisons were made to the results of myelography. There were 15 cases of false-negative results when compared to the myelogram. This was speculated as being due to mild or symmetric bilateral root involvement at the involved levels. No blinding procedures were reported.

MRI

A retrospective investigation by Goldberg (45) s ied 31 patients who had infrared lumbar thermogr and MRI as part of their clinical assessments. Myel raphy was carried out in eight of these patients. T were no instances where a normal thermogram correlated with an abnormality (e.g., severe degene tion, disc protrusion) on MRI (sensitivity of 100 The abnormal thermograms, especially when the f ings were unequivocal, agreed well with an abnorma on MRI and sometimes myelography. No statisti comparisons were performed between the diffe groups. All of the MRIs and "most" of the thermogr were blindly interpreted. Goldberg concluded that frared thermography is an important initial test f patient suffering from persistent low back pain. A ative thermographic image is unlikely to be correla with an abnormality on MRI, CT or myelography t is amenable to surgical intervention.

Plain X Ray

In a blinded study by Karpman and Knebel (telethermography was used to evaluate the lumbar s of 44 patients with acute traumatic injuries and subjects who underwent pre-employment physi Five of the pre-employment subjects gave a histor low back pain. The patients who suffered traum injuries also had a physical and roentgenological ass ment. In no cases were abnormal roentgenogra findings associated with a normal thermogram (se tivity of 100%). In the injury group, 35 of the patie had abnormal thermograms (26 with normal roent ograms and 9 with an abnormal roentgenogram). authors concluded that thermography was useful documenting the soft tissue injury and following patients' clinical course. They also speculated that s there were many subjects who had abnormal therr grams but no present history of low back pain, infra thermography might be a useful screening tool to predict those patients who might in the future dev low back injuries.

Stress Plain Film Radiography

Kneebone and Grand (47) attempted to corre spinal dysfunction as evidenced on lateral flexion ra graphs and telethermography in a group of 10 patie They found an 80% concordance of the thermog with the side of lateral flexion or coupling dysfunct No control group was used and blinding proced were not reported. The interexaminer reliability of interpretation of lumbar lateral flexion roentgenogr is also unknown or equivocal (48). The authors suggest the need for further research in this area. The thermograms were performed in the neutral as well as the extremes of lateral bending. Their subject population appeared to have a predilection for hypothermic areas at or near the site of fixation dysfunction, which agrees with other investigations (49).

Surgical Findings

Edelken et al. (17) reported on 93 patients with clinical signs and symptoms of herniated lumbar discs who had thermograms performed. Twenty-nine of the patients were eventually operated on. Abnormal thermograms were present in 23 of these patients. The hot spots generally extended from the low lumbar area toward the central gluteal area. The asymmetries were either unilateral or bilateral and localized to the level of the herniated disc. No blinding was reported in this investigation. Of the 29 patients eventually operated on, myelography revealed the proper level in 23. There were three false positives and three false negatives. Thermography yielded five false negatives and one false positive. The conclusions of the authors were that thermography was a complement to myelography and in some instances could be supplementary.

Back Pain and Radiculopathy

Ellis et al. (50) thermographically evaluated 49 symptomatic and 37 pain-free individuals to determine if thermography could detect abnormalities in the symptomatic group that did not have obvious musculoskeletal findings as an explanation for their pain. All thermograms were interpreted in a blinded fashion. Of the 49 chronic pain patients, 41% showed thermographic abnormalities. It was noted that whenever thermographic findings were present in the back, extremity or peripheral manifestations were observed. None of the 37 controls was determined to have thermal asymmetries (specificity of 100%).

Maultsby et al. (51), in a blinded study, compared telethermography of the lumbar spine and extremities to pain diagrams drawn by the patients. Forty randomly selected records were retrieved from a pool of 112 chronic orthopedic patients. The four examiners agreed in 80% of the cases. The amount of agreement due to chance was not computed.

Sherman et al. (52) used telethermography on 125 patients referred for studies concerning upper and low back pain, leg pain and phantom body pain. All thermograms were blindly reviewed. The authors used efficiency to determine the diagnostic usefulness of thermography. The efficiency of a test is the percentage of patients correctly classified as diseased or healthy. Efficiency is extremely sensitive to false negatives and false positives. For the 16 patients with low back pain, the efficiency rating was 56%. In contrast, the three patients with painful knees yielded an efficiency rating of 98%.

Gillstrom (53) used telethermograpy in the evaluation of patients with low back pain and sciatica. In both prospective and retrospective analyses, he found moderate agreement between the dermatomal complaint and the thermographic asymmetry. In patients who had low back pain without radiculopathy, the thermographic findings agreed in 16 of the 25 patients (64%). The greatest amount of agreement (95%) was observed when the sciatica corresponded to S1 nerve root involvement. No blinding procedures were reported in this investigation. Many of these patients had thermographically performed pre- and post-treatment (surgery or autotraction), and in most cases the temperature differences were less following intervention. In few patients, however, did the skin temperature asymmetries totally remiss.

Leroy et al. (54) outlined the basic uses of thermography in the patient with low back pain. They stated that thermography (telethermography and LCT) was an effective and reproducible test for low back pain patients, but provided no experimental data to substantiate their conclusion.

In a pilot study by Tichauer (55) of 8 patients with back pain and 14 without, paraspinal infrared thermograms revealed a statistically significant association between back pain and an abnormal thermographic composite. Both hot and cold spots were reported in this small sample of subjects. No blinding procedures were discussed in the paper.

Thermography as a diagnostic predictor for patients with back pain or sciatica was determined by Mahoney et al. (56, 57) to be without merit. These studies have been criticized for having considerable design flaws, including the technical quality of the thermograms and photographs (58, 59).

Einsiedel-Lechtape et al. (60) reported on telethermographic examinations of the posterior trunk in 22 patients with herniated cervical or lumbar discs. They found a large variation in skin temperature in the pain-free subjects ($n = 58$) and, thus, could conclude little about thermographic manifestations involved in the symptomatic patients. Fifty-five percent of the patients with cervical disc herniations were identified by posterior neck thermography. The omission of extremity thermographic examinations makes the extrapolation to standard thermographic protocols invalid.

Other early, unblinded works (61) failed to show definitive posterior trunk thermographic manifestations in patients (n = 5) with herniated cervical or thoracic discs. In a "small group" of patients, the thermogram agreed well when degenerative joint disease or malalignment of the vertebral column was present.

Sacroiliac (SI) Dysfunction

Diakow (62) reported on a patient with SI syndrome (63) and thermographic asymmetry of the right and left SI articulations and buttocks. The thermographic asymmetry and the patient's symptoms resolved following 4 wk of sacroiliac manipulation of the fixated left SI joint. The patient also had cryotherapy (i.e., ice pack) applied at home for 3 wk.

Jacobsson and Vesterskold (64) used telethermography to evaluate the SI joint in 72 pain-free subjects and 82 patients with active sacroiliitis. In their qualitative assessments of the thermograms, they noted that there was a large variability of normal (pain-free vs. symptomatic) patterns in this region. An interesting finding was that of subclinical hot spots at the superior portions of the SI joints in many subjects.

Agarwal et al. (65) used telethermography to assess patients with ankylosing spondylitis (AS). The thermographic analysis included the trunk and the right and left sacroiliac articulations. The cervical area was evaluated only when clinically involved. Thirty-one patients were examined (ages: 18–65 yr), 28 of which were men. Approximately 60% of the patients had thermographic abnormalities, usually evidenced by hot spots over the SI joints or corresponding to the midline where advancing inflammation was present. The thermograph correlated well with the erythrocyte sedimentation rate and to a lesser extent with radiographic changes. In many patients, completely fused SI joints resulted in a quiet thermographic picture. The clinical advantage of infrared thermography is mainly its noninvasiveness. More conventional and invasive methods of sacroiliitis assessment include radionuclide scanning and radiography.

Sadowska-Wroblewska et al. (66) performed thermographic examinations on 22 AS patients and 100 pain-free controls. They concluded that thermographic examinations in this area of the spine were difficult, but might provide additional information, especially when the disease was active. In many individual cases, the temperature of some symptomatic articulations was over 1.0° C higher than in the normal subjects. Hc ever, there was no statistically significant differe between the pain-free and AS patients.

Greenan and Caygill (67) investigated the sensitiv of infrared thermography in the detection of sacroilii Thirty patients with AS, 27 pain-free subjects and patients with other causes of low back pain were amined using generally accepted thermographic pro cols for skin temperature abnormalities around th articulations. Five of the 30 clinically diagnosed patients did not meet the New York criteria for defi tive disease (68). Furthermore, seven of the patie took nonsteroidal anti-inflammatory medication on day of the assessment, possibly influencing the resu of thermography. The results of the thermograms w blindly interpreted with respect to the diagnostic ca gory. The study showed a trend toward abnormal th mograms in those patients with pronounced or a vanced sacroiliitis. None of the patients with ot causes of lower back pain had increased thermal acti in the SI region. Due to patients having taken medi tion and others without definitive diagnoses, it is di cult to determine the sensitivity of telethermogra for the differential diagnosis of AS.

Scoliosis

Protocols for telethermographic screening for adol cent scoliosis have been presented by Woodrough (6 Marked asymmetry is often noted in anterior therm grams of scoliosis patients.

A preliminary study by Cooke et al. (70) fou telethermography to have a sensitivity of 98% and specificity of 91% in the identification of radiologica determined scoliosis. One hundred fifty-four childr were evaluated. There were 29 young outpatients tending a scoliosis clinic and 125 relatively norm adolescents. Eventually 44 children were identified the thermogram as having scoliosis. This number w confirmed radiographically from a sample of 53 ch dren (29 symptomatic, 24 asymptomatic). The chara teristic image of the paraspinal area in someone wi scoliosis often shows increased heat on the conv portion of the curve. This may be due to low gra sustained muscular contraction in the area.

Cacquino et al. (71) advised the use of thermograp for evaluating a possible site of tension of the spi following Harrington's surgical procedure. Proper su gical technique may be enhanced with thermograph information. This was based on preliminary experien with 60 patients.

Visceral Disease

Kobrossi and Steiman (72) reported on a patient with mbined musculoskeletal (motion restriction) and visceral disease (duodenal ulcer). Although telethermography is incapable of differentiating somatovisceral ɔm viscerosomatic reflexes, the authors discussed a ..e for telethermography in evaluating autonomic function. Most tests that are influenced by changes in tonomic tone (e.g., blood pressure monitoring) reflect neralized autonomic activity.

Banner (73) attempted to correlate the results of telethermography, palpation and gastrointestinal fluoscopy in patients with duodenal ulcer. He found no correlation, but did admit to a small number of subjects with definitive diagnoses ($n = 13$) as a confounding ctor in the design. The thermographic reliability was o questioned by the author, since the ambient air temperature was difficult to control in the summer onths when the experiment took place. He concluded at more comprehensive and detailed studies needed to be performed in order to more fully evaluate the role of thermography and osteopathic palpation in the evaltion of duodenal ulcer.

Trigger Points

Thermographic imaging of trigger points was invesated by Fischer and Chang (74). The trigger points usually appear as a focal hot spot 0.5–1.0° C warmer than the surrounding area or contralateral reference ɔint. They found telethermography to be superior to thermocouple device in imaging these phenomena in their sample of 14 patients with low back pain. The gger points were confined primarily to the gluteal d lower lumbar points.

Fischer (75) used lower body thermograms to image e area of pain in 638 consecutive patients. He found e technique to be helpful in confirming reports of pain confined to only one area of the body. Hot spots represented abnormal findings of hyperalgesic areas due active or latent trigger points. Patient sensitivity to ese areas was determined by pressure algometry.

Diakow (76) reported on two patients with trigger ɔint syndromes, which were effectively documented th thermographic imaging. The thermographic examination should be compared with a palpatory assessment in those patients with suspected myofascial trigger ɔint syndromes.

Headache

Swerdlow and Dieter (77) used posterior cervical and oracic telethermography to evaluate 438 headache patients. They found that the types of thermographic patterns did not remain constant over several months, nor did they correspond to the various subdiagnoses of the patients. The thermography was performed when the patients were headache free. All analyses were performed blinded to diagnostic category. The follow-up time for 30 subjects of 5–6 months could add to the variability of the thermogram due to intervening treatment or traumatic episodes. The authors found that the cervical region (C1-C7) was the warmest area of the spine. This increased emission could be due to differences in vascular anatomy of the region or from sustained muscle contraction due to anterior carriage of the head and neck or other factors.

Psychogenic Pain

Hendler and Uematsu (78) reported on 224 patients who underwent thermographic examination following referral to a psychiatrist for "psychogenic pain." Forty-three of these patients (19%) had an abnormal thermogram in an affected extremity. The positive thermogram eventually led to more accurate diagnoses such as reflex sympathetic dystrophy and thoracic outlet syndrome.

Shandell and Saboda (79) used telethermographic, physical and psychometric examinations on 60 chronic pain patients. Forty-two (70%) of the thermograms were interpreted as abnormal. Approximately 45% of these patients had evidence of a psychological disorder. Seventy-two percent of the patients with normal thermograms manifested clinically substantial psychopathology.

Spinal Manipulation

Kelso and Johnston (80) reported on a patient with a persistent thermographic abnormality at the T6 level. Comparative thermographic examinations without intervention for a 6-month period showed that the geographical area of the hot spot did not vary by more than 10% in size. Two hr following manipulative reduction of the vertebral dysfunction, the hot spot was reduced by 20%. The type of manipulative treatment (e.g., thrust, soft tissue manipulation) was not defined.

LCT

CT, EMG and Myelography

Newman et al. (81) performed a comparative study of LCT to test its correlation with other diagnostic tests (i.e., CT, myelography, EMG, clinical assessment). One hundred fifty-five chronic back pain patients were evaluated. Each had back pain of at least 6 months duration. The mean age was 40.5 yr and 48% of the sample had previous lumbar spine surgery. LCT of the lumbar spine and related dermatomes was performed. To test the interexaminer reliability of LCT, two examiners blindly interpreted the thermographic results of 155 patients. The thermograms were categorized as normal or abnormal based upon a predetermined agreement on what would constitute a positive finding. The overall agreement was 96.1%. The amount of agreement due to chance (e.g., Kappa) was not computed. Thermography correlated best with the EMG and the neurological examination, with the concordance at 75%. Thermography agreed with the myelogram in 54% of the cases and 58% of the time for the CT scan. There were very few false negative examinations (4–8%) when compared with the other diagnostic tests. There was a tendency for the CT scan or myelography to indicate an abnormality in the previously operated patient. This was not true for thermography, the EMG or the neurological assessment.

Nakano (82) used LCT to evaluate 109 patients (61 men and 48 women, age 15–73 yr) with traumatic low back pain. Forty-three patients or 39% revealed abnormal thermographic findings. Further diagnostic workups (EMG, CT, myelogram) on these 43 patients were performed following the thermogram. The reviewers of the other diagnostic tests were blinded to the results of LCT. Of the 43 patients with abnormal thermograms, EMG, CT and the myelogram agreed in 39 instances (91%). Forty patients had demonstrated disc protrusions, two showed facet syndrome and one had a severe spondylolisthesis. Of the 66 patients with a normal thermogram, the authors noted that they had less physician visits and other medical therapies when compared to those with positive LCT.

Using qualitative LCT in the diagnosis of patients with low back pain and sciatica, Getty (83) found the procedure not to be valuable. Bony entrapment syndromes of the lateral recess or intervertebral foramen appeared not to be identified by LCT. Ultimately, only 19 of the 107 patients were offered surgical treatment. The results of LCT were compared to a surgeon's assessment, EMG and myelography. Only thermograms of the lower extremities were made, which is contradictory to normal protocol for the evaluation of a patient with low back pain and sciatica.

Nakano (84) reported on four patients with neurogenic thoracic outlet syndrome, which was identified with LCT. The thermograms agreed with the results of EMG. After sympathetic block of the afflicted limb, each case responded with transient remission of hypothermia.

Surgical Findings

Mills et al. (85) compared LCT to surgical finc ($n = 19$) and the surgeon's overall assessment ($n =$ They found that LCT agreed poorly with these para eters and other modes of diagnosis (e.g., EMG, myelogram). Their conclusion was that LCT was n reliable test for predicting nerve root compression c to lateral recess stenosis.

Palpation

Diakow et al. (86) attempted to correlate LCT of t spine with palpatory indicators of spinal dysfunctio 10 subjects with chronic manifestations of segme abnormalities. Skin rolling, passive motion palpati and tenderness scans showed generally weak corre tions (Pearson's $r < .6$) with the thermographic ass ment. This pilot study had a number of problems w design (acknowledged by the authors). Many inves gations have disclosed generally poor interexami reliability of motion palpation as an indicator of sp dysfunction. The unknown reliability of tendern scans and skin rolling further complicates the pict The authors did find generally hyperthermic paraspi areas in their small sample of subjects. This is in co trast to other investigations (49), although the subje population in these studies had comparatively grea disability.

In an investigation by Deibert and England (8 thermal changes associated with the osteopathic les (somatic dysfunction) were studied. LCT (crysta graphic) showed a generalized, increased temperatu at the site of the lesion in the six subjects tested. Th patients were preselected based on clinical evidence recurring chronic lesion patterns. Following manip lative treatment, five of the six patients had reductio in the thermal emissions of the area. No blinding control population was reported for the experiment.

Back Pain and Radiculopathy

Rubal et al. (88) used LCT to determine the incider of temperature asymmetries of hospitalized patien with low back pain ($n = 62$) and the patterns of control group ($n = 22$). Patients with discogenic a soft tissue abnormalities had significantly greater sk temperature abnormalities when compared to the co trols. The hot spots on the back were often correlat with palpable tenderness of the associated soft tissu The authors concluded that LCT of the lumbar spir was a useful supplement to clinical methods for objectively documenting soft tissue trauma of the low back. The lack of any blinding procedures for reviewing the thermograms by the authors may have created a bias in the analysis.

Pochaczevsky (89) used LCT to evaluate 70 patients with traumatic injuries of the spine and extremities. Seventy percent of these patients had an abnormal thermogram. No blinding procedures or controls were reported. The thermogram correlated closely with the patient's report of pain and was helpful in identifying potential malingerers. Pochaczevsky further described indications for LCT in the evaluation of posttraumatic pain (90). In the absence of focal paraspinal asymmetries, at least two related extremity dermatomes should have abnormalities in order to make a diagnosis of spinal root compression or irritation syndrome. In one of the patients cited, he illustrated a linear zone of increased emission along the costal border (from a previous laceration) and bilateral linear zones radiating laterally and inferiorly from L4-L5 (indicative of nerve root irritation) in a 65-yr-old who had suffered a fall.

Pochaczevsky (91) used LCT to evaluate 115 hospital patients with root compression syndromes. Seventy-two of these patients had myelograms and 44 underwent surgery. Compared to the clinical assessment, thermography agreed in 76% of the patients. The myelogram, in comparison, was positive in only 63% of the cases. Of the presented surgically operated patients, the thermogram was in agreement in 91% of the cases. The myelogram agreed in 86% of these patients.

Facet syndrome and its thermographic manifestations were investigated by McFadden (92) in 15 patients. In these patients, there was usually a spot of increased thermal emission just lateral to the L4-L5 or L5-S1 facet joint levels. Following facetal injections of anesthetic, the area of abnormality increased in temperature, and the patients reported a reduction in pain. One control subject failed to show thermal manifestations following injection of hypertonic saline into the capsule.

Hand-Held Instruments

In a study by Perdew et al. (93) to determine the reliability and concurrent validity of several body surface temperature instruments (i.e., absolute infrared radiometer, differential radiometer, absolute thermocouple and differential thermocouple), each was applied successively to eight points on the back of 46 adult males. Side by side and unilateral measurements were made at the levels of L5, L1, T6 and C7. The instrument tested was applied to the center point of a 1-in circle at these locations. In general, the correlation coefficients of reliability for test-retest data were high. Concurrent validity values (i.e., correlation coefficients) ranged from low to moderately high. One of the instruments (absolute radiometer) was defective and affected some of the correlation values. Details of any blinding procedure were not reported by the investigators. The statistical analysis of their study has been criticized (94). Good correlation does not necessarily mean good concordance, should additive or multiplicative bias exist (95).

Infrared Instruments

Haldeman (96), observing the Synchro-Therme (hand-held graphic output infrared sensor) under test conditions on 50 relatively pain-free chiropractic students, noted that it could be a fruitful area for future research. He gives no quantitative data in his paper, so no conclusions can be made concerning reliability or effectiveness.

Spector et al. (97) tested the inter- and intraexaminer reliability of an IR-Onics DTG Infrared Detector under dynamic scanning conditions. Twelve subjects were analyzed at several spinal levels (i.e., T1, T5, T9, L1, L5). Coefficients of reliability (analysis of variance) approached unity in most cases. The range was from .940 to .995. This was true when the patient was scanned in the prone, seated or standing positions. The authors concluded that the instrument was sufficiently reliable to permit further validity and outcome studies.

DeBoer et al. (94), under controlled and blinded conditions, tested the inter- and intraexaminer reliability of a paraspinal, hand-held infrared thermographic instrument. Twenty-four relatively pain-free chiropractic college students served as subjects for the experiment. Two infrared sensors (Decade III R, Exergin Co., Natwick, MA) were fixed together so that the examiner could handle the devices as one unit. The spine was scanned from the level of the S2 tubercle toward the base of the occiput. A graphic recording was made for each scan. However, the data from only the lumbar and thoracic regions were analyzed due to technical difficulties in the other areas (e.g., hair). Continuous data were analyzed with the ICC, and break analysis was scrutinized with a dichotomous choice statistic. The overall ICC for the three examiners was 0.657. Intraexaminer reliability ranged from 0.591 to 0.799 (moderate to good reliability). Analysis of the temperature differentials (i.e., breaks) revealed local paraspinal differentials greater than 0.5°F in 16 of the 24 subjects.

The average interexaminer agreement was 75% and the intraexaminer agreement was 74%. Statistical analysis, using the dichotomous item reliability test, surprisingly, yielded higher interexaminer reliability, but relatively low intraexaminer values. Analysis of the data, assuming a break as a differential greater than 2.0°F, yielded similar results. The authors concluded that infrared radiation temperature readings in their study were moderately reliable, but that further research was needed.

Keating et al. (98) used a Dermathermograph instrument as part of an overall assessment (e.g., motion and static palpation, etc.) of the lumbar spine in 25 pain-free and 21 symptomatic subjects. Concordance for interexaminer agreement was evaluated with the Kappa statistic. The authors found moderate but generally weak levels of interexaminer agreement (Kappa range, 0.0–0.65). Agreement was poor for the upper lumbar levels and L4-L5. The mean Kappa for L5-S1 was 0.59 (good) and 0.46 (good) at L3-L4.

Spinal Manipulation

Brand and Gizoni (99) used an infrared gun to evaluate three areas of the spine (T1, T7, L5) before and after a single chiropractic adjustment. Eighteen undefined patients participated as subjects in the experiment. A significant reduction in temperature was seen at the T1 and T7 levels following treatment.

Wood (100), in a single blind study, compared thermographic results with postural abnormalities of the pelvis (subluxation). Fifty-one patients were evaluated, ranging in age from 18 to 65 yr. A hand-held infrared radiation detector (Orthion Orthotherm IR Dynamic Thermography System) was used to analyze the patients. The author concluded that there was a "statistically significant correlation" of a relatively cold posterior superior iliac spine on the side of pelvic deficiency. The statistical methodologies employed lack sufficient detail to make conclusive remarks regarding this preliminary investigation.

Thermocouple Instruments

Trott and Maitland (101) conducted a survey to test the value of the Nervoscope as a diagnostic instrument. This is a paraspinal thermocouple device which gives primarily a qualitative assessment of thermal asymmetry. Relative differences in paraspinal skin temperature were depicted as a sway in the movement of the meter to one side or the other over a short vertical distance of the spinal column (e.g., one functional spinal unit). Their results indicated that the instrument agreed with clinical findings in the lumbar spine in 67% of the 14 patients tested. Agreement with clinical findings of the thoracic spine (no neurological deficits) was 21% the 14 patients tested. The examiners' use of the ins ment while the patient was in the prone position il trates their lack of familiarity with the device. They a attempted to assess concordance with other diagnos tests of unknown reliability and validity. The c analysis did not use appropriate statistics of conco ance, which makes suspect their conclusion that t instrument has little diagnostic value.

Plaugher et al. (102) expanded on the work of T and Maitland by testing the inter- and intraexamir reliability of the Nervoscope. Nineteen relatively pa free chiropractic college students were used as subj for the blinded investigation. Three areas were assess for reliability: C4-T2, T4-T8 and L2-L5. A determi tion was made if a positive finding existed in any of three areas and was evaluated with the Kappa statis Good inter- and intraexaminer agreement was seen i the thoracic region (K > 0.56). The cervicothoracic a failed to show good interexaminer concordance; authors concluded that caution should be used in t interpretation of asymmetries in this region. The lu bar spine could not be evaluated with the Kappa sta tic due to the high percentage of positive findin detected in this region. If "readings" were detected i two examiners in a given region, their location v evaluated with the ICC. This yielded good intraexa ner correlation (ICC > 0.50). Interexaminer agreeme for the first series of observations had a low ICC va (<0.3). The second series of observations yielded go interexaminer concordance (ICC = 0.64). The autho speculated that as the instrument was used in a repe sequence, positive findings became more stable a frivolous temperature fluctuations were "erased." Th cautioned against applying the results of the investig tion to a clinical setting unless the involved protoc was followed. This study needs to be repeated with more symptomatic and larger sample of patients. Sin the Nervoscope is used in a dynamic scan of the par spinal tissues, irritation or erythema (i.e., red respons of the skin often results. The effects of this irritation c skin temperature are unknown. A study of the the mogram following skin stimulation or aggravation pain in the patient may provide useful information to the stability and variability of skin temperature asyn metries.

Comments

In order to critically evaluate a new clinical tool, it necessary for the interpretation to take place und blinded conditions. Many of the clinical investigatior presented here did not follow such a protocol since the were based in the clinical setting. In Meeker and Gahlinger's review of neuromusculoskeletal thermography in 1986 (1), they urged further investigations with more attention to blinded and controlled designs. Since 1986, there have been several blinded telethermographic investigations (14, 27–29, 50, 51) that tend to support its effectiveness (i.e., high sensitivity) as a diagnostic assessment for cervical and lumbar radiculopathies, disc protrusion and back pain. Telethermography may have a role as a pre-employment screening tool, since it appears to be more sensitive than plain X ray for identifying individuals at risk for developing back pain (46). Telethermography compares favorably to anatomical tests (e.g., CT, myelogram) and, to a lesser extent, physiological tests such as EMG.

For LCT, there are a few blinded studies (81, 82) which support its use as an effective (high sensitivity) diagnostic tool when comparing it to other more standard tests (e.g., EMG, CT and myelogram) for patients with chronic back pain and traumatic injuries of the spine. Other thermographic instruments have, thus far, not been tested for sensitivity.

Attempting to determine sensitivity and specificity for thermography in the absence of an acceptable gold standard for comparison is questionable. Comparing thermography to an anatomical test, such as CT or myelography, or to a surgeon's findings of a small subset of the original study population is questionable, although telethermography appears to correlate well. In these comparison design experiments, the superior or reference examination is difficult to determine in the absence of a definitive gold standard. Comparing thermography to a reference test, such as a CT scan, assumes a priori that the CT will be infallible. These types of comparisons will always show the new test to be inferior to the reference (15). The incidence of asymptomatic disc protrusions confirmed by CT decreases its credibility as an entirely accurate test for symptomatic disc lesions.

Especially in unblinded comparisons, the tendency for one diagnostic test to drive the results of another has to be considered. More important is the issue of validity in attempting to correlate an anatomic abnormality with a physiological test. While structure does govern function, it cannot be said that an abnormality in anatomy will always lead to an abnormality in physiology. There is not a known gold standard for sympathetically mediated dermatomal skin temperature abnormalities.

The hand-held instruments, which tend to be more unique to the chiropractic profession, have, in a few cases, been shown to have acceptable levels of interexaminer reliability. Most of these studies were performed on relatively pain-free chiropractic students; therefore, it is difficult to generalize the reliability results to actual patients. Conducting future investigations on symptomatic patients while attempting to determine the validity of the various instruments should be a high priority for the chiropractic profession.

Thermography shows promise as a relatively stable outcome measure for determining the effectiveness of a given modality of treatment. Future research into the effects of spinal manipulation may wish to consider the use of thermography. Previous investigators (103) have shown sympathetically mediated vascular effects following chiropractic adjustments. A follow-up to this experiment would be to determine if asymmetries of skin temperature in a symptomatic population normalize following intervention.

Basic science studies into the phenomena of skin temperature are relatively few in number (104, 105). Clinically relevant data could be generated from such work, provided that the methods for creating thermal asymmetries in laboratory animals are similar to the mechanism of nerve or soft tissue dysfunction in the human.

Sackett et al. (16) have provided eight guidelines for determining the clinical usefulness of a diagnostic test. They are as follows:

1. Has there been an independent, "blind" comparison with a "gold standard" of diagnosis? Studies comparing telethermography and, to a lesser extent, LCT, have been performed. Other thermographic instruments await further study.

2. Has the diagnostic test been evaluated in a patient sample that included an appropriate spectrum of mild and severe, treated and untreated disease, plus individuals with different but commonly confused disorders? Little data exist for any of the various instruments in this regard.

3. Was the setting for this evaluation, as well as the filter through which study patients passed, adequately described? Most of the studies cited adequately described the setting for evaluation.

4. Have the reproducibility of the test result (precision) and its interpretation (observer variation) been determined? Few studies exist on examiner reliability. Of those telethermographic studies reviewed, most showed moderate levels of examiner reliability. The hand-held instruments have not been tested with symptomatic subject populations, although preliminary evidence has suggested moderate levels of reliability in some spinal regions.

5. Has the term "normal" been defined sensibly as it

applies to this test? Normative data for skin temperature are relatively strong for telethermography (full body) and LCT (neck and upper extremities). Normative data for the hand-held instruments are absent.

6. If the test is advocated as part of a cluster or sequence of tests, has its individual contribution to the overall validity of the cluster or sequence been determined? Thermography is one of only a few tests of physiology for abnormalities of the spinal column. How the thermographic results are weighed with other tests of spinal dysfunction remains ill defined.

7. Have the tactics for carrying out the test been described in sufficient detail to permit their exact replication? Protocols for most of the thermographic instruments have been adequately described.

8. Has the utility of the test been determined? The ultimate criterion for a diagnostic test or any other clinical maneuver is whether the patient is better off for it. Unfortunately, there are little data for any of the various instruments in this regard.

Thermographic researchers should attempt to address the guidelines provided above in future studies. While there is a large thermographic data base, most studies have failed to address all the preceding issues. The low cost and noninvasiveness of thermography make it an attractive vehicle for spine-related research. The chiropractic profession can make a substantial contribution in this area (both clinical and basic science studies) and intensified efforts should be a high priority.

CONCLUSION

Recent, blinded investigations into the effectiveness of telethermography have tended to confirm the mostly positive conclusions (high sensitivity) of earlier unblinded studies in comparing telethermography with reference tests such as CT or the myelogram. Back pain, radiculopathy and disc lesions often show thermal manifestations of their effects, which can be detected by telethermography. Interexaminer reliability for telethermography has a paucity of evidence, but appears to show promise as a reliable tool. Normative data for telethermography are strong.

LCT has received less attention in the literature. However, investigations into normal temperature variation of the neck and upper extremities is present. The few blinded comparison studies showed good examiner reliability, but conflicting results have emerged when comparing the test with reference tests such as CT and EMG. Methodological flaws exist in some LCT research. The low cost of this instrument should make future, blinded studies easy to produce.

Interexaminer reliability for the hand-held infrared instruments appears to be moderate. Further resea in the area of examiner reliability needs to incorpo more symptomatic patient samples. Comparing t hand-held instruments to telethermography or L should be a fruitful area for research.

Interexaminer reliability for hand-held thermoco instruments is less strong when compared to infra devices. Research in this area is still in its infan Examiner reliability studies and comparisons with n sophisticated thermographic instruments should swer the many unresolved questions concerning th devices.

The use of the surgeon's assessment or other t (e.g., CT, EMG, myelogram) as the gold standard the validation of thermography should be questio Studies need to be performed using telethermogra and LCT as outcome measures.

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Clinical Necessity
&
Outcome
Assessment

A premise for instrumentation

William J. Rademacher, D.C.

ABSTRACT. *Instrumentation has been integral to chiropractic since the introduction of the neurocalometer in 1924. Although technology has produced instruments other than the neurocalometer, they all claim to measure a physiologic response of the vertebral subluxation complex (VSC), which is mediated via the sympathetic nervous system (SNS). The research of Dr. Irvin Korr demonstrates interaction of the SNS with somatic dysfunction. In conjunction with other clinical findings, the instrumentation may augment the detection and the confirmation of the reduction of neurophysiological dysfunction secondary to vertebral dysfunction.*

KEY WORDS: (MeSH) Thermography—Autonomic nervous system; (Non-MeSH) Instrumentation—Surface temperature detection—Neurocalameter

HISTORICALLY, THE DEFINITION OF VERTEBRAL subluxation has included two basic components, namely osseous misalignment and interferences to the quality or quantity of transmission of nervous energy. Although many methods have been developed to attempt to assess the structural component of the vertebral subluxation and its potential reduction, the chiropractic profession has developed few methods to assess the neurophysiologic effects of chiropractic adjustments.

One such attempt has been the development of devices to detect alterations in cutaneous heat distributions. This article provides a brief historical background surrounding the development of these devices and discusses the premise upon which the use of these devices is predicated.

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CHIROPRACTIC TECHNIQUE

HISTORY

The roots of the use of heat sensing instruments by the chiropractic profession can be traced to Dossa D. Evins, D.C., a 1922 graduate of the Palmer School of Chiropractic. While a patient of R.S. Marlow, D.C., of San Antonio, Texas, Evins was exposed to a method of chiropractic analysis common to the day in which the chiropractor passed the dorsum of the hand along the spine to detect "hot spots" on either side of the vertebral column. These "hot spots" were presumed to be areas of vertebral irritation and were used to guide the clinical decision regarding the presence or absence of a vertebral subluxation [1] (pp. 1–2).

With this knowledge in mind, Evins developed an instrument designed to detect, with continuous accuracy, what the dorsum of the chirporactor's hand was attempting to perform. Evins brought the device to the attention of his alma mater's president, Dr. Bartlett J. Palmer; and following a year of testing, Palmer presented the device, which became known as the neurocalometer (NCM), to the profession at the 1924 lyceum sponsored by the Palmer School of Chiropractic [2]. In doing so, Palmer stated that his purpose in bringing the NCM to the field doctors was to improve the doctor's clinical service to the patient [3].

EQUIPMENT

The NCM is a bipolar instrument and it ". . . consists principally of three units: galvanometer, thermo-couple circuit, and housing. The galvanometer used in the neurocalometer is especially designed and constructed for extreme sensitivity, accuracy, and durability but the principle on which it operates is the same as other galvanometers. It consists of a horse-shoe magnet which makes the field circuit. Between the poles is inserted an armature, to the shaft of which is attached the indicator. Dissimilar elements form the thermo-couple, which is connected to [the] galvanometer so that its action is dual; that is, one side is working antagonistic to the other side. The temperature generates the electromotive force, and if this temperature was [the] same each side would be the same and the indicator would not move because there would be a definite balance between the two. But, if the temperature was greater on one side [or lesser on one side] it would generate more electro-motive force than the other side because of the difference in the temperature and would move the indicator in the direction to the side of the greatest temperature. Thus the reading would be the difference in the temperature of the two sides rather than the temperature of each side [The indicator will swing to the side of warmer temperature or conversely, away from the colder side.].

"The Neurocalometer is a . . . temperature differentiating instrument, indicating the difference in temperature that exists between two terminals. The movement of the indicator over the graduated dial is in points of reading and does not indicate the degree of temperature. It shows the difference in temperature of the two sides; that is, [a] comparative reading. The indicator moves so that the technician can determine which side is the warmest, and how much, as compared with the other side" [1] (p. 7) (Fig. 1).

The manual for the neurocalometer stated that the perceived purpose was ". . . to determine the

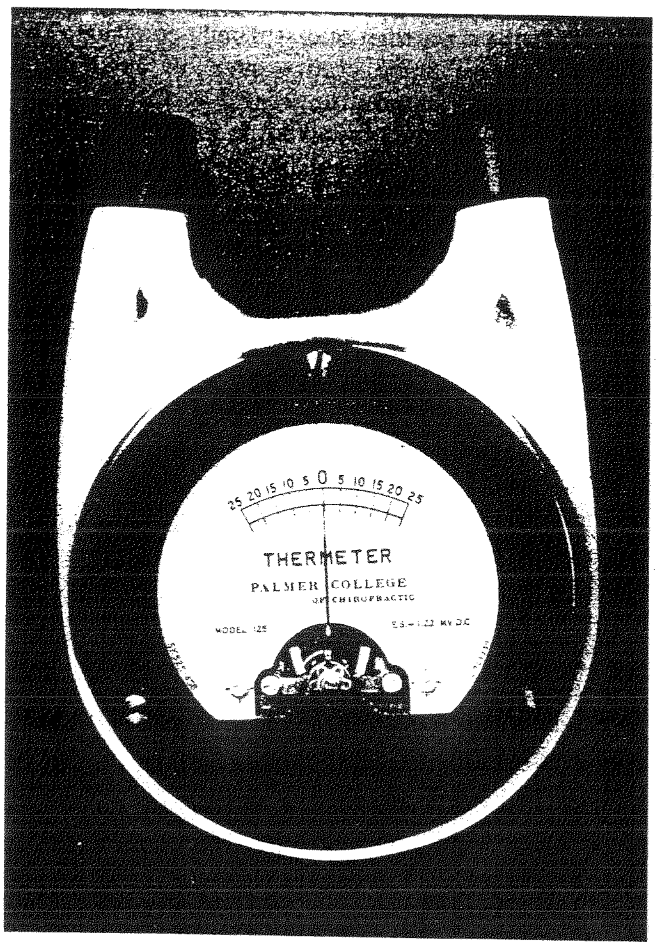


Fig. 1. The thermeter, a thermocouple instrument designed to detect cutaneous temperature variations on opposing sides of the spine.

presence of a nerve pressure . . . . After an adjustment the Neurocalometer is used to determine whether or not the subluxation has been corrected. Successful use of this instrument requires extreme accuracy in every phase of technique and also a thorough understanding of the action of the indicator. This understanding is termed Interpretation" [1] (pp. 7–8).

NCM TECHNIQUE

The technique of obtaining a reading included the preparation of the patient, the doctor's stance, the doctor's grasp of the instrument, the gliding movement of the instrument, and the observation of the indicator on the dial [1] (pp. 8–16). The important aspect of the interpretation is the determination of a pattern for the individual patient. In essence several readings of a like graph reading (NCM recording marked on a paper) or indicator swing (without the benefit of a graph) give reason to indicate the existence of a spinal subluxation [1] (p. 26) (Fig. 2).

NERVOUS SYSTEM

According to the NCM manual, what the NCM was measuring was an abnormal neruophysiological aberration resulting from the vertebral lesion. It was not recording degrees of temperature difference. The vertebral subluxation complex has five components: kinesiopathology, neuropathophysiology, myopathology, histopathology, and pathophysiology. The neuropathophysiology causing nerve injury, the histopathology resulting in damage to the nerve tissue as well as other structures of the vascular supply and the soft tissue support of the spine along with the pathophysiology directing a malfunction of the glands and viscera would be the most notable VSC components to evoke changes of the nervous system from its normal function [4]. Hence, it becomes necessary to understand the role of the nervous system at the cutaneous level.

The sympathetic nervous system is primarily responsible for the mediation of skin temperature. The sympathetic system is catabolic. Its actions include dilating blood vessels in skeletal and cardiac muscles and increasing sweat secretion [5]. Acetycholine, the cholinergic neurotransmitter from the postganglionic sympathetic axons, supplies the sweat glands and the piloerector muscles [5] (p. 92). The response for the sweat gland is to control temperature [5] (p. 87). The sympathetic nervous system will also constrict cutaneous blood vessels [6].

The sympathetic preganglionic axons originate in the intermediolateral column of the spinal cord and exit with the ventral spinal nerve roots of T1–L2 [5] (p. 89). "Some of the nonmyelinated postganglionic fibers (C fibers) given off from the neurons in the sympathetic trunk ganglia form the gray rami com-

Skin, connective tissue, musculature, and viscera lying within a vascular nerve region may be involved in the 'autonomic irritation syndrome.' Every blood vessel is enmeshed by the autonomic nervous system with a double innervation: through the posterior roots (the peripheral nerves), and also through perivasal routes (the rami spinales longs and the sympathetic trunk). The nerves at the surface of the media are predominantly sympathetic, and those in the adventitia are predominantly afferent. Both may undergo degeneration in a nerve root injury" [11] (p. 270). Hence, the vertebral dysfunction may alter the skin surface temperature.

PRECEDENT FOR INSTRUMENTATION

The research and opinions of Irvin M. Korr, Ph.D., Sc.D. provide a physiologic substantiation for the role of instrumentation. The emphasis of instrumentation is predicated on heat differences as potentially influenced by altered neuronal function. This aberrant function in turn may result from spinal malfunction. The following discussion of Dr. Korr's research includes observations of cutaneous temperature differences along with electrical skin resistance changes resulting from neuronal alterations. This is not meant to be confusing but rather to illustrate that skin temperature variation may not be the only potential observable and measurable component of vertebral lesion and neuronal aberration. Research has demonstrated the elevated electrical skin resistance (ESR) result from low sweat gland activity because of an impaired sympathetic nerve supply [12]. In his investigation of regional and segmental differences in the sympathetic activity as indicated by cutaneous sudomotor and vasomotor changes, the ESR in subjects yielded a topographical pattern of distribution, relative to right and left sides and segmental levels of the back, that remained constant from weeks, to months, and in some cases years. (This extensive monitoring suggests good intraexaminer reliability though not statistically verified.) The sympathetic patterned differences were attributed to disturbances of the viscera or myofascia as suggested by the areas of low skin resistance, low skin temperature, and skin pallor as they were reflexly linked to pain from the myofascia and the viscera [13].

In response to adaptation ". . . the efferent components of these patterns (motoneurons and preganglionic autonomic neurons largely spinal in origin) are multisegmental and under the control of bulbar, diencephalic and cortical centers, their activity is continually influenced by afferent impulses that arise in thermal receptors, pressure receptors, proprioceptors, pain endings, etc., and that are conducted to the spinal cord by sensory fibers entering via the dorsal roots" [13] (p. 62). Dr. Korr's studies provided a strong indication that the areas of low-resistance irregularity start as reflex responses to a flow of impulses having their origin in somatic or visceral structures or even in the very nerve fibers irritated by them. Clinical evidence suggests that target tissues (visceral or somatic) that sustain afferent bombardment for an extended time would result in a pathological change such as fibrosis of a muscle that has been chronically stretched, irritated, or made ischemic [13] (p. 63). Further, because ". . . the affected areas may be limited in extent to single dermatomes, it appears that individual ganglia, gray rami communicantes, ventral roots, spinal nerves or their branches may in some cases be directly, rather than reflexly, irritated" [13] (p. 65).

To continue this thought of adaptation, Dr. Korr's paper on cutaneous patterns suggests that ". . . in the face of chronic stress or irritation and of sustained reflex activity, adaptive changes would take place either in the stressed or irritated tissue (e.g., fibrosis of muscle), in the participating neruons (e.g., altered excitablity), in the responding organs or tissues (e.g., altered contractility of blood vessels, altered secretory activity of sweat glands) or in combinations thereof" [14]. In a later paper, he noted that a significant aspect of the sympathetic nervous system is to adapt the circulatory, metabolic, and visceral activity to the demands of the musculoskeletal system and the body's posture. Although the adaptations of cardiac output, the vascular flow distribution regulated via peripheral resistance, cutaneous heat dissipation, and the release of metabolites have a systemic nature, they also have a local impact as it relates to the location and the amount of muscular activity. The sympathetic nervous system would be informed about any injury or malfunction to a musculoskeletal joint and that there would be local response if a vertebral segment was involved [15].

To tie all of this information together, it is proposed that a vertebral lesion may be responsible for the sympathetic aberrancies which produce the changes that can be monitored or measured. Dr. Korr indicated that constant local, regional, or dermatomal increase in sympathetic activity is related to "spinal and paraspinal motor dysfunction," which may be detected by palpation. It can be ". . . concluded that peripheral sympathetic pathways at segmental levels corresponding to somatic dysfunction in and around the spinal column are in a state of chronic facilitation" [15] (p. 78). The result of continuous sympathetic stimulation is facilitatory in which the afferent discharge frequency is increased and the threshold is lowered [15] (p. 78).

The indications of the vertebral subluxation would parallel the osteopathic lesion. They would include tenderness and/or pain, muscle function alteration, changes in the viscera, the vasomotor, and the sudomotor responses. In essence, the disturbances involve the sensory, motor, and autonomic nervous system functions. The musculoskeletal stress institutes an unequal flow of impulses entering the central nervous system, which upsets the delicate balance of the nervous system with which the subluxation is connected [16]. The physiology department at the Kirksville College of Osteopathic Medicine evidenced that the segmental pathways controlling the sensory and the autonomic functions may be held in a hyperirritable or hyperactive state. Pain thresholds outlined the sensory function while measurement of cutaneous sweat gland and blood vessel activity outlined the autonomic function. The autonomic activity of local or segmental hyperirritable sympathetic pathways was determined by low electrical skin resistance and cool skin. Thermal radiation revealed lowered skin pain threshold in the same area [16] (p. 150). The lack of symmetry in skin temperature observed in a vascular response between the right and left side of the same involved segment indicates a disturbance in the vasomotor activity of that given area. Just as there is a causal relationship in increased irritability of the sensory and motor pathways in vertebral lesions, there is one with respect to low electrical skin resistance, decreased skin temperature, and weak red responses [16] (p. 151).

What is the significance of facilitation? When the vertebral lesion is present, the tissues receiving their nerve supply from that segment become sensitized to stimuli affecting the individual both internally and externally. In facilitation of the sensory pathway, there is easier access to the nervous system, meaning that environmental changes have an exaggerated impact on the individual with vertebral lesions.

Motor pathway facilitation result in muscular tensions being sustained, responses that are exaggerated, asymmetries of posture, and a restriction of motion that is painful.

Finally when the sympathetic pathways are facilitated, the sweat glands and the cutaneous blood vessels innervated from the vertebral lesion have their function altered [17].

The cause and the effect of vertebral lesions are very poignant. An individual may have an aggravation of incipient pain of vertebral dysfunction when they are exposed to any environmental changes such as cold temperatures and emotional stresses [14] (p. 64). The sensory sympathetic pathway may be aberrant during vertebral lesions.

"Sympathetic stimulation introduces no new qualities, but modifies (increases or decreases, accelerates or retards, stimulates or inhibits) the inherent functional properties of the target tissue, each, therefore, responding in its own manner" [15] (p. 80). During a vertebral lesioned state, the sympathetic pathways are producing aberrant signals to the structures they innervate, which are beyond the capabilities of the target tissues homeostatic mechanisms. A chronic vertebral lesion is either bordering on or in an alarm state.

Since the vertebral lesion can be at a continual threshold alarm, the sympathetic mechanisms can quickly reach maximum activity under the slightest stimulation because of the low physiologic reserve. From Dr. Korr's research of the skin, the responsibility to compensate is shifted to the other segments and organs, thus impairing the individual's total resources. In a chronic vertebral lesion, the original sympathetic aberrancies may be replaced with the opposite reaction as in hyperhidrosis yielding to hypohidrosis and vasospasm changing to vasomotor atonia with stasis, engorgement, inflammation, and swelling. The explanation for the change is the the initial response mechanisms may "fatigue out" [17] (p. 153).

In addition, the "local sympatheticotonia may actually produce parasympathetic disturbances. Two basic mechanisms are indicated:

1. Through (sympathetic) vasomotor fibers controlling blood flow through the parasympathetic cranial and sacral nuclei and parasympathetic nerve trunks, and
2. Alteration of the tissues so that the afferent discharges from these tissues to parasympathetic centers will also be altered.

Such false and unbalanced 'signals' from these tissues will disturb the regulatory parasympathetic reflexes and mask the original sympathetic manifestations" [17] (p. 153).

The need to monitor vertebral lesions in the symptomatic patient is obvious, but what of the apparently healthy individual? Erratic sudomotor and vasomotor changes in supposedly healthy people ". . . may reflect subclinical and asymptomatic disturbances of afferent bombardment, over selected dorsal roots, or of direct irritation of nerve fibers or ganglion cells" [14] (p. 72). Thus, continuous irritation of peripheral sympathetic structures or sensory fibers in spinal nerves results in visceral and somatic dysfunction, which may become life threatening [15] (p. 85). From years of research involving apparently healthy subjects, Dr. Korr observed ". . . signs and symptoms of visceral disease (for example, coronary artery disease and peptic ulcer) appeared months and years after the demonstration (or first appearance) of prominent areas of low electrical resistance in dermatomes related to the involved viscera. (Some of these symptom-free subjects who later developed visceral disease had had preexisting skin resistance patterns resembling those found on patients with similar diseases.) In other subjects symptoms and disease in somatic or visceral structures segmentally related to the low-resistance dermatomes appeared for the first time (or intermittently) following periods of severe stress, such as final examinations, systemic infections, and emotional conflicts" [16] (p. 151). This implies that chiropractic instrumentation could be utilized to locate the subtle effects of vertebral lesions prior to their symptomatic expression. Areas of skin temperature differential, identified by various heat sensitive devices, could lead to the identification of involved vertebral segments, whose subclinical dysfunction could be normalized (reduced) through specific chiropractic adjustments.

Monitoring the correction of the vertebral lesion is important following the chiropractic adjustment. The adjustment ". . . results in the reestablishment of coherent patterns of afferent input such that local adjustive reflexes are once more appropriate and harmoniously integrated in the total, supraspinally directed patterns of activity and adaptive response" [15] (p. 86). In essence, the ". . . osteopathic lesion [vertebral lesion] marks a segment in which, or through which, the probability of disease is relatively high . . . the osteopathic lesion [vertebral lesion] reveals early invasion of physiologic reserve and predisposition to disease. Osteopathic lesions [vertebral lesions] appear to be or to reflect the 'silent, insidious, fifth column disorders' which leading medical thinkers have concluded need to be sought' in apparently well people' and which are the earliest vanguards of chronic disease" [17] (p. 155).

The ". . . early diagnosis and treatment of the osteopathic lesion [vertebral lesion] offer a direct and systematic approach to the prevention of chronic disease for which, as far as we can tell, there is as yet no substitute" [17] (p. 156). "The therapeutic effect (among others) of manipulation [chiropractic adjustment] is still to slow the vicious cycle and reduce the sympathetic discharge to the visceral and somatic structures which have become reflexly coupled to their mutual detriment" [15] (p. 87). The chiropractic adjustment delivered by a doctor of chiropractic ". . . excites somatic afferent fibers in the musculoskeletal structures of the spine. These afferent excitations may, in turn, provoke reflex responses affecting skeletal muscle, autonomic, hormonal, and immunologic functions" [18].

FURTHER EMPHASIS

In a report on thermography by H.I. Goldberg et al., it was noted that the human skin is nearly flawless in yielding infrared radiation and that the radiation level recorded is ". . . a direct function of the temperature at the surface of the body" [19]. In their study of patients with herniated discs, they found a few individuals who had both back pain as well as lumbar dysfunction, and that they consistently had pathologic thermograms. The lumbar dysfunction was directly resulting from intervertebral disc degeneration and posterior joint disease. A myelogram of each patient revealed a block because of the malalignment and the dorsal thickening of the ligaments [19] (p. 790). Since the small group previously mentioned would have an involvement of both the muscles and ligaments in the motor unit degeneration, it is a distinct possibility that the supporting musculature will be in different stages of contraction which will cause heat. There will be a vascular transfer of heat from the contracted muscle to the skin over that area [20]. As a result "when a subluxation exists it causes unequal contraction of muscles. This unequal contraction should be observable by heat-detecting equipment." Thermography would be able to detect the subluxation effects [21]. Hence, the observable heat from the group of lumbar malalignment secondary to degeneration can result from the muscle contraction as well as from a potential neural component as evidenced by the myelographic block and the resultant intervertebral foraminal compromise due to the disc degeneration. Evidence of skin temperature changes from the latter would be supported by the research of Dr. Korr.

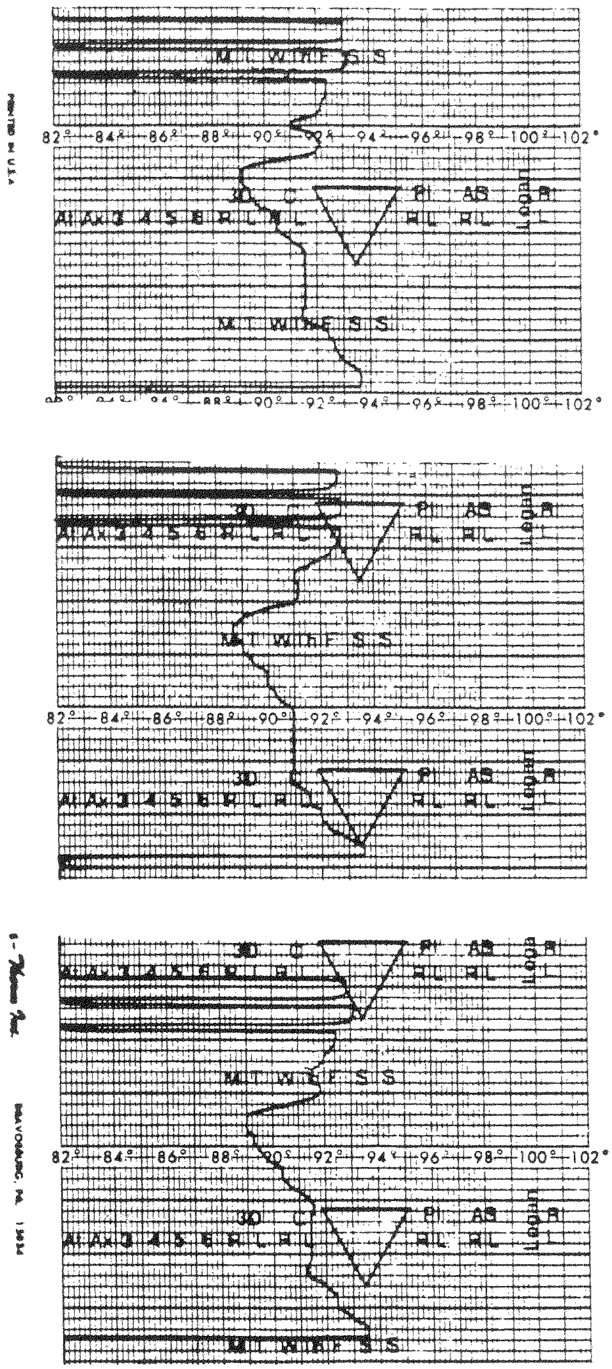
PURPOSE OF INSTRUMENTATION

There would be a twofold benefit to the utilization of instrumentation—detect the existence and the correction of vertebral lesions. Not to be used singularly, instrumentation can be a valuable component to the doctor of chiropractic's clinical findings in evaluating the patient's spinal function.

The findings of palpation (static and/or motion) of the segmental involvement, tissue response (tonicity: normal, hyper-, hypo-), challenge system results (e.g., Activator leg checks, muscle testing), Thompson-Derefield leg checks, and X-ray analysis (neutral, postural stress loading, and motion studies), etc., to point to the existence of a vertebral lesion would be substantiated even further with confirmatory instrumentation data. Following the chiropractic adjustment of the vertebral lesion, there will be a reversal (partial or complete) of the positive findings including a change in the instrumentation readings. Hence, instrumentation along with other clinical and X-ray findings may assist the doctor to know when a vertebral lesion is present.

THE ROLE OF INSTRUMENTATION

As noted in Dr. Korr's work, the vertebral lesion creates neuronal dysfunction and one possible parameter to ascertain this dysfunction is the skin temperature because of the sympathetic nervous system involvement. A heat-sensitive instrument (e.g., NCM [neurocalometer], nervoscope, thermeter, chiro-therm, synchro-therme, DTG [Derma-Therm-o-Graph], Visi-Therm II, etc.) will note skin



FIRST READING
Taken during interview

SECOND READING
Taken after interview

THIRD READING
Taken after x-rays were taken

Please note that the first three readings on this patient have a similar overall pattern. This is called "Chiropractic Patterning." Another reading should be taken after the adjustment to record changes that occur.

Fig. 3. The DTG pattern analysis. The first, second, and third readings all demonstrate a similar overall pattern. Interpretation of such a pattern indicated evidence of neurophysiologic interference secondary to vertebral subluxation. This is adapted from *Results*, copyright 1986, page 67; permission granted.

temperature differences with regard to potential vertebral lesion correction. The pre- and postchiropractic changes may indicate that influence has been provided to the nervous system.

Interpretation of the data from instrumentation such as the NCM and the DTG is based upon a pattern system in which there is a similar paraspinal temperature variation that is reproduced in

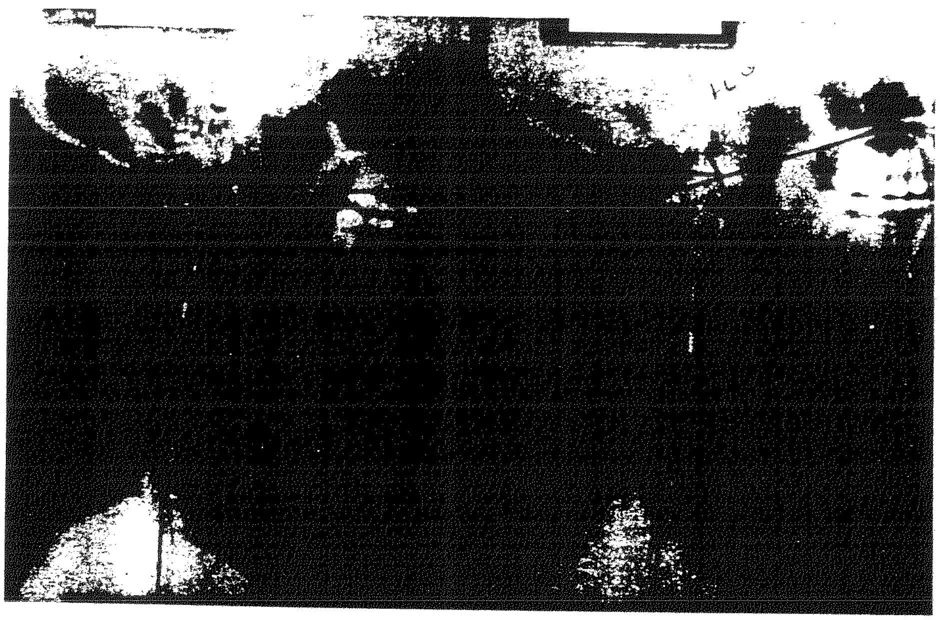
SYMPTOMS: Neck pain on and off for 10 years.

HISTORY: Injured spine doing exercises 10 years ago.

NO. ADJUSTMENTS: 1 5th C

NO. VISITS: 3

RESULTS: Asymptomatic



PRE 11-2-85 (-26cm) **POST 11-5-85 (+60cm)**

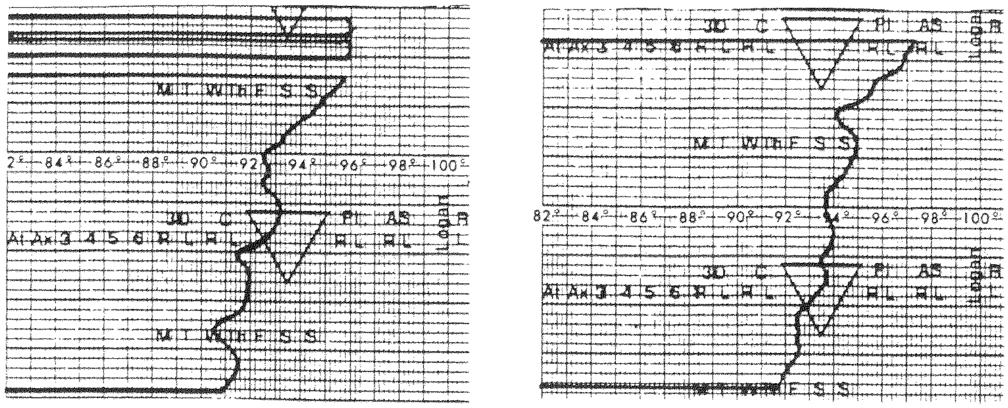
Fig. 4. Case no. 14564. A brief clinical history is presented along with a pre- and a post-neutral lateral cervical X-ray to delineate the spinal biomechanical change following vertebral subluxation correction. This is adapted from *Results*, copyright 1986, page 240; permission granted.

successive readings as measured against a straight line (minus the influence of drugs and/or alcohol) or ever changing reading. Once the pattern has been established, it is corroborated with the other clinical findings and the vertebral lesion is adjusted.

Following the correction, the clinical findings are reevaluated along with obtaining another spinal reading. Just as there will be improvement of the previously noted clinical findings, there will be a reading different from the original pattern.

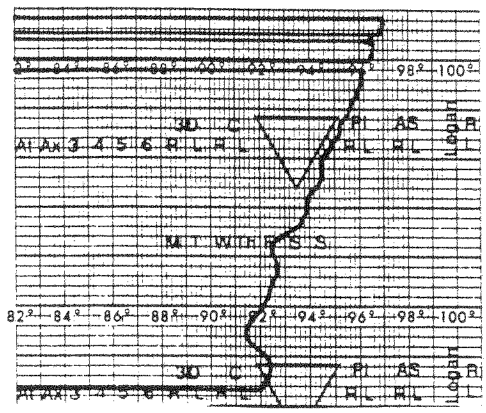
The same can be said for the use of the nervoscope in which effects of neuronal dysfunction are noted from the interpretation of a "break" or abrupt swing of the indicator needle, which suggests asymmetrical temperature distribution [22]. Following the correction of the vertebral lesion, a satisfactory result would be determined by either the elimination of the "break" or a reduction in its severity. Obviously, there would also be required accompanying clinical findings to support the "break" interpretation.

The differing methods of data interpretation utilizing the pattern or the "break" method simply indicate alternative ways to use the equipment in the clinical analysis of the patient. Such methods would not be anymore contradictory than a chiropractor using his/her skill of adjusting to render care to a pet or other animal in need of an adjustment.



PRE 11-2-85 POST

Pre-x-ray shows a -26cm curve. Patient's pelvis was perfect. 5th Cervical adjustment given.



NO ADJUSTMENT

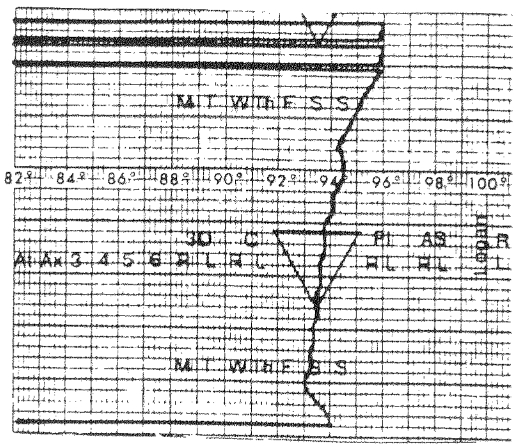
PRE 11-3-85

Patient improved. No adjustment.

Fig. 5. Case no. 14564. Pre- and post-DTG readings of this case recorded on 11/02/85. Also a pre only reading recorded on 11/03/85. Since this reading was not similar to the pattern of the pre reading of 11/02/85, no adjustment was given. This is adapted from *Results*, copyright 1986, page 241; permission granted.

Instrumentation was and is used by doctors of chiropractic as a monitor of body physiology. When there is a vertebral lesion, it is proposed that a pattern of cutaneous skin temperature alteration is unchanging and therefore established as evidence of neuronal disturbance/dysfunction. Evidence of this stems from the observations of Dr. B.J. Palmer, the examples presented Dr. W.V. Pierce [25] and also from Dr. Korr's observations of supposedly healthy individuals who demonstrated repeated patterns of low electrical skin resistance, as a result of their spinal lesion, prior to the onset of their symptoms. Further monitoring with instrumentation following vertebral lesion correction becomes an objective method to monitor change in body physiology as detected through the skin temperature.

Even though criticism may be leveled that the method to obtain the reading is subjective, it must be understood that, as an example, NCM protocol dictated that an adjustment for vertebral lesions was only to be administered when a pattern was established. Hence, a sloppy technique in using the



NO ADJUSTMENT

PRE 11-5-85

Post x-ray taken (see page 240), shows a +60cm curve in just 3 days. No adjustment given. Patient asymptomatic and did not return for care. Contacted patient by phone and she reported that her problems never returned.

Fig. 6. Case no. 14564. Prereading only on 11/05/85. No adjustment was given since the reading did not resemble the established pattern of the prereading of 11/02/85. This is adapted from *Results*, copyright 1986, page 242; permission granted.

NCM would not be able to reproduce a pattern. Further, the post reading following the adjustment indicated a change was made when the pattern was reduced or eliminated.

Examples of success with NCM pattern work can be appreciated from the efforts at the B.J. Palmer Chiropractic Clinic [23]. Eight different cases from the clinic were reviewed that showed dramatic health improvement as the patients were adjusted and monitored with specific emphasis given to the NCM pattern analysis. The cases included liver cancer, sciatica and low back pain, epilepsy (adult and child), multiple sclerosis, encephalitis, hydrocephalus, and tumors [23]. The significance of these profound examples of health improvement is better understood knowing that all patients were medically examined and evaluated prior to chiropractic evaluation that included X-rays and instrumentation. The initial and follow-up examinations and evaluations were exhaustive, to say the least [24].

Regarding the use of the DTG, Dr. Pierce explains the protocol of utilization in chapter six of his text *Results*. He too refers to the advantages of a pattern analysis while employing an accurate technique (Fig. 3). Like the eight cases from Dr. Palmer's research, Dr. Pierce devoted chapter 10 of his text to demonstrating the improved health results of patients as monitored by their pre and post DTG changes. Dr. Pierce did include the comparison of subsequent biomechanical X-ray changes toward normal following the patient's chiropractic adjustments [25] (Figs. 4–6).

CONCLUSION

The beginning of instrumentation with the NCM gave the doctor of chiropractic a means by which to measure some of the physiologic effects of the vertebral subluxation complex. Anatomy of the nervous system and the spine reveal a direct interrelationship of spinal malfunction and neuronal disturbances. Although theoretical in nature, the establishment of a rationale of use and interpretation of instrumentation has been created. The research findings of Dr. Korr have substantiated the ability to monitor aberrant neuronal physiology as affected by the vertebral lesion. The inclusion of instrumentation as directed by protocol of its use may significantly add to the patient's evaluation and overall health, in knowing when and when not to adjust. Further research is required to discover the maximum potential such instruments may hold for the chiropractic profession.

ACKNOWLEDGMENT

I want to acknowledge Walter V. Pierce, D.C., Ph.C., Sc.D., for his permission to use material from his text—*Results*—and for his significant contribu-

tions to chiropractic, especially his work with instrumentation.

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THERMOGRAPHY

Infra-Red Thermal Imaging of the Vertebral Subluxation Complex

By David J. BenEliyahu, DC

Abstract

Infra-Red Thermography can provide objective documentation for one of the pathoneurophysiology components of the vertebral subluxation complex. The facet joint capsules and intervertebral disc have been demonstrated to be densely innervated by afferent nociceptors and mechanoreceptors. Spinal kinesiopathology, histopathology of the disc and degeneration of the motor unit can all result in pathoneurophysiology. Thermal imaging can be useful for differential diagnosis as well as a treatment assessment tool to monitor a patient's condition and response to care. Case reports are presented to demonstrate the utility of Infra-Red Thermography in clinical chiropractic practice.

Introduction

Infra-Red Thermography (IRT) has been well documented in the scientific literature as to its sensitivity, specificity and predictive value in spine related disorders (1, 2, 3, 4). In the cervical spine, thermography has been shown to be useful in radiculopathy and disc protrusion cases (2, 5, 6, 7). In the lumbar spine, where the preponderance of literature support exists, much work has been done with radiculopathy, disc herniation, low back syndrome, facet syndrome and myofascial pain syndrome (8-24).

Infra-Red Thermography measures and records cutaneous infra-red heat emission. Cutaneous infra-red emission has been shown to be symmetrical from right to left homologous body parts within a few small tenths of a degree (1, 2, 3, 10, 25) (Table 1). It has been demonstrated that temperature differences in excess of 0.65°C from right to left is a statistically significant finding for pathoneurophysiology.

Infra-Red Thermography has been shown to be useful in lumbar facet syndrome cases by Wexler, McFadden, BenEliyahu, Leroy and Chapman (2, 7, 18, 20, 22, 26, 43). In a case study presented at the Ninth Annual Symposium of the International Academy of Back and Manipulative Sciences, IRT was shown to be a useful tool in the diagnosis of lumbar facet syndrome. IRT was correlated to lumbar spinographic findings and was found to have a high correlation and sensitivity (23). An increased thermal signal (hyperthermia) was consistently seen at the spinal/paraspinal region, and there were often patchy variable findings seen in the lower extremities (increased and decreased thermal signal in the lower extremity thermatomes).

Case Report 1 - Lumbar Facet Syndrome

A 37-year-old female presented with low back pain of three months duration. The pain radiated into the buttock, hip and thigh. Orthopedic testing revealed a positive Kemps test, positive Elys, double leg raise, and pain and limited motion on extension and rotation. Deep tendon reflexes were normal, dermatomal testing was normal. Radiographic findings disclosed positive McNabs Line, Hadleys S curve, abnormal lateral bending, an increased disc angle and subluxation was detected at L4/L5. Infra-Red Thermography scans disclosed hyperthermia at the lumbar paraspinal region and hypothermia at the ipsilateral lower extremity. (Fig.1A and Fig. 1B)

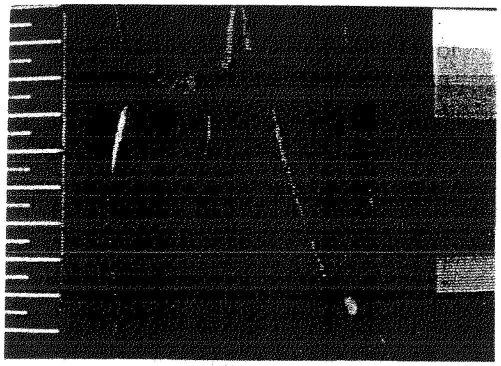

Figure 1A

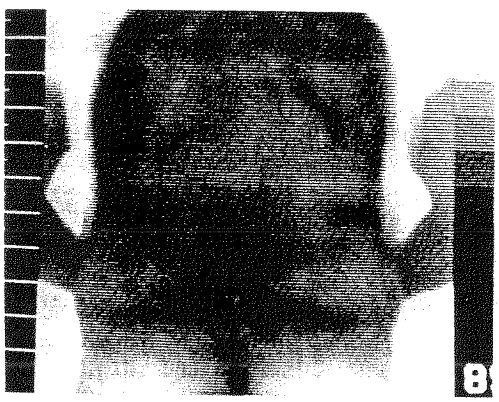

Figure 1B

Table 1
Thermal Symmetry of the Skin

Confidence factor:	50%		84%	98%
Body segment	χ	SD	+ 1SD	+ 2SD
Forehead	0.12	0.093	0.22	0.30
Cheek	0.18	0.186	0.37	0.56
Chest	0.14	0.151	0.19	0.34
Abdomen	0.18	0.131	0.31	0.44
Cervical spine	0.15	0.091	0.24	0.33
Thoracic spine	0.15	0.092	0.24	0.33
Lumbar spine	0.25	0.201	0.45	0.65
Scapula	0.13	0.108	0.24	0.35
Arm-biceps	0.13	0.119	0.25	0.37
Arm-triceps	0.22	0.155	0.38	0.54
Forearm-lateral	0.23	0.198	0.43	0.63
Forearm-medial	0.32	0.158	0.48	0.64
Palm-lateral	0.25	0.166	0.42	0.59
Palm-medial	0.23	0.197	0.43	0.63
Fingers-average	0.38	0.065	0.44	0.50
Thigh-anterior	0.11	0.085	0.20	0.29
Thigh-posterior	0.15	0.116	0.27	0.39
Knee-anterior	0.23	0.174	0.40	0.57
Knee-posterior	0.12	0.101	0.22	0.32
Leg-anterior	0.31	0.277	0.59	0.87
Leg posterior	0.13	0.108	0.24	0.35
Foot-dorsum	0.30	0.201	0.50	0.70
Foot-heel	0.20	0.220	0.42	0.64
Toes-average	0.50	0.143	0.64	0.78
Trunk-average	0.17	0.042	0.21	0.25
Extremities-average	0.20	0.073	0.27	0.34

Case Report 2 - Cervical Facet Syndrome

A 37-year-old patient injured her cervical spine in an automobile accident. She experienced neck pain, interscapular pain and a dull ache into her upper arm and superior angle of the scapula. An MRI was done to rule out discopathy and was found to be negative. Physical/orthopedic testing revealed a positive compression test, pain on spinous percussion, negative distraction, Valsalva, Spurling, Adsons, Allens and Wrights test. Reflexes were normal and there was hyperesthesia at the supraclavicular area and the upper lateral arm. Radiographic findings disclosed a reversed cervical curve and subluxation at C2/C3 and C5/C6. Myofascial exam disclosed evidence of trigger points at the levator scapulae, trapezius, and rhomboids. Infra-Red Thermography scan disclosed hyperthermia at the paracervical spine and focal hot spots compatible with trigger points at the trapezius, levator scapulae, and rhomboids. (Fig. 2)

Discussion

There has been much work and interest in the chiropractic and medical fields on the topic of lumbar facet syndrome as it relates to the patient's health (20, 26-43). In the chiropractic field, Facet syndrome has been interchangeable with Vertebral Subluxation Complex. Kellgren (1977) injected hypertonic saline into the facet joints and mapped out the patients' pain patterns (41). McCall (1979) also injected hypertonic saline into the facet joints and mapped out similar referred pain maps in the back, hip, and thigh (40). Mooney and Robertson did similar work and also found that there was a pain referral map that could be seen (39). The one thing that was in common in all these studies was the overlap in the lumbar

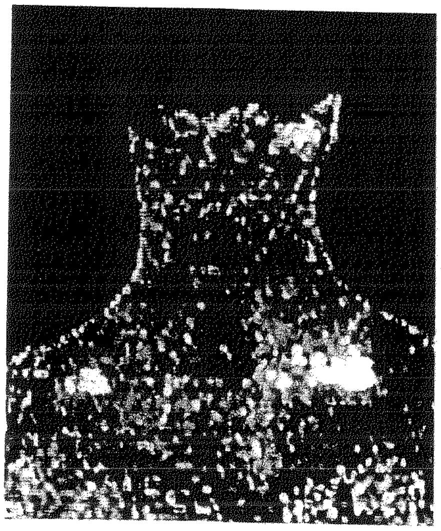

Figure 2

pain zones. The overlap of findings is due to the polysegmental innervation. The apophyseal joints are innervated by medial branches of the dorsal ramus. When there is fixation, imbrication/malalignment and aberrant motion, an afferent nociceptive barrage will occur. There will then be associated paraspinal reflex spasm of the local musculature (39).

Nociceptive Afferent Stimulation can occur from mechanoreceptive (Type 4 receptors) and chemoreceptive inputs. Type 4 receptors contain myelinated and unmyelinated nerve endings.

Work on lumbar facet syndrome in the chiropractic profession has been done by Cox and Banks (33, 38). Spinographic parameters and treatment protocols were reported. Cervical facet joint patterns of pain has recently been published by Dwyer and Bogduk in the journal *Spine* (44). It is clear from their work that pain referred patterns will usually appear in certain regions based on the segmental level involved. (Fig. 3) It is evident that these areas are also easily seen on thermographic scanning.

The use of IRT in documenting subluxation or facet syndromes has been reported in the literature. The case reports presented here display patients with pathoneurophysiology from vertebral subluxation. Since the articular facets are densely innervated and IRT can image pathoneurophysiology, IRT is well suited for use in clinical chiropractic practice. IRT may be used in the differential diagnosis and case analysis (extremity findings differ from that of radiculopathy cases), as well as a treatment assessment tool. It can also be used to objectively monitor a patient's program of care and to objectively document when the patient's pathoneurophysiology has resolved.

Conclusion

Infra-Red Thermography has been shown to be a useful diagnostic and assessment tool for the pathoneurophysiology component of the vertebral subluxation complex. Hyperthermic findings are typically seen at the paraspinal regions of the lumbar spine and findings will often be found in the lower extremity. Infra-Red Thermography is suited to clinical chiropractic practice.

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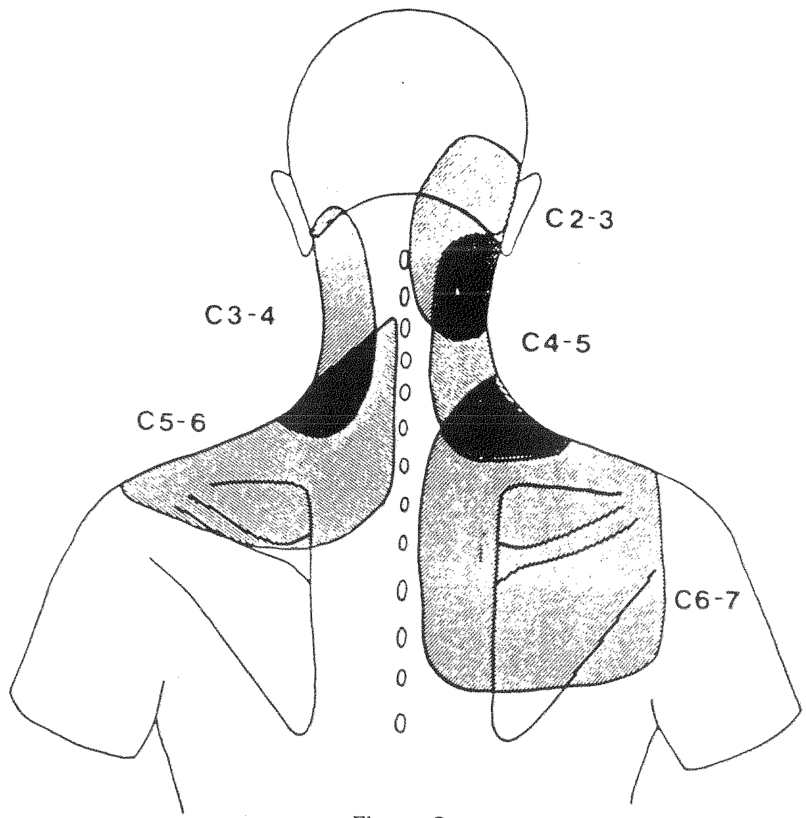

Figure 3

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continued

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David BenEliyahu, DC

has had many papers on thermography published in *JMPT, Journal of Manual Medicine, Chiropractic Sports Medicine* and other journals. He has also presented papers on thermography at national and international symposiums. A graduate of National College with an undergraduate degree from New York State College, Dr. BenEliyahu practices in Selden, New York.

THERMOGRAPHY

Chiropractic Thermography

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Brian S. Stillwagon, DC
Dale L. Dalesio, BS

Thermography is a color picture which shows temperature variations on different parts of the body. It is a safe, non-invasive procedure and does not use ionizing radiation.

The raging question that faces chiropractic is, "Why is so much attention being focused on thermography lately?" The answer: there is a new dimension in thermography which cannot be denied. By way of a color picture of the entire back, a thermogram shows the body's reaction to the chiropractic adjustment.

Thermography can be used as a monitoring system to aid the chiropractor in case management. It is objective evidence which denotes improvement or helps the doctor to know when a chiropractic adjustment is needed.

Thermography also provides us with information not seen on a x-ray, MRI, CT scan, EMG or palpation.

There are two approaches in thermography, traditional and chiropractic.

Traditional thermographers use high resolution telethermography systems which provide non-contact electronic thermal imaging. Another widely used method is contact thermography or liquid crystal thermography.

High resolution thermography, as used in traditional thermography, has been used for many years as an adjunctive procedure. It has been used in musculoskeletal conditions, peripheral vascular disease, breast conditions, neoplastic and inflammatory conditions, to mention a few. High resolution systems are also used by chiropractic thermographers.

Low resolution thermography is more concerned with detecting dermatome patterns or other patterns of temperature abnormalities that are fairly large in surface area, rather than smaller patterns of temperature for differential diagnosis.

Chiropractors should read "The AMA Council Report on Thermography." This is a 3500 word report by a 15 member panel of the Scientific Affairs Committee, that clearly states:

- The presence of a significant temperature difference between corresponding areas of opposite sides of the body is suggestive of nerve impairment, since defective vasomotor mechanisms result in thermal asymmetry.
- Thermographic study of patients with spinal root compression nearly always reveals thermal asymmetry, with decreased temperatures in the involved dermatome.
- Thermography can detect sensory/autonomic nerve dysfunction.

These are all important reasons why the chiropractor should be interested in using thermography—because it documents objectively, changes in the nerve system following the adjustment.

Will thermography replace x-ray, MRI, or CT scans? Not likely. We will always need these tests, because they study anatomy whereas thermography measures function of physiology.

The system which will be discussed in this article is the Visi-Therm II, non-contact computerized electronic infrared thermography. This system is ideal for the chiropractor because it uses a patented method of an array of infrared sensors which provides low resolution thermal images at very low cost.

Low resolution thermography provides thermograms, showing before and after results which demonstrate the impact of the chiropractic adjustment on correction of the vertebral subluxation.

Case Study

The following case study will show the procedures employed in low resolution chiropractic thermography, using the Visi-Therm II.

This patient is a 27-year-old female injured in an automobile accident in September 1989. She experienced neck and shoulder pain, headaches, lower back pain radiating into the right leg. She also had numbness and tingling of both hands.

The adjustments made on this case over the period of care were a right positive ilium, forward motion drop headpiece adjustments of C5 and C6 along with a one time toggle of the atlas.

As you can see, thermography will document the changes which take place following chiropractic adjustment of the vertebral subluxation.

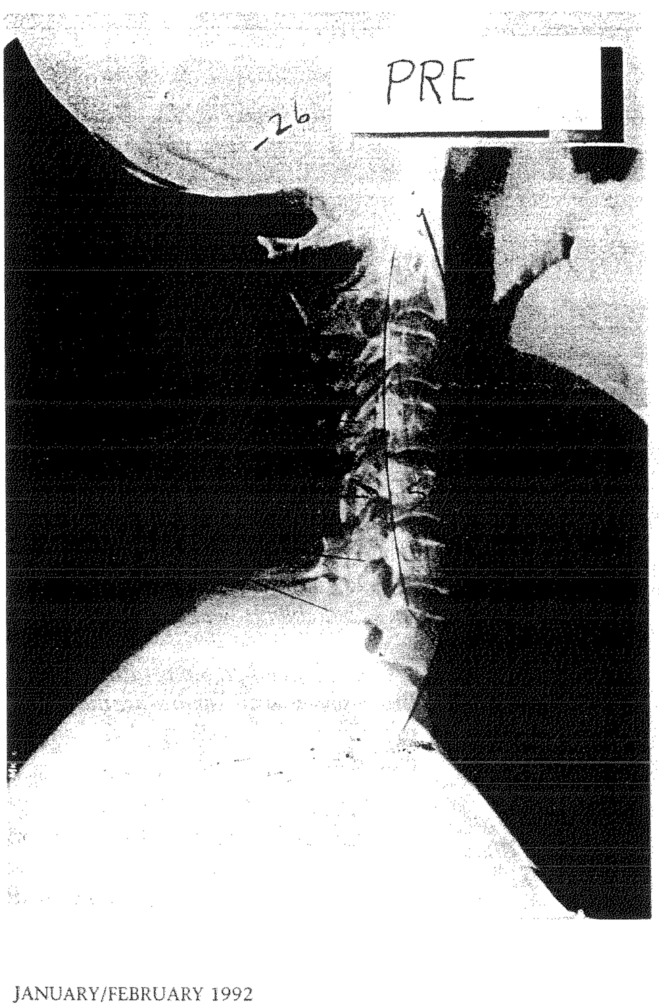
Low resolution thermography offers the following benefits to the chiropractor:

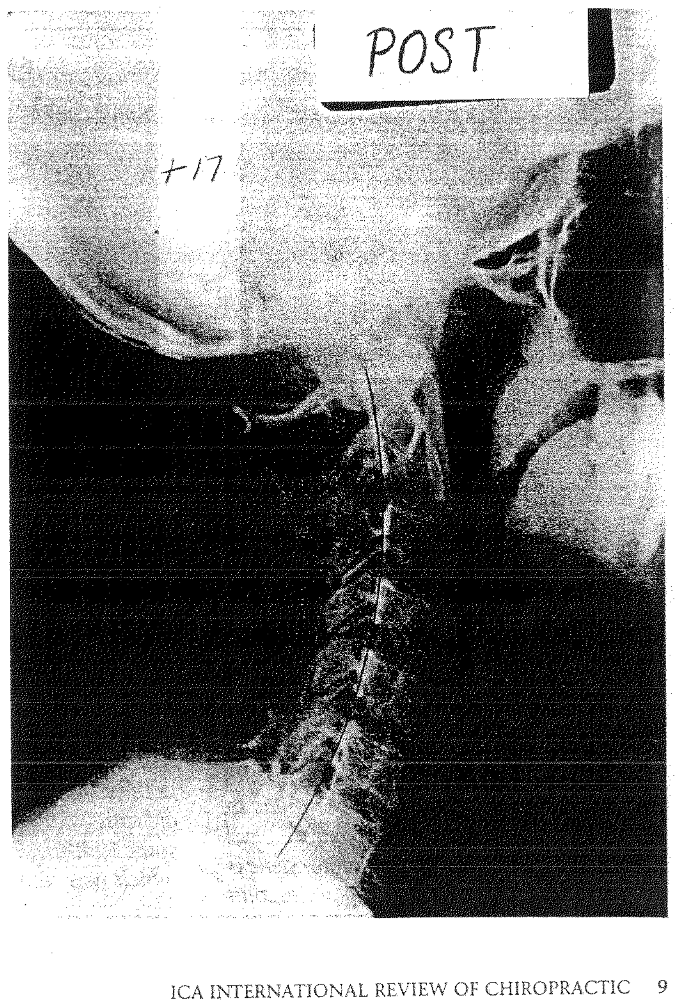
- It creates a dynamic and rapid change for chiropractic because it documents the impact of the chiropractic adjustment on the vertebral subluxation.
- Thermography can be used with any technique.
- Increased interest from the legal profession because thermography can aid in proving injury related cases.
- Thermography shows and documents neurophysiologic change in patients.
- Thermography cannot be faked or fabricated; it is non-invasive and no risk to the patient.
- The insurance industry will be better able to reduce the cost of determining disability, and terminate benefits on cases that are malingering.
- There are no contraindications to using thermography.
- Thermography gives you better patient control. ■

PRE AND POST X-RAYS OF THE CERVICAL SPINE SHOW EVIDENCE OF THE STRUCTURAL IMPROVEMENT FOLLOWING ADJUSTMENTS:

LEFT: Pre film lateral cervical view shows kyphosis of cervical spine. Radius of curve along George's Line is -26 cm.

RIGHT: Post film lateral cervical view shows return of lordotic curve. Radius of curve along George's Line is +17 cm.





INITIAL THERMOGRAMS WERE TAKEN FOLLOWING THE USUAL CUSTOMARY EQUILIBRATION AND PROTOCOL PROCEDURES

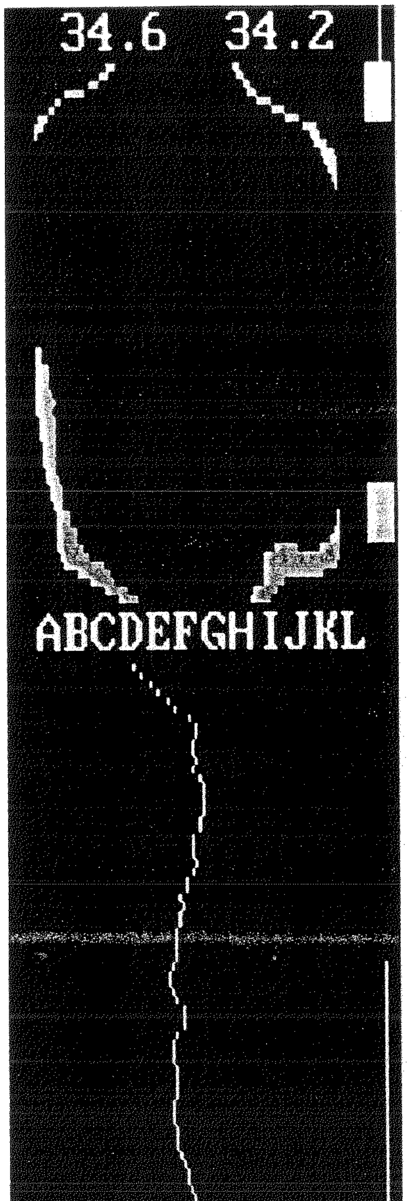


Figure 1

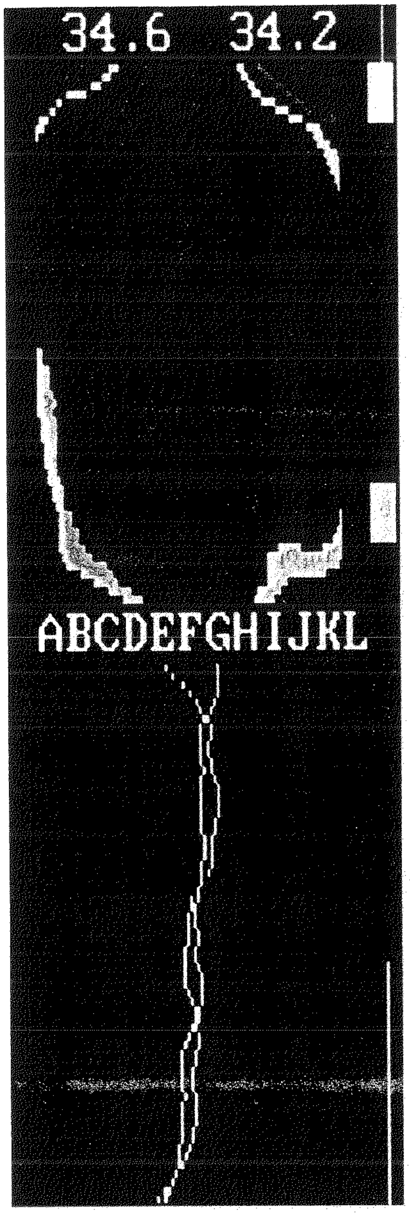


Figure 2

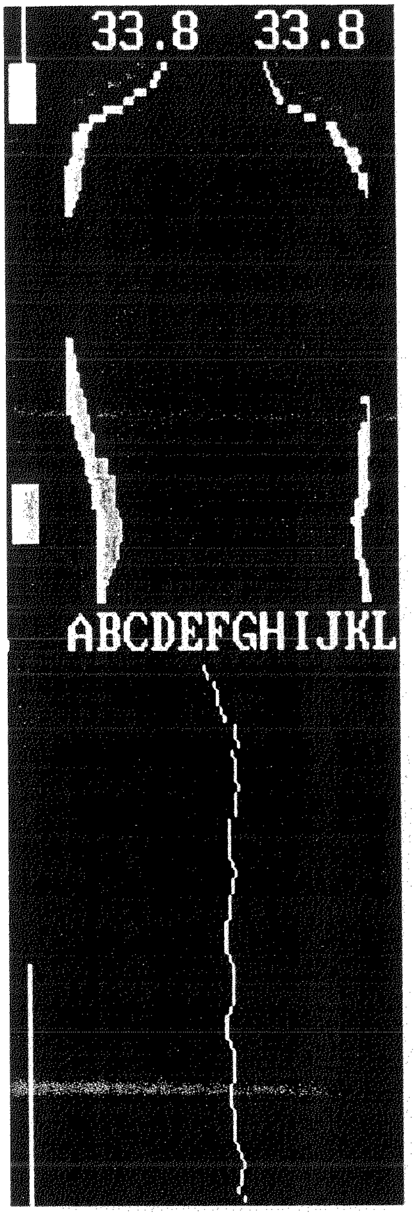


Figure 3

FIGURE 1. Thermogram taken at start of care. Full spine thermogram shows increased heat of the left cervical area. Immediately below the scan is a line graph which confirms the increased heat with the line graph showing a swing to the left in the cervical area. This line graph is similar to that of the Neurocalograph or bilateral (dual) probe instruments. The color scale is to the right of the scan. The top white color is the warm end of the scale.

FIGURE 2. Same thermogram. Immediately below the scan is a display of two segmental line graphs. Notice there is a marked deviation of the line graphs in the cervical spine. These line graphs are displayed indicating segmental differences from one side of the back to the other. The segmental line graphs are similar to the single probe instruments like the Derma Therm-O-Graph. Ideally these line graphs will superimpose when there is symmetry in the scan. It is obvious with the deviation or "split" of these line graphs in the cervical spine that these graphs also confirm that which was seen on the thermogram.

S.N. These line graphs are a unique feature of the Visi-Therm II. They aid the thermographer in determining the temperature difference from one side to the other. This feature is very helpful for observing subtle differences in color or for those individuals who are colorblind.

The numerical values above the scan are the left and right temperatures taken in the fossa below the ear and are the same as the Chirometer readings. They are displayed in Celsius scale.

FIGURE 3. Post thermogram. Notice the improved symmetry in the cervical area on the thermogram. Notice the improvement in the bilateral line graph below the scan.

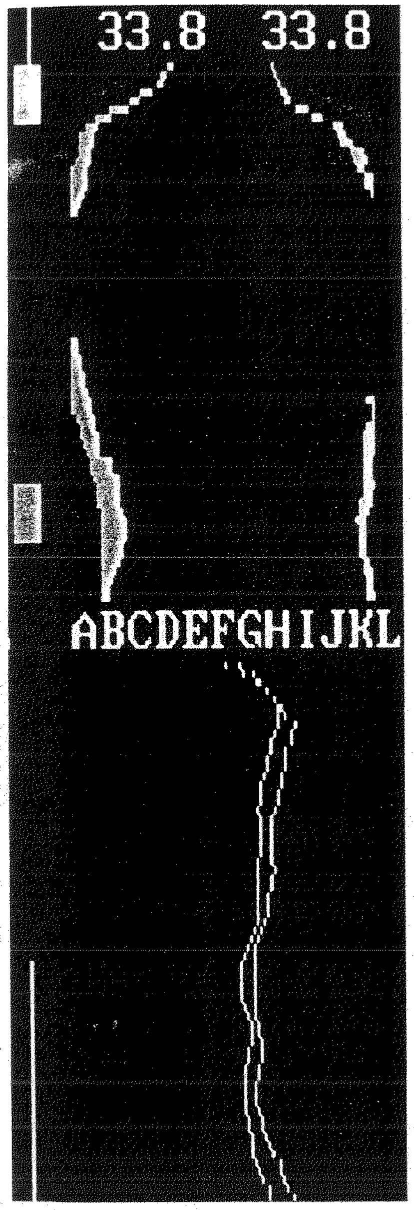


Figure 4

FIGURE 4. Post thermogram. Notice how the segmental line graphs are superimposed in the cervical area.

S.N. The line graphs which chiropractors have used for years, confirm what we see on the thermogram.

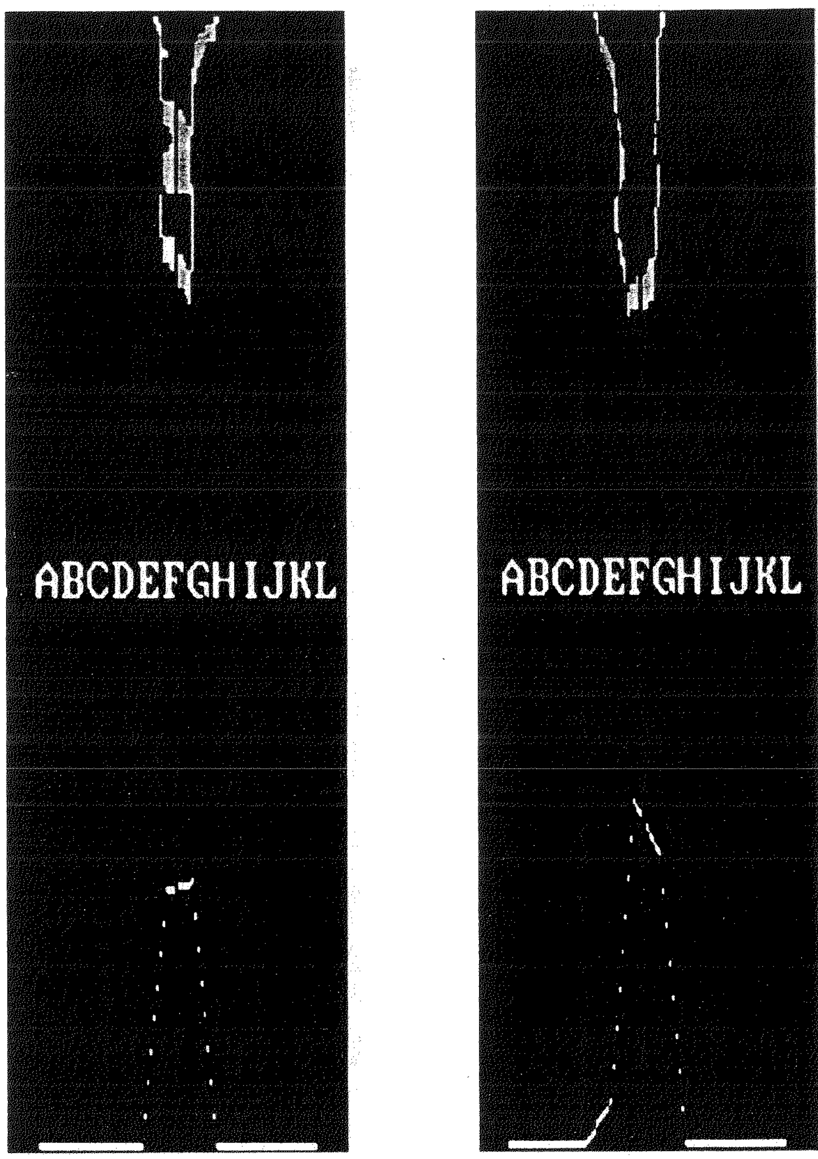


Figure 5

Left posterior arm

Right posterior arm

FIGURE 5. Pre thermograms of the left and right posterior arms. Notice the left posterior arm scan is colder than the right.

This is confirmed by another feature of the Visi-Therm II, called the horizontal line graph. The amplitude of the graphs which are cross sections of any level of the extremities indicate the temperature difference from one side to the other. The left side is colder by 0.9 degrees Celsius. Temperature differences can be detected as little as 1/10 of a degree Celsius. These scans indicate involvement of the C6-C7 dermatomes.

"Low resolution thermography creates a dynamic and rapid change for chiropractic because it documents the impact of the chiropractic adjustment on the vertebral subluxation."

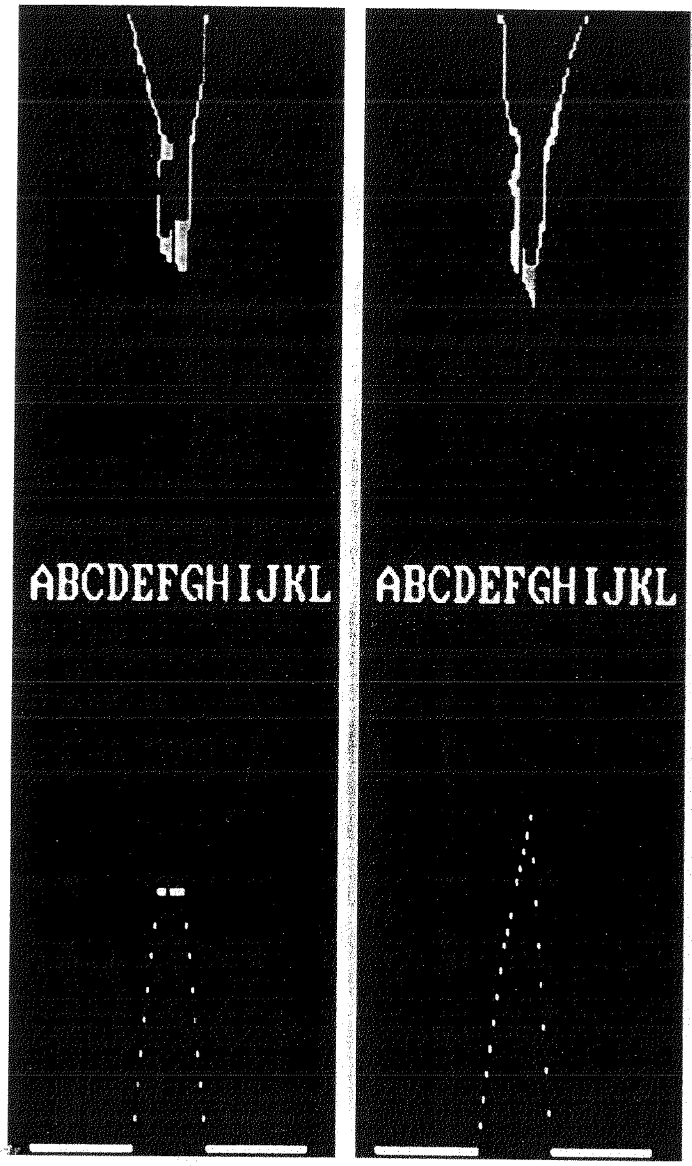


Figure 6

Left medial arm Right medial arm

FIGURE 6. Pre thermograms of the left and right medial arms. Not only do we see an obvious color difference in the thermograms but the horizontal line graph shows the left side colder by 1 degree Celsius. The thermogram shows some involvement of the C-8 dermatome.

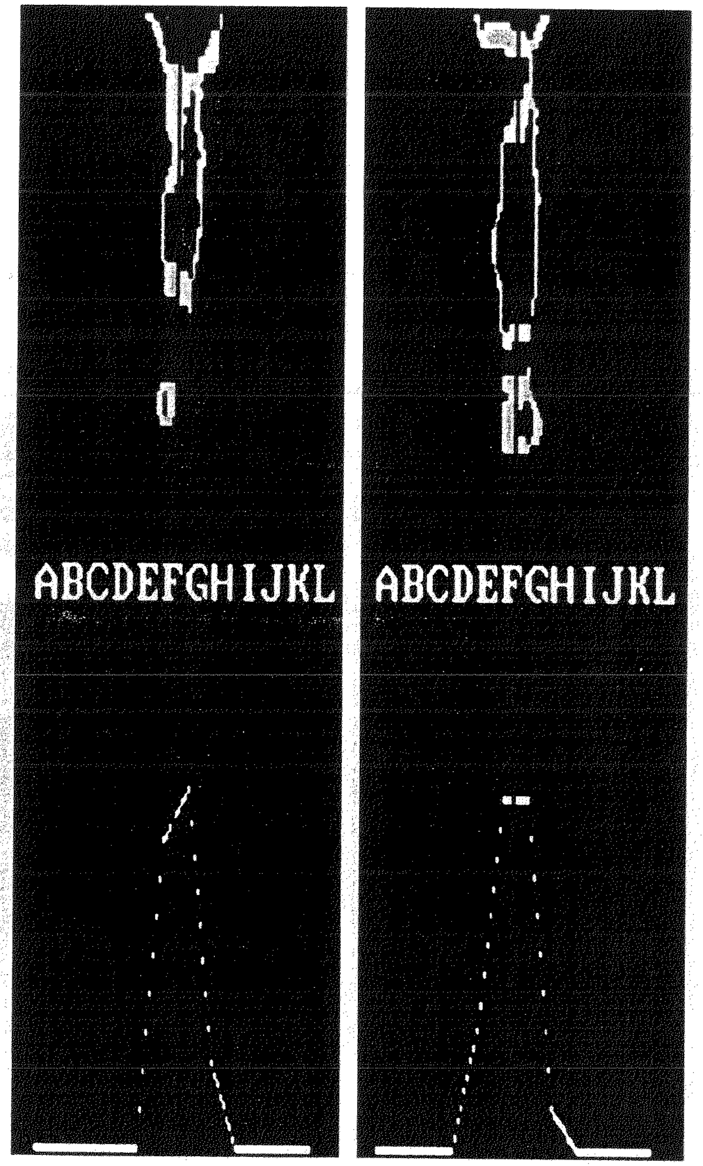


Figure 7

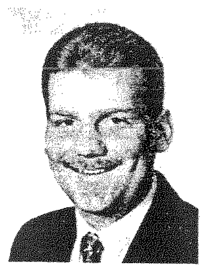
Left posterior arm Right posterior arm

FIGURE 7. Post thermograms of the left and right posterior arms are showing improved symmetry. The horizontal line graphs confirm this.

G. Stillwagon

K. Stillwagon

B. Stillwagon



D. Dalesio

Drs. G. Stillwagon, Kevin Stillwagon and Brian Stillwagon *are graduates of Palmer College. They teach thermography at Life College, Palmer College, Pennsylvania College of Straight Chiropractic and the Chiropractic Institute of Thermography.* ***Dale Dalesio*** *is a graduate electronic engineer and teaches at California University of Pennsylvania.*

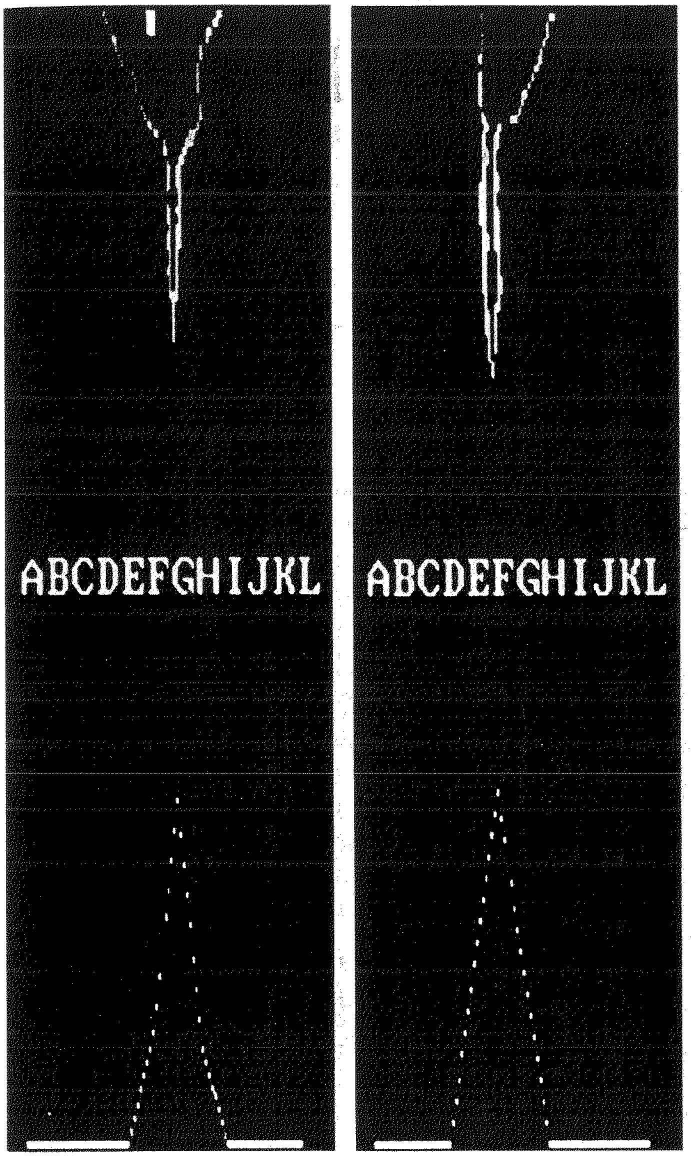


Figure 8

Left medial arm — Right medial arm

FIGURE 8. Post thermograms of the left and right medial arms have also shown improved symmetry. Once again confirmed with the horizontal line graphs.

> ***"Thermography is subjective evidence which denotes improvement or helps the doctor to know when a chiropractic adjustment is needed."***

INTERNATIONAL

Review

OF CHIROPRACTIC

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"The **science** of chiropractic deals with the relationships between the articulations of the vertebral column and the nervous system, and the role of these relationships in the restoration and maintenance of health.

"The **philosophy** of chiropractic is based upon the premise that disease or abnormal function is caused by interference with nerve transmission and expression, due to pressure, strain or tension upon the spinal cord or spinal nerves, as a result of bony segments of the vertebral column deviating from their normal juxtaposition.

"The **practice** of chiropractic consists of analysis of any interference with normal nerve transmission and expression, and the correction thereof by an adjustment with the hands of the abnormal deviations of the bony articulations of the vertebral column for the restoration and maintenance of health, without the use of drugs or surgery. The term "analysis" is construed to include the use of x-ray and other analytical instruments generally used in the practice of chiropractic."

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COVER

Wyont B. Bean, Jr., (3rd from left) president of the Georgia Club at PSC, presents a check to Mr. Hugh E. Chance, ICA Executive Director, as part of PSC students' $1,746.50 contribution to "Fill the Colleges" program. From left to right, Ralph D. Morris, Georgia Club Vice President of Dallas, Ga.; Robert T. Argoe, Club Treasurer from Atlanta, Ga.; Wyont B. Bean, Jr., also from Atlanta; and ICA Executive Director Hugh E. Chance.

CHIROPRACTIC INTERPRETATION OF HEAT FINDINGS ADJACENT TO THE SPINE

Taken from the lecture notes of
DR. ELMER L. R. CROWDER
Palmer School of Chiropractic

The study of the interactions of systems with the environment involving heat and work has been the preoccupation of scientists for many years. The consideration of biological systems as analogous to thermodynamic systems is not, however, clearcut. This is because the thermodynamic variables do not by themselves specify a living system.

Two fundamental problems in thermodynamics may be stated in terms as follows:

1. If a system changes its state from state A to state B, what work will be done?
2. If a system exists in a given state, how stable is that state?

Regulating System

The main center for the control of body temperature is situated in the forepart of the hypothalamus—that region at the base of the brain near the origin of the pituitary stalk. Isolation of this region by section of the brain stem of upper spinal cord renders an animal poikilothermic; that is, incapable of maintaining the height of its temperature independently of the temperature of the environment. The center exerts its influence upon body temperature through the autonomic nervous system causing vasoconstriction or vasodilation, sweating, increased muscular tone, etc. The center is influenced by afferent impulses initiated in the temperature receptors of the skin and by changes in the temperature of the blood supplying this region of the brain. (1)

It is apparent that the hypothalamus contains two opposing thermoregulatory centers which, by their descending connections, bring about coordinated and integrated neural discharges to structures involved in maintaining a constant body temperature. In the intact animal these two centers operate reciprocally. The hypothalamus centers have been likened to thermostats which operate automatically. (2)

A thermostat requires a receptive mechanism to sample the temperature as well as an executive mechanism to bring about the appropriate regulation. The messages from thermareceptors are presumed to reach the hypothalamic thermoregulatory centers where they initiate the appropriate reciprocal actions. In addition the messages from thermopreceptors presumably feed into other ascending pathways to thalamus and cortex and constitute the basis of sensation of temperature which provides a cue for complex adaptive behavior. (2)

The function of this thermoregulatory system can be disturbed by interfering with the descending connections and the messages of communication. This loss of communication between the innate centers in the brain and tissue cell would obviously result in incoordination of the adaptative behavior.

We return to problem 1, "What work will be done if a system (the human body) changes its state in response to demand for adaptation?" We understand that surface area temperature provides a convenient reference for expression of metabolism (3)—it further conveniences us to use this medium as a measurement of the amount of work being done to meet the demands of external environmental conditions and internal physiological and emotional conditions. **The total work accomplished by the body is exactly equal to the amount of energy expended,** consequently, we will measure the degree of success of metabolic response in terms of heat released.

The radiation formula which expresses the exchange of radiation between two bodies at different temperature is —

$$Q = k\ e\ e'\ So\ (T - To)$$

Q = the energy exchange

k = proportionality factor depending upon the size, shape, and localities of the bodies

e = absorbing power of the receiver

e' = emitting power of the emitter

So = Stefan-Boltzmann constant (1.37x10-11 Cal/Sec.—cm. 2)

T = Absolute temperature of the emitter

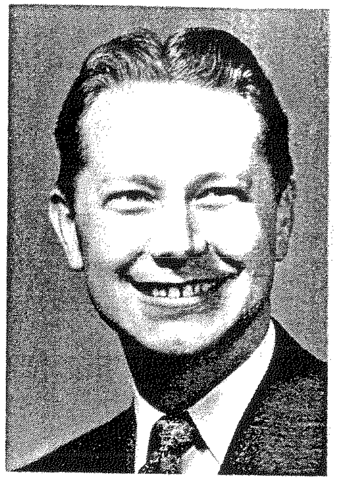
To = Absolute temperature of the absorber

An intelligent look at the formula reveals this to be an impractical way to approach the problem in the office of a practicing chiropractor. An attempt to control the factors involved would prove prohibitive except in the laboratory. However, a standard can be established which is workable. It employs the use of the two detector, differential reading instrument. By measuring the heat radiation on either side of the body along the spine near the avenues of distribution of nerve fibers which serve as the connecting medium between the temperature receptors and the executing body in the brain we can arrive at a usable reference. This establishes the constant within the measured body. This is to say that the variables or changes of metabolism become our constant of measurement. If an expression of metabolism is our aim, then we will do well to learn all possible about the symbolism of our heat readings.

Differential heat readings have their basis in the bilateral structures of the human body. With the dividing line between the two halves being an exact and distinct one from the divisions and distribution of the nervous system to all tissue supplied by it. Fritz Kahn, M.D. (4) states "The descending and ascending nerve tracts that connect the brain with the rest of the body pass from one side of the spinal cord to the other at the level of the neck and emerge on the opposite side of the body. The right half of the brain supplies the left half of the body, and vice versa."

The second problem of thermodynamics is, "If a system exists in a given state, how stable is that state?". It is as stable as the demands placed upon it, and the degree to which the executing body (Innate Intelligence) and its machinery can satisfy these demands. This is to say, it is as stable as the processes of adaptation going on within. The human, living body is a dynamic, intelligently directed and coordinated machine, responding to stimulation in direct proportion to the strength of the stimulus. This describes the healthy body, under control and direction of Innate, 100% of time in 100% of material.

Interference to the normal flow of mental impulses from the control center to the effector will proportionately limit the response to stimulation. To limit response to stimulation is to limit work; to limit work is to limit adaptation. Adaptation is the law of survival; it is the adjustment of living matter to environmental conditions and to other living things. This ability is a fundamental property of protoplasm and constitutes a basic difference between living and non-living matter. (5). It is also defined as a change in structure,

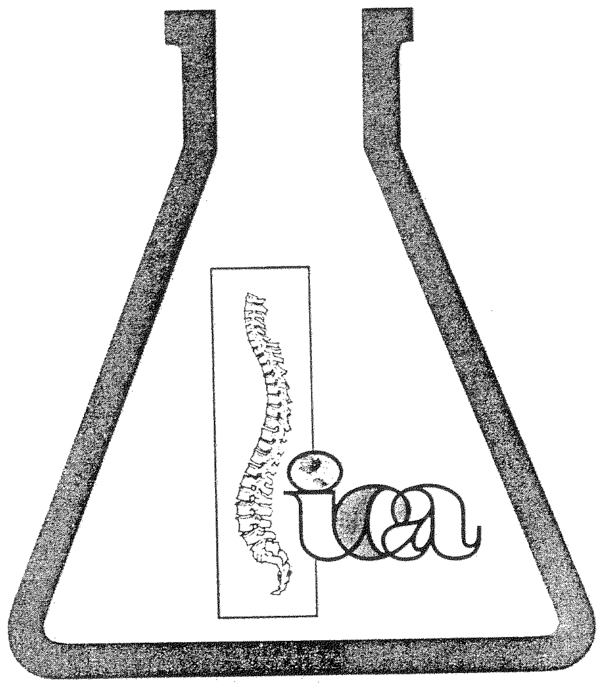


Dr. E. L. R. Crowder, Davenport, Iowa, 1947 PSC graduate, is operational director of the PSC student clinic and head of the school's instrumentation department.

function, or form that produces better adjustment of an animal or plant to its environment (7). If production of adaptation is limited, there will be an imbalance in work to do and work being done; this will result in a persistant physiological attempt to meet the demand. Differential heat recordings will reveal a persistancy of characteristic imbalances which will continue until the interference is corrected. These heat recordings are patterns of the interference and are to be associated with the vertebral subluxation. Heat recordings of a temporary or non-persistant nature are to be interpreted in terms of routine physiological, metabolic and emotional regulations. They are sometimes referred to as stress readings.

References —

(1) Best & Taylor—"The Living Body"
(2) Ruch & Fulton—"Medical Physiology & Biophysics"
(3) Stacy, Williams, Worden & McMorris—"Essentials of Biological & Medical Physics"
(4) Fritz Kahn, M.D.—"Man in Structure and Function"
(5) Columbia Encyclopedias
(6) Dorland's Medical Dictionary
(7) Webster's unabridged dictionary



INTERNATIONAL SCIENCE Review OF CHIROPRACTIC

JANUARY 1967 VOLUME 1 NUMBER 1

Published by International Chiropractors Association

vestigational New Drug exemptions. Meanwhile, FDA may make further charges involving Cass Research Associates, accused last week by the agency of falsifying efficacy data on Riker Labs' Norgesic Tablets. There are at least two or three other drugs for which the Cambridge, Mass., firm furnished data that was decisive in FDA's granting marketing approval. The idea of forming an ad hoc advisory committee to look into the whole problem is being talked about in the Medical Bureau. Rep. L. H. Fountain's (D-N.C.) House Intergovernmental Relations subcommittee may ask FDA staff members some questions on the subject at a one-day hearing next week.

Meantime, FDA Commissioner Dr. James L. Goddard told the Proprietary Association in a speech that many physicians have written the agency complaining about non-prescription drug advertising. Dr. Goddard said the Federal Trade Commission, which has jurisdiction over proprietary drug ads, shares his concern. By the way, Dr. Goddard admitted wryly that he is getting letters from physicians suggesting that he spend less time going after manufacturers of prescription drugs and more time on non-prescription drug products and advertising.

IRON WORKERS INCLUDE CHIROPRACTIC

Information recently released by Mr. Wesley Jeltema, Executive Secretary, Associated General Contracts (Michigan Department) stated that the Iron Workers Insurance Fund of Western Michigan has accepted the inclusion of chiropractic services for its members. This action was effective as of April 1, 1966. The contract for the Iron Workers covers all of Western Michigan and many other areas within the State of Michigan. This is a signal achievement by ICA officials working in conjunction with the AGC.

Mr. Jeltema also stated that similar recommendations have been made to other insurance funds to include the same services for the carpenters, laborers and operating engineers. As soon as proper contracts have been made, these other unions will have the request introduced into their councils.

Completion of this insurance work was the result of conferences between ICA, Mr. Jeltema and other AGC officials.

PCC PLANS M. H. PALMER STATUE

The Sigma Phi Chi sorority, headquartered at Palmer College of Chiropractic, Davenport, Iowa, announces a drive for funds to place a life-size statue of Dr. Mabel Heath Palmer on the grounds of the college.

Those who believe as they do are asked to contribute to the statue fund. Checks may be sent to "Mabel Palmer Memorial Fund", Palmer College of Chiropractic, 1000 Brady Street, Davenport, Iowa. All gifts to the fund are tax exempt.

SKIN TEMPERATURE DIFFERENTIAL ANALYSIS

By John L. Miller, B.A., D.C.

The NCM has been a part of chiropractic analysis for approximately four decades. During these years, skin temperature differential analysis has served as a valuable tool in the application of the chiropractic principle. However, during these same years the NCM and skin temperature differential analysis have been the brunt of considerable intra- and extra-professional criticism. Fortunately, many dedicated men have used their minds and their years to better understand and apply the information gleaned from the temperature differences found at the surface of the skin. It is because of this that we today have a better understanding of what we see and why we see it. It is the acquisition of better understanding that stands as the goal of this discussion.

The objective of skin temperature differential analysis as a chiropractic procedure is that of monitoring the function of the nervous system. Information gained in this manner is of valuable assistance in determining the existence or absence of abnormal neurological control of the heat dissipating function of the skin. That this approach is valid can be understood when the following factors are noted:

1) Physiologists agree that one of the major functions of the skin is the dissipation of varying quantities of excess heat in order to maintain a constant optimum internal body temperature;

2) Physiologists are unanimous in their agreement that the heat dissipating qualities of the skin are directly under the regulation and control of the nervous system.

With these two factors in mind a logical conclusion is that abnormal function of the nervous system may be expressed as abnormal control of the heat regulating mechanism of the skin, which in turn is reflected as abnormal surface temperature differentials. Such an abnormality stands in the chiropractic analysis as a signal of the presence of neurological interference. Thus, while other parts of the analysis, e.g., x-ray, palpation, leg checks, etc., are to a great extent bone oriented, skin temperature differential analysis offers the chiropractor the opportunity to monitor in a relatively direct fashion the function of the nervous system itself. It is suggested that those interested in a better understanding of the mechanism of heat dissipation in the skin should consult any good physiology text on this subject.

Briefly, the heat mechanism of the body can be explained as follows. Heat is a form of energy and as such is produced by living cells as a by-product of metabolism. A certain amount of the metabolic heat produced by body cells is necessary to maintain body temperature at an optimum and normal level. Heat in excess of this amount must be eliminated by the body. The blood has many functions, one of the most important being the distribution of body heat. In this respect the blood acts very much like the water in a hot water heating system. It transports heat from its source (individual cells) throughout the body.

The vascular bed of the skin has two important functions—nutrition of the skin and body temperature regulation, the latter being by far the more important. It is well known that the nervous system is the dominating factor in the regulation of cutaneous vessels, constricting and dilating them for the purpose of body temperature control, much as a radiator is turned on and off.

Heat, of course, leaves any object from its surface. If an object has a great surface area as compared to its mass, heat will leave it very quickly. If little surface area is available then heat dissipates very slowly. Before heat can be lost at the surface of an object however, it must be transported to that surface. The human body uses the flowing blood stream for its heat transport mechanism. Varying quantities of blood are allowed to pass through the cutaneous vessels to be cooled, depending on the metabolic state of the body and the amount of excess heat present. The amount of blood passing through the skin is almost entirely controlled by the nervous system, the temperature of any one area of the skin being a reflection of the neurological control of that area. Abnormal or normal temperatures of the skin then become an indicator of normal or abnormal functions of the nervous system.

Physiologists tell us that there is no normal skin temperature, only a normal temperature range. Skin temperature continually changes as the amount of excess heat present changes with an ever-shifting metabolic rate and environment. As is true with many physiological systems, normal function is a continuing adaptative process.

We note this with skin temperature differential analytical instruments. Persons free of neurological interference tend to display skin temperature differentials which continually change; but when the vertebral subluxation and interference to normal neurological function appear on the scene these changing differentials become static. They no longer display normal adaptability, and at this time the patient is said to be in pattern.

Due to the vast overlapping of the nerve supply to the skin it is not practical to use surface temperature differentials as an indicator of the location of the involvement. It does, however, serve as a valuable tool indicating *when* interference expressed as abnormal skin temperature differentials exists, and perhaps more important as an indicator of that time when it no longer exists.

UPPER CERVICAL FIXATIONS

By Henri Gillet, D.C.

One of the difficulties in the study of the spinal fixations is th fact that there are multiple possibilities of such fixations—muscu lar, ligamentous, and also of articular nature. Some of these fix ations are very important while others are less important. Som are correctable, others are not. Some are primary, while other disappear spontaneously upon correction of fixations elsewhere.

It is normal that we start with the study of the upper cervic region because of its mobility and the widespread effects of sub luxations of this region on the rest of the spine and the whole body

This widespread effect is not singular to the upper cervica region alone. In fact, the following law may be stated: The effec tive correction of any abnormality in any part of the spine wil have a spontaneous and distal corrective effect on every other part

In order to more easily comprehend the normal mobility of thi region, and especially the mobility between the occiput and th atlas, it will be necessary to begin by forgetting for a while th habitual point of view that the head (occiput) is a fixed point, and that all the tissues of the body must be adjusted to it. True, this conception did aid the profession a great deal in studying this region, but now that this need has passed, it is imperative to come back to a clearer picture of what happens when a subject moves his neck.

We do hope, therefore, that it will be useless to emphasize the fact that every human (in fact, every vertebrate) flexes, bends, rotates, etc., the head and neck, and that the occiput is not held like a block of concrete, in mid-air, with the rest of the body moving under it. We will admit that for spinographic analysis it was easier to measure the position of the atlas in relation to the occiput, but, when movement is being considered, as in our case, it is necessary to take a step backward and review this concept.

When the head is flexed forward and backward, the occipital condyles rock upon the lateral masses of the atlas, while the atlas moves in a similar fashion on the axis, the axis on the third cervical, etc. This statement sounds elementary, but it is too often forgotten when the doctor lets himself be hypnotized by an x-ray picture of the spine.

Let us consider for a moment the atlas "sideslip". Instead of stating that the atlas has become displaced on the occiput, we would say the opposite. In fact, we say that it is always necessary to consider two bones in any description of either displacement, subluxation, or fixation, for a vertebra is never displaced in relation to itself but to some other structure.

IMAGING

Thermography in Chiropractic

By Clayton Reynolds, D.C.

Since the beginning of mankind, body heat has been vitally important to man's survival. The ancient cave man strived to stay warm in the winter, protecting and preserving his body heat through the use of animal skins as clothing and caves as shelters from the weather. He also strived to stay cool in the hot summer days by seeking out shade and wearing less clothing. The cave man knew when he was uncomfortably cold or hot, but he had no knowledge of how important body heat was to his total health.

The first reference to heat being used for diagnostic purposes was Hippocrates. (1) Early evidence indicates that Hippocrates utilized a thin covering of wet mud over the body part in question and observed which area dried the fastest. He postulated that this drying effect was due to increased body heat in the area as a result of an underlying disease process. As you might expect, this procedure was quite crude. However, considering the technology of the day, it was quite a feat to develop this procedure.

Seeking answers to health problems during Hippocrates' day was a risky business. It had taken hundreds of years to develop a simple understanding of basic human anatomy. At that particular time in history they were groping for answers just as we still do today. However, it is quite interesting that even at this early date, body temperature was considered a crucial element in the health care of an individual. It took centuries before it was possible to achieve accurate measurement of the temperature of the human body. We had to wait until Sanctorius, an associate of Galileo, developed a working thermometer. Sanctorius also attempted to use his thermometer to study the temperature of man. Later Fahrenheit and Celsius worked to quantify the temperature and give it a scale that would determine basic differences between temperatures.

It was in 1740 that George Martin published his first important work on the temperature normals for a human body. (2) However, it was not until 1870 that we had the introduction of the modern medical thermometer. This was preceded by a German physician, Carl Wunderlich, who published an extensive work on the temperature of healthy individuals in 1868. Wunderlich established the specific thermometric standards that we use today for normal body temperatures.

Modern thermal imaging had to wait until the 1800's when the astronomer, Sir William Herschel, (1) performed remarkable experiments to measure the spectrum of the sun rays, followed by his son, Sir John W.F. Herschel, in the 1840's who discovered that those rays contained heat on the infrared side. (1) This was the first recording of infrared rays. One hundred years later, in 1940, infrared technology was developed. Imaging of thermal emissions technology has exploded since the 1940's, and thermal imaging has ridden the tide of technological improvement. From core temperatures of oral and anal thermometer readings to surface temperatures of infrared telethermography, the measure of body heat is vitally important in diagnosing health and sickness in the human body.

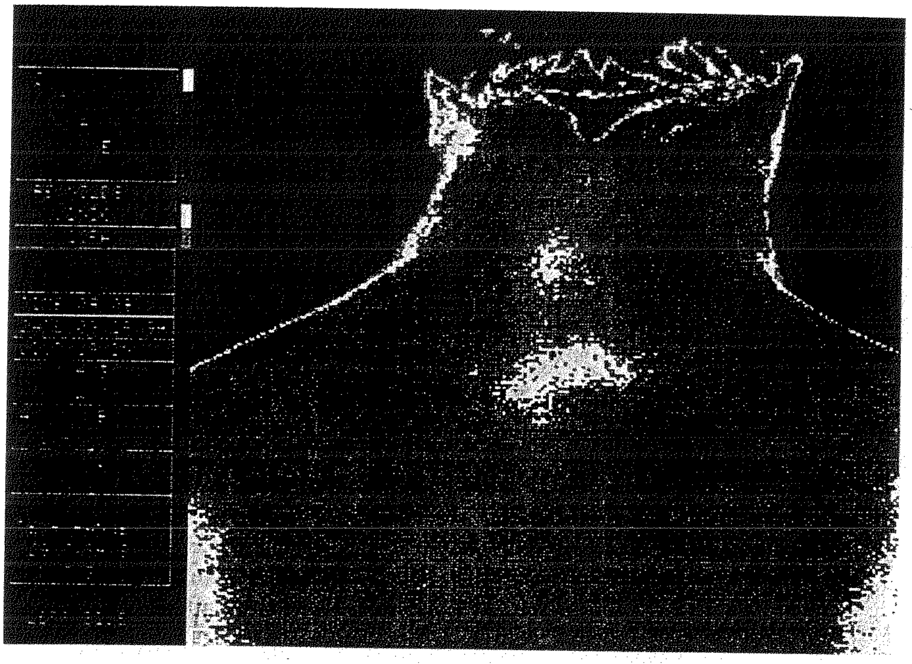


Figure 1–P.A. cervical view exhibiting abnormal hypothermia at the level of C-1 extending inferiorly and obliquely into the right shoulder.

Heat is continually being produced in the body as a by-product of metabolism. On the other hand, heat is also continually being lost to the surroundings. (3) The human body must delicately balance heat production and heat loss. The heat production comes from basic metabolism. In other words, as the body functions, a natural by-product is heat. This heat must be dissipated in order to maintain a balance of body temperature. The greatest loss of heat in the body is accomplished through radiation, aproximately 60%. Second is evaporation, approximately 22%. The third is conduction, approximately 12% to air and 3% through objects. (3) It is easy to see that the majority of heat loss in the body is through radiation from the body. Thermal imaging of this radiation is becoming vitally important in monitoring the physiological response of the body in both health and in sickness.

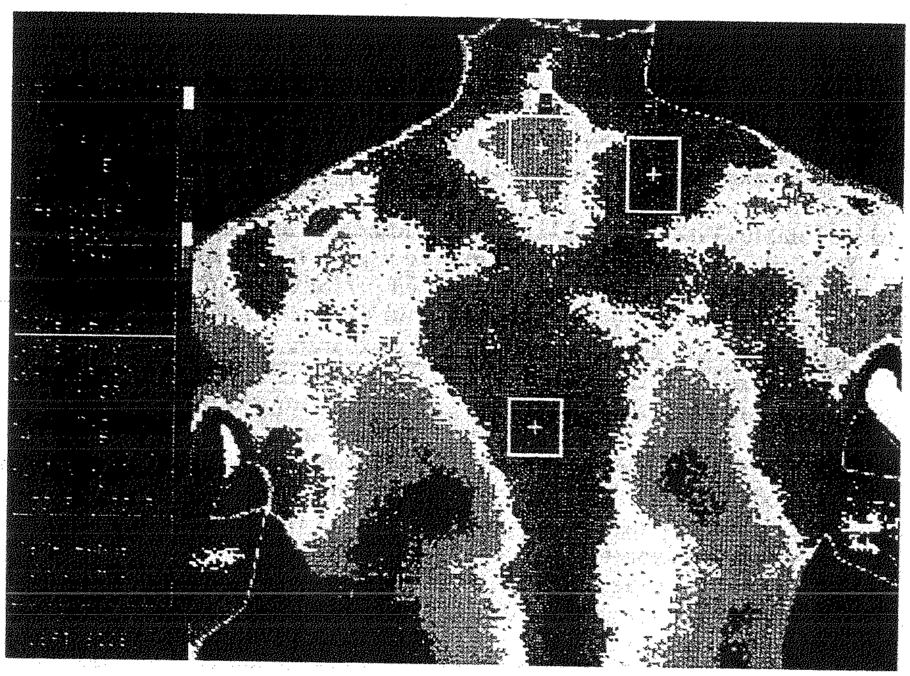


Figure 2–P.A. thoracic view showing abnormal findings using temperature boxing A, B. and C.

Thermal imaging is actually the oldest form of heat diagnosis that we know of. As previously mentioned, beginning with Hippocrates and his mud packs, through today's telethermography, we can determine the difference in skin temperature down to tenths of a degree. How important is thermal imaging? Thermal imaging is one of the few true monitors of body physiology. And, body physiology is basically function. Is the body functioning properly, or is it not? Being able to monitor physiology allows the doctor a tremendous insight into the health equation of the patient. Dr. Seguin, an American physician at the turn of the century,

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continued

published a work that lamented the inability to accurately measure temperature of the surface of the body. (2)

Today, we can measure the temperature of the surface of the body with precision and ease. Technology allows us a number of varied ways of detecting heat on the surface of the skin. Examples would be thermocouple devices, liquid crystal thermographic devices, and infrared telethermography. All of these, and others, have specific benefits and detractors. Each technology, when used for the specific purpose for which they were designed, are effective diagnostic instruments. As an example, infrared telethermography (IRT), when compared with MRI and CT for detecting chronic back pain, actually exceeded the predictive values of the other imaging techniques (IRT, 92%; MRI, 89%; CT, 87%; Myelography, 80%). (4)

Thermal imaging in chiropractic dates back to the 1920's when Dosa Evans developed a thermocouple device that would measure the difference in temperature from one side of the spine to the other. (5) Dr. B.J. Palmer used this instrumentation to develop a diagnostic procedure of pre-adjustment readings and post-adjustment readings after the chiropractic adjustment to determine the results. This system has been used extensively [illegible] thousands of chiropractors for years. The purpose of thermography in chiropractic has basically revolved around detecting the vertebral subluxation. This is based on three physiological postulates: (5)

1. The human body is segmented into "dermatomes"
2. Side-to-side temperatures are generally symmetrical unless dysfunction exists
3. Any anomalous deviation from a gradually increasing paraspinal skin temperature from S2 to C1 may suggest the vertebral subluxation complex (VSC) or remote dysfunction.

The chiropractic paradigm consists of locating and correcting vertebral subluxations (the cause), the central tenant of chiropractic practice, which should be the primary focus of the practice of chiropractic. Generally speaking, medicine relieves symptoms while chiropractic corrects the underlying cause of the health problem. In Dr. Sid E. Williams' book, *The Chiropractic Clinical Paradigm: A Research Challenge,* he states that "It is our hypothesis that spinal subluxations interfere with nervous system coordination of homeostasis and are capable of causing degradation of any and all functions of the body. They can do this by directly irritating so-

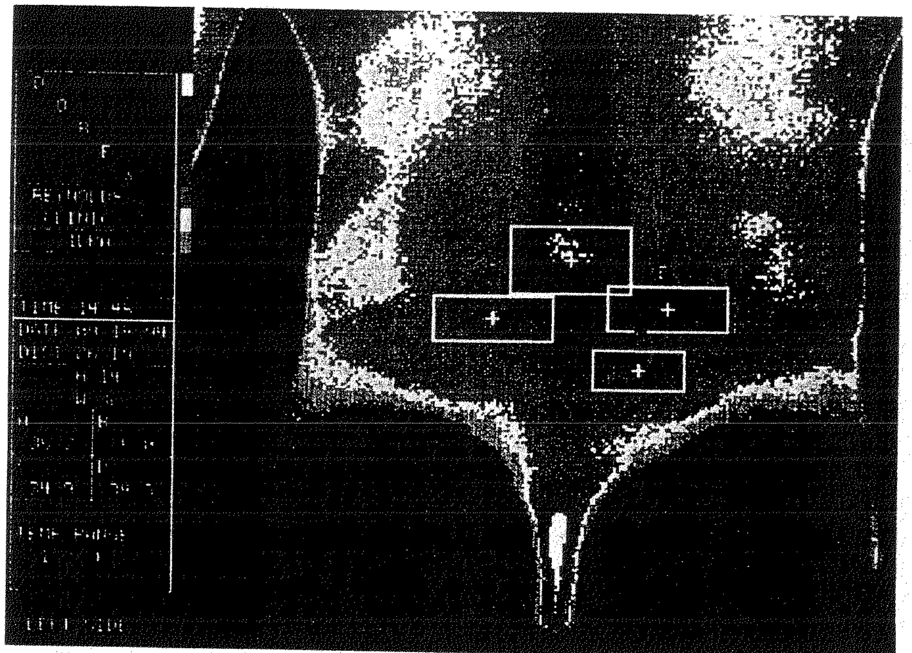

Figure 3–P.A. lumbar view showing abnormal findings using temperature boxing A, B, C, and D.

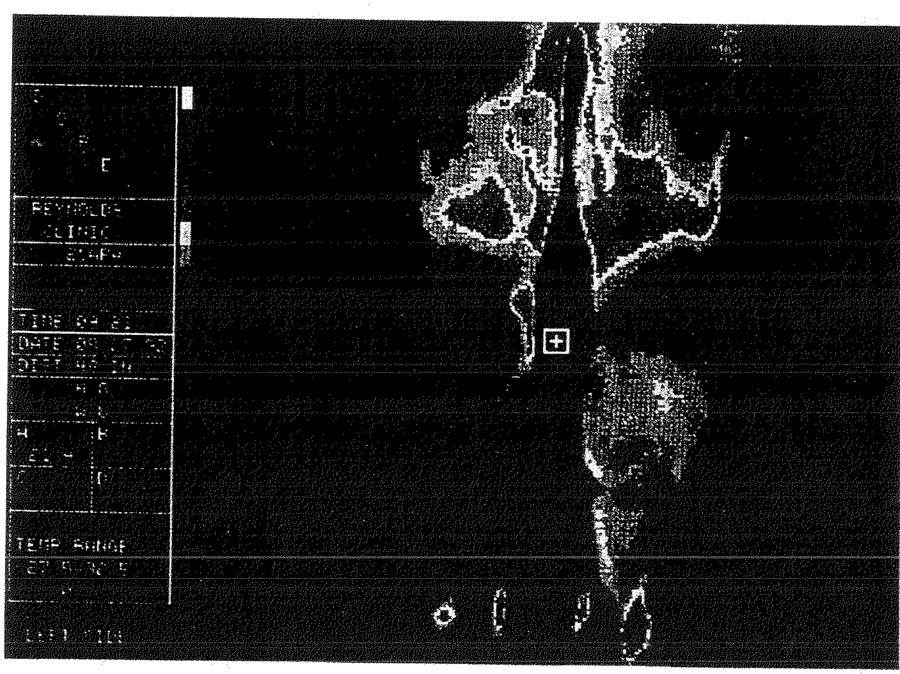

Figure 4–P.A. view of the lower legs showing a hypothermia of the left lateral aspect of the left leg.

matic motor fibers, sensory fibers, autonomic fibers, and central nervous sytem fibers, as well as indirectly interfering with central nervous system function via the many reflex mechanisms." (6)

A vertebral subluxation consists of five primary components:

1. Spinal Kinesiopathology
2. Neuropathy
3. Myopathology
4. Histopathology
5. Pathology

This definition incorporates biomechanical and pathophysiological manifestations. As stated in *The Documentary Basis for Diagnostic Imaging Procedures in the Subluxation-Based Chiropractic Practice,* (ICA 1992), "A number of procedures have been utilized in chiropractic practice to detect and evaluate vertebral subluxations:" (6)

I. To detect biomechanical changes:
  - A. Postural analysis
  - B. Static palpation
  - C. Motion palpation
  - D. Static radiography
  - E. Functional radiography
  - F. Computed tomography
  - G. Magnetic resonance imaging

II. To detect neurophysiological changes:
  - A. Orthopedic examination
  - B. Neurological examination
    1. Reflexes
    2. Muscle strength tests
    3. Dermatome examination
    4. Functional leg checks
  - C. Thermography
  - D. Electromyography

The most commonly used chiropractic examinations to detect biomechanical changes include postural analysis and static palpation. The examination used with the greatest accuracy and reproducibility results is the static radiograph. To detect the neurophysiological changes, the most commonly used chiropractic procedures are the orthopedic and neurological exams, followed by thermography and electromyography. Vertebral subluxation consists of both biomechanical aspects of vertebral misalignment, which can be documented via radiographic examination, and a neurophysiological testing that can be documented by various testing procedures, including thermal imaging.

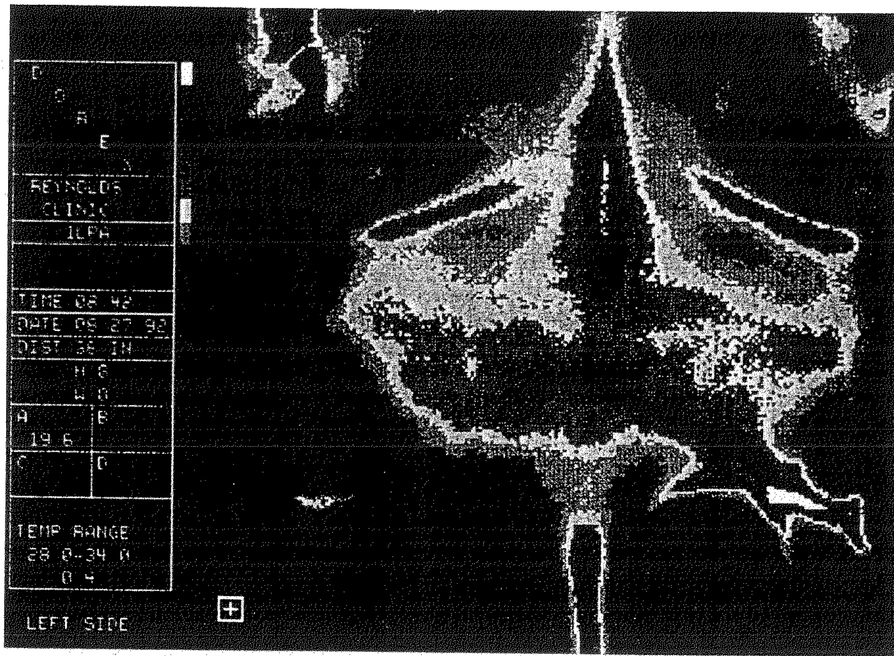

Figure 5–P.A. lumbar view exhibiting abnormal hypothermia at L-5 radiating laterally into the right buttocks.

The chiropractic algorithm is as follows: Patient enters with a spinal or neurological-related symptom. The doctor performs a focused chiropractic history and a physical examination. If this physical examination does not exhibit any red flags for possible spinal fractures, infections, cancers, or other syndromes of a medical nature, then one proceeds to determine the existence of a vertebral sublux-ation. Next, the location of that vertebral subluxation and the effects of that vertebral subluxation on the physiology of the patient must be determined. In other words, at this point the chiropractor's concern is finding the vertebral subluxation, determining how to correct the vertebral subluxation, and then correcting the vertebral subluxation. This is followed by a post-correction monitoring of the results of the correction.

How do we go about doing this? First of all, finding the vertebral subluxation is not easy. In the past, the chiropractor palpated, found the bone that he perceived to be out of alignment, and immediately adjusted that perceived misalignment, and then re-palpated to see if he had corrected it. Why did he do it this way? He had no other tools at his disposal. Since 1895 more and more diagnostic tools have become available to the chiropractic profession. As these tools became available, the next challenge was relating the use of them to the practice of chiropractic. One of the first was the x-ray, which gave the chiropractor the obvious advantage in being able to visualize the vertebral structure he was attempting to adjust. X-ray visualized the mechanical misaligment of the vertebrae as it relates to the one above and the one below. (7) X-ray imaging allows for visualization of the overall spinal structure to determine which areas are primary or secondary areas of involvement.

Thermography allows one a visual perception of the patient's physiology. It's like a window into the physiological homeostasis of the patient. Is that patient's body machine functioning normally, equally, and symmetrically, or is there malfunction in that patient's body machine that is creating an asymmetrical physiological response? Today the practicing chiropractor, fortunately, has the ability to both look inside the patient via the x-ray, the CAT scans, the MRI's, and

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look at the patient's physiology through thermography, EMG, SEP's, and other means of testing.

How important is proper testing? That depends on the circumstances. However, often seemingly minor injuries left undetected eventually grow into life-threatening conditions. Foreman and Croft in *Whiplash Injuries* state: "It is well known that seemingly minor trauma can produce significant injury. The symptoms may be late in appearance, however. Omission of proper diagnostic steps may result in misdiagnosis of an underlying lesion that, if left untreated, could become chronic and highly resistant to treatment later. In the worst of all possible scenarios, this misdiagnosis could result in death." (1)

Initial documentation is vital in today's health care world. All treatment today is predicated on necessity, whether it's medical necessity or chiropractic necessity. All care, all testing is predicated on this premise of medical or chiropractic necessity. Therefore, in the initial phases of the history, examination, and testing prior to treatment, one must document the need for care or document the need for referral to a different specialty. Once an appropriate diagnosis has been made, then the doctor can deliver the appropriate adjustment. After the adjustment one must look to means of assessing the procedure to determine if the necessary correction has been made or if additional care may be indicated. In the event that a working diagnosis is found to be inefficient in correcting the vertebral subluxation, then it may be necessary to re-examine and re-test to determine the appropriate change that may be required to achieve a successful care program.

Because thermography is non-invasive and involves no ionizing radiation, the test has been proposed as a physiologic test with clinical utility for documenting the presence or absence of radiculopathy (nerve root compression). (8) Utilizing thermographic imaging is a safe, non-evasive procedure that can be repeated over and over again without any hazard to the patient at all. This alone is a major factor for consideration in using thermography to determine if a change in care is needed. As the doctor's care progresses, the patient's biomechanics and/or neuropathology may change. As these changes occur, the need to change the kind or type of adjustment may be necessary. Many times during the course of care a point is reached where the patient has pla-

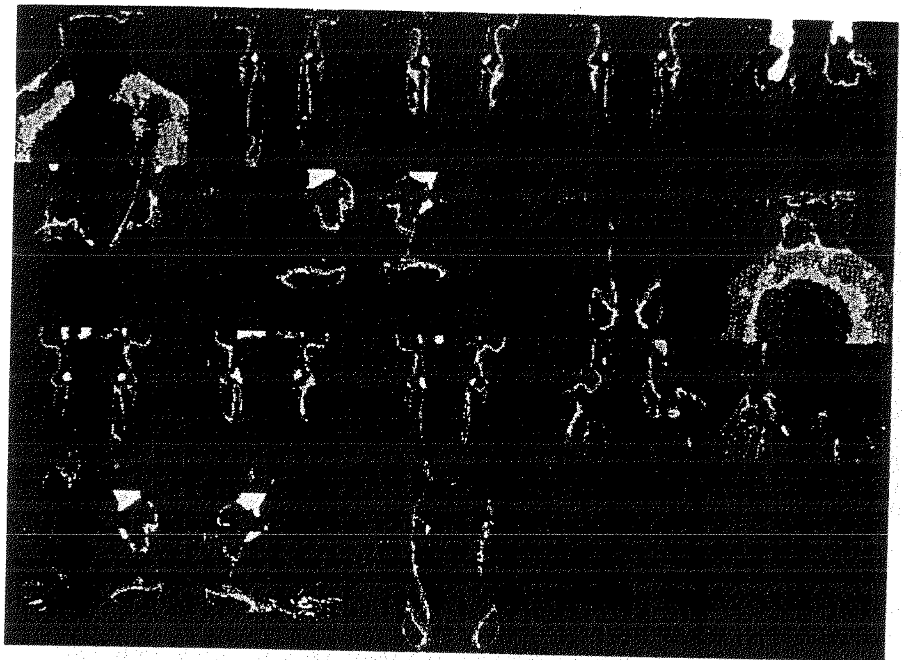

Figure 6–A complete cervical examination including a P.A. cervical and additional views of the upper extremities and hands repeated one time.

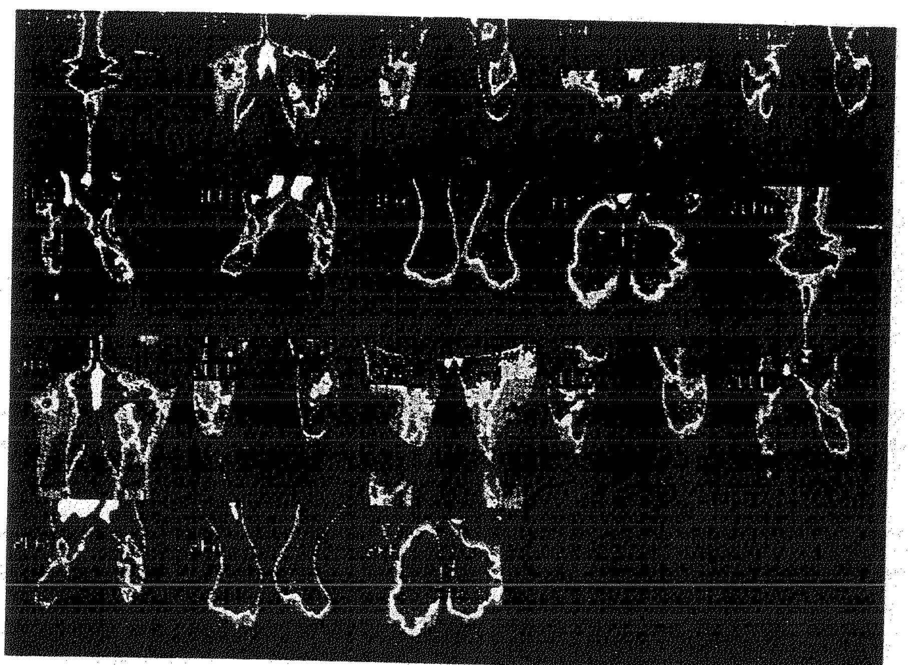

Figure 7–A complete lumbar examination including a P.A. lumbar and additional views of the lower extremities including the feet repeated one time.

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teaued as far as gaining additional benefits. At this time a thermographic examination may be ordered to assess and determine if the original subluxation still exists or if a new subluxation is present, and whether a resulting change in care is necessary.

Determining the nature of a permanent injury is difficult at best. However, there are certain guidelines that the American Medical Association uses as a guide for determining permanent impairment. Any supplemental information that the treating chiropractor can include will enhance the efficacy of the finding of a permanent injury. Thermography can be used in this regard.

"Chiropractic and thermography have a long history beginning with its original founder's understanding of heat and its effect on the human body."

Thermal imaging has a long and illustrious history in the healing arts beginning with Hippocrates and extending up until the space age technology of infrared telethermography today. There is no doubt that thermal imaging is going to be a vital cog in the wheel of healing for generations to come. Chiropractic and thermography have a long history beginning with its original founder's understanding of heat and its effect on the human body. As chiropractic grew so did the technologies that allowed for the use of thermography in the imaging of the physiological response of the human body. Thermography's greatest asset in the chiropractic practice is a physiological insight into the vertebral subluxations that present themselves in the patient. Finding the subluxation, fixing the subluxation, and visualizing the post-testing to know that the subluxation has been corrected is indeed a venue for the use of chiropractic thermography. To image a subluxation in any form is indeed difficult, however, the accumulative knowledge of various testing procedures compile a comprehensive image of the vertebral subluxation. In the course of this treatment, we must document the care, because care is predicated on necessity. Thermography is a vital link in determining the necessity of care.

For the practicing chiropractor, the need for simple, quick, and efficient methods of testing is essential. Chiropractic has a venerable history of using x-ray for the biomechanical, and thermal detection for the neurophysiological. In today's environment, the use of biomechanical and neurophysiological imaging is quick, efficient, and cost effective in validating the existence of the vertebral subluxation. It is interesting to note that in *The Chiropractor Adjuster*, by the founder of chiropractic, D.D. Palmer, (1910), (3) states "that if any undue amount of heat is confined in one locality of the body, it is known as an inflammation. If this elevation of temperature is generally diffused throughout the body, it is termed a fever. In health, heat production and heat dissipation are evenly balanced." (9) As we can see, even in the birth of chiropractic finding of temperature differences are vitally important. ■

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Research on Purpose

Christopher Kent, D.C., FCCI

Paraspinal skin temperature differentials and vertebral subluxation

Alterations in skin temperature patterns are associated with aberrations in the function of the autonomic nervous system.

The autonomic nervous system controls the organs, glands, and blood vessels. It is responsible for relating the internal environment of the patient to the dynamics of the outside world. One important function of the autonomic nervous system is temperature regulation.

When the outside environment is cool, the body will attempt to conserve heat, resulting in constriction of the arterioles in the skin. When the outside environment is warm, and the body seeks to eliminate heat, vasodilation of the arterioles in the skin will result. (1)

In a healthy patient, skin temperature patterns will be constantly changing, but symmetrical. This is because a healthy body is constantly adapting to the environment.

Vertebral subluxations result in thermal asymmetries and/or fixed patterns. The levels of thermal asymmetry are not necessarily the levels of subluxation, and may change with time. The value of the thermal scan is in determining the overall degree of autonomic abnormality, and the response of the patient to the adjustment.

Two mechanisms have been proposed which relate to altered skin temperatures, the segmental and the nonsegmental.

The segmental model

According to the segmental model, sensory irritation via the recurrent meningeal nerve may result in a sympathetic response of vasoconstriction. This will produce thermal asymmetry in the "thermatome" affected.

A thermatome is similar to a dermatome, but refers to a region of temperature change rather than sensation. When this mechanism is operative, the level of the thermal asymmetry is often the same as the level of subluxation, or is close to it.

Some clinicians report that chronic subluxations or long standing organic disease may be associated with segmental responses. Segmental facilitation of the lateral horn cells of the spinal cord may produce similar changes.

The nonsegmental model

Sensory innervation of the intervertebral discs and facet joints is not only segmental, but is also nonsegmental through the paravertebral sympathetic trunk. Therefore, a subluxation at any level of the spine may produce thermal changes throughout the entire spine. Depending up on the degree of chronicity, these changes may be fluctuating or "fixed" into a pattern.

Clinical analysis

In the analysis of thermal differentials, we are concerned with two factors, symmetry and pattern.

Symmetry refers to the difference in temperature between the left side at the right side at like points along the spine. It has been demonstrated that specific temperatures vary greatly from person to person. Actual temperatures also vary in the same person from moment to moment. However, the differences in temperature from side to side are maintained within strict limits in healthy persons.

Uematsu et al determined normative values based upon 90 asymptomatic "normal" individuals. These authors stated: "These values can be used as a standard in assessment of sympathetic nerve function, and the degree of asymmetry is a quantifiable indicator of dysfunction...Deviations from the normal values will allow suspicion of neurological pathology to be quantitated and therefore can improve assessment and lead to proper clinical management." (2)

These values have been incorporated into the Insight 7000 software. Mild, moderate, and severe asymmetries are identified by color bars. Temperature differences between one and two standard deviations indicate a mild asymmetry; two to three standard deviations a moderate asymmetry; while three or more are indicative of a severe asymmetry.

It must be remembered that since vasomotor activity should be a dynamic process, the levels of asymmetry will change from session to session unless a chronic subluxation is present. Even though the levels change, a patient with acute or subacute subluxation will usually have approximately the same number of levels out of range, although the levels themselves may change.

The thermal sensors, when properly used, provide excellent reliability (reproducibility) of temperature measurement. However, temperature patterns on a patient change from moment to moment unless chronic subluxation is present. This may incorrectly lead the examiner to believe that the instrument or procedure is not reproducible. Reproducible readings indicate chronic subluxation. This is NOT a normal or desirable state of affairs.

Patterns

B.J. Palmer developed and used a system of skin temperature analysis called the "pattern system."

Miller described the basic premise of pattern analysis as follows:

"Persons free of neurological interference tend to display skin temperature readings which continually change, but when the vertebral subluxation and interference to normal neurological function appear on the scene, these changing differentials become static. They no longer display normal adaptability, and at this time the patient is said to be `in pattern.'" (3)

Clinical observations from users suggest the following:

1. In normal (unsubluxated) patients, thermal patterns will be constantly changing, and will exhibit acceptable symmetry.

2. In acute and subacute subluxations, there will be levels out of range, but the pattern will vary.

3. In chronic subluxations, the pattern will be fixed, and there will be levels out of range.

4. Levels of asymmetry often do not relate to the level of primary subluxation.

5. Chronic organ dysfunction (visceroautonomic) may result in a focal segmental asymmetry.

6. Thermal patterns measure autonomic activity. Levels of thermal asymmetry may not correlate with levels of EMG asymmetry, since EMG is measuring muscle activity, not autonomic function.

These observations should be tested through formalized research. The chiropractic profession pioneered skin temperature differential analysis with the introduction of the neurocalometer over 70 years ago. Strengthened by extensive clinical experience and ongoing research, paraspinal skin temperature differential analysis is strongly established in the practice of subluxation based chiropractic. (4)

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Chiropractic Instrumentation — An Update for the '90s

JOHN S. KYNEUR and STANLEY P. BOLTON

ABSTRACT: Chiropractic instrumentation is the use of electrical devices to aid in determining the existence of and changes to vertebral subluxation in chiropractic practice. Three instrument categories are identified — thermoelectrical, bioelectrical and photoelectrical. Thermoelectrical instruments initiated chiropractic instrumention over 65 years ago. This paper traces the historical origin and development of the use of thermal instruments in chiropractic, reviews and discusses five thermoelectrical instruments used in chiropractic practice, and outlines the physiological rationale for their use. Some clinical trials are noted. It is concluded that fundamental research into the neurology and physiology of paraspinal heat mechanisms is needed. Further clinical research into paraspinal heat and spinal biomechanical dysfunction relationships in the spinal subluxation complex is also needed.

INDEX TERMS: Chiropractic/instrumentation; differential thermal analysis/instrumention; chiropractic/methods.

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INTRODUCTION

Instrumentation has been an element of chiropractic clinical practice for over 65 years. Chiropractic instrumention supplements case history, spinography, neurological testing and orthopaedic examination in the clinical search for chiropractic subluxation and in assessment of adjustment procedures.

Chiropractic instrumentation is defined as the use of electrical devices to aid in determining the existence of vertebral subluxation and of change following spinal adjustment. A 1986 South Australian survey found that 27% of chiropractors currently use instrumentation in that state.[1] Stillwagon, in surveys conducted during seminars, claims there is a 15% usage within chiropractic practice.[2]

Kimmel[3] lists 3 types of electrical instruments which have been used by chiropractors: (a) thermoelectrical, (b) bioelectrical, and (c) photoelectrical.

Thermoelectrical instruments, using the thermocouple principle, initiated instrumentation in chiropractic clinical practice. Thermoelectrical instruments measure paraspinal skin temperature and include the five instruments discussed in this paper.

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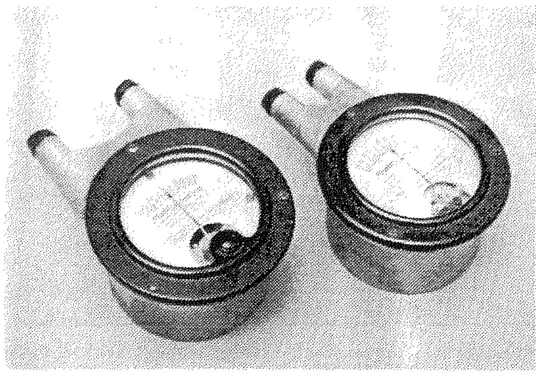
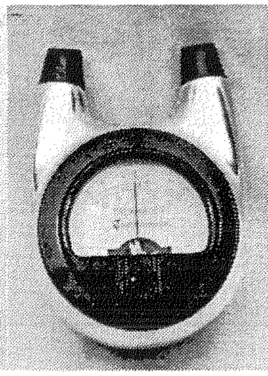
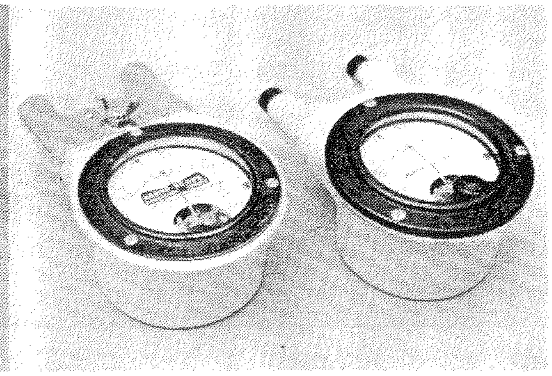
Bioelectrical instruments measure skin resistance to the passage of a small electric current or galvanic skin response. The best known example in chiropractic was the Ellis Microdynameter (MDM), a popular instrument of the 1940s and 1950s. The MDM was strongly criticised both within and outside the profession. B.J. Palmer[4] found that "its method of pickup contained innumerable, impossible-to-eliminate variables," while the US Department of Health, Education and Welfare's Food and Drug Administration (FDA) used its advertising copy as evidence against it,[5] claiming it to be a menace to patients' health. Similar bioelectrical devices have been used in research by the chiropractic,[6] osteopathic[7,8] and medical professions.[9-12] Bioelectrical instruments have all but disappeared from contemporary chiropractic practice.

Photoelectrical instruments, not in common use in chiropractic today, include the Analyte and the Visual Nerve Tracer (VNT)— or, to use the latter's full title, the "Photoelectrical visual nerve tracing instrument"[13]— developed by Adelman and Weiant. Essentially, these instruments consisted of a matched pair of photoelectric cells which evaluated the reflection of light from engorged vascular beds under the skin.[14] Kimmel[15] and Triano[16] recognise these instruments as forerunners to modern day thermography. Of the Visual Nerve Tracer, Triano further notes that "little has been found in the available literature to substantiate the reliability of this instrument."

The inclusion of instrumentation in chiropractic practice warrants wider understanding and further scientific study. This paper traces the history, interpretation and rationale for use of thermoelectrical instruments in chiropractic practice.


Standard Neurocalometer (left) for use on adults, infant Neurocalometer (right) for use on babies and children.


Standard Thermeter


Standard Nervoscope (right), Nervoscope with variable probe widths and contour/flex terminals (left). Both instruments have standard and high sensitivity options.

It notes some clinical trials and concludes that further basic research and trials are needed.

Table 1 lists, in three categories, instruments which have been used by the profession since the inception of chiropractic instrumentation.

Table 1

INSTRUMENTS USED IN CHIROPRACTIC PRACTICE

Thermo-Electrical	Neurocalometer, Neurocalograph, Chirometer, Nervoscope, Temposcope, Analagraph, Thermoscribe, Synchrotherme,* Dermothermograph, Dermoscope, Thermo-o-meter, Calor-o-meter, Superthermo-meter, Pyrometer, Neuropyrometer, Universal skin thermometer, Thermodeltameter, Delta-T, Vasotonometer, Magnetic skin thermometer.
Bio-Electrical	Ellis Microdynameter, Rx-Micro-tabulometer, Psychgalvanometer, Clinical Dermohmeter, Polygraph, Micro-neurometer, Psychroneurometer, Electropsychometer, Index-o-meter, Neuromicrometer, Bio-neurometer, Neuropsychometer, Bioelectrometer, Analytical pocket pH meter, Galvanopsychometer.
Photo-Electrical	Spectro-photometer, Colorscope, Analyte, Colorimeter, Mercury quartz lamp, Ultra violet light source, the visual nerve tracing instrument, the photronic dermatome analyser.

Instrumentation types (after Kimmel)
* Marketed in the USA as the 'Deltatherme'.

HISTORICAL BACKGROUND

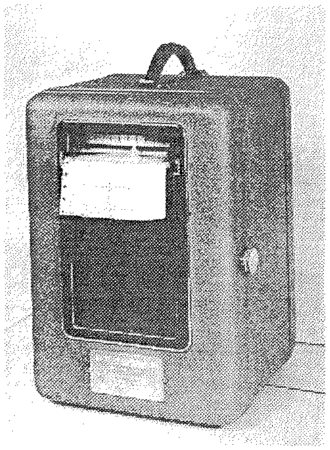
Quigley[17] describes how "B.J. (Palmer) had long taught that warmer spots along the spine signalled a subluxation. He referred to these areas as 'hot-boxes' from a common railroad-car problem in which the lack of lubrication in the wheelbox allowed friction to develop an extremely hot box and often a fire. The chiropractor was trained to seek out these hot areas with the more sensitive back of his hand" as a preliminary to spinal adjustment in the early days at the Palmer School of Chiropractic (PSC) in Davenport, Iowa, USA.

Dossa Evins is reported by Dye[18] to have worked on this spinal heat concept as a facet of the chiropractic spinal subluxation complex from 1920-1922. Dossa Dixon Evins was born in Blodget, Missouri on 13 February 1886. He studied engineering at the University of Arkansas and served during World War I in the radio department of the US Secret Service. He contracted tuberculosis and spent several years in a sanitarium. His search for health led him to Dr R.S. Marlow of San Antonio, Texas, a chiropractor, from whom he greatly benefitted. During treatment he noted that his chiropractor used the back of his hand on patients' backs, in a sort of exploratory fashion, and was told that chiropractors looked for 'hot-spots' as an indication of 'nerve pressure'. In 1920 he enrolled at PSC and, after graduation in 1922, practised in Kansas City, Missouri, where he took up in earnest the development of an instrument to detect 'hot spots'.[19,20]

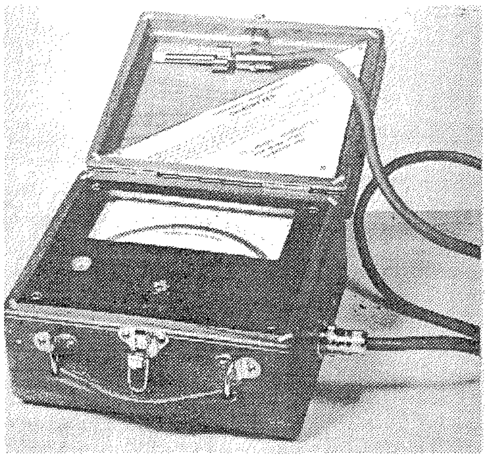
Evins introduced and applied the thermocouple principle to spinal analysis when he returned to PSC in 1923. The thermocouple principle, as a method of measuring heat differentials, was discovered by the German T.J. Seebeck in 1829.

Seebeck found that an electric current will flow in a circuit consisting of two dissimilar metallic conductors with two junctions of these wires a distance apart, called a thermocouple, when one junction is at a higher or lower temperature than the other. The electromotive force (EMF) producing this current is known as the Seebeck Thermal EMF.[21] The instrument invented by Evins was made up of a number of thermocouples in two probes, termed thermopiles, which were connected to a galvanometer, set in a hand-held instrument case. It is used straddling the spine to compare paraspinal heat and aid more accurately than palpation in pinpointing 'hot-boxes'. It was called a Neurocalometer (NCM). B.J. Palmer realised the potential of the NCM and worked to have the instrument patented in time for the 1924 Lyceum.

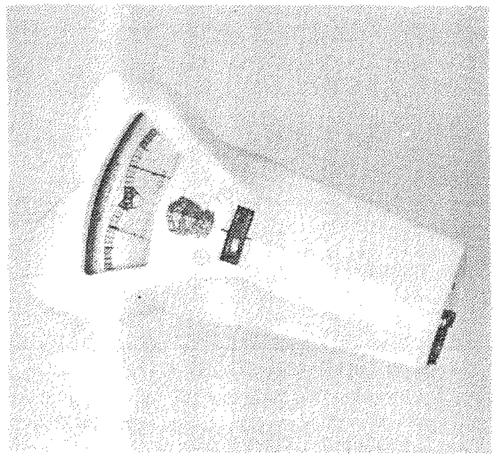
On 24 August 1924 B.J. announced the introduction of the NCM. Lyceums and homecomings were regularly held at PSC and drew chiropractors from all over the world. These annual gatherings continue today.



Neurocalograph Model B



Chirometer



Synchrotherme

The name neuro-calo-meter (nerve-heat-measure), was a composite designation devised by B.J. to describe the instrument's purpose.[22] But the main objections to the NCM were the cost and B.J.'s insistence that it be used by chiropractors.

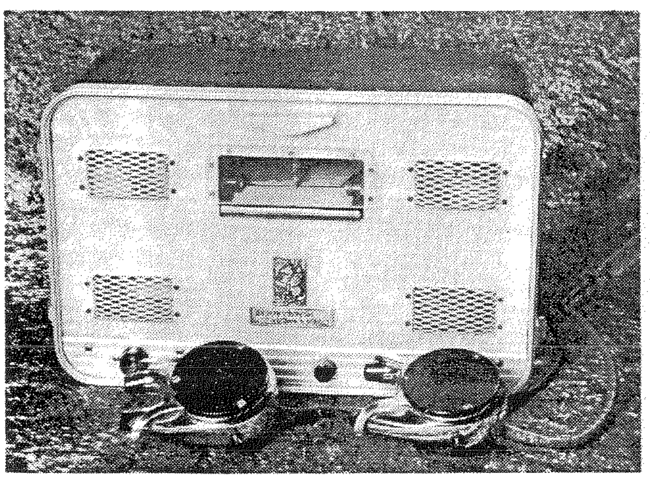
The NCM was not to be sold, B.J. explained, as recorded by Quigley, but would be leased for $3,500 with a monthly rental of $5 per instrument. Quigley[17] notes that at the time an expensive car cost about $1,000 and an average home approximately $3,500. This commercialism and his method of presentation to the profession clouded any merits the particular instrument had and prevented a rational discussion of the physiological principles relating to it. Gibbons[23] termed this Lyceum as "the neurocalometer debacle of 1924."

Initially rejected by a large section of the profession, the NCM nevertheless survived and came to be used by a significant number of practitioners who regarded it of similar importance in the 'scientific' practice of chiropractic to the earlier introduction of the use of x-ray to chiropractic practice. It is noteworthy that the introduction of x-ray by B.J. in 1910 had caused a walkout.[18] The specialised use of x-ray in spinal analysis by chiropractors has become known as spinography. Introduction of the NCM was the commencement of the use of instrumentation in chiropractic practice.

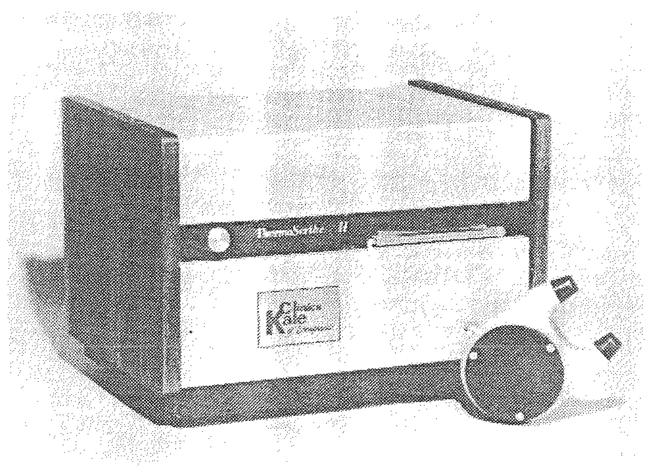
Graph-recording of NCM readings by mechanical means was a logical development of visual and hand-noted NCM readings. By 1939 the Neurocalograph (NCGH), developed by the PSC consultant engineer Otto Schiernbeck, appeared as a sophisticated self-recording NCM. Its introduction eliminated the human element of error in recording neurocalometer work and allowed more accurate comparisons.

Other heat-reading instruments, similar to the NCM, were later manufactured by independent companies and appeared on the market. Among the better-known instruments were the Nervoscope (NS) and the Neuropyrometer (NPM).

The Nervoscope, manufactured by Electronic Development Laboratories, New York, was developed in the 1940s. Its graphing companion is the Analagraph (AG). In addition, a table-top galvanometer, termed the

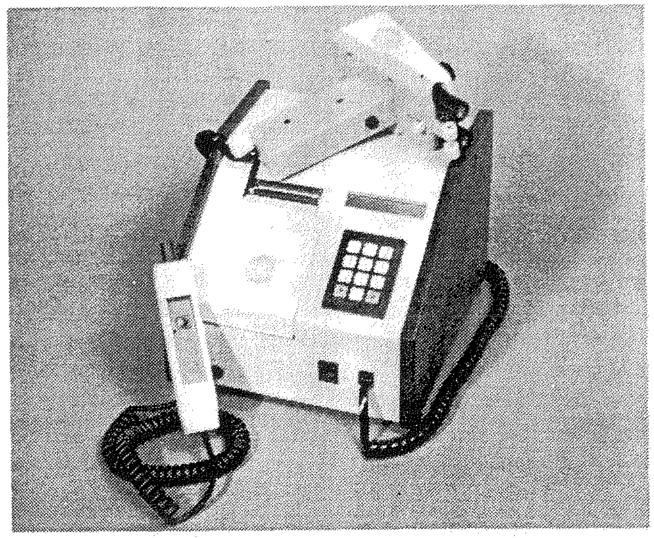


ThermoScribe Model I with junior and senior pickups



ThermoScribe Model II

Dermathermograph DT-25


Accolade System III

Analascope (AS), was manufactured. This allowed the patient to see the reading as it was being made. The AS may be described as a high-gain vacuum-tube voltage-controlled amplifier.[24]

Murdoch Engineering of California produced the Neuropyrometer (NPM). The NPM later became known as the Thermeter (TM), with the Thermoscribe (TS) as its graphing companion.

All the above-named heat-reading instruments are still marketed today. All are available for individual sale except the NCM, which until recently was available on lease only.[25] All make use of the thermocouple principle, and measure comparative heat by conduction from skin contact probes straddling the spine.

With these spine-straddling comparative heat-readers it was realised that there was no way to know if an area was bilaterally hot or bilaterally cold. Further, contact fixed probes could be improved by reaching closer to the transverse processes of the spine, and hence the neurological bed, particularly in the upper cervical spine.

Thus heat-reading instruments were devised to fill this gap. In the 1950s the Chirometer and the Vasotonometer, the latter leading to the Synchrotherme, emerged.

In contrast to the comparative heat-readers, the Chirometer (CM) and the Vasotonometer (VTM) are direct temperature reading instruments. CM uses the thermocouple principle, while VTM introduced use of the thermistor in chiropractic instrumentation. The thermistor is a thermometer whose impedance varies with the ambient temperature and is therefore able to measure extremely small changes in temperature. Thus the spine-straddling comparative heat-reader can be defined as a 'relative-thermal instrument' which reads comparative heat differentials, while the direct temperature reader can be defined as an 'absolute thermal instrument' which reads single or 'spot' temperatures.

The development of the VTM emerged from the study of vasomotor control and thermoregulation taken up by Dr A.R. Petersen of Davenport, Iowa in 1951, to fulfill the need for bilateral temperature comparisons.[26]

The VTM was found to be difficult to use, introducing many variable factors in its analysis. Because of this, three further prototypes were developed before leading to a final instrument of this type known as the Synchrotherme (ST).

Using two separate thermistors, ST straddles the spine in a skin contact glide and records these two separate temperature-reading channels onto one graph paper.

As two separate channels are recorded, ST may be described as a mobile bilateral temperature recording instrument, while the CM may be described as a static unilateral temperature-reading instrument.

Considerable work on development and interpretation of the Synchrotherme was done by Petersen,[27] Himes,[27] Watkins,[28] Haldeman, Grice, Gitelman,[29] and Bailey[30,31] at the Canadian Memorial Chiropractic College, Toronto, Canada, in the '60s and '70s. Despite thousands of hours spent in development and research of this instrument, the Synchrotherme is no longer available to the profession.

In the 1960s Vernon Pierce of Dravosburg, Pennsylvania developed the Dermathermograph (DTG), the first model appearing on the market in 1963. This instrument, and models following, are single-probe instruments using a different heat-sensing technology. All other thermal instruments up to this time were of thermocouple or thermistor technology, requiring skin contact and measuring heat by conduction. The DTG is an infrared heat-sensitive instrument which measures skin surface temperature by radiation without direct skin contact. While early model DTG instruments used the sacrum as the starting temperature and produced a differential heat-reading of the spine relative to the sacrum,[32] current models measure absolute temperature recorded on graph paper in the range of 27.8°-38.9°C. The most recent DTG is the

DT-25. This model and an offering from Sherman College of Straight Chiropractic, called the Accolade-System III, represent state-of-the-art infrared detecting instrumentation. Table 2 summarises the history of chiropractic thermoelectrical instrumentation. Table 3 summarises features of the five thermoelectrical instruments discussed.

Table 2

BRIEF HISTORY OF CHIROPRACTIC THERMOELECTRICAL INSTRUMENTATION

INSTRUMENT	SUMMARY OF DEVELOPMENTS
Neurocalometer (NCM)	Invented by Dossa Evins 1920-1922. Introduced to the chiropractic profession at PSC Lyceum, August 1924. Engineer Otto Schiernbeck introduced the NCM's graphing ally, the Neurocalograph, in 1936. Ancillary equipment includes the Neurotempometer for constant glide and posture constant chair for repeatable patient positioning.
Nervoscope (NS)	Introduced in the 1940s, NS is similar to the NCM. Manufacturer's innovation is the table-top Analascope, allowing the patient to view the meter reading. Graphing companion, the Analagraph, introduced in the 1950s.
Chirometer (CM)	Introduced in the late 1940s—early 1950s CM is a companion to the NCM/NCGH for direct temperature reading. Current model includes digital temperature display.
Synchrotherme* (ST)	Developed from studies on thermoregulation of A.R. Petersen from 1951. Original instrument termed Vasotonometer. Progressed through several variations resulting in the Synchrotherme in the late 1960s. Instrument manufactured by Jintan Terumo (Japan), graphing apparatus by Leeds and Northrup (Canda).
Dermathermograph (DTG)	Developed by W.V. Pierce. Introduced to the profession in 1963. Various models developed by W.V. Pierce and G.K. Stillwagon. The most recent model, the DTG-25 represents 25 years of development (1988). Includes digital display and is computer-compatible.

* Marketed in the USA as the 'Deltatherme'.

Table 3

FEATURES OF FIVE THERMOELECTRICAL INSTRUMENTS USED IN CHIROPRACTIC INSTRUMENTATION

Neurocalometer (NCM)	Consists of a microvoltmeter (or microammeter) in series with 10 series-connected thermocouples arranged in two groups (thermopiles) of five thermocouples per group. The two thermopiles are separated a distance between group centres of approximately five centimetres. The circuit arrangement is such that the meter deflection is proportional to the difference in temperature between the two thermopiles.**
Nervoscope (NS)	NS consists of a zero centred meter having a sensitivity of 0.45 mV from zero to the right or left full scale marking. Each thermocouple element contains 8 thermocouples connected in series to form a very high output thermopile. The instrument has a sensitivity control switch, and the detection elements have an adjustable width for use on adults or children.
Chirometer (CM)	A direct temperature reading instrument, with single thermopile probe. The Chirometer measures temperature comparing it with a known factor (room temperature previously calibrated). A portable instrument with sensitivity remaining unchanged within the reading limits of the dial (60-140°F).
Synchrotherme (ST)	A U-shaped instrument which is not a differential unit. Its two thermistor pickups yield separate readings. Matched thermistor sensors of high sensitivity exhibit a fast response time. A wheel mechanism on the probes reduces skin contact irritation to a minimum. A worm gear motor drive unit allows a constant rate of glide.
Dermathermograph (DTG)	DTG is an infrared detector with a ⅓-second response time. The DT-25 has been redesigned around microprocessor electronics. It has a thermal writing plotter, key pad data entry with audible and printed five-second indications to help maintain a constant rate of glide. This model is also portable when operated from a 9V DC battery.

** La Mothe D.J. Determination of the sensitivity and the calibration of the Neurocalometer. Int Chiropractors' Assoc Sci Rev Chiropr, 1965; 2(2).

DISCUSSION

The five instruments discussed represent a range of heat-reading instruments used in chiropractic instrumentation employing varied and/or similar procedures with different, and sometimes conflicting, interpretation. In chiropractic instrumentation, attempts have been made to standardise procedures and reduce the variable factors such as operator control, technique of glide, *etc.*

Although comparisons have been made between different types of thermal instruments and a high reliability found,[33] no study has been published in the literature of the accuracy of similar instruments. For example, there are no available studies of comparisons between the NS, NCM and TM for reliability. For the purpose of this paper it is assumed that the instruments discussed are functionally optimum, and techniques for their use consistent with recommended procedures.

The Neurocalometer (NCM) and Nervoscope (NS) are two spine-straddling comparative heat-reading instruments, technically similar in their application of thermocouple technology.

Both instruments and their graphing companions, the Neurocalograph (NCGH) and the Analagraph (AG), respectively, use a steady glide in probe-skin contact from sacrum to occipital base to produce visually metered readings or recorded graphs.

Two different methods of interpretation have developed from their use in chiropractic practice. The method commonly associated with the NCM is termed 'pattern' analysis, and the method generally associated with the NS is termed 'break' analysis. The two systems are not compatible and indeed have different conclusions and rationales:

- A 'pattern' may be defined as two readings of the spine, separate in time, having similar characteristics peculiar to that individual which return and stay, different to the assumed normal, suggesting nerve interference.[34]
- A 'break' may be defined as a peak having a sharp deflection in a single reading during a glide covering only one or two vertebrae of the individual spine, different to the assumed normal, also suggesting nerve interference.[35-37]

For both NCM and NS, the assumed normal is a straight or relatively shallow curved line without sharp deflections (Figures 1a and 2a), because the temperature of the two sides of the body adjacent to the spine normally vary only slightly. Both 'pattern' and 'break' readings may change or disappear following spinal adjustment or adjustments.

PATTERN ANALYSIS

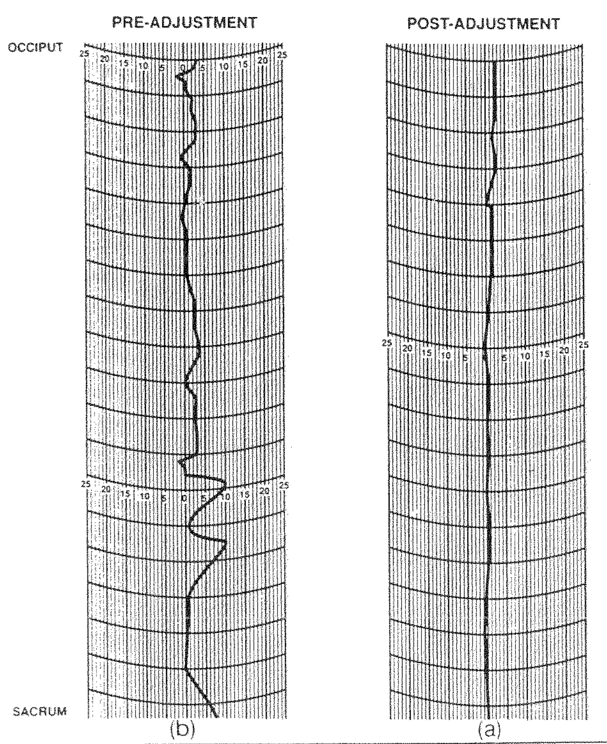


Fig. 1. Illustration of 'pattern' analysis: (a) assumed normal, (b) 'pattern'.

A study of the NCM and NCGH is a study of the HIO adjusting/pattern analysis system as distinct from the NS and AG break analysis system, which has been more closely associated with Gonstead adjusting procedures.

HIO and Gonstead workers differ markedly in their interpretations. The difference in essence is that 'pattern' analysis does not place importance on location for adjustment choice, while 'break' analysis does.

Not only does Gonstead suggest that the break may indicate the location of the subluxation and hence area for adjustment, but also suggests the break can be interpreted as acute, very acute, chronic and characteristic.

Figure 2b shows assumed subluxations at the break levels of T2, T6, T10 and L1. According to Gonstead theory, the direction of the break is toward the side of the

BREAK ANALYSIS

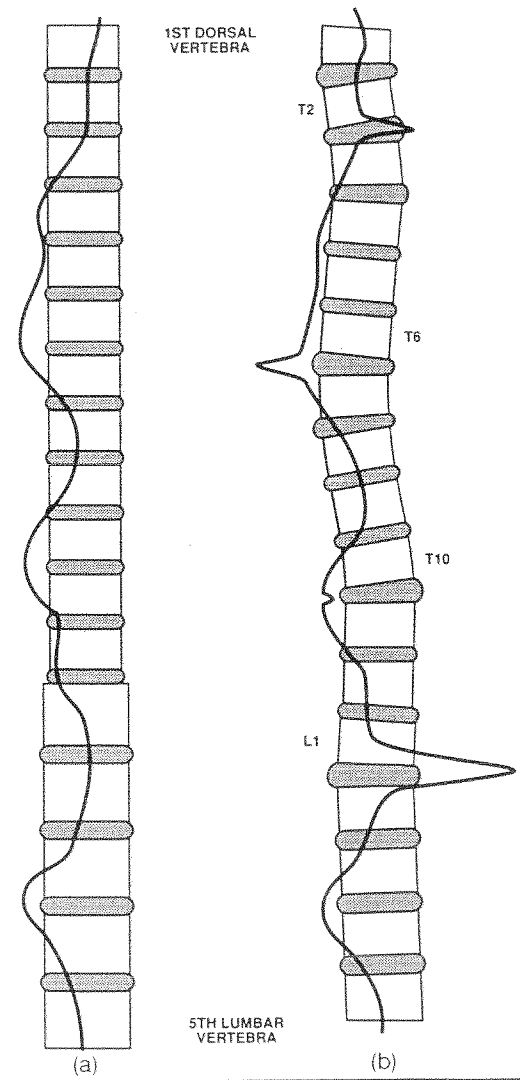


Fig. 2. Illustraion of 'break' analysis: (a) assumed normal, (b) 'breaks'.

protruding disc. Gonstead suggests that the freely moving apophyseal joints have no causal relationship to the condition of vertebral subluxation and hypothesises that the disrelationship of the facets is the result of, and secondary to, the misalignment at the fibrocartilaginous joint, that is, at the intervertebral disc.[35]

The T2 and T6 subluxations are considered acute as the needle deflects towards the side of the protruding disc as determined from x-ray analysis. At the level of T10, the needle also deflects toward the side of the protruding disc.

A chronic subluxation is suggested at L1, because the pointer deflects away from the side of the protruding disc. The location of subluxation in Gonstead analysis is thus determined by the position and direction of the break when correlated with AP full spine radiographic analysis.

The position of NCM workers is that "Many chiropractors have understoood that various 'breaks' or peaks seen in NCM readings denote not only the presence of abnormal neurological function but also its location. While this may have been the conclusion drawn early in the development of NCM interpretation, it has not been the interpretative understanding since the 1930s."[38]

The problem of location to NCM workers is summarised by Miller,[39] who states, "There is no normal skin temperature, only a normal temperature range. Skin temperature continually changes with an ever-shifting metabolic rate and environment. Persons free of neurological interference tend to display skin temperature readings which continually change, but when the vertebral subluxation and interference to normal neurological function appear on the scene, these changing differentials become static. They no longer display normal adaptability, and at this time the patient is said to be 'in pattern'."

From the early '30s to 1961, the Palmer School of Chiropractic developed and taught NCM pattern analysis almost exclusively. This was in conjunction with specific adjustive techniques and spinographic line analysis of the occipito-atlanto-axial area, and became known as the B.J. HIO (hole-in-one) system. During that period the B.J. Palmer clinic kept extensive records of both upper cervical and full-spine NCM readings. It was found that while frequent and extensive heat differentials were noted at various levels of the spine, exclusive adjustment of the upper cervical region caused these 'break' readings in the lower spine to disappear. Workers in this area such as Sherman[40] and Duff[34] found that 'break' readings below axis were never constant. Conclusions drawn were that subluxations frequently existed far removed from their most evident manifestation; that heat differential readings did not necessarily indicate location for spinal adjustment; and that spinal analysis should never be based solely on symptoms.

Several solutions to the problem of the inability of NCM to compare marked temperature differences bilaterally hot or bilaterally cold have been used. For example, a diagonal glide, where one probe is at a higher level and the other at a lower level, has been used. Gillet suggested a short probe fitting into the palm of the hand with the longer probe gliding over the paraspinal skin, first to the right, then to the left of the spine.

The Chirometer (CM) was developed as a companion instrument to NCM to overcome some of these limitations and the physical inability of NCM probes to contact the atlas transverse process region, thereby providing supplementary information.

CM is a direct single-probe spot temperature-reading instrument using the thermocouple principle.

Precalibrated to room temperature, it can be used to compare any two like areas of the spine. It is generally used as a direct heat-reading measure of the upper cervical region.

Whereas spine-straddling instruments glide over the posterior aspect of the spine and may be as far as 75mm from the spinal nerves, CM can get much closer, perhaps as close as 30mm. CM does not have a graphing component.

The region of the first and second spinal nerves are read by CM at four locations, two on each side of the body: at the fossa beneath the pinna of the ear (styloid fossa) and on the superior nuchal notches near the great occipital nerves (Figure 3). The latter is closer to the skin surface than any other portion or branch of the second spinal nerve.[41]

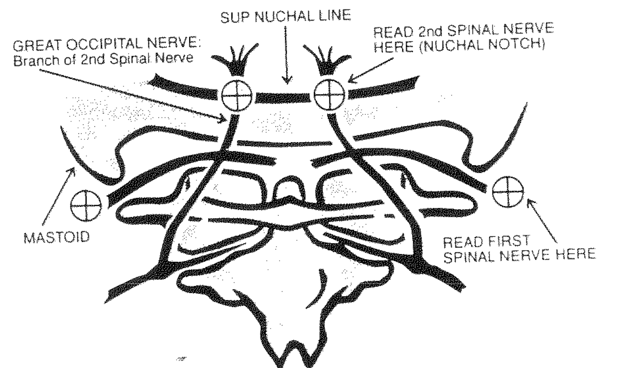


Fig. 3. Four upper cervical Chirometer contact points.

The purpose of the readings is to determine if there is potential nerve interference to the first or second spinal nerves in an atlanto-occipital or atlanto-axial subluxation.

A half-degree difference between like areas is interpreted as an indication that the patient requires an adjustment. The average temperature range is from 0.2°-0.6°C difference, occasionally as high as 1.3° to 1/7° difference.

It is noted with NCM/NCGH studies that indication of whether to adjust is determined by the presence of the pattern. Although location for adjustment choice is of no significance in pattern analysis, CM reading is used to determine the side of laterality for atlas correction.

Atlas laterality is determined by comparing CM readings and choosing the cold side as the side of laterality.[42] A CM reading is considered to be normal when both sides are equal in temperature.

A study by Pullella *et al.* at Palmer College in 1974[6] found CM to have a fairly close correlation with leg length check. Quigley[42] suggests a high degree of correlation has been found between upper cervical laterality in x-ray line analysis listings and CM temperature difference readings, although no published paper of case studies or clinical trials has been noted. The use of CM to determine laterality for atlas adjustment and correlation with leg length needs validation.

It is interesting to note that CM reading techniques in the styloid fossa is also part of dermathermograph procedures. The Dermathermograph (DTG) is a single-probe infrared heat-sensitive instrument measuring skin surface temperature by radiation, without skin contact. All heat-reading instruments previously discussed in this paper measure heat from skin contact, while DTG measures radiant heat.

DTG, in its present form, is an infrared radiometer used to measure paraspinal temperature from sacrum to occiput. It is a hand-held instrument with a trigger control mechanism which links it to the graphing part of the instrument. Optimum operating results are achieved by maintaining approximiately 6-12mm of spacing between the skin and the window of the instrument. The glide is made from sacrum to occipital base. Left and right styloid fossa regions are then also recorded. As an 'absolute thermal instrument' it may be described as a mobile unilateral temperature recording instrument.

Articles on current interpretation of DTG readings accessed by the authors are few. Thus one is left, for the most part, to make assumptions from the tome, *Results*.[43]

A normal DTG reading is a continuous, relatively straight line from sacrum to occiput, or a straight line with gradual temperature increase from sacrum to occiput with equal left and right atlas transverse area readings (Figure 4a and 4b).

Cold readings (Figure 4c), suggesting areas of vasoconstriction, are considered to be major areas of concern in reading DTG graphs, although Stillwagon and Pierce[44] emphasise that DTG is not used to indicate location of subluxation.

As no skin contact is required, it is believed DTG is less influenced by skin blemishes, scar tissue and the like which, undetected, could produce a false reading in skin contact instruments.

In recent years Stillwagon[45] has moved into the area of electronic thermography units and has developed the Visitherm, which provides bilateral (NCM) and segmental (DTG) heat readings as well as temperature differences between one side of the spine and the other. Such an instrument has practical and clinical research potential. The authors have been unable to access articles of interpretation on Visitherm in the literature.

The Synchrotherme (ST) was developed by Petersen with assistance from Bailey, Watkins, Himes and others.[26-30] This instrument simultaneously measures

DERMA THERM-0-GRAPH TEMPERATURE DIFFERENTIAL READINGS

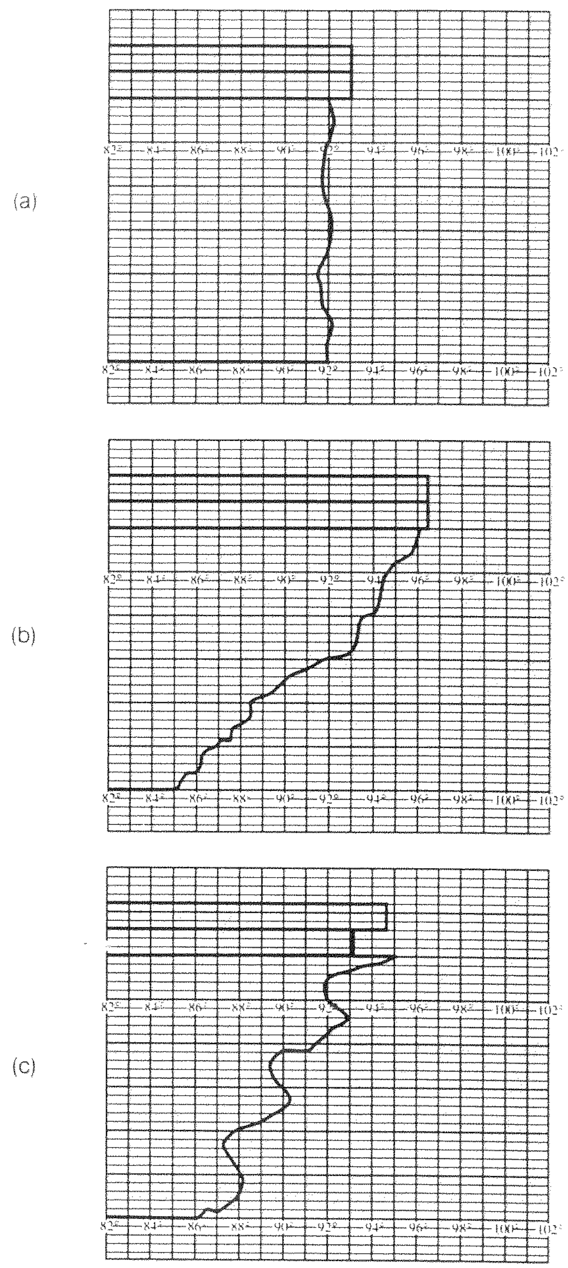


Fig. 4. DTG readings: (a) and (b) are assumed normal; cold readings in (c) are considered of major concern.

bilateral paraspinal skin temperatures and records these two channels on a graph. Using thermistor technology, it is an 'absolute thermal instrument' and may be described as a mobile bilateral temperature recording instrument.

An interpretation of the patterns of ST readings is offered by Davies.[46] A summary of his writings represents current thinking on bilateral temperature interpretation.

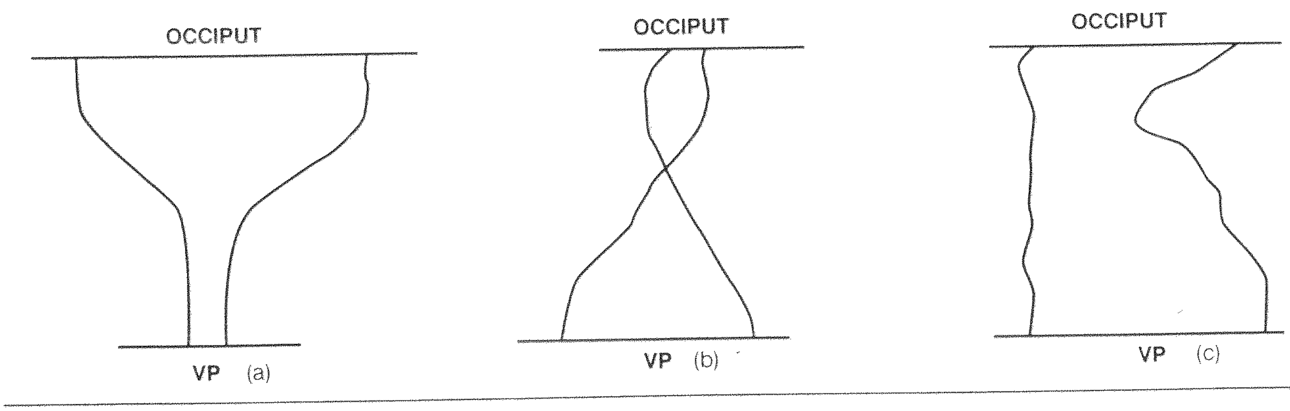


Fig. 5. Assumed normal full-spine Synchrotherme reading.

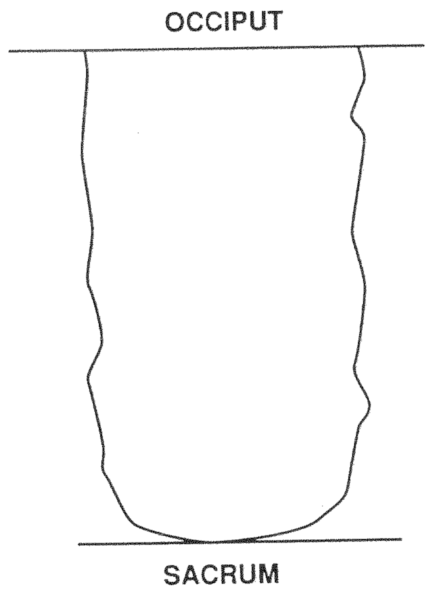


Fig. 6. Abnormal cervical spine Synchrotherme readings.

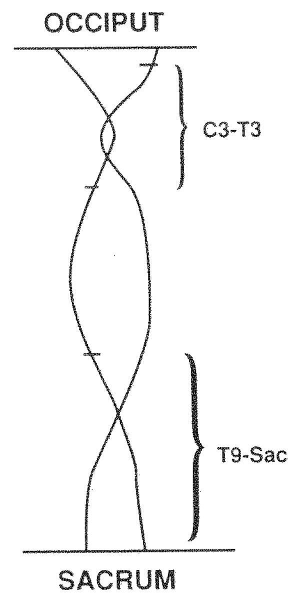


Fig. 7. The hourglass full-spine Synchrotherme reading is said to represent a subluxated spine.

The normal graph of ST (Figure 5) consists of a steady bilateral temperature increase from sacrum to occiput. A general 'fluffiness' is noted, and it is recommended that the patient should never be adjusted while this configuration exists.

Davies states that "It is imperative that the doctor understands what is implied by the word 'normal'. It is merely a state in which the nerve system is not being impeded or hindered in causing the body to constructively adapt to its environment both internal and external. It in no way implies absence of symptoms which may very well exist in a state of constructive adaptation."

In interpretation of variations to the assumed normal ST full spine readings, three configurations may appear in the cervical region (Figures 6a, 6b and 6c), suggesting areas of the spine to be adjusted. The graph in Figure 6a shows a bilateral 'collapse' from C2/3 down to the upper thoracic region. Such pattern suggests pelvic involvement. Cervical adjustments are not indicated. Figure 6b shows a mid to upper cervical bilateral collapse. Interpretation of this configuration suggests a biomechanical derangement in the upper thoracic spine. Figure 6c, the third type of configuration seen, is a unilateral collapse. This suggests neurological involvement opposite the collapse, which is at left atlas or axis.

In the full-spine ST graph, the configuration of an hourglass shape is said to represent a subluxated spine (Figure 7). It has also been shown in ST work that the atlas and sacrum have special significance in terms of improvement towards the assumed normal graph pattern.

Neurocalometer, Nervoscope, Chirometer, Synchrotherme and Dermathermograph studies suggest that normal paraspinal heat readings are essentially symmetrical. In addition, ST and DTG normal readings also suggest a gradual incease in temperature from sacrum to occiput.

A recurrent theme in thermal instrument study is that the presence of nerve interference in subluxation is independent of symptoms. This is evident in the writings of the NCM workers like Palmer, Sherman, Miller and Duff, and those of ST and DTG workers. Although Gonstead appears to be more symptom-orientated, he suggests that one should also look for other evidence of biomechanical derangement.

Gonstead adheres to the theory that breaks are the site of subluxation, while Palmer found breaks disappear following upper cervical adjustment, and Watkins[28] found heat levels to be different to the determined aberrant spinal motion. The authors suggest that although clinical data is being amassed, not enough scientific and statistical methodology has been applied to validate or modify conflicting interpretation.

PHYSIOLOGICAL RATIONALE

Given that classical chiropractic subluxation combines spinal misalignment with neurological insult, what are the physiological mechanisms of abnormal paraspinal heat readings?

The major control and regulation of skin temperature is under neurovascular control *via* the sympathetic nervous system. Guyton notes that "approximately 8% of the fibres in the average skeletal nerve are sympathetic fibres, a fact that indicates their importance."[47] Thus thermal instruments may be said to monitor the heat of spinal nerves *via* their sympathetic components, but it must be noted that there are other factors influencing skin temperature.

Hobbins suggests that the surface conduction of the skin in disease and injury, vascular areas of arterial perfusion, venous drainage and lymphatic content all influence skin temperature.[48] Stillwagon suggests the influence of local pH and "various neuroactive substances", presumably histamines and prostaglandins, influence skin temperature.[44] Kimmel reminds us that emotional states, basal metabolism, smoking and the specific dynamic action of foods all need to be accounted for in the use of thermal instruments.[5] To these must be added recent assertions of Hospers and Gaudet, who found that changing weight-bearing conditions altered readings obtained.[49] Consequently, the thermal instrument user, whether using thermocouple, thermistor or infrared detector, should, to use a phrase of B.J. Palmer, "eliminate the variables."

The condition known as sympathicatonia (increased tonus of the sympathetic system) is suggested as one mechanism of vertebral subluxation pathology. The extensive work of Korr, including temperature and galvanic skin response studies, produced the concept of the "facilitated segment" whereby spinal dysfunction at segmental areas sensitises the autonomic nervous system.

Sympathicatonia would produce a cold region identifiable in 'pattern', 'break' and direct temperature reading instruments. Stillwagon notes that, "after the sensory neuron synapses with the sympathetic nervous system, the pre-ganglionic sympathetic fibres can ascend or descend in the chain several levels before exciting response." This could account for poor correlation of 'breaks' to physical findings in 'break' analysis.

Both Stillwagon[44] and Gonstead[35] agree that the acute vertebral subluxation involves vasodilation with increased blood flow to the surface and consequent hot areas. The mechanism suggested is not one of sympathetic dysfunction, but of antidromic excitation of substance P-related unmyelinated sensory fibres.

Antidromic means reverse flow conduction of an impulse in a direction opposite to the normal, a phenomenon that has been investigated by, amongst others, Sherrington and the Nobel laureate Krogh.[50]

Stillwagon's theory[45] is that acute vertebral subluxation causes antidromic stimulation of the dorsal root resulting in substance P release, vasodilatation and heat. When substance P is depleted, the vasoconstriction mechanism involving sustained sympathetic reflexes takes over, resulting in cold areas.

Some 30 years before Stillwagon, this question was raised by Weiant and Adelman,[13] who asked: "What if posterior root fibres are irritated and centrally moving impulses spill over into lateral horn cells from which emanate sympathetic vasoconstrictor fibres to the arteries?"

In his analysis of the 'break' system, Davies[46] notes that breaks do occur. As for the sympathetic mechanism, a major problem he perceives with such an interpretation is that the distribution of sympathetic nerve fibres covers at least one dermatome above or below the dermatome of origin on the skin surface.

In considering the antidromic vasodilator effect, Davies states that "due to the location of the posterior ganglion in relation to the intervertebral foramen and the intervertebral disc, it would be fairly difficult for mechanical pressure to be brought to bear distal to the ganglion and thus, accordingly, the antidromic effect is not a possibility."

Davies also notes that the distribution of fibres carrying the antidromic impulses would be the same as that of the sympathetic overflow and so would not likely produce such a localised phenomenon as the 'break'.

In a statement on sympathetic neurodystrophy, Triano[16] notes that the difficulty with this concept, as well as others involving instrumentation, is that the pathophysiological factors of subluxation have not been clearly delineated.

A common point in chiropractic instrumentation over the decades is that changes from the normal in paraspinal heat readings indicate a need for spinal adjustment.

Variations to this classical chiropractic approach are suggested from non-chiropractic sources. Over the past three decades, interest in thermography has developed in the medical profession. Recognising that interference to the sympathetics is occurring, as evidenced with electronic or liquid crystal thermography, attempts have been made to alter this by ganglia blocks, ischaemic blockade, as well as TENS, acupuncture, and local injections of histamines and substance P or, as recorded by Kukurin,[51] nutritional vasodilator therapy.

The objective of these varying approaches is similar. Thus workers outside the chiropractic discipline, interested in spinal heat correlation, lend support to the physiological rationale of linkage between variant heat and abnormal function, identified and used, albeit crudely, from the earliest days of chiropractic practice.

CLINICAL TRIALS

In the past two decades, chiropractic instrumentation trials have been carried out at Palmer, Canadian Memorial, New York and Texas chiropractic colleges in the US and Canada, and at the University of Adelaide's department of physiotherapy in South Australia. Although none of these trials are conclusive or without reasonable criticism, the trend toward applications of scientific principles and statistical methodology is worthy of note.

For any instrument to be effective it must be valid, reliable and objective. Validity is the extent to which something measures what it is supposed to measure.[52] Reliability is the ability of a measure to give similar values when measured upon separate occasions by the same observer in the absence of intervening treatment, while objectivity is the extent to which different observers can obtain similar values of a measure from independent measurements.[53]

A concept evident in Neurocalometer literature is that a pattern could be present without the patient presenting symptoms. Alternatively, a patient with symptoms may not have a pattern, and no adjustment would be given on that day. Similarly Synchrotherme researchers suggested that neuropathy presented itself as the first evidence of developing pathology.[27]

The Synchrotherme trial at CMCC described by Haldeman[29] included assessment of changes after adjustment. Haldeman noted that in the majority of cases the graph changed after adjustment, but he also noted that there was little control over the adjustment procedure. Haldeman's opinion conflicts with those of NCM and early ST workers. Haldeman states, "If the severity of symptoms can be determined by the degree of irregularity and the constancy of the irregularity of the graph, then the instrument could have clinical value."[29]

Physiotherapists Trott *et al.*[37] set out to determine the validity of the Neurocalometer in terms "of diagnosis of spinal pain syndromes." A Nervoscope was obtained, and areas of 'break' were compared with 'objective physical signs' and carefully determined 'areas of pain'. The conclusions were that the Neurocalometer (in fact, a Nervoscope was used) is not of practical value in the diagnosis of intervertebral joint injury; that the "method of physical examination" is better; and that the instrument costs too much ($225.00 in 1972)! The 'physical examination method' of the Trott *et al.* study is not outlined in the article. As to the finding that the instruments cost too much, it is probably fortunate that these researchers were not around in 1924. Yet, the study's finding tends to support the understanding of NCM workers from the 1930s that the break cannot be taken to be the location of vertebral subluxation.

The Palmer College study of 1974[6] and the Texas College study of 1982[53] are similar in that they both attempt to correlate various instruments and methods used in chiropractic. Whereas both studies have applied scientific and statistical methods, the number and type of variables measured intrude into the entire procedure. Indeed, of the Texas college's trial, Addington suggests that "the study should be repeated using a much more limited set of evaluative measures."[53]

Palmer College's 1976 study[33] was concerned with reliability and concurrent validity of the various body surface temperature measuring instruments. A high correlation was exhibited. Workers at the New York Chiropractic College[54] noted that the Palmer study was performed under static conditions (those conditions under which detection and measurement instruments are not moved by the practitioner with respect to the patient while measurements are underway) and suggested there was a pressing need for the study of dynamic thermography in which infrared measurements are made while the instrument is moving with respect to the patient.

The New York study's meticulous experimental design showed the dermathermograph-type instrument to have high reliability. Its authors, Spector *et al.*, also explored whether the reliable methods developed for dynamic thermography should be integrated into a system of non-invasive methodologies, including Moire contourography, electromyography and video postural and topographical biofeedback in combination with plumb line and horizontal references. Such a system appears to have considerable potential, especially with the application of computer capabilities which might be linked to this method.

CONCLUSION

- The chiropractic profession has used and developed thermal instruments in assessing paraspinal heat as an aid to identify and monitor spinal subluxation for over 65 years.
- Thermal instruments in current use in chiropractic practice involve thermocouple, thermistor and infrared sensing technology.
- Thermal instrument users agree that there is a correlation between paraspinal skin temperatures and abnormal spinal articular relationship, but not necessarily at the same level.
- A recurrent theme in thermal instrument interpretation is the notion that apparently abnormal paraspinal temperatures, suggesting classical chiropractic subluxation of neurological insult and spinal dysfunction, is independent of symptoms.
- Clinical studies suggest that the concept of spinal neuropathy is the first evidence of developing pathology in the chiropractic subluxation complex.

- Fundamental research studies into the full nature of paraspinal temperature and the nervous system are needed.
- Further controlled clinical research into the relationship of paraspinal heat and spinal biomechanical relationship and dysfunction is also needed.

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Book Review

Reagan's America: Innocents at Home. Gary Willis. Heinemann, 1987. ISBN 0434 866237. 480 pages. RRP $39.95.

Admonished as a lad to read at least three "other" books to each "special interest" book, this rule of thumb continues to enrich adult life — for it broadens the mind, sharpens the wit, and is a constant source of hidden, unexpected gems to be mined. One such gem is Gary Willis' mini-pen portrait of B.J. Palmer, the entrepreneur, in his book, *Reagan's America: Innocents at Home.*

Gary Willis is the Henry R. Luce Professor of American Culture and Public Policy at Northwestern University on Chicago's north shore. His book on Reagan is his sixth on American Presidents. It traces Reagan's early Huckleberry Finn years in the Midwest, through radio to film, politics and the country's highest office.

Neither "Dutch" Reagan nor B.J. could possibly have foreseen that the sportscaster employed by B.J. at WOC in Davenport, Iowa — reputedly the first radio station west of the Mississipi — would, half a century later, occupy Washington's White House as President of the United States.

This reviewer first knew B.J. as a six-year-old youngster and later as one of his students. Wills' pen portrait of B.J. the entrepreneur, in Chapter II (Davenport), is one of the best he has read. Noting that B.J.'s business enterprises were all designed to support the Palmer School of Chiropractic, Wills writes, "few pennies dropped through the cracks of a Palmer enterprise."

Radio station WOC — initials for "Wonders of Chiropractic" (Wills reports "World of Chiropractic") — was a pioneer in US radio. It was ten years old when Reagan arrived in 1932 to work as a sportscaster, and was among the first radio stations to relay broadcasts from New York. Radio was one of the few growth industries through the depression, and Reagan's family money earned through that period came from the B.J. empire, Wills notes. Reagan had a free ticket for all his meals at the Palmer School Cafeteria in Davenport, a town described by Mark Twain as the "beautiful city crowning a hill" which "stretched itself rearwards up a gentle incline." It was the first large city in which Reagan had lived other than Chicago, where he lived as an infant.

Quoting Ambassador Jeane Kirkpatrick, Wills notes the indelible character-moulding influence the Midwest had on Ronald Reagan, his brothers and family. But he worked only three months in Davenport, then went to Des Moines to continue in radio at WHO, which B.J. developed in his network. Here, for the first time, Reagan "had a considerable degree of independence, money and fame." He worked for a man "with a genius for promotion," writes Wills. Yet curiously this period was omitted from Reagan's own memoirs. B.J. Palmer was "the most unforgettable character he (Reagan) would ever forget."

Reagan's America incorporates an early photograph of B.J. Palmer, the Palmer residence on Brady Street and "A Little Bit o' Heaven." The book is well referenced and worth reading for more than its gem on B.J. the entrepreneur and references to chiropractic.

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THE UTILITY OF INFRA-RED THERMOGRAPHY IN CLINICAL PRACTICE

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ABSTRACT

Infrared Thermography has been well documented in the scientific literature as a useful tool for clinical practice. The diagnostic information obtained is useful not only for differential diagnosis but for treatment assesement as well. Infrared Thermography has been demonstrated to be useful in lumbar radiculopathy, sports injuries, myofacial pain syndromes, Reflex Sympathetic Dysfunction, disc disease, entrapment neuropathies, TMJ syndromes, vascular conditions and Thoracic Outlet Syndromes. This literature review presents an overview on the diagnostic utility of Infrared Thermography for the practicing chiropractor.

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INTRODUCTION

Infrared thermography (IRT) is a diagnostic imaging tool that is capable of recording cutaneous temperature via infrared emission. Cutaneous infrared emission is regulated by the sympathetic nervous system and chemical mediators. Infrared heat emission from the body has been shown to be symmetrical from right to left homologous parts within a few tenths of one degree C. Uematsu and Edwin published normative data from a study of 90 healthy subjects over a five-year period; see Table 1[1] At two and five-year follow up, the small inside temperature differences were found to be reproducible and statistically significant. Similar studies were done by Goodman and by Yuen et al., and in the cervical spine/upper extremity regions by Feldman and Nickoloff.[2,3,4] When temperature differentials (delta T) from right to left sides exceed published normals, one may assume patho-neurophysiology. However, current diagnostic standards generally require a 1.0°C temperature differential from right to left sides.[5,6]

Chiropractors treat a wide variety of conditions, most of which are neuromusculoskeletal. Many of these conditions can cause local and referred pain. Vertebral subluxations, facet joint dysfunction, myofacial trigger points, sports injuries, and disc protrusions can all cause pain local to the area of involvement as well as referred pain in the extremities. Myotomes, scleratomes, and dermatomes are all part of the embryological somite. As such they share segmental innervation and can refer pain via common neural networks. Kellgren injected hypertonic saline into various scleratogenous structures and interspinous ligaments and recorded their pain referral zones. He found very specific and segmental patterns. Kellgren also injected hypertonic saline into different muscle groups and recorded their pain referral zones.[7] Mooney and Robertson studied facet syndrome by injecting hypertonic saline into facet joints and recording their referral zones.[8] Travell and Simons have published much work on the local and referred pain zones of myofascial trigger points. Most recently, Jinkins et al. mapped out autonomous " head zones" of pain referral in patients with lumbar disc extrusions and herniations; see Figure 1. All of these researchers were able to document that these different structures will cause local and referred pain, and there is much overlap on many of these maps.

It is now apparent that thermography is a tool that can readily image these vicarious local and referred pain zones. The common mechanism is autonomic somatosympathetic reflex pathways with an afferent sympathetic limb. The thermal response to injury or trauma can be either hypothermia or hyperthermia. Hobbins has stated that hypothermia can be due to increased postganglionic sympathetic fiber function or hypersensitization alpha receptor activity of the dermal receptors. Hyperthermia is due to increased postganglionic sympathetic fiber function and decreased sensitivity of the alpha receptors.[11]

Infrared thermography has been most noted for the detection of "nerve fiber irritation" in dermatomal patterns, following specific dermatome maps. However, research in the chiropractic and medical fields indicated that the thermography may not be recording sensory dermatomes. A recent study by Yuen et al, comparing IRT to EMG concluded that thermography does not have the "site specificity" that EMG seems to have. The apparent reason for this is that EMG records "motor nerve" activity while IRT records and measures autonomic activity.[1]

In a research clinical study performed by this author and presented at the Foundation for Chiropractic Education and Research International Conference on Spinal Manipulation, IRT findings for 66 patients with disc protrusions were compared.[1], The study found that 81% of the patients with single-level disc protrusions (without root compression) did not reveal an "51 dermatomal fields. The study concluded that thermography measures "autonomous" zones much like Jinkins had proposed. We proposed to call these findings "autonomes" or an "autonomal pattern." The area of thermal findings had been previously labeled by Leroy et al., as a "Thermatome." However, since the areas of the thermal asymmetry and observation are usually clinical and symptomatic, autonome may better describe these findings in an imaging and clinical setting.

DISC DISEASE:

Thermography has been shown by numerous investigators to be a valuable patient-management and diagnostic tool for cervical and lumbar disc protrusions.[14,5,6,7] Chafetz et al., documented 10% sensitivity in a correlation study of CT and IRT for patients with lumbar disc herniations.[18] Recently neurosurgeons at several hospitals have begun to utilize IRT during lumbar discectomy procedures. 19 IRT was used to document pre- and postdiscectomy changes at the plantar feet. When the plantar feet returned to thermal symmetry, the surgeon "closed" the patient and terminated the operation. IRT was also shown to be useful in a clinical study of 23 patients with MRI-documented lumbar disc protrusions. IRT scans were done pre- and post- chiropractic treatment. Chiropractic treatment was shown to be highly effective in reversing thermal asymmetries of the extremities as well as in reducing clinical symptoms; see Figure 2.[20] Another interesting observation is that clinical, symptomatic improvement usually preceded total return to thermal symmetry and autonomic neurophysiology.

IRT was also shown to be a useful tool for the diagnosis and management of cervical disc herniations. In a study done by this author and Silber, IRT was shown to have 84% sensitivity and 78% positive predictive value for cervical disc protrusions.[21]

The most common thermal observation seen is hyperthermia at the spine and hypothermia at the extremities; see Figure 3.

COMMON ENTRAPMENTS:

Carpal Tunnel Syndrome is an entrapment and injury of the median nerve at the wrist's carpal tunnel. The observed thermal findings may be present as hypothermia or hyperthermia, with hypothermia as the common finding in a long-standing condition and hyperthermia in acute cases.[22] Either way the median nerve distribution is usually affected on the palmer surface of the hand without any dermatomal patterns above the wrist. Thermography shows high correlation with electrodiagnostic studies in carpal tunnel syndrome.[23,24]

A study was done on 90 patients with a follow-up of 24 months. The thermal pattern showed hypothermia over the median nerve distribution for patients with carpal tunnel syndrome. Thermography was shown to have 80% specificity and 96% sensitivity for carpal tunnel syndrome.[25]

Meralgia Parasthetica is an entrapment of the lateral femoral cutaneous nerve. This peripheral nerve supplies the anterolateral thigh. The patient usually will display a thermal change along the distribution of this nerve, Electromyography and nerve conduction velocity studies cannot detect this problem at all. Thermography is highly sensitive for this diagnosis and is probably the test of choice. In a study by Gateless et al., thermography was sensitive for meralgia parasthetica in 10 out of 11 patients.[26] Other entrapments that can be imaged thermographically but are less common in clinical practice include common peroneal nerve, superficial peroneal nerve, tarsal tunnel syndrome, sural nerve, and superficial radial nerve (Saturday night palsy).

MYOFASCIAL PAIN SYNDROME:

Thermography is very useful in the diagnosis and documentation of myofascial pain syndrome and trigger points.[21,28] When trigger points are suspected by clinical and physical examination, they can be objectively imaged and assessed using thermography. Trigger point and referral zones show up as focal areas of hyperthermia, round and avoid in shape. They are commonly seen in the following muscle groups: trapezius, SCM, levator scapulae, rhomboids, infraspinatus, lattisimus dorsi, subclavius, multifidi, serratus posterior superior and inferior, gluteus medius and minimus, piriforms, temporal is, and masseter muscles. Trigger points have referred pain zones that can refer pain or tingling into the extremity. These referred pain zones appear to be thermographically active and are hypothermic in nature. Thermography will therefore aid the physical exam in differentiating radiculopathy versus myofascial pain zones by the presence or absence of an autonomal pattern. The doctor can also assess the patient's treatment response by rescanning to see if the trigger points are now inactive.

It has been postulated by Hobbins that the focal areas of hyperthermia seen over the trigger points are not the actual trigger points but a somatocutaneous referral zone.[29] It is believed that the zone in Travell's myofascial book (The Trigger Point Manual) and not the "X" which is isothermic.

It has been shown that muscle and joint nociceptors are small unmyelinated nerve fibers. It has been shown by Travell, Kellgren, and others that muscle nociceptors will refer pain via somatocutaneous reflex to cutaneous areas. Fisher and Chang placed thermistors into the trigger points to determine absolute temperature; they found the muscle to be colder than the skin, see Figure 4.[27]

TEMPOROMANDIBULAR JOINT SYNDROME (TMJ):

TMJ syndrome can be a source of great discomfort and pain for the patient. This disorder can be imaged thermographically and diagnosed in conjunction with physical examination.[30,31,32,33] The patient will typically complain of facial pain, headache, jaw pain, joint pains, auditory disturbances without ear pathology, neck pain, interscapular pain, and back pain. The thermography exam will typically disclose:

1. Hyperthermia of the TM joint
2. Hyperthermia of temporalis muscle
3. Hypothermia in the region of the cheek with trigger points at the angle of the mandible

In 1987 Weinstein and Weinstein published a protocol forthermographic evaluation of TMJ disorders.[31] They proposed a series of 27 color views including standard front, right lateral, and left lateral face, with an additional several views for trigger-point study. The trigger points must be 1°C above the surrounding temperature, 5-10mm in size, and unaffected by alcohol spray the trigger-point hyperthermia will reemerge within three minutes. The protocol also suggests that the facial TMJ study be done with the thermal range set at 0.5°C per color bar due to increased facial vascularity. The study should be done in triplicate at 15-minute intervals. Diagnosis now requires a 0.5°C delta T (two-color change) from the clinical area of suspicion to the normal asymptomatic side.[32] The following is the suggested TMJ protocol, with published normative values for the facial region given in Table 2:

1. First facial series; front right lateral and left lateral face
2. Anterior cervical series
3. Second facial series

4. Posterior cervical trigger-point study
5. Third facial series
6. Interscapular trigger-point study

Chapman has found that primary TMJ will show focal hyperthermia over or near the involved TMJ joint and secondary TMJ will show myofascial hyperthermia over the temporalis, pterygoids, or masseter areas in the contralateral side of primary TMJ due to compensatory kinetics and myofascial irritation. [33]

CEPHALGIA

Migraine Headaches are vascular phenomena of altered vasoconstriction and vasodilation of the cerebral arteries that are usually hemicranial in nature. Many studies have shown that there will be a "cold patch" as a marker for this type of vascular headache.[24,35,28,27,38]

In a study by Swerdlow and Dieter, not only did vascular headaches display a thermographic "cold patch" on the facial thermogram, but 82% displayed permanent cold patches, suggesting possible genetic influence.[25] There appears to be a vascular instability associated with headache physiology. A good study and future research project would be to measure the ability of chiropractic adjustments to reduce this permanent "cold patch." Since spinal manipulative therapy in the cervical spine has input into the cervical sympathetic associated with the vertebral artery, it is plausible that thermography can help document the efficacy of chiropractic in headache patients.

Cluster Headaches will display hypothermia over the supraorbital region (sometimes seen in a "Chai sign," which is a hypothermia pattern over the face and frontal region which appears like the Hebrew symbol "Chai").[34,30] Kudrow found that 67%-75% of cluster patients had an ipsilateral decreased supraorbital temperature and that only 25% (32/130) had an observable Chai sign.[39] A Chai sign was a contralateral hypothermia. Kudrow also found that the Chai sign was 88% specific for cluster headaches.

A study was done by Drummond and Lance on 11 patients with spontaneous cluster headaches and 22 patients with cluster headaches induced headaches by nitroglycerin or alcohol. There was observable increased heat loss from the affected orbital region. In some patients the increased heat loss or hypothermia spread above and below the eye and to the nose. Drummond and Lance postulated that the vascular changes seen thermographically were secondary to vasodilator pathway of the trigeminal nerve (afferent) and greater petrosal nerve (efferent limb); see Figure 4

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FACET SYNDROME/SUBLUXATION:

Generally, facet irritation, subluxations, and biomechanical improprieties will appear as a focal hyperthermic area either over the spinous process or the transverse process of the level involved.[34,47] Wexler did much work in the area of lumbar facet irritations and the patterns they display on the isotherm function available on electronic infra-red equipment. Specific patterns are seen for involved levels, and L4/5 and L5/S1 facet patterns have been documented.[42]

Vertebral subluxations were also studied for their thermographic appearance. Thermographic imaging displays areas of focal hyperthermia either over the spinous process or the transverse process paraspinally of the involved level. A pilot study comparing the dynamics of lateral flexion lumbar bending studies on x-ray to thermographic findings has shown a correlation of pathomechanics to pathoneurophysiology.[43] More research is needed to this area.

Research has shown that the unmyelinated fibers found in joint nociceptors do cause a somatocutaneous referral pain, and referral areas have been mapped out.[22,44,45,40,47] Nociception appears to be processed spinally and preganglionic fibers cause sympathetic efferents to cause somatocutaneous hyperthermia. Mooney and Robertson injected hypertonic saline into the lumbosacral facet joints at L3/L4, L4/L5, L5/S1 and mapped out the somatocutaneous referral zones.[44] Kellgren injected hypertonic saline into the interspinous ligaments of the spine and also mapped out the somatocutaneous referral zones.[47] Somatocutaneous reflexes and referral zones much like myofascial referral zones are hyperthermic. McFadden published a paper describing 15 case reports of patients with lumbar facet syndrome. Increased vascular heat emission patterns were seen spinally and para-spinally. Thermography was described as a viable tool to assess facet syndrome.[41]

McCall et al. injected saline into lumbar facet joints (periscapular and intrafacet).[49] Specific pain referral maps were etched out. This represents a somatocutaneous referral system and confirms the work of Kellgren documenting scleratomal patterns.

Scleratogenous pain refers to pain originating from structures such as bone, facet joints, ligaments, etc. Scleratomal patterns will be seen as hyperthermic due to somatocutaneous reflex pathway.

Leroy et al. found that in facet syndrome there is an area of increased thermal emission of 1^{o}-$2^{o}C$ in a circular pattern either unilaterally or bilaterally at the level involved.[50] With a facet block at L4/L5, referred thermographic changes will occur corresponding to the L4 dermatome at the medial gastocnemius. This would be considered a scleratomal referral pattern due to somatosympathetic or somatocutaneous referral. Scleratomal pain charts and maps have been published in books and in the literature, an example is given in Figure 6.

REFLEX SYMPATHETIC DYSFUNCTION/CAUSALGIA:

Reflex sympathetic dysfunction (RSD) is a complex, multisymptom condition that will usually affect the extremities. It is generally poorly understood and often misdiagnosed. RSD affects various tissues: nerve, skin, muscle, blood vessels, and bone. The patient will symptomatically complain of:

1. Pain that is severe, burning, and constant
2. Swelling
3. Decreased range of motion with motor dysfunction
4. Muscle spasms
5. Trophic skin changes with dryness and nail changes
6. Vasomotor instability (Raynaud's hyperhydrosis)
7. Bony change (osteoporosis, Sudeck's atrophy)
8. Joint tenderness and pain

There are typically three stages:

Stage 1. 1-3 months in duration. Patient complains of chronic pain or burning sensation with hyperesthesia, local, edema, stiffness, myospasm, limited range of motion, and vasospasm This stage has also been labeled "sympathetic maintained pain syndrome" due to sympathetic efferent hyperactivity.

Stage 2. Lasts 3-6 months. Advancing pain and edema, nail changes, osteoporosis, muscle atrophy.

Stage 3. Marked trophic changes, intractable pain, muscle atrophy, weak joints, Sudeck's atrophy

The etiology of RSD may be trauma, ischemic heart disease or myocardial infarction, cervical spine disorders, cerebral lesions, infections, or surgery. The underlying pathophysiology is due to an initial trauma resulting in chronic irritation of a peripheral sensory nerve. This produces an increased numbness of afferent impulses to the spinal cord. A sympathetic reflex will occur, causing vasoconstriction of the small vessels, and for reasons unknown the sympathetic reflex arc does not shut down and chronic sympathetic hypertonia results.

Thermography is well suited to early diagnosis of this most disabling condition, since thermography has such high sensitivity to sensory nerve damage. Thermography has been shown to have 88% accuracy for RSD.

The thermal findings usually seen will be a diffuse hypothermia not following any pattern and usually affecting many surfaces of the extremity with a delta T greater than 2°C. In one study, two-thirds of the cases showed diffuse hypothermia while one-third showed hyperthermia.

It must be understood that the first stage of RSD is a stage of sympathetic hyper-reflexia. During this stage the body is employing a defense mechanism by causing vasoconstriction, but the mechanism does not shut off. This stage has been labeled "sympathetic maintained pain. ,[47,31,33,34] It is characterized by vasomotor changes, hyperpathia and allodynia. It is this stage that conservative treatment has the best chance of stopping the progression to stage two and finally end-stage three. Medical treatment generally consists of sympathetic block, drug therapy, and in end-stage cases sympathectomies.[55] Conservative care when RSD is recognized early may include physiotherapy, TENS, exercise, and biofeedback.[52,55,56,57] Recently Pavot et al., presented a paper on RSD and acupuncture at the proceedings of the 18th meeting of the American Academy of Thermology. They found that acupuncture with electrical stimulation caused decreased pain and post-treatment thermal changes in RSD cases.[58]

A challenge test should be performed when thermography suggests RSD. This test has been called the Cold Stress test (CST) or Autonomic Challenge.[54,52] The test consists of putting the hands or feet in cold water (usually 10°C) for about one minute and monitoring the sympathetic response. Typically in RSD, either no change or a wider delta T will result. This is due to sympathetic vasoconstrictive loop.

THORACIC OUTLET SYNDROME:

Thoracic outlet syndrome (TOS) represents a nerovascular compression syndrome due to etiologies such as cervical rib, scalenus anticus hypertrophy, and pectoralis minor tendon hypertrophy. Components of the lower and middle brachial plexus can be effected. Multiple studies have shown thermography to be sensitive for the diagnosis of TOS. A study by Pavot and Ignacio found 100% correlation of EMG to thermography in cases of TOS.[60] The thermal findings included a decrease in temperature of 1° - 2°C in the affected extremity, usually the forearm or hand. Seventy percent of the patients displayed C7 nerve fiber irritation (depending on whether the lower or middle plexus was affected). Thermography was also found to be useful in cases of traumatic thoracic outlet syndrome.

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SPORTS INJURIES

Infra-red thermography is a valuable tool for the diagnosis and clinical management of sports injuries.[62] IRT scans show typical patterns for certain conditions and can be very useful. Lateral epicondylitis will typically display focal hyperthermia at the lateral epicondyle. Osgood Schlatters disease will reveal focal hyperthermia at the tibial tubercle. Patellofemoral syndrome (PFS) and chondromalacia most typically show a global hypothermia over the anterior knee and patella. In a study presented at the American College of Sports Medicine by this author, 30 patients with signs and symptoms of PFS showed a statistically significant finding of hypothermia over the patella, see Figure 7 [63] IRT was shown to have 85% sensitivity and 90% specificity. Shin splints and stress fractures image as hyperthermia. Shoulder impingements image a hyperthermia at the shoulder. Bicipital tendinitis and overuse injuries in general will appear as hyperthermia.

These are all expected findings. However, IRT's largest contribution to sports injuries is in the area of an unexpected RSD. Sometimes, for reasons poorly understood, there will be a reflex sympathetic dysfunction (RSD) or sympathetic maintained pain syndrome following a trauma. This will appear as a diffuse regional hyperthermia on the order of 2 to 4 degrees C cooler than the normal side. For example, in a patient who sprained an ankle, one would expect hyperthermia at first due to inflammation, but for reasons unknown a global hypothermia will sometimes occur. This finding carries with it a poor prognosis and usually indicates a longer recovery period than usual due to sympathetic hyperactivity; see Figure 8.

Thermography and Patient Management

Since thermography is a picture of real-time neurophysiology, it is an appropriate and useful test to assist in the clinical decision-making process. The test can be performed after the initial study to test for patient response to treatment. This will help the treating doctor to make clinical decisions such as whether the patient may return to work, should the patient change occupations, whether the injury is permanent, or whether a different mode of treatment is necessary. Using thermography the doctor can follow the patient's progress through a treatment plan. If the thermography exam discloses multiple nerve root level involvement of a dermatomal pattern in the extremities, this may indicate clinical problems such as disc protrusion. The doctor may then order a CAT scan or MRI to investigate the problem further. Reflex lymphatic dysfunction might be considered if multiple surfaces of the extremity are hypothermic with a change in temperature greater than 2 degrees C, and then proper treatment may be administered immediately.

Thermography is a vital tool for doctors of chiropractic in addition to the physical exam and X-ray studies because subluxations are not just static pathomechanical problems but pathoneurophysiological problems as well. Radiographic study can accurately depict static and dynamic pathomechanics, and thermography can accurately depict dynamic pathoneurophysiology from the vertebral subluxation and other neuromusculoskeltal disorders.

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TABLE I

THERMAL SYMMETRY OF THE SKIN[1]

Confidence factor:	50%	84%	84%	98%
Body Segment	x	+1SD	+1SD	+2SD
Forehead	0.12	0.093	0.22	0.30
Cheek	0.18	0.186	0.37	0.56
Chest	0.14	0.151	0.19	0.34
Abdomen	0.18	0.131	0.31	0.44
Cervical Spine	0.15	0.092	0.24	0.33
Thoracic Spine	0.15	0.092	0.24	0.33
Lumbar Spine	0.25	0.201	0.45	0.65
Thigh-Anterior	0.11	0.085	0.20	0.29
Thigh-Posterior	0.15	0.116	0.27	0.39
Knee-Anterior	0.23	0.174	0.40	0.57
Knee-Posterior	0.12	0.101	0.22	0.32
Leg-Anterior	0.31	0.277	0.59	0.87
Leg-Posterior	0.13	0.108	0.24	0.35
Foot-Dorsum	0.30	0.201	0.50	0.70
Foot-Heel	0.20	0.220	0.42	0.64
Toes-Average	0.50	0.143	0.64	0.78
Trunk-Average	0.17	0.042	0.21	0.25
Extremities-Average	0.20	0.073	0.27	0.34

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ADVANCES IN PARASPINAL THERMOGRAPHIC ANALYSIS

Harry Wallace, D.C., Joni Wallace, D.C. and Roy Resh, B.S.

ADVANCES IN PARASPINAL THERMOGRAPHIC ANALYSIS

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ABSTRACT

Basic theory and common practice in temperature-based chiropractic assessment procedures and instrumentation are reviewed. Segmental spinal thermoregulatory function is presented as a refining mechanism for hypothalamic core-temperature control. Spinal nerve-cell-body function is suggested as the primary mechanism responsible for the asymmetries and anomalies commonly observed in paraspinal and other thermograms. Paraspinal cutaneous thermal asymmetries and anomalies are shown to be suggestive of various pathophysiological alterations, and in particular, the vertebral subluxation complex (VSC). Scientific hypotheses and experimental data relevant to historical and present diagnostic paraspinal thermography are presented, along with a review of representative instrumentation. The potential impact on chiropractic of these postulations, and of newly available, high-precision, computerized spot-radiometry (spot infrared thermography) is examined.

KEY WORDS: Chiropractic, Thermography and Thermo-regulation.

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BACKGROUND

Paraspinal cutaneous thermal anomalies have long been held to be suggestive of vertebral subluxation. A review of analytical theories relating to thermography and its use in chiropractic indicated a need for a more complete understanding of the relationship between thermographic data and spinal health. In this study we completed an in-depth review of literature relating to cutaneous thermography, analyzed the basic theory of commonly used instrumentation and postulated new concepts relating to paraspinal thermoceptive neuronal sympathetic function.

Chiropractic — The Early Leader

Historically, temperature measurement has been the most common *objective* diagnostic modality in health practice. Thermal measurement devices range from simple mercury-in-glass thermometers for core temperature measurement to highly sophisticated thermographic imagers that provide a "picture" of variations in the heat radiated from the skin. In the 1920s, Chiropractors launched into thermography with the Neurocalometer developed by B. J. Palmer and Dossa Evans. This instrument incorporates dual thermocouple thermometers that are mounted two inches apart. Electrically, the thermocouples are differentially connected and their output drives a strip-chart recorder. When the dual thermocouple is moved along the paraspinal skin, the recorder trace represents a scan of differential temperatures.[1,2]

The early chiropractic investigators lacked the advantages of modern computerized equipment and rigorous analytical techniques. They did, however, pioneer in the development of these three physiological postulations upon which most clinical cutaneous thermography is based:

1. The human body is segmented into "dermatomes";
2. Side-to-side skin temperatures are generally symmetrical unless dysfunction exists;
3. Any anomalous deviation from a gradually increasing paraspinal skin temperature from S2 to C1 may suggest the vertebral subluxation complex (VSC) or remote dysfunction.[1-3]

There are far reaching health implications in these postulations because they suggest that paraspinal thermography should provide a "window" into the entire sympathetic nervous system.[4]

Theory and Practice in Thermo Graphic Assessment

Modern medical theories and clinical findings parallel many of the early thermographic concepts related to chiropractic assessment procedures. As thermal detectors are moved upward from S2 to C1, the NCM and several other chiropractic instruments produce strip chart recorder traces that represent variations in the temperature difference across the spine. Significant temperature anomalies, or "breaks," are said to be suggestive of a VSC.[1-3,5,6] Many investigators have also theorized that any consistent "pattern" in spinal temperature differentials also suggests a VSC. This is the "pattern of interference" theory which proposes that interference with neuronal function at the spinal level creates side-to-side paraspinal thermal anomalies that may persist until the eliciting VSC is corrected.[7] Some practitioners employ analogous single-trace thermography that provides a strip-chart record of the actual temperature along one side of the spine, usually from S2 to C1. Thermal anomalies in these single-measurement traces are also said to suggest the location of a VSC.[6] Recent thermographic developments also include low-resolution and high-resolution imaging systems and liquid crystal contact sheets. Such "imagers" display grey-scale or color "pictures" representing the thermal pattern of a large skin territory on a video monitor or a flexible sheet. Thermal anomalies in adjacent dermatomes are considered to be suggestive of sympathetic neuronal function. Information relating to sympathetic function in turn helps to localize the VSC and other dysfunctions.[5-8]

Medical science has long postulated that definable mechanisms within the sympathetic nervous system give rise to paraspinal cutaneous thermal anomalies. It is generally accepted that various internal and external mechanical, thermal and pain-inducing stimuli elicit sympathetic neuronal response. Thermoregulatory function, which is considered to be primarily sympathetic, is now thought to be centered in the hypothalamus and refined at each spinal-cord segment.[9]

This physiological theory, which can account for many normal and abnormal paraspinal skin temperature anomalies, tends to be validated by a wealth of anecdotal and experimental data.[10-24] Much of the relevant chiropractic literature emphasizes relief of nerve-pathway interference as the main health benefit from correction of a VSC. On the other hand, modern sympathetic physiological theory, supported by thermographic findings, tends to suggest that relief of noxious sympathetic neuronal function may have more significance. Although it was the early leader, the chiropractic community has waxed and waned in the use of thermographic aids in the assessment of physiology and a VSC. Much of the recent scientific thermographic literature is from the medical community, which seldom considers a VSC as a possible contributor to their findings. The information presented in many of the scientific articles reviewed by the authors, however, strongly support the concept that carefully developed thermographic findings tend to validate chiropractic adjustment as a vital health practice.

Face Validation by Various Practitioners

Thermography, as with many other analytical procedures, has been partially validated by a long history of successful use by experienced practitioners. Glen, Kevin and Brian Stillwagon (D.C.s) are among the most well known advocates of clinical thermography. They assert that chiropractic should concentrate more on correction of the root causes of the abnormal physiology that temperature findings can reveal, and less on anatomical and chemical dysfunction.[25,26] David BenEliyahu, D.C., states: "Thermography is a non-invasive, risk-free diagnostic procedure that images cutaneous infrared heat transmission."[27] "A Thermogram is essentially a 'heat map' of the dermal contour" according to Timothy Conwell, D.C. Wm. Hobbins, M.D., Director of Thermal Image Analysis, Inc., concludes: "Thermography will offer the practicing Chiropractor an excellent way to objectively document for diagnosis and for demonstration of treatment benefits."[29] Neurosurgeon Jose Ochoa writes: "the cutaneous territory affected by sensory symptoms exhibits matching (temperature) abnormality... (and is) indicative of sympathetic vasomotor unbalance."[30] He also states (with Bill Triplett): "At present, thermography is the most valuable test available for evaluating the autonomic nervous system."[31] Margaret Abernathy, MD, Editor of Thermology, views thermography as "A window on the sympathetic nervous system."[32]

THEORY AND PRACTICE IN THERMOGRAPHIC INSTRUMENTATION

Contacting Instruments (Thermocouple, Thermistor, etc.)

Both Dossa Evan's Neurocalometer (NCM) and the early Chirometer employed differentially connected thermocouple elements mounted two inches apart on a sensing head.[1] To examine a subject with these instruments, the sensing head is centered with moderate pressure on the spine at S2 and moved slowly to C1. If there is no side-to-side temperature difference, the voltage output remains zero. Similar operation is also described in literature for the non-recording "Nervo-Scope" and "Temp-o-scope."[5,33] Because these differential instruments don't display actual temperatures, no indication is provided showing which side of the paraspinal skin surface is hotter or colder than normal.[5]

Skin contacting instruments require good heat conduction between the epidermis and the thermal-sensing elements. Moving thermocouples can't "dwell" for several time constants at each point of interest, so thermal "lag" will occur. In addition, contacting instruments may create measurement error due to:

1. Inadequate heat exchange between the skin and the temperature detector;
2. Variations in glide speed;
3. Combined mechanoceptive and thermoceptive neuronal function which tends to rapidly alter skin temperature;
4. Non uniform pressure;
5. Inadequate "dwell" time;
6. Path-of-travel variations; and
7. Non uniform starting and ending points. Also, the temperature information from such instruments may be difficult to interpret or compare with the results of earlier examinations.[1,3,5,34]

Non-Contacting Instruments (Infrared Radiation)

Non-Contacting temperature instruments sense variations in the quantity of heat radiated from the surface of interest. All objects above absolute zero (-273° Celsius) exchange radiant heat with hotter or colder objects in the direct line-of-sight. The rate of heat exchange between two objects depends upon:

1. Their absolute temperature difference; and
2. Their individual thermal emissivity.

The "gold standard" heat emitter is a perfectly smooth dull-black body. This body has an emissivity of "1" because it absorbs all radiated heat.[34]

Electromagnetic waves are radiated at many frequencies. Microwave, heat and light frequencies overlap. Human thermoceptors and optical rods and cones combine to sense radiated heat and light energy ranging from 0.3 to nearly 100 microns(10^{-6} meters) in wavelengths. Visible-light (the higher frequencies) ranges between 0.38 microns for violet and 0.76 microns for deep red. Infrared radiation covers the remainder of the heat spectrum up to wavelengths of 100 microns. Heat radiated from human skin at 37°C (98.6° F) has a wavelength of approximately 9.3 microns, which is within the "near infrared" region of the electromagnetic spectrum. Normal, healthy human skin has an emissivity of approximately 0.97 +/- 0.01, which means that it is a good heat absorber or emitter.[3,34]

To avoid sensing light radiation, optical filters that limit sensitivity to the 8-12 micron range should be employed with thermal sensors for human skin. Some thermal detectors are held at a very-low, constant temperature by immersing the case in boiling liquid nitrogen or argon. This increases detector sensitivity and provides a known-temperature reference. Commercial non-contacting, vapor deposited infrared detectors:

1. Require no surface contact;
2. Respond rapidly to temperature changes; and
3. Use microscopic thermocouple junctions that facilitate "thermopile" construction to gain high thermal sensitivity.[3,35-37]

"Spot" infrared radiometric instruments are common in chiropractic. They measure the infrared electromagnetic energy emitted from a localized area or territory (often a flat, circular target). The field of view usually forms a cone in front of the detector. Unless all objects within the measured target territory have the same temperature, however, the quantity of heat detected will change with distance to the targets.[38-40] A spot radiometer that incorporates a focusing lens and collimating-barrel combination can limit the field of view to a small, almost constant-diameter target. A fresnel focusing lens may be used to direct most of the heat energy received to the relatively small heat detection surface inside the infrared detector.[3,41]

When a precision infrared detector is moved over the skin surface, the thermal data obtained can easily be converted into digital signals which in turn may be displayed on computer video monitors. If the detected field of view is limited, a representation of the thermal variations occurring along a narrow scan path can be graphically displayed as a color trace. Different color computerized overlay comparisons with previous scans of the same territory may be presented to review the thermal history of the skin surface.

Imaging Radiometry

Various highly-sophisticated thermographic instruments have been developed to image the variations in radiant heat emitted from large surfaces. In one type of commercial instrument, a single, liquid-nitrogen-cooled, infrared detector receives the heat reflected from a set of "raster-scanning" mirrors or prisms.[38,39] These rotating mirrors have an effect similar to a focusing lens/collimating barrel combination. A small, focused detection "spot" scans horizontally and vertically across the target surface, receiving infrared radiation. The radiated energy is converted into temperature data which is stored, processed and displayed by a computer which presents it in the form of contoured thermal "images" of various colors. Each 1° C increment (sometimes less) of temperature is displayed as a different color or shade, resulting in a contoured image on a video monitor which represents a thermal "map" of the surface being scanned.

Various thermographic instruments operating on these principles are used in chiropractic and medicine for diagnostic and outcome evaluations. The most expensive present colorgraphic or grey-scale high-resolution or low resolution images while others offer colored thermal traces which may be overlaid to assess progress.[38-55]

The Neurocalometer provided an essentially infinite temperature resolution. If a compromise of 0.3°C thermographic resolution is assumed to be suitable for precision chiropractic paraspinal analysis, however, at least 15 colors are needed to present a typical fullback image. This large number of colors may make interpretation of thermal anomalies quite difficult. Grey-scale data presentations offer increased resolution, but still require precision imagers and well trained interpreters. Conversely, computer-assisted "spot" radiometry can produce thermal traces and images of relatively-high (0.05° C) resolution, making them more straightforward to interpret.

Thermographic Radiometric Instrumentation

Two types of non-contacting computerized infrared instruments which illustrate variations in non-contact thermographic technology are:

1. Multi-channel low-resolution spot radiometers with 12 infrared detectors mounted at 1-inch increments on a horizontal frame (VISI-THERM II)[42]; and
2. Cryogenic-cooled-detector thermal-imaging cameras (inframetrics, Agema, Mikron, etc.)[43-49]

Other non-contacting thermographic instruments include the Derma Thermograph,[6,50] Pyroelectric Videcons[51] and Charge-Coupled Devices. (Liquid-Crystal and NCM-type thermographic instruments are also available, but these are contacting devices which may create artifacts by eliciting sympathetic dermal vasomotor function.)[52-54] Many of the thermographic instruments referenced here were recently reviewed in Chiropractic Products.[55]

THERMOREGULATION AND THERMOGRAPHY

The Physiology of Thermoregulation

Thermography images the status of dermal thermoregulatory function. Regulation of core temperature for body-heat maintenance is believed to be primarily a hypothalamic function. Local thermoregulation within each spinal dermatome is held to be modulated by spinal neuronal function.[9] Present theory assumes that temperature anomalies in the paraspinal skin surface arise principally from variations in segmental (local) thermoregulation. Dermatomal anomalies are therefore hypothesized to arise from lesion or other non-uniform conditions within the involved body segment. As illustrated in Figure 1, hypothalamic "background" thermoregulation establishes the "set point" for body core-temperature (typically 37° C). The hypothalamic temperature "set point" tends to remain very constant for each individual, normally varying only slightly and slowly in daily and seasonal rhythms.[56,57] In response to pathophysiological alteration, however, this body-temperature "set point" may vary instantly and significantly. An example is fever, which may be produced almost instantly in response to an infectious insult.[58]

Hypothalamic/Spinal Thermoregulatory Relationships

Thermogenesis, which is mainly visceral, is known to be regulated by sympathetic spinal neuronal function under the influence of hypothalamic thermoregulation. Normally, core temperature is held essentially constant by the modulating function of sympathetic spinal nerve-cell bodies located between T2 and L2. Heat generated as the blood flows through the heart, liver and kidneys provides the major contribution to core heat. Regulation of skin surface radiation is the main controlling mechanism for preservation or dispersion of this core- heat. Spinal nerve-cell bodies control core temperature by regulating the dilation or constriction of the arterioles and capillaries within the innervated dermatome.[3,56-58]

The setpoint of hypothalamic "background" temperature can be inferred from oral, rectal or tympanic thermometry. This set point, however, is refined at each spinal segment by thermoregulative "C" sympathetic nerve cell bodies. Local, seg-mental thermoregulation by spinal cell bodies was shown to function even in the absence of hypothalamic input in decerebrate rabbits.[60] Spinal nerve-cell bodies respond to thermoceptive, nociceptive and mechanoceptive afferents within their respective (and sometimes adjacent) dermatomes. During segmental nociception, this spinal modulation increases local skin temperatures, sometimes by as much as 5°C above the temperature of adjacent dermatomes. These thermoregulatory phenomena were validated by a number of investigators who studied animal and human neuronal function during the 60s and 70s.[60-67] In cases of reflex sympathetic dystrophy and similar dysfunction, segmental thermoregulation modulates local skin to below the core temperature. In rare cases, skin temperatures have even appeared to be below normal room temperature without sweating effects.[68-70]

Typically, in each dermatomal segment, efferent axons extend from the thermoregulatory spinal-cord "C" cell bodies to the paraspinal ganglions. At the ganglions, these neurons synapse with post-ganglionic thermoregulative efferents, some of which terminate cutaneously. Cutaneous thermoregulatory function may occur in sympathy with noxious inputs from the same dermatomal segment (such as might be elicited by the VSC). Cutaneous sympathetic thermoregulatory neuronal function regulates vasomotor activity within the dermal arterioles and capillaries. Vasodilation tends to increase skin temperature, resulting in a greater heat transfer rate to the surrounding environment. Conversely, vasoconstriction causes the skin to approach ambient temperature, tending to conserve core heat.[58]

Simplified Pkysiology of Thermographic Findings

Segmental thermoceptive spinal nerve cell body function was found to almost instantaneously modify the local temperature set point after a pathophysiological alteration such as a spinal insult or adjustment. The result is rapid skin-temperature changes within the involved segment(s).[9,58] Both thermoceptive and nociceptive responses may be referred by sympathetic fiber function to uninvolved dermatomal sites. Whether or not pain is involved, vasodilation within the dermal papillary beds is a common result, tending to create "hot" thermographic findings within the involved half of the dermatome. If there is no correction of the lesion, vasodilation often gradually decreases. After a period of months, vasoconstriction may begin and the dermis in the involved half-segment tends toward ambient temperature, resulting in significant "cold" thermographic findings.[71] Cutaneous skin-temperature anomalies over dermatomal trigger points were found to be generally unrelated to local deep-tissue lesion.[72,73]

Viscera, muscle, ligament, joint, synovia, even nerve-tissue organs all have sympathetic "somatocutaneous" zones which may change thermally during nociception. The immediate thermographic result is usually "hot", and may occur simultaneously in several cutaneous territories. If the lesion persists over a long period without correction, such as is common with a VSC, "cold" thermographic findings may eventually result. Although the presence of multiple anomalies in thermographic findings suggests pathophysiological alteration, the practitioner's responsibility is to isolate lesion location and severity. Clinical thermography is based primarily upon four related hypotheses:

1. Skin-temperature regulation is segmental at the spinal dermatome level;
2. Spinal cell bodies modulate hypothalamic thermoregulation;
3. Remote lesion (including a VSC) generally creates asymmetrical sympathetic paraspinal skin temperature variations; and of special interest to chiropractic,
4. Significant temperature deviations from right-left symmetry or a uniform increase from sacrum to atlas suggest abnormal conditions.[30,58]

It is assumed that in properly stabilized subjects, abnormal thermographic findings result primarily from variations in alpha-receptor regulation of skin papillary bed circulation. Lacking neurochemical involvement, these alpha receptors are responding to post-ganglionic fiber function under the direct influence of pre-ganglionic spinal nerve-cell-fibers in the involved dermatome. In essence, thermographic clinical analysis measures the physiological status of post-ganglionic fibers and their alpha-receptors. Under these assumptions, cutaneous temperature responses typically denote:

1. Thermographically "Hot"
   a. Decreased sympathetic-fiber function
   b. Neurochemical alpha-receptor blockade
2. Thermographically "Cold"
   a. Increased sympathetic-fiber function
   b. Increased alpha-receptor sensitivity[9,58]

Functional Illustration

In the simplified illustration of figure 2, a thoracic VSC elicits nociceptive neuronal function that passes through the ganglion to the dorsal and ventral horns at the spinal cord. The elicited autonomic spinal-cord nerve cell function vasodilates skin capillaries. This vasomotor function results in a localized temperature increase, primarily within the involved right half of the dermatome. (Internuncial neuronal function at the spinal cord may result in similar but lower temperature increases within the left half of the elicited dermatome.) The higher blood-flow rate in right half cutaneous territories typically results in increased radiant heat emission from the paraspinal surface. The side-to-side skin temperature differences become the thermal asymmetry that differential thermographic scanning systems detect and display. In addition, local paraspinal skin temperatures (especially at trigger points) within the involved segment will usually be higher than in the adjacent dermatomes. The result is vertical thermal anomalies that may be revealed either by a single-detector paraspinal scanner or by dual-detector and wide-area scanners that present absolute-temperature displays.

EXPERIMENTAL VERIFICATIONS

Physiological Findings

Innervation by sympathetic fiber within the intervertebral discs is a fairly recent discovery. This discovery, however, gives the essential support needed to justify paraspinal thermographic assessment of a VSC. Because intervertebral discs are innervated, they are able to elicit sympathetic nerve function which in turn creates paraspinal thermal anomalies.[74-76] Malik Slosberg concluded that therapeutic manipulation had a definite effect upon spinal afferent inputs. Obviously, thermoceptive function elicited by a non-VSC lesion or other stressors may also produce paraspinal thermal anomalies. Although paraspinal thermal anomalies may be suggestive of various nociceptive conditions within the involved dermatome(s), these anomalies may often be suggestive of a VSC.[77]

Generalized Thermographic Findings

The experimental evaluations of both symptomatic and asymptomatic patients by Sumio Uematsu and others gives excellent support to the assumptions outlined previously.[78-83] Well designed thermographic investigations by John Jinkins helped to isolate lumbar disc extrusion.[84-85] Infrared mapping of the cerebral cortex confirmed that thermal anomalies suggest dysfunction.[86] Thermographic analyses of breasts, extremities, forehead to back thermal ratio, etc., produced similar results.[87-89] Many investigators performed experimental evaluations to quantify typical cutaneous thermal responses to internal and external challenges. In one study, nearly 40 minutes were required for the skin to return to normal temperature after severe hot and cold challenges on the lumbar-thoracic paraspinal skin and posterior thigh.[90] When a hand was immersed in cold water, the skin temperature of the ipsilateral foot invariably dropped in temperature.[91] Stimulation of spinalthalamic tract neurons in monkeys revealed various dermatomal sympathetic responses, further indicating that spinal nerve-cell fiber function refines hypothalamic function.[92]

Through experimental evaluation, investigators were able to establish a thermodynamic model for the skin. This model implies that thermoregulation is very dynamic, even under normal conditions. In nude subjects experiencing the moderate cold-temperature stress of room temperature (70-73° F), skin temperatures began to oscillate. These oscillations had an average period of 30 minutes (after an initial 30 minute equilibration). Under greater cold stress, similar oscillations occurred that were not always symmetrical from side-to-side. With stress applied, side-to-side and local temperature oscillations were dramatically higher in frequency for symptomatic than for asymptomatic patients. These and many of the studies referenced earlier tend to prove that normal thermoregulation is indeed symmetrical and that either horizontal or vertical asymmetry suggests lesion, stress or both.[93,95]

Investigators who employed autonomic challenges report various abnormal thermographic findings thought to be related to sympathetic nervous system function.[96-99] One author found discernible thermographic effects from low-frequency vibration induced upon the lumbar spine, a common hazard in many occupations.[100] Another used computer-aided thermographic image subtraction to image large subcutaneous blood vessels. The exact location of large subcutaneous blood vessels is important in the analysis of high-resolution thermographs because they are likely to create small thermal anomalies which reflect no abnormality.[101]

Thermography Compared with other Diagnostic Modalities

Lawson Cannon reported a 90% sensitivity for thermography, higher than for CT, EMG and myelography. He also reported correlations between "other clinical findings" and thermography of between 93 and 100% for various experienced practitioners.[12] Several authors who compared thermographic and other instrumental modalities, including: evoked potentials, myelography, electromyography, CT, MRI, and EIT, etc., found in most cases that good correlation existed between modalities.[102-110] Chiropractic and medical literature detailing general clinical and individual case studies also give encouraging anecdotal evidence of the validity of thermography as an objective patient-assessment modality.[111-123]

Thermographic Analysis Protocols

To develop repeatable, scientifically-defensible assessment data, precision instrumentation should be combined with strict adherence to standardized test protocols and informed interpretation. If protocols aren't carefully established and followed, artifacts may be produced which are difficult to separate from useful data.[124] Most thermographic protocols are similar in their requirements.[125-127] A draft-free examining room is needed where the temperature is held within a narrow range [some recommend that the room be relatively cool (approximately 66-68°F) to create moderate thermal stress]. Some call for at least 15 minutes for equilibration during which skin surface to be scanned remains nude. Subject position, wall construction, stool height, same time of day for repeat examinations, psychological factors, etc., are all considered important. For at least 4 and up to 24 hours, subjects are encouraged to avoid eating, bathing, strenuous exercise or activity, nicotine, prescription drugs (especially pain medicine), skin ointments, and hot or cold caffeinated or alcoholic beverages. (All of these requirements aren't necessarily valid for chiropractic assessment.)

Based on present technology, cutaneous thermographic findings are a reflex of:

1. Segmental thermoregulation;
2. Core-heat thermoregulation;
3. Environmental exposure;
4. Physiological status; and
5. Individual-unique responses.

Abnormal paravertebral thermographic patterns may relate to either skeletal neuronal interference or to sympathetic response to a VSC or other nociceptive lesion in remote or local organs or tissue (or combinations of these conditions).[30] Chiropractors report that paraspinal skin temperatures usually change immediately after a spinal adjustment, making thermography an effective clinical tool for patient assessment.

"X-ray defines (anatomical) structure, MRI defines (body) chemistry, and Thermography is used to define (physiological) function," states Rockley.[128] (Emphasis added). Thermography provides a way to visualize spinal neuronal function, i.e., physiology. "...Thermography is often the only diagnostic test which can accurately measure the amount of musculoskeletal or neurological damage ... setting the stage for an accurate diagnosis and prognosis."[13] Whether or not pain is present, paraspinal thermography can reveal abnormal sympathetic nerve-fiber function which may in turn be indicative of the VSC.[3] Infrared thermography is one of the few diagnostic tools which may be used repeatedly with no known hazard to the patient. It also has important legal implications, especially in the establishment of need for treatment and confirmation of injury.[129,130]

CONCLUSIONS

There is sound thermoregulative physiology to support paraspinal thermographic findings for clinical assessments, especially to help assess a VSC. To provide maximum benefit, computerized infrared paraspinal thermography should present "heat only" data, have high thermal resolution and produce repeatable scan-to-scan data. Also, permanent recording of all significant scan data and user-friendly operation which integrates well with typical clinical and clerical office routines are essential.

Paraspinal thermography has been a useful diagnostic test for remote lesion within an involved body segment. There is a need for further scientific investigative effort to provide additional support for the major premise of this paper, i.e, anomalies in sympathetic spinal thermo-regulation are often suggestive of the VSC because sympathetic spinal cell-body function modulates hypothalamic control. Chiropractic has long pursued the highest-possible objectivity in the validation of its spinal assessment and adjustment procedures. More general use of high-resolution, high-accuracy computerized thermography could produce significant improvements in health care and advance the entire profession.

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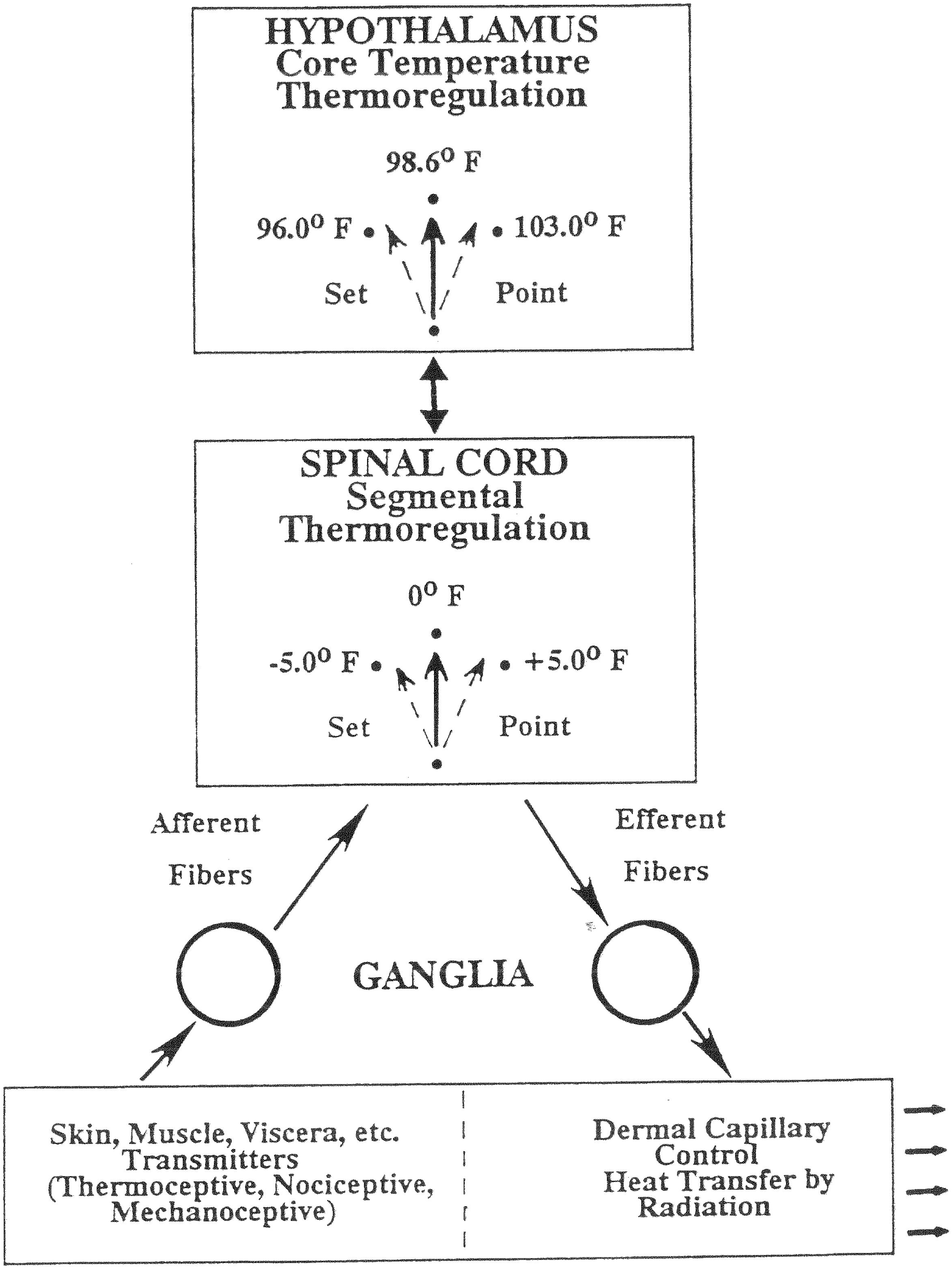

Figure 1. Simplified Representation of Thermoregulation

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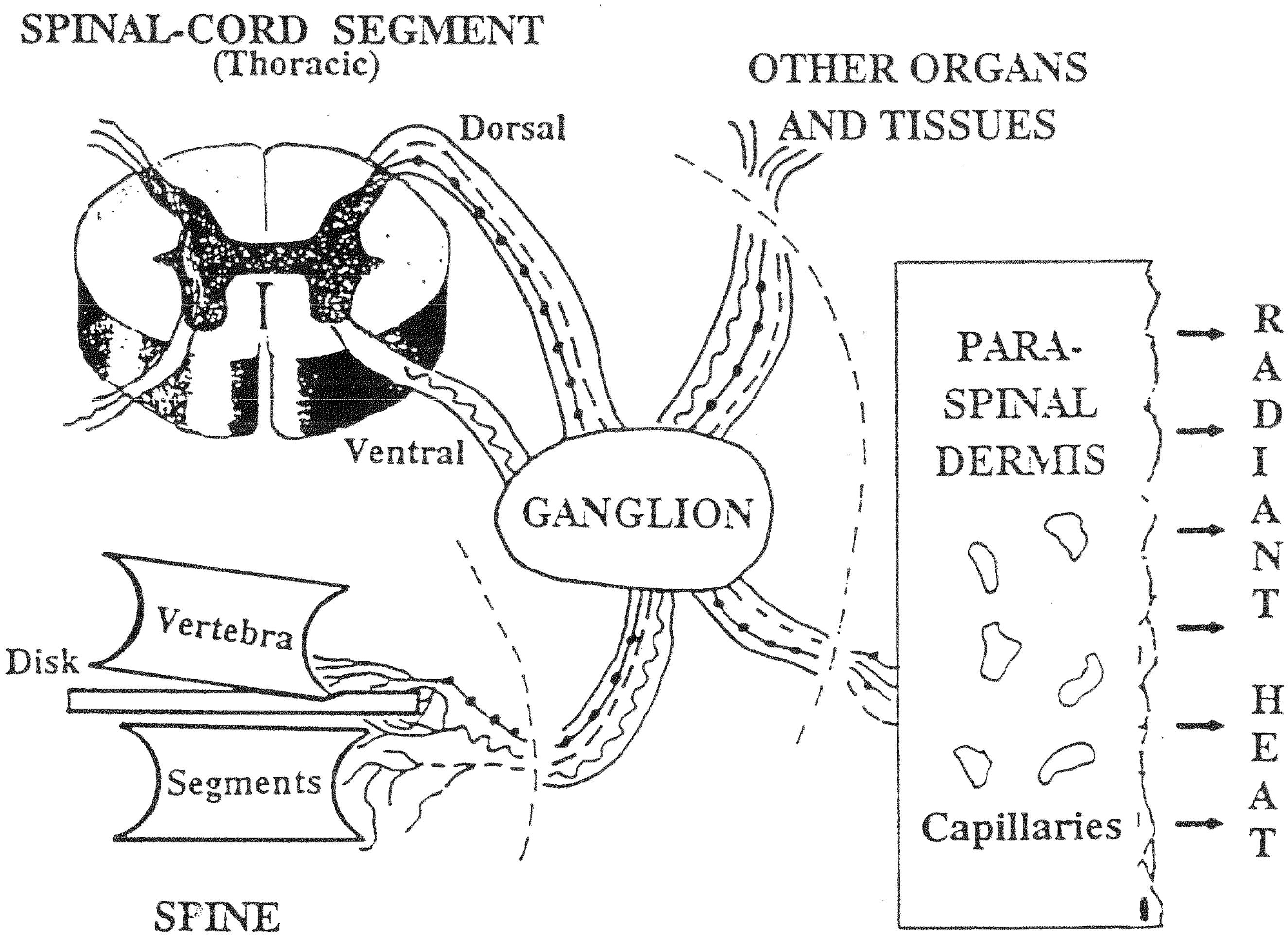

Figure 2. Representation of Sympathetic Function

The Role of Diagnostic Instrumentation in the Evaluation of Spine Trauma

Purpose: Emerging technological advancements have resulted in new ways for physicians to evaluate clinical presentations of spine trauma. Motivations for ordering and rationales for the application of diagnostic instrumentation in spinal trauma from payer, medicolegal, and clinical perspectives are provided. Specific consideration of the clinical utility of plain film radiographic imaging, surface electromyography, computerized inclinometry, and videofluoroscopy is given. **Methods:** Qualitative review of selected peer-reviewed literature. **Summary:** Clinicians should consider both the practical utility and impact on the management of spine trauma when weighing the need for diagnostic instrumentation. Physical examination can be supplemented with instrumentation to augment findings such as range of motion, muscular activity, and routine diagnostic imaging. However such usage is seeing increased scrutiny by payers. Plain film imaging continues to have diagnostic value in trauma assessment, however, the literature does not support the use of surface electromyography, videofluoroscopy, and computerized inclinometry as improving diagnostic accuracy, enhancing clinical management, or improving patient outcomes under chiropractic care. Key words: *defensive medicine, fluoroscopy, health insurance reimbursement, malpractice, radiography, spine, wounds and injuries*

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TRENDS IN health care have shifted strongly toward increased accountability. This finding is especially true in third party payment and liability arenas where requests to objectify physical examination findings, the clinical status, and need for care are routinely made. Trauma cases in particular are likely to be managed in the context of health care insurance or liability payment systems where there is increased pressure to demonstrate clinical problems objectively. Many trauma cases also have the added burden of litigation where "hard" clinical findings are preferred to justify the trauma diagnosis and course of care. Clinical workups with few objective findings may be scrutinized and challenged by payers or legal representatives. When pressures such as these are imposed on treating physicians, some physicians turn to technological advances and diagnostic instrumentation in an attempt to supply measurable, objective "proof" to substantiate injury, justify the need for care, and demonstrate that care being provided is having a positive effect. Often the result is a quantity versus quality approach to the clinical evaluation where the physician may call for special diagnostic studies and supplemental instrumentation that may not contribute substantially to care planning or treatment outcomes.

Technological advancements have offered many new methods to evaluate and quantify trauma findings. While the trauma examination can be supplemented with an extensive variety of diagnostic instrumentation, most do not have clear

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evidence that establishes efficacy and clinical benefit. Physicians apply instrumentation at their own discretion, and diagnostic protocols pertaining to necessary applications may vary widely between different providers for similar case presentations. Although it can be true of currently accepted clinical procedures, an abundance of new, evolving, costly, and controversial technologies adds new challenges for patient care. Payers are left wondering what tests are necessary in which cases and when special studies and diagnostic instrumentation provide significantly meaningful information.

The cost per case of any one type of special diagnostic procedure is typically considerable. Taken together and applied across health care in general, the cost of instrumentation and diagnostic testing in trauma management is surely significant. There is growing interest in payer communities and medicolegal arenas to be able to identify when each of the various forms of diagnostic instrumentation are necessary. In fact, as was the case in magnetic resonance imaging (MRI) scans, instrumentation may be clinically embraced and widely used before the usefulness of the information provided is fully understood. Guidelines for use typically follow much later after utilization data have been gathered, more experience has been gained, and analysis has been performed.

Diagnostic tests may be widely employed before a sound clinical decision-making framework is supported either by consensus or evidence. Because advancements in diagnostic technology frequently occur more rapidly than such frameworks are developed, physicians are often left to make diagnostic test choices by personal judgment, anecdotal evidence, or marketing materials alone. However, if a technology later turns out to be of limited value, physicians may be left with expensive tools that yield little benefit to care quality or make good business sense.

Likewise, payers continue to be plagued with the dilemma of wanting objective evidence of injury but are often required by contract or regulation to reimburse only for those tests that are clinically necessary. Information summarizing appropriate clinical applications of diagnostic testing in cases of trauma is often lacking, and the clinical necessity of some diagnostic tests, especially those that are new or less frequently used, is difficult for providers and payers to verify.

While it may be tempting to offer any quantifiable measurement as evidence of a diagnosis or need for care, the issue of the relevance of supplemental instrumentation findings is at the foundation of good clinical care delivery. Many factors bear on ordering diagnostic testing in the trauma case. From a medicolegal perspective, any ability to demonstrate and quantify the extent of trauma is encouraged. However, the use of supplemental diagnostic testing drives up the cost of an injury claim, potentially with little or no change in the treatment provided. Physicians practicing "defensive" health care can rationalize the use of almost any diagnostic procedure, especially when the potential harm to the patient from such testing is minimal.

Payers contribute to the increased use of instrumentation by motivating physicians to provide "hard evidence of injury" and by challenging claims where injuries are not "objectively" verified. Some diagnostic instrumentation vendors promote practice building through additional billings or promises of higher reimbursement and emphasize the value of patient education to support its use. Although a wide spectrum of motivational issues prompt the inclusion of instrumentation in the evaluation of trauma, patients are best served if a sound clinical rationale is routinely applied. This rationale should be geared to added diagnostic "yield" that results in the design of more appropriate care measures. Unfortunately, third party payer policies, medicolegal demands, real or perceived malpractice risks, marketing or business motivations, and the natural growth of clinical innovation continue to influence the use of diagnostic instrumentation.

MOTIVATING FACTORS INFLUENCING DIAGNOSTIC TEST USAGE

The third-party payer perspective

When considering trauma management, it is probably more common for purchasers of health care to be someone other than the person receiving the care. Third-party (nonpatient) payers include liability carriers, occupational injury payers, government entities, self-insured groups or companies, and private health plans. Although the specific policies governing reimbursement for diagnostic instrumentation may differ, payment is typically considered appropriate when the studies ordered can be shown to have a reasonable and necessary basis. Some payers have the luxury of determining coverage issues in advance while others are left to determine the appropriateness of a given procedure and the reasonableness of making reimbursement for the service retrospectively. In either case, payers generally require confirmation that a legitimate need exists for the diagnostic procedure in question. In cases of retrospective review, it is not uncommon for emerging technology and instrumentation to be challenged with respect to necessity, particularly if a procedure is expensive or repeated over time.

Instrumentation may be especially challenged when there are wide practice pattern variations in its use. To illustrate this point, consider the following actual trauma claims that were sent for peer review.

Two different chiropractic providers submitted records and billing, each showing evaluations for similar presentations of spine trauma with similar localized complaints. Each provider requested payment for clinical examination procedures and the course of care. The insurance carrier was bound to pay only reasonable and necessary charges associated with the injury. The first provider submitted charges for a physical examination, regional radiographic studies, and a 2-month course of tapering therapies. The second submitted charges for a physical examination, multiregional radiographic studies, multiregional scanning surface electromyography (EMG) studies, multiregional videofluoroscopy studies, computerized intervertebral mobility assessments, and computerized inclinometric studies. The second provider used a similar therapy approach but the duration was much longer. Both providers use identical ICD-9 diagnosis codes of sprains, strains, and spinal subluxations with records indicating that the injuries were of similar severity in similarly conditioned individuals. The care progression showed each provider periodically conducting interim examinations at approximately the same intervals. The first provider monitored progress with quantified physical examination findings including range of motion studies, VAS, and functional surveys. The second provider supplemented each interim examination with surface EMG studies and separately billed computerized inclinometric and intervertebral motion tests; follow-up cervical and lumbar videofluoroscopy studies were obtained on every other interim evaluation (every 2 months). The course of care paralleled the treatment provided. VAS and functional surveys responded in a similar fashion with the results showing less than occasional symptoms with mild intensity of symptoms and no functional limitations at 2 months. The longer duration of care in the second case was reportedly necessitated by findings from the instrumentation studies conducted. A request made by the claims adjuster for additional clarification from the treating providers showed no substantive differences in intake or interim presentations, other than findings of uncertain significance demonstrated by diagnostic instrumentation.

Understandably, many questions arise from a claims point of view: What made these two cases different? What was there about the second case that necessitated an additional array of special diagnostic studies? Why did the second case need a longer course of care? Did the information provided from the special studies substantiate the need for additional care? How clinically significant were these findings? Was the first case underdiagnosed and undertreated, or vice versa? Are the charges for the extra instrumentation in the second case necessary and payable on that basis? Unfortunately, claims personnel are often left with very little information to sort out this confusion. Equally unfortunate is the frequency at which differing degrees of instrumentation are applied to similar case presentations.

Strategies for managing problems of this nature are being made on the health policy level. Attention to the cost-benefit relationships is a driving force in this regard. Policies for reimbursement are ideally based on whether tests offer significant diagnostic or therapeutic utility; however, policies can also be set arbitrarily or with little clinical rationale. Private health insurance and occupational injury carriers often have the benefit of establishing payment policies in advance. Unlike these purchasers, liability payers typically are not in a position to mandate preauthorizations and may not be able to survey claims until long after diagnostic studies have been obtained. Their concern is that they will be responsible for payment of services that have questionable clinical utility and that they will have no clear way of determining what was and was not truly necessary. The typical recourse is to ask the attending physician to justify the level of testing conducted and to obtain independent opinions regarding the testing rationale. This approach can rapidly become adversarial, and payment may be denied if an appropriate level of justification is not provided, or if peer review processes fail to uncover a sound clinical basis. Ironically, reimbursement denials may precipitate a pattern of increased alternative instrumentation to offer additional "proof" of clinical disorders or to support care delivery.

Medicolegal perspectives

The litigious nature of our current society creates a constant focus on thorough diagnostic evaluations. The resulting attitude is one where exhaustive diagnostic testing is thought to be protective for physicians. Limitations to diagnostic testing may be somewhat threatening from a malpractice perspective. When the Agency for Health Care Policy and Research (AHCPR) released its *Clinical Practice Guidelines for Acute Low Back Pain in Adults*[1] in 1994, the recommendation to delay diagnostic imaging for acute low back presentations that did not have "red flag" indicators (eg, trauma, age, failure to respond within 1 month) concerned providers. Although the guideline attempted to incorporate a clinically sound rationale in its diagnostic testing recommendation, some physicians expressed concern at the increased malpractice risk exposure for not imaging these back pain patients prior to delivering care. Despite these objections, experience has shown that when specific guidelines are applied, modifications in practice characteristics usually follow.[2]

Physicians remain concerned over any possible increased malpractice risk and support general use of instrumentation to reduce that risk. Lalla and Lalla[3] reiterate a risk management undercurrent of contemporary clinical decision making that the blanket use of diagnostic testing reduces malpractice risk. They state that "any time a patient receives chiropractic care without spinal X-rays, the doctor's malpractice risk management ratio goes up and the incidence of malpractice increases."[3(p??)] From this perspective, it is easy to rationalize that diagnostic instrumentation in general is necessary without regard to its impact on case management. However, risk of litigation is not certain, and increasing evidence supports the appropriateness of standards such as the AHCPR guidelines that routinely delay imaging a couple of weeks to see if the acute low back patient responds.[1,2]

Discussions about diagnostic testing in the context of reducing malpractice exposure often fail to include the question of benefit to the delivery of treatment. For example, a risk management argument can be made that it is best to order a magnetic resonance imaging (MRI) scan to assess the possible presence of soft tissue pathology such as discopathy, even though specific treatment considerations may remain unchanged in light of those findings. While such information may contribute to prognostic capability, is there value added by having available this information on a large number of individuals when delaying it will reduce the use of resources on those patients who will respond rapidly? The practice of "defensive" health care would suggest that the more diagnostic testing done the better, so long as the testing itself has a low risk of direct harm to the patient. A legal or malpractice position is typically in favor of more diagnostic testing with little attention to cost. In this light, instrumentation is rarely discouraged.

From another medicolegal vantage point, clinical documentation is routinely used in the litigation of trauma cases. Details from instrumentation obtained in the context of clinical management are typically used to support a level of injury and need for care, despite the fact that the information gained may have questionable clinical value. Some providers may be motivated to use whatever diagnostic means may be available to support an injury and justify the need for care. Attorneys looking to "build" their case may support this position. Combined with the fact that liability payers are typically limited in their reimbursement discretion, instrumentation may be more readily conducted in the trauma-related arena.

Social and marketplace perspectives

The escalating cost of health care has become a significant social problem. Patients who have their bills paid by third parties become desensitized to the costs incurred. They may undergo procedures that would otherwise be questioned due to cost and the clinical value of the information gained. All too often, these patients do not ask about the necessity of special studies and whether the findings from these studies will significantly impact the direction of their care or narrow the available treatment options. The burden for payment becomes broadly distributed across society, in part by increased health care and liability premiums. The high cost of health care rests largely on the employer community as it relates to higher health care insurance premiums. Employers faced with increased costs for employee benefit packages are forced to choose how they will structure future benefits. They continue to demand high-quality health care services at reasonable prices. Employers frequently turn to managed care programs to determine what services are necessary and to contain the cost of care.

Inflated costs of trauma management are also distributed to liability insurance carriers. Premiums for liability insurance continue to rise in proportion to the cost of delivering care for trauma cases. At present, liability carriers have little control over diagnostic testing costs as they are incurred. They are typically left hoping that the trauma assessment strategies used by providers are efficacious. Retrospective review processes are employed when questions arise.

Diagnostic instrumentation plays a large role in the overall financial impact of health care delivery, and these issues have been a focus of national guideline development.[1] Diagnostic instrumentation incurs direct costs, and false positives may serve as justification for unnecessary care (eg, disc surgery because of a positive imaging finding of disc herniation). Although the rapid pace of technology advancement may preclude consideration and timely integration of new technologies into existing guidelines, ultimately market demand for the efficacious use of diagnostic testing will prevail. Technologies are either embraced as having clinical value and included in benefits structures, as has been the case of plain radiography, or they are left out for lack of support, as has occurred with thermography. Most accepted technologies have demonstrated indications for use. In the meantime, emerging technologies are increasingly in marketplace limbo, each judged on a claim-by-claim basis pending future studies. Processes for evaluating new technology are emerging to aid in related health policy and practice implementation on a prospective basis.[4] The future of a technology will likely depend on how much it meets predetermined inclusion criteria.

Clinical perspectives

Clinically based considerations are the most important influencing factors because they directly relate to the best treatment of the patient. Optimal clinical reasoning weighs both cost-benefit and risk-benefit issues when making recommendations for patient evaluation and care.

The clinical issue of instrumentation has received several detailed and summary assessments.[1,5,6] The Mercy Consensus Conference reported that "the technological explosion in health care delivery has advanced far beyond valid clinical utility."[5] Table 1 presents criteria against which instrumentation can be evaluated. The most important criterion is test validity; that is, whether the test accurately measures the desired function and if that measurement is pertinent to the patient's condition.

Table 1. Criteria to evaluate instrumentation

- Validity
- Discriminability
- Accuracy
- Precision
- Reliability

Table 2. Primary screens for technology assessment

- Effectiveness (Does it work?)
- Appropriateness (Is it needed?)
- Informed decision making (Is it wanted?)
- Insured services considerations (Should the public pay?)

Triano[7] described a variety of instrumentation available to chiropractors, some of which increased the ease and accuracy of diagnosis and therapy. Chiropractors clearly have more diagnostic avenues available now than at any point previously. However, each new advance brings increased cost.[4] The wave of technological advancement has been accompanied by views on how to conduct technology assessment so that policies can be set appropriately.[4,7–9] Hansen and Mootz[4] describe Deeber's four-phase model of technology assessment (Table 2) and caution against common misconceptions and faulty assumptions regarding technology assessment. These problems include the selective inclusion and improper interpretation of the literature, the poor selection of consensus panelists, and the reliance on technology developers and entrepreneurs alone.

From the clinical perspective, instrumentation is valuable when it provides significant clinical insight (ie, a specific diagnosis can be ruled in or ruled out) and when the information gained contributes to or changes the direction of the care than would otherwise be taken. Unfortunately, emerging technology may have little support from sound clinical studies, and marketing materials or anecdotal evidence may inflate the value. Scientifically unsupported protocols for instrumentation use have even been adopted by government agencies and submitted back to the chiropractic profession for use.[10] Despite the fact that these protocols lack scientific justification and accompanying supportive research, some chiropractic providers attempt to substantiate the clinical necessity of performing instrumentation on the basis of the published protocols rather than case-specific clinical necessity or sound research-based conclusions.

Practically speaking, the value of diagnostic instrumentation lies with its ability to affect clinical impressions, decision making, and intervention. Points of clinical rationale for ordering diagnostic tests in trauma cases are delineated in Table 3. Tests must provide meaningful and beneficial information. Special studies that only provide isolated clinical indicators that do not substantively influence diagnoses or courses of care perpetuate waste. Moreover, this type of special testing, if employed to provide a measure of outcome, has little practical benefit, especially when more meaningful outcome measures are readily available.

REVIEW OF SELECT INSTRUMENTATIONS

Several forms of diagnostic instrumentation that are readily available in the clinical setting are reviewed and weighed against the criteria presented in Table 3. The subsequent discussions are presented solely from a perspective of clinical usefulness without considering other reasons to order these tests.

Plain radiography

The value of plain radiography for the purpose of assessing spinal trauma is well established.[1,5,11,12] In the context of trauma evaluation, it is often necessary to rule out entities such as fracture and instability, and radiography is well suited to fill such a role in the differential diagnosis process. Information gained from radiology studies may significantly contribute to diagnostic impression and alter the direction of treatment.[12] Notwithstanding these positive aspects, not all trauma patients may be appropriately studied radiographically. Rather, the selection of patients should take into account many factors, with weight given to the history and physical examination.[13] Miller and Craw[12] described factors that were considered to be indicators for radiographic study in the cervical spine trauma case. Most of these factors may be extrapolated to other spinal regions.

It is clear that plain radiography has sound clinical value in the evaluation of spinal trauma when assessed against its ability to affect diagnoses and treatment avenues and when other methods for gaining this information are considered. There is sound clinical support pertaining to issues from Table 3, and guidelines for use have been reasonably developed. However, case-specific issues are the final consideration because radiography may not be indicated if the information gained ultimately does not alter patient management decisions.[14] For example, while minor trauma may be a red flag for radiography in an older patient at higher risk of fracture, it need not be a routine justification for X-ray in a younger patient with otherwise normal clinical findings.[12]

Table 3. Points of diagnostic testing rationale for trauma presentations

- The diagnostic test must aid in the differential diagnosis of the condition (help differentiate between distinct diagnostic entities).
- Testing must provide information not readily available by less expensive, less invasive, and reasonably equivalent means.
- Testing must provide information that will significantly alter the clinical management options otherwise being considered.
- Testing must meet reliability, validity, discriminability, and precision thresholds.

Computerized inclinometry

Range of motion assessments are an integral part of the musculoskeletal examination in general[5] and trauma cases in particular. In fact, range of motion alterations are expected in the trauma presentation. Advances in instrumentation have yielded new ways to assess range of motion, most notably relating to computer-assisted devices to determine ranges. The value of computerized inclinometry over other methods and as a stand-alone diagnostic procedure has raised concern as it applies to the appropriateness of charging separately for that service and because many impairment ratings are based on range of motion limitations.

With respect to insight gained from range of motion assessments in general, values for normal ranges of motion vary depending on the source.[14,15,17] Yougas and associates[18] recently described further variation in expected normal ranges depending on age. Various methods and instruments for measuring ranges of motion are readily available including CROM-type instruments, dual-bubble inclinometers, single-inclinometer methods, protractor goniometers, digitized dual-bubble inclinometers, and computer-based moment arm inclinometers. Although instrumentation is generally recommended for range assessments,[15,17] there is no preferred standard measuring device.

Strender and coworkers[19] reported that examiners generally agreed on the presence of pathologic ranges even without the use of inclinometry, though the range was not specifically quantified. Leibenson and Phillips[20] reported on several low-cost methods of assessing lumbar ranges, each with similar reliability, but with greater convenience reported with inclinometric assessments. The inclinometer method was the only one found to support the impairment rating methodology.[15] Other sources report that inclinometry is more suitable for use in assessing spinal function,[5] and noncomputerized methods have shown high reliability and validity.[21]

Computerized inclinometry has been shown to have good device accuracy, but the procedure is prone to administrator or human performance variable error.[22] Comparisons between bubble inclinometers, computerized inclinometers, and dual long arm subtraction goniometers have shown that the different instruments can be used with the same level of reliability.[23] However, the general interpretation of range of motion must be performed with caution. An investigation[24] of confounding factors identified variable time of day measurements as an element to be considered. Lowery and coworkers[25] reported that all 81 normal subjects that they tested using a dual-bubble inclinometer method showed impairments based on the American Medical Association (AMA) criteria.[16] The impairment rating ranged from 2% to 38.5%, with a mean value of 10.8%. They concluded that impairment based on range of motion may be overstated by up to 38%.

Although there are many sources describing methods of measurement and the integral nature of range of motion assessments as they relate to the musculoskeletal examination, the type of information gained is limited by most accounts. Range measurements offer no insight into factors that may alter the range, and findings from range of motion assessments alone do not specifically rule in or rule out common differential diagnoses of musculoskeletal trauma. In fact, range of motion abnormalities may not be indicative of significant functional pathology at all. Impairments based on range of motion restrictions may be overstated. especially because AMA ratings relating to the range of motion model are not age adjusted.[16] Range of motion restrictions alone do not appear to be a reliable basis for the redirection of clinical care.

Surface EMG

Surface EMG has been available for clinical use for over 10 years. It has probably been used more actively in the research setting to describe muscle activity under various controlled observations. Surface EMG provides limited information about muscle activity. Past evaluations have shown conflicting correlation of surface EMG with pain and with its ability to differentiate pain intensity levels.[1,26] Christensen and Tran[27] found that surface EMG had a high false diagnostic ratio when used to predict pain from isometric muscular contractions. Surface EMG studies, however, have demonstrated altered fatigue rates and muscular activation levels in pain patients.[28,29] Postural distortions have been found to correlate with altered surface EMG readings, increasing with the degree of imposed twisting.[30] Another study[31] showed that feelings of "tension" may or may not be associated with increased muscular activity, as demonstrated by surface EMG, and that some pain precipitators, specifically those that are psychosocial, may not be mediated through increased muscle activity.

One authority[1] states that surface EMG is not an effective method for assessing acute spinal problems. The Mercy Consensus process concluded that the clinical usefulness of surface EMG is limited because the discriminability of the procedure has not been evaluated.[5] Moreover, altered muscle tone is expected with acute spinal symptoms and the meaning of surface EMG measurements in these cases is uncertain and does not contribute significantly to clinical decision making. More recently, Osterbaur's review[32] of available chiropractic technology found that the diagnostic reliability of surface EMG is not well supported and that it remains a task for the research setting.

Surface EMG protocols suggest that the presence of a variety of muscular abnormalities is sufficient cause for ordering surface EMG studies in clinical management.[10] Common indications are summarized in Table 4.

These indications were supplemented with recommended guidelines for the frequency of application of surface EMG,

Table 4. Commonly claimed indications for ordering surface EMG

- Palpable paraspinal spasm
- Tests that meet reliability, validity, discriminability, and precision thresholds
- Palpable paraspinal muscular asymmetry
- Asymmetric ranges of motion
- Paraspinal tenderness (pain on pressure)
- Paraspinal pain reported by the patient
- History of trauma to the spine
- Diagnosis of nerve root irritation evidenced by abnormal neurologic examination findings
- Clinical presentation of antalgic gait or lean
- Diminished or asymmetric paraspinal muscle strength demonstrated by manual or electronic testing
- Thermographic evidence of paraspinal muscle dysfunction

but the supportive evidence on which these guidelines are based was not provided. Recommendations called for surface EMG studies on follow-up every 2 to 3 weeks or after 10 to 12 treatment applications. These protocols further suggest that acute cases may require surface EMG assessment on a more frequent basis.

A review of these indications shows a list of previously identified physical examination findings. The addition of surface EMG as a primary diagnostic test in trauma cases where these findings have already been established offers no additional diagnostic benefit. Moreover, the added information offered by surface EMG has no driving influence on treatment options otherwise available. Recommendations regarding the frequency of use of surface EMG[10] remain essentially unsupported, and the necessity of protocols of this nature are highly questionable with respect to necessity, especially considering the limited information provided versus the cost and the negligible impact on clinical decision making.

Videofluoroscopy

Although available as a diagnostic tool, videofluoroscopy (VF) is not used often due to the cost of equipment and facilities. However, some physicians have employed this tool in the assessment of musculoskeletal trauma.

Croft and associates[33] showed some diagnostic and clinical benefit for VF. They found "fair" to "moderate" agreement among radiologists in interpreting VF studies as being normal or abnormal, with hyper- and hypomobilities grouped together in the abnormal pool. Their discussion comments on the field use of VF ranging from an "everyday tool" to a study that should be applied only in certain circumstances. Further they state that the issue of appropriate patient selection remains unanswered.

Miller and Craw's[12] review of diagnostic imaging for cervical trauma makes no mention of VF use in the diagnostic imaging consideration. Foreman and Croft[11] describe the role of VF as "limited," especially relating to the diagnosis of instability. They state that although VF offers information about subtle variations in segmental motion, normal motion patterns have yet to be reliably established. They discuss studies in which VF identified abnormal motion not otherwise detected, but patient presentations and selection in these studies were not adequately described. A suggested protocol for patient selection is provided that includes a history of trauma, neck pain unresponsive to conservative care, verified instability on plain radiography, and the follow-up evaluation of instability. Thoracic and lumbar VF studies were not recommended.

Schultz's[34] review of VF described the lack of information about "normal motion" parameters against which abnormal motion is judged and related that interpretation of VF was an area of "most confusion." He concluded that the literature lacks both controlled and prospective studies on VF. Moreover he feels that the impact of the lower level literature has been overgeneralized by current proponents of VF. He describes the current technology and terminology as being poorly standardized, as are reporting methods. Moreover, it was his belief that a "great deal of basic research was needed before the technology could be applied to large patient populations."[34(p77)] Consensus review of VF found the instrument to be promising, but suggested that intersegmental irregular motion could not be considered abnormal in symptomatic patients and that conclusions about the normalcy or abnormality of results appear to be unreliable.[5]

VF appears to have some useful applications in case-specific trauma evaluations. Those cases would involve a history of significant trauma with the presence of suspected segmental instability. Otherwise, and as a general assessment method, VF lacks supportive evidence. The subtle motion finding information available from VF studies is prone to interpreter inconsistencies, and there are no agreed upon normal parameters on which to base a comparison. VF studies, with the limited exceptions as noted, likely offer little in the way of substantial diagnostic information that would contribute to changes in treatment or clinical decision making in presentations of trauma.

FUTURE USE OF INSTRUMENTATION

Considering the driving forces behind clinical examination options, there will likely be a continued tendency to call on diagnostic instrumentation in the evaluation of trauma. The most important basis on which decisions for its use should be made is clinical rationale. Future applications should be assessed for their impact on patient care, clinical decision making, and diagnostic triage. This approach will help ensure the most appropriate and necessary use of resources and the most efficacious approach to patient care.

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① Thermography
② workers' compensation
③ Diagnostic Imaging
④ instrumentation

Thermography — A Chiropractic Natural

BY PAUL L. HELZER, D.C., PH.D.

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As a student 20 years ago at Palmer College, I recall working with various instruments which had been developed and used by very prominent scientists within our profession. Many of these instruments were used to determine the effects of mechanical improprieties of the spine and their influence on the neurovascular effect of the subdermal vascular bed.

While many doctors maintained differences on what part, if any, these instruments would play in their own practices, all agreed that they were mechanically capable of accomplishing what they were designed to do. The Derma Thermograph, one of the oldest of these instruments, was considered one of the benchmarks in chiropractic instrumentation. Why then do we now see so much controversy over the use of thermography in the care of neuromuscular disorders? I can only assume that it must be due to either a lack of information or a lack of understanding by those in the health-care community.

A Lack of Understanding

However, further research shows that there are more than 5,000 published articles, written by very respected people of all academic backgrounds, that support the use of thermography. I must, therefore, dismiss the lack of information as a cause and address the issue of a lack of understanding.

In 1990, I became board qualified in diagnostic thermography, and since then I have performed more than 1,000 studies, for both defendants and plaintiffs. I have addressed adjusters, carriers and juries until I'm exhausted, but I believe I am slowly turning the tide. This is not an article to extol the virtues of this diagnostic equipment through an exhaustive explanation of scientific facts and conclusions. Rather, let us approach it through an examination of the current status and use of thermography in the field today.

First, I'm tired of hearing the American Medical Association's stance, and the report of the neurosurgeons, on thermography and Medicare. I am a chiropractor; my peers are chiropractors, and most importantly, the American Chiropractic Association and the International Chiropractors Association have endorsed and approved thermography's use for their members.

Enough said? No, not yet.

Here in California, our state associations and our state board have approved the use of thermography, stating that it is not experimental and that it is probably generic to the practice of chiropractic. Still not enough? How about considering that the California Division of Workers' Compensation (traditionally very conservative and a trendsetter for the state) allows for payment and has created separate billing codes to facilitate the use of, and payment for, thermography.

Let's look further. Does thermographic evidence stand up in court? The State Supreme Court of New Jersey, in a landmark case, supported and extolled the use of thermography in a case involving multiple disciplines versus organized insurance companies. In a similar case in Florida, State Farm was not only ordered to pay a doctor of chiropractic for his test, but it was also given a $250,000 fine for not complying in a timely fashion. There have been difficulties, but these facts cannot be ignored. Any logical mind must deal with them when drawing conclusions regarding the use of thermography.

The Role of Thermography

Okay, so it's all right to use thermography now. *How* do you use it? Let's not go with my opinion; after all, reason and logic are my only tools. Follow the ACA guidelines, particularly those regarding soft tissue injuries and neuropathic disorders. (Did I hear subluxation complex somewhere in there? Yes, of course I did.) How many times have we taken cases that have failed with the allopathic approach and become successful because what we do works, and then we have to listen to the voodoo response of psychosomatics or spontaneous remission?

Thermography demonstrates and validates physiologic malfunctions in a unique way that no other test does. It's safe and non-invasive, and it can be used to provide a window — previously unavilable — for discovering problems in children and pregnant patients. Previous testing methods often left these patients in a symptomatic state that was questionable, because we couldn't verify and validate their conditions, even though they could have been in as much pain as anyone else. Or, what about the patient who often comes to us in pain after having gone the medical route and having been told there is nothing wrong, or that they are a "head case"? Thermography opens a window in these areas, as well.

I can remember the early days of computerized axial tomography (CAT) scans, magnetic resonance imaging and mammograms, before reason and logic forced the insurance carriers to accept them. As recently as five years ago, I was begging carriers to accept MRIs and still receiving the old "experimentally unproven" line. Now they ask me why I haven't done them yet!

Gentlemen, stand your ground! Thermography is not new. We have been measuring human body temperature and correlating that with the patient's care since Hippocrates' time. Did the man who developed the thermometer for human diagnosis face such difficulties? I'm sure he did.

Dr. Palmer's Invention

Finally, consider the story of a very well known chiropractic educator in Davenport, Iowa, who realized the need for chiropractic diagnostic equipment that could be interpreted by *all* disciplines. He developed a machine to detect and measure the effects of spinal nerve pressure and subluxation correction. It was "new" and "experimental," and of course, used by "those chiropractors."

The sad truth of this story is that Dr. B.J. Palmer's wonder machine — the electroencephalomentipograph — was eventually abandoned and left to collect dust, but not because it didn't work. Perhaps it did too well for our forefathers to comprehend at that time. Simply, the lack of understanding, the inability to grasp the importance and impact of the idea, not the lack of information, doomed it to the closet.

Palmer's concept was well ahead of its time, yet no one now disagrees that it, and its design, evolved into the electromyography (EMG) and NVC equipment that we now accept as standard diagnostic tools in all disciplines.

A Call for Support

To allow computerized thermography to fall into this same abyss of apathy is not only to deny patients its safe usefulness, but also to deny the whole field of thermodiagnostics. Do we throw out thermometers? No! We must learn and develop with it, or someday someone else will be poking around in our old closet and they will "discover" thermography, much like the allopaths "discovered and developed" EMG right under our noses.

What can you do to develop this technology? Locate doctors near you who are certified and use thermography. Visit their facilities and learn more about how thermography may serve you and your patients. Invite these doctors to your society meetings and civic clubs. Help them get the word out. Invite them to relicensure or management seminars and treat them as fellow chiropractors and colleagues should be treated.

I truly believe that thermography is here to stay. The military is already developing it as a replacement to radar to counter the new stealth technology. But most of all, it is only the beginning of a new generation of diagnostic tools that will be completely safe for our patients. Perhaps, the "new era" will be led by such "radicals" as we who dare to believe it can be done!

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Objective Proof: Thermography Documents Chiropractic Efficacy

BY GLENN STILLWAGON, D.C., PH.C., AND BRIAN S. STILLWAGON, D.C.

Thermography; public opinion;

research; Documentation

Why don't decision makers such as the news media, legislators, members of Congress, the present administration, insurance companies, the scientific community and the majority of Americans take chiropractic seriously?

Why aren't *we* chiropractors taken more seriously?

Consider this thought: Maybe *we* have been the problem. Perhaps we have caused the dilemma in which we find ourselves.

Chiropractors say, "We correct vertebral subluxation complexes," and we expect everyone to understand what we mean when we say that. We haven't communicated our message very well. Chiropractors understand the "Above Down, Inside Out" philosophy after sitting in the classroom for six to eight years, but people on the outside don't have the same advantage or understanding of chiropractic philosophy. They need something visual to look at in order to understand.

The decision makers say, "OK, you claim you correct vertebral subluxation complexes. Let's see the evidence. We've heard enough anecdotal stories; we've heard about your miracle cases. Just show us some documentation of what you do."

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And that's when chiropractors begin to backpedal and use the old cliché, "We don't have to prove it; it works." That's our present situation.

We submit to you that this is a very serious problem. It's much like the child who asks, "Mommy, can I do ...?" She replies, "No, you can't!" The child then asks, "Why not?" Mommy's reply is, "Because I said so." From a professional standpoint, just to say, "It works!" is not a fair answer. Don't you agree?

The Need for Documentation

Chiropractic gets results. We have all seen them. Some results have been claimed to be life saving, others miraculous. That's how chiropractic has grown. It's based on clinical results. People just feel better.

We often attend seminars and hear story after story about the miracles that have happened. The speakers will go on at length with tales of how one single adjustment on a patient suffering a heart seizure restores him to years of good health. Or, you've heard of the child suffering from a severe attack of asthma, who, after an adjustment, is normal again. We could relate more of these dramatic stories, but I'm sure you've heard them all.

After the speakers have finished, we often approach them and ask, "Do you have any pre and post studies of instrumentation findings? Do you have any pre and post records of X-rays, videofluoroscopy, thermography, surface electromyography or other studies which could be used in a research study of the case?"

You guessed it! Invariably, they begin to get uncomfortable and say, "Well, uh... no... not really... you see..." Had some of these speakers documented all of these miracle cases (and we've heard lots of war stories over the years, haven't we?), we would have had ample published material in indexed journals to substantiate the claim that correcting the vertebral subluxation complex will make dynamic changes in the nerve system. These corrections often bring about healing responses in the body that will affect the cardiovascular system, gastrointestinal system, immune system and virtually every organ, gland, system and function.

The scientific community would then be able to review, accept or duplicate that which chiropractic has already documented. None of this has happened because, over the years, chiropractors generally have not been inclined to do research or publish their findings. Had they been taught how to organize and prepare the material for publication, there are thousands of case records in chiropractic files across our nation that, if organized and published, would elevate chiropractic in the eyes of the decision makers. Had the chiropractic lecturers documented all the stories told to their audiences over the years and published their material, the chiropractic profession would be better off than we are now.

Documenting Results

The time has come for us to start documenting objectively that we do change the nerve system when we make a chiropractic adjustment. This is what the decision makers are expecting from us. In the past, technology prevented us from demonstrating objectively what we were doing to evaluate and correct the vertebral subluxation complex. At the present time, we have the technology that can provide us with this information.

Chiropractors have always recognized the body as one interconnected whole, philosophically, as well as looking at the spine as a synchronous unit. The communication system between the brain and various cell types is dependent upon an integrated supply of nerve energy. Interesting developments in science, especially in non-invasive procedures, are now enabling us to observe these changes taking place in the body. Enough studies have been conducted using these methods to know what the accepted ranges are.

We know chiropractic works. The question is, "Are we ready to use technology that gives objective evidence that doctors can agree with, to establish conclusively that we do exactly what we say we do?" By using this approach, everyone, regardless of technique or procedure, can use the very same regimen and prove the efficacy of their technique or procedure. There are many different models used in chiropractic today — biomechanical models, palpation models and instrumentation models, just to name a few. Good, effective models dealing with the anatomical aspect of the vertebral subluxation complex are presently available and in use.

With the availability of new non-invasive procedures, the chiropractic analysis can be objective in nature. This will give us the added dimension of the physiologic components of the vertebral subluxation complex. What is it that's happening in the nerve system as a result of structural change? Structure affects function, but to what degree? How will we be able to know?

Thermographic Evidence

The Visi-Therm II, a non-contact computerized electronic infrared thermographic system, has been designed to add a new dimension to chiropractic to help us answer

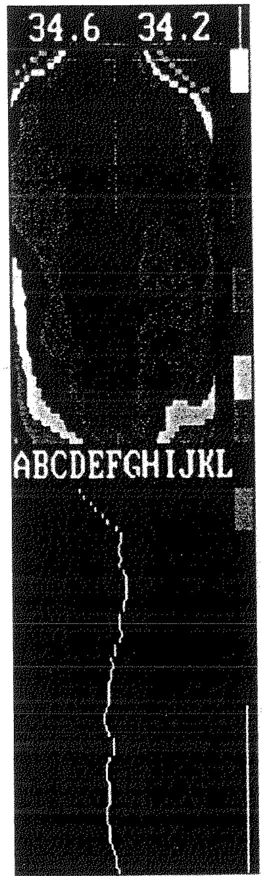

FIG. I

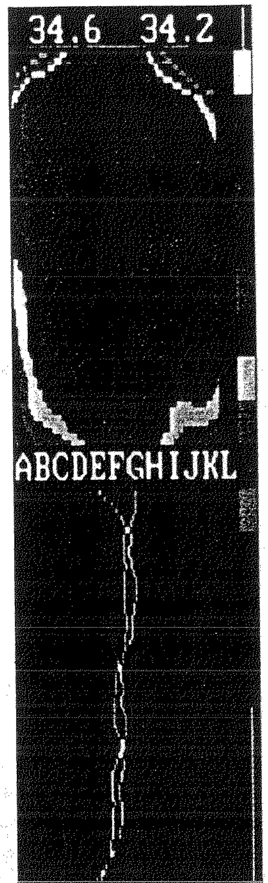

FIG. II

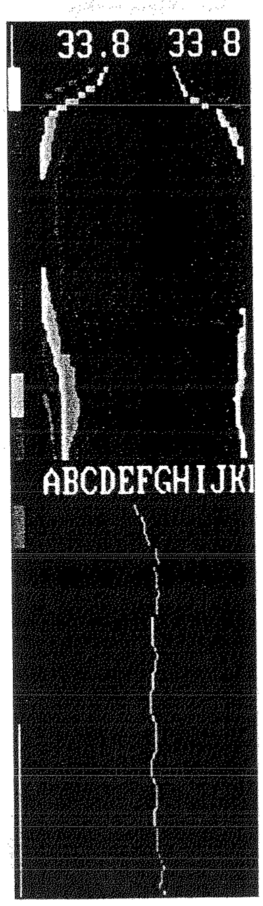

FIG. III

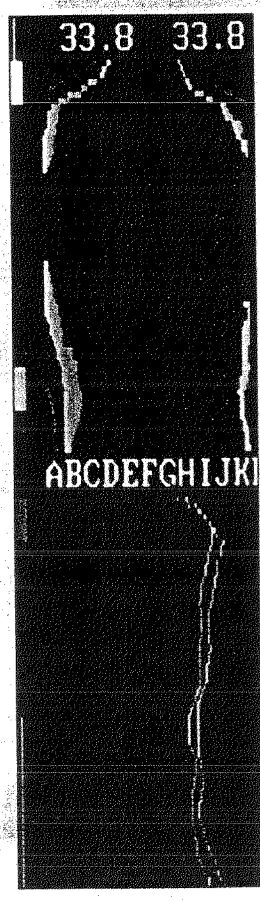

FIG. IV

FIG. V (LEFT)

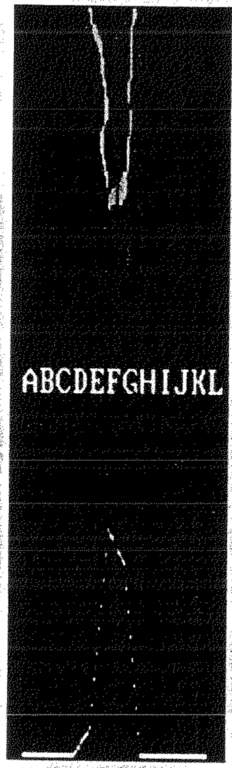

FIG. V (RIGHT)

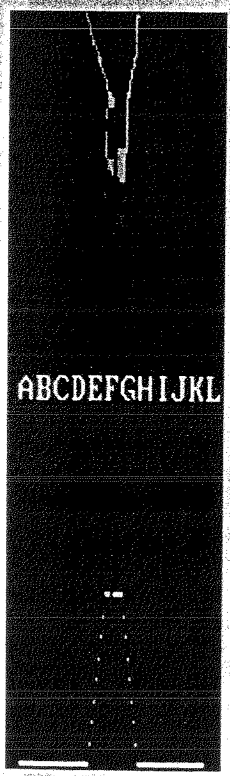

FIG. VI (LEFT)

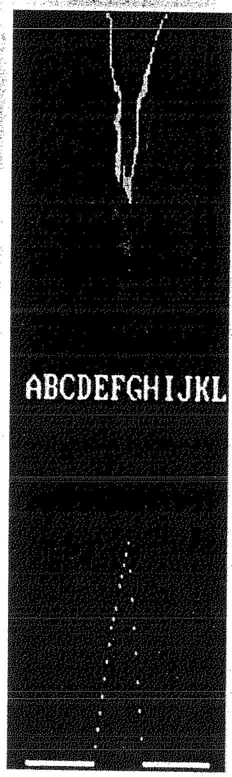

FIG. VI (RIGHT)

these questions. Chiropractic thermography is new technology which will enable us to document the impact of the chiropractic adjustment on correction of the vertebral subluxation complex.

Thermography provides color pictures that show temperature variations on different parts of the body. It is a safe, non-invasive procedure that uses no ionizing radiation. Thermography can be used as a monitoring system to aid the chiropractor in case management. It is objective evidence that denotes improvement or helps the doctor to know when a chiropractic adjustment is needed.

Thermography also provides us with information not seen on an X-ray, MRI, CT scan or EMG or gathered by palpation. There are two approaches in thermography, traditional and chiropractic. Traditional thermographers use high-resolution tele-thermography systems which provide non-contact electronic thermal imaging. Another widely used method is contact thermography, or liquid crystal thermography. High-resolution thermography, as used in traditional thermography, has been used for many years as an adjunctive procedure. It has been used in analyzing musculoskeletal conditions, peripheral vascular disease, breast conditions and neoplastic and inflammatory conditions, to mention a few. High-resolution systems are also used by chiropractic thermographers.

Chiropractic thermography, using low resolution, is more concerned with detecting dermatome patterns or other patterns of temperature abnormalities that are fairly large in surface area, rather than smaller patterns of temperature for differential diagnosis.

Chiropractors should be interested in reading "The AMA Council Report on Thermography," a 3,500-word report by a 15-member panel of the Scientific Affairs Committee. That report clearly states:

- The presence of a significant temperature difference between corresponding areas of opposite sides of the body is suggestive of nerve impairment, since defective vasomotor mechanisms result in thermal asymmetry.
- Thermographic study of patients with spinal root compression nearly always reveals thermal asymmetry, with decreased temperatures in the involved dermatome.
- Thermography can detect sensory/autonomic nerve dysfunction.

These are all important reasons why the chiropractor should be interested in using thermography, because it documents, objectively, changes in the nerve system following the adjustment. Will thermography replace X-ray, MRI or CT scans? Not likely. We will always need these tests because they study anatomy, whereas thermography measures function or physiology.

The Visi-Therm II system is ideal for the chiropractor because it uses a patented method of an array of infrared sensors which provides low-resolution thermal images at very low cost. Low-resolution thermography provides thermograms, showing before and after results, which demonstrate the impact of the chiropractic adjustment on correction of the vertebral subluxation complex.

Case Study

The following case study will show the procedures employed in low-resolution chiropractic thermography using the Visi-Therm II system.

This patient is a 27-year-old female injured in an automobile accident in September 1989. She experienced neck and shoulder pain radiating into the right leg. She also had numbness and tingling of both hands. Initial thermograms were taken following the customary equilibration and protocol procedures.

Figure I — Thermogram taken at the start of care. The full-spine thermogram shows increased heat of the left cervical area. Immediately below the scan is a line graph that confirms the increased heat, with the line graph showing a swing to the left in the cervical area. This line graph is similar to that of the Neurocalograph or bilateral (dual) probe instruments. The color scale is to the right of the scan. The top white color is the warm end of the scale.

Figure II — Same thermogram. Immediately below the scan is a display of two segmental line graphs. Notice there is a marked deviation of the line graphs in the cervical spine. These line graphs are displayed indicating segmental differences from one side of the back to the other. The segmental line graphs are similar to the single probe instruments like the Derma Therm-O-Graph. Ideally, these line graphs will superimpose when there is symmetry in the scan. It is obvious with the deviation or "split" of these line graphs in the cervical spine that these graphs also confirm that which was seen on the thermogram.

These line graphs are a unique feature of the Visi-Therm II. They aid the thermographer in determining the temperature difference from one side to the other. This feature is very helpful for observing subtle differences in color or for those individuals who are colorblind. The numerical values above the scan are the left and right temperatures taken in the fossa below the ear and are the same as the Chirometer readings. They are displayed in Celsius scale.

Figure III — Post thermogram. Notice the improved symmetry in the cervical area on the thermogram. Notice the improvement in the bilateral line graph below the scan.

Figure IV — Post thermogram. Notice how the segmental line graphs are superimposed in the cervical area.

The line graphs, which chiropractors have used for years, confirm what we see on the thermograms.

Figure V — Pre-thermograms of the left and right posterior arms. Notice the left posterior arm scan is colder than the right. This is confirmed by another feature of the Visi-Therm II, called the horizontal line graph. The amplitude of the graphs that are cross sections of any level of the extremities indicate the temperature difference from one side to the other. The left side is colder by 0.9° Celsius. Temperature differences can be detected as little as 1/10 of a degree Celsius. These scans indicate involvement of the C6-C7 dermatomes.

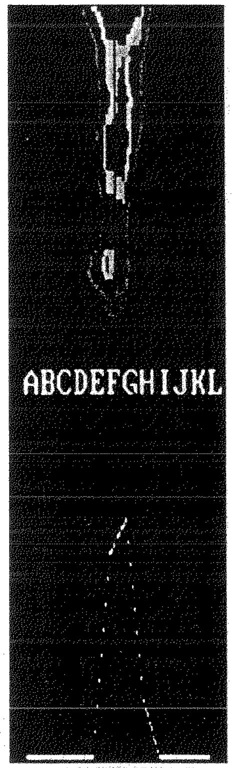

FIG. VII (LEFT)

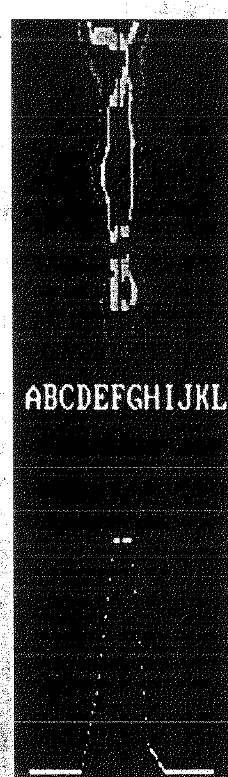

FIG. VII (RIGHT)

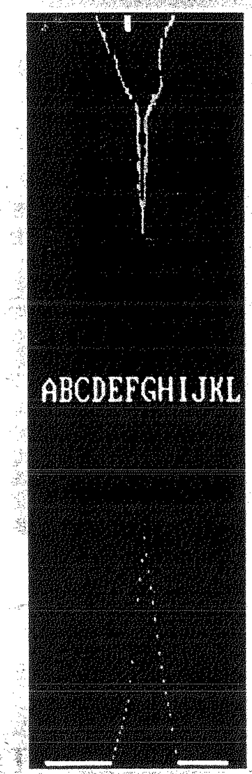

FIG. VIII (LEFT)

FIG. VIII (RIGHT)

Figure VI — Pre-thermograms of the left and right medial arms. Not only do we see an obvious color difference in the thermograms but the horizontal line graph shows the left side colder by 1° Celsius. The thermogram shows some involvement of the C8 dermatome.

Figure VII — Post thermogram of the left and right posterior arms are showing improved symmetry. The horizontal line graphs confirm this.

Figure VIII — Post thermograms of the left and right medial arms have also shown improved symmetry. Once again, this is confirmed with the horizontal line graphs.

The adjustments made on this case over the period of care were a right positive ilium, forward motion drop headpiece adjustments of C5 and C6, along with a one-time toggle of the atlas. As you can see, thermography will document the changes which take place following chiropractic adjustment of the vertebral subluxation.

Low-resolution thermography offers the following benefits to the chiropractor:

• It creates a dynamic and rapid change for chiropractic because it documents the impact of the chiropractic adjustment on the vertebral subluxation.

• Thermography can be used with any technique.

• Increased interest from the legal profession because thermography can aid in proving injury related cases.

LOW-RESOLUTION THERMOGRAPHY PROVIDES THERMOGRAMS, SHOWING BEFORE AND AFTER RESULTS, WHICH DEMONSTRATE THE IMPACT OF THE CHIROPRACTIC ADJUSTMENT ON CORRECTION OF THE VERTEBRAL SUBLUXATION COMPLEX.

• Thermography shows and documents neurophysiologic change in patients.

• Thermography cannot be faked or fabricated. It is non-invasive and poses no risk to the patient.

• The insurance industry will be better able to reduce the cost of determining disability, and carriers can terminate benefits on cases that are malingering.

• There are no contraindications to using thermography.

• Thermography gives you better patient control.

• The decision makers will have visual objective proof of what chiropractors do.

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Body temperature 38-41

Biomechanics

The Evolution of Modern Paraspinal Thermography

Homeostasis
Thermography

BY LOUIS H. TISCAREÑO, D.C., AND WILLIAM C. AMALU, D.C.

The evolution of modern paraspinal thermography has been driven by the chiropractic profession's core principle that both health (homeostasis) and disease are nervous system dependent. Today, as never before, the health sciences are recognizing the need to monitor the nervous system's function due to its unique role in the maintenance and restoration of health.

Gray's Anatomy (1991) states that "homeostatic responses are innate in *all* living organisms, but with increasing size and complexity of structure, the range and flexibility of responses have steadily increased in parallel with the evolution of the nervous system." It further states that "its structure and activities are inseparable from every aspect of life; physical, cultural and intellectual."

There is no longer any doubt within the scientific community that the nervous system is a major, if not *the* major, contributing factor in the maintenance of health. All of this, combined with health care's new focus on outcome-based approaches, has created the need for an objective means to determine the need for care and the effectiveness of the care rendered. With the advent of modern computerized paraspinal thermography, the field chiropractor now has the means for monitoring nervous system function on a pre-and post-adjustment basis, thus fulfilling the needs of modern outcome-based care.

It was fortunate for our profession that Drs. D.D. and B.J. Palmer had the foresight and wisdom to include both the *neurophysiological* and *biomechanical* components into the subluxation complex. Uniquely, it is the neurological component that distinguishes our profession from all other healthcare disciplines. Yet, our current emphasis has been almost exclusively on aberrant spinal biomechanics — leg length deficiencies, postural imbalances, weakened muscles and aberrant joint motion, to name a few. We often claim that we can affect the neurology of the body by restoring normal spinal biomechanics (via adjustments), but until now the technology has not been available to objectively quantify neurophysiological changes on a pre and post-adjustment basis.

Detecting "Hot Spots"

The initial attempt to quantify nervous system function was undertaken by Dr. B.J. Palmer in the early 1920s. He was responding to the claim by some practitioners that they could detect "hot spots" over the spine with the palm or back of their hands. These "hot spots" were thought to be present when a subluxated vertebra caused "pressure upon the surrounding tissues of a nerve energy. This resistance, in turn, causes excess heat (hot spots) at that point."

In 1923, Dr. Palmer enlisted the assistance of Dr. Dossa Evins to research and design an instrument that would be able to measure these areas of excess heat. Evins' research led to the development of the Neurocalometer (NCM) which was based on the thermoelectric principle discovered by German physicist T.J. Seebeck in the 1820s. Seebeck had discovered that an electrical current flows in a circuit made up of two dissimilar metallic conductors (thermocouples) when the temperatures of their two junctions are different. The NCM was a hand-held, bi-probed thermocouple instrument that measured comparative or relative (right to left) skin temperatures on a horizontal plane. With its terminals straddling the spinous processes, the instrument was firmly glided over the spine. Palmer claimed that when the instrument passed over a point where a nerve was impinged, the "excess heat" produced by the subluxation would "cause the needle to deflect in a certain characteristic way (pattern), showing so many points on its meter."

Further, he claimed that the instrument could locate the exact point where the nerve pressure existed. Of course, even if the nerve could possibly emit heat due to compression alone, to locate the exact point would require an instrument that could isolate this "excess heat" through inches of dermis, adipose, muscles, tendons, ligaments and flowing blood. This would be an impossible feat by any standard, as the surrounding tissues and flowing blood would certainly dissipate this low level of heat emission before it reached the skin. What he had actually done, however, was to invent one of the first instruments to measure skin temperature differentials (thermography).

Although his interpretation of what he thought he was doing was incorrect, his discovery of using paraspinal skin temperature differentials to monitor the nervous system was quite significant. Today, physiologists such as Guyton inform us that the temperature of the skin is under the direct control of the *sympathetic nervous system*, which regulates the quantity (volume) of blood flowing through the dermis via vascular contraction and dilation. In actual sense then, we can monitor the real-time neurophysiology of the body via the thermodynamics of the dermis.

The discovery of the NCM represented a major contribution to the evolution of the chiropractic practice. At last there was a method to "objectively" (though crudely by today's standards) monitor the effects the subluxation and the adjustment had on the neurophysiology of the body. However, the NCM's use presented a significant obstacle in that it was too dependent upon the memory and interpretive skills of the doctor. The doctor not only had to use extreme care in gliding the instrument over the spine, but also had to simultaneously memorize every deflection of its needle and the exact location of each deflection. At the conclusion of the scan, the doctor would have to transcribe from memory onto recording sheets all of the needle deflections and their locations. It can be easily seen that this information, which was so critical to the care of the patient (the primary indicator for the adjustment), could be erroneously recorded.

This led to the development of the Neurocalograph (NCGH) by Otto Schiernbeck. The NCGH was essentially an NCM hooked up to a recording device that would automatically produce a hard copy readout of all the thermal shifts, totally eliminating the need for memorization and transcription. The NCGH, using vacuum tube technology, was a major technological advancement over the NCM, and was chiefly responsible for establishing the thermal pattern (thermography) as an indicator for the subluxation.

Building on a Good Idea

The success of the NCM/NCGH soon spawned the development of other instruments using similar technology. Three of the most noteworthy were the Nervoscope/Analograph, introduced in the late 1940s, the Thermeter/Thermoscribe, introduced in the 1950s, and the Syncrotherm, which appeared in the 1970s. Both the Analograph and the Thermoscribe were, and still are, thermocouple instruments. The Syncrotherm differed in that it used thermistors (highly sensitive thermocouples) and simultaneously recorded direct separate channel readings of both the right and left sides of the spine onto hard copy readouts. Research on the Syncrotherm was terminated by Canadian Memorial Chiropractic College in the 1970s, while production of the Analograph and Thermoscribe continues today.

Although these thermocouple instruments represent major efforts to quantify and monitor nervous system function, the outdated technology used in these instruments present many significant limitations. The most crucial problem encountered involves the thermodynamics of the thermocouples themselves. When the metallic thermocouple probes are placed on the skin, the colder wires quickly warm toward the temperature of the skin while the skin's temperature is cooled toward the temperature of the metal thermocouples, thus changing the actual skin temperature being read via conduction (adhering to the Zeroth Law of Thermodynamics).

Some doctors attempt to overcome this problem by "seasoning" or acclimating the probes to the patient by allowing the thermocouples to warm on the skin for up to 30 seconds before beginning the scan. Unfortunately, this does not change the immutable laws of thermodynamics (Zeroth). For example, the "acclimated" probes have now reached 88° F and the scan is begun. As the 88° F probes encounter a hotter or colder area of the spine, the contact of the probes will change the actual temperature of the skin, warming the cold area and cooling the hotter area, thus producing a false reading.

Another complication associated with these instruments is that they have the propensity to produce hyperemia. The design of thermocouples necessitate that they be firmly cupped to the skin while the doctor glides the probes along the surface. This produces both friction and discomfort which causes the nervous system to respond reflexively with the production of hyperemia. Any discomfort will also cause the paraspinal musculature to contract or "tense up" in response. The combination of both of these responses can drastically alter the vascularity of the dermis, thus changing the true temperature of the skin and resulting in altered readings. The single problem inherent in the use of thermocouple instruments can be summed up in one word — contact. If contact with the skin could be avoided, none of the problems discussed above would occur.

Infrared Sensor Technology

The use of non-contact paraspinal thermography was ushered in with the advent of infrared (IR) sensor technology. Of historical note, IR technology was not available to our profession until the mid 1950s, as it was classified by the military due to the Korean War. The first use of infrared instrumentation in the chiropractic profession was introduced by Dr. Vernon Pierce in 1963, with the invention of the Dermathermograph (DTG). Since the DTG is only a single-probed direct temperature scanner, and does not measure paraspinal differentials, it does not gather enough thermal data to be classified as a full paraspinal thermography unit.

The initial IR units were crude at best. The sensitivity of the sensors was low and their use in the hairline was prohibited. Today, the newest computerized infrared thermographic (CIT) scanners have taken paraspinal thermography to its highest level, while addressing all of the limitations associated with the thermocouple and early infrared scanners. These state-of-the-art units incorporate extremely sensitive (up to 1/100th of a degree F) and stable IR sensors, fiber optics, travel distance encoders and computer thermal data processing. These new units house their sensors in a solid block of aluminum, which allows them to maintain their peak efficiency throughout each scan.

Since the instrument is also non-invasive (non-contact), it produces no hyperemia, thus making intra- and inter-examiner reliability studies a reality. Additionally, these CIT scanners have the unique ability not only to record thermal differentials (right to left paraspinal thermal asymmetries) on the horizontal scale, but also to record the direct temperatures on the vertical scale (absolute paraspinal temperatures of the right and left independently). Computer thermal processing also allows the doctor to quantify the exact temperatures of all the "breaks," or thermal shifts, within the pattern. These new CIT scanners are also designed to read accurately into the hairline and to the occiput without distortion. Another plus is that these units are extremely easy to use and can be mastered in a clinical setting in about a week. The incorporation of all of the above cutting-edge technology insures that the practicing field doctor can produce accurate, repeatable and valid paraspinal thermographic scans.

Monitoring the Nervous System

As mentioned before, the healthcare field is recognizing the need to monitor the nervous system's function due to its unique role in the maintenance of global bodily function. More than 20 years of research and 6,000 peer reviewed and indexed journal papers have confirmed thermography as a valid diagnostic test of real-time neurophysiology. Within the chiropractic and medical professions, such groups as the AMA Council on Scientific Affairs, the ACA Council on Diagnostic Imaging, the ICA Council on Diagnostic Imaging, the American Academy of Pain Management, the American Academy of Physical Medicine and Rehabilitation, the Congress of Neurological Surgeons, and the American Academy of Head, Neck, Facial Pain and TMJ Orthopedics have all issued policy statements confirming thermography's validity as a diagnostic imaging tool. The medicolegal system allows thermography to be introduced as evidence in court cases, and it is accepted by federal agencies and departments as being valid and useful.

Thermography is used across the United States in such prestigious centers as Johns Hopkins University School of Medicine, Georgetown University School of Medicine, Cedars-Sinai Medical Center and Tulane University, to name a few. Overseas, thermography is used at the Louis Pasteur Institute in Paris, the University of Copenhagen, Verona Italy University Hospital and Yeshiva University Medical School in Tel Aviv. The weight of the evidence indicates that thermography is a valid scientific procedure.

With the increasing costs of running a practice concerning many clinicians today, incorporating thermography into patient care becomes a viable issue. The cost effectiveness of paraspinal infrared thermography is quite evident when compared to telethermography (camera units).

The most important point here is the focus of care. If the clinician is primarily concerned with investigating the spine (CNS and/or immediate PNS) as the cause, then paraspinal IR thermography is all that's needed. Even if a radicular problem presents itself, the extremity dermatome/thermatome will not be thermally positive without the concomitant paraspinal area being positive also.

This becomes significant when the costs of paraspinal IR thermography and telethermography are weighed. The average paraspinal unit costs more than $20,000. This is a very high price to pay if you're primarily concerned with spinal (CNS and/or immediate PNS) causes. Interestingly, paraspinal IR thermography has the unique aspect of actually being more accurate than telethermography. With paraspinal thermography, the actual temperature of the paraspinal skin is recorded at every point that passes under the sensors. Telethermography only displays temperature "zones" on the body which are, therefore, not as accurate as pinpoint temperatures.

With more and more doctors turning to objective diagnostics and results-oriented (outcome-based) care, the need for paraspinal thermography is quickly outweighing cost concerns.

Today, the computerized infrared thermograph (CIT) scanner of the 1990s represents the epitome of research and technology in paraspinal thermography. More than 6.000 peer-reviewed papers in the past 20 years have established computer-aided infrared thermography as the new standard in sub-threshold neurodiagnosis, thus rendering the thermocouple technology of the past obsolete.

If the chiropractic profession is going to continue to stand on its core principle that the subluxation, and its adjustment, does affect the neurophysiology of the body, it becomes absolutely necessary, as responsible clinicians, to monitor its function using the best technology the world has to offer. Through the use of paraspinal thermography, we, as a profession, have the unique opportunity to establish neurophysiological responses as the major factor within the subluxation complex, thus expanding the boundaries of the chiropractic practice beyond aberrant spinal biomechanics to the boundless limits of the nervous system itself.

About the authors: Louis H. Tiscareño, D.C., and William C. Amalu, D.C., are the president and vice president, respectively, of the International Upper Cervical Chiropractic Association. They are both certified chiropractic upper cervical specialists, having completed 160 hours of postgraduate course work. Any questions regarding the application of paraspinal thermography or requests for a list of references for the above article should be directed to Dr. Tiscareño at (510) 757-9200 or Dr. Amalu at (415) 361-8908.

Chiropractic Thermography For Outcomes Measurement of the Vertebral Subluxation Complex

By Glenn Stillwagon, D.C., Ph.C., and Dale Dalesio

Chiropractic thermography provides visual documentation of the patient before and after care, as an outcomes measurement.

Outcomes measurements will become the focus for more doctors in this decade.

With the increased use of "spinal manipulation" by other practitioners, chiropractors must become more effective and efficient in their delivery of health care, so as to remain in a leadership position.

Outcomes measurements will aid doctors in measuring the progress of their patients and the effectiveness of their adjusting procedures. Patients will have the evaluation at the beginning of care, along with their other examinations. On future visits they will be measured using the method of technology choice of the doctor.

The present standard of health care in America is based on treating the patient, and then doctors wait to see what happens. Rarely are outcomes measurements used; that's why our health-care system needs to be fixed.

With today's rapid changes in technology, doctors will begin to use measurements on patients, and they will know whether or not the procedure they are using is getting the desired changes. When positive changes have been made, the results will follow.

THE BIOMECHANIC AND NEUROPATHOLOGICAL PARADIGM

When we consider the two major emphases in chiropractic, biomechanics and neuropathology, we know a new paradigm will develop on the horizon in the health-care delivery system.

Most doctors over the years have observed one aspect of care, the anatomical measurement. They fail to measure the most elusive part of the vertebral subluxation complex, that which is happening in the nerve system of the patient.

Chiropractors work with the skeletal system, attempting to change it to a biomechanic model, or what they think the spine should look like. After they reach that

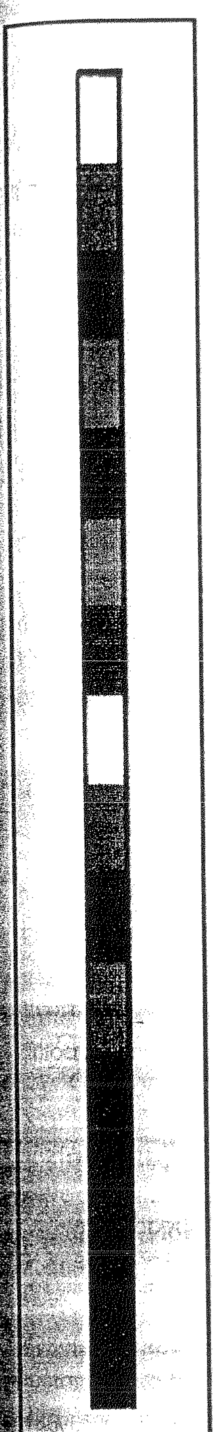

Figure 1: Color Scale - 15 colors, including black background

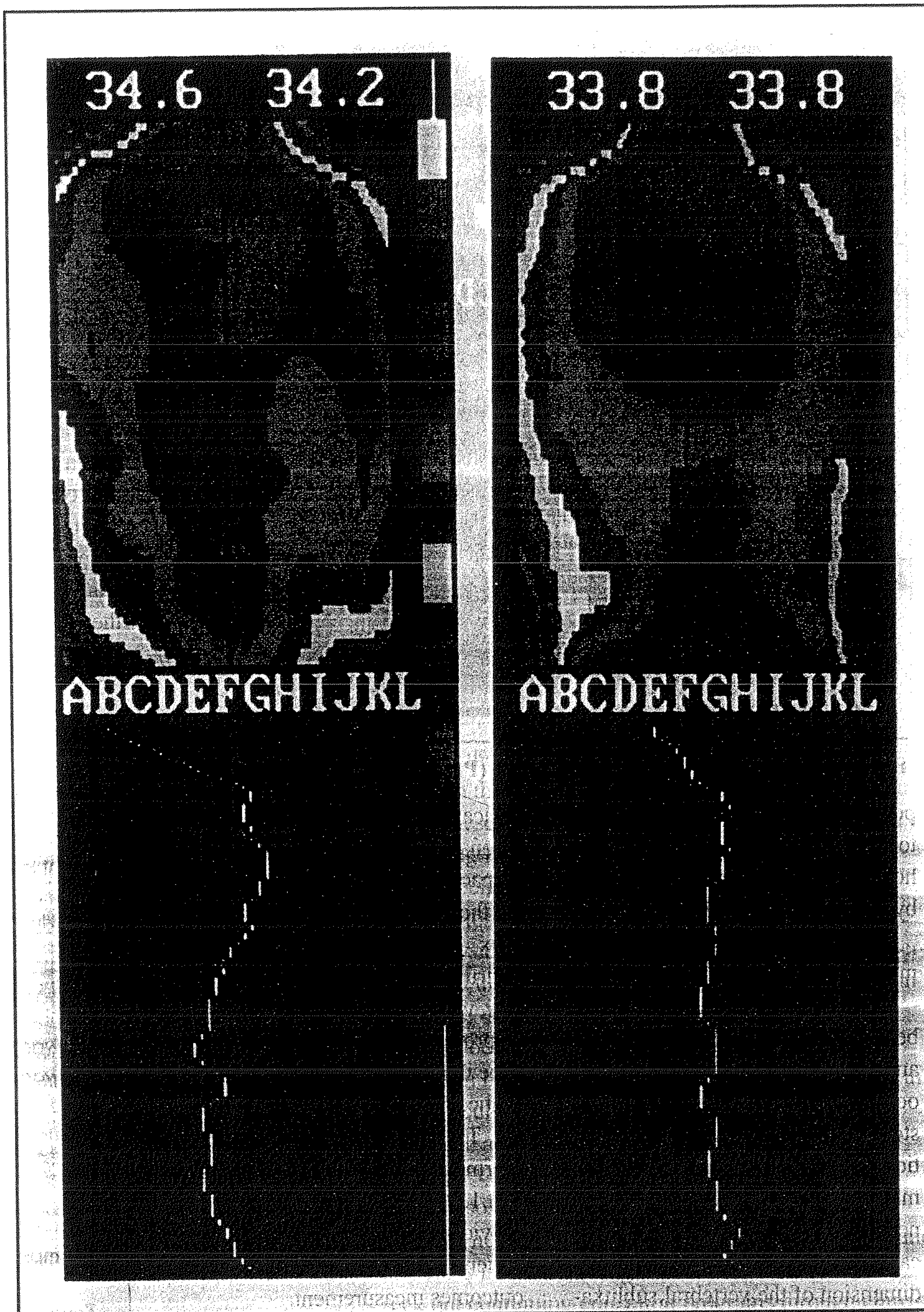

Figure 2: Visi-Therm Thermography Scan (14-second scans)

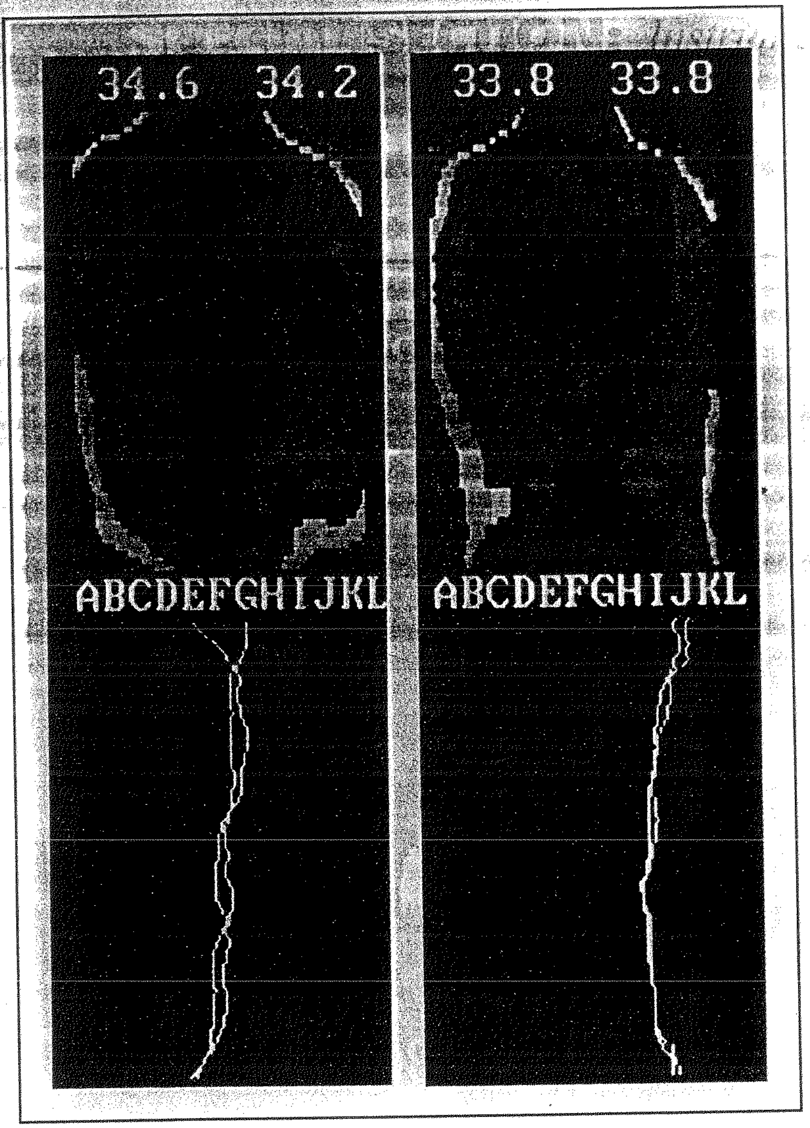

Figure 3: Back Scan - Bilateral Graphs (Pre and Post)

point of structural change, they need to have an outcomes measurement of how the nervous system is affected by those changes.

Chiropractic needs a measurement of anatomy and neuropathology.

Anatomical measurements can be made with X-ray, MRI, motion and static palpation and other methods. That's where most chiropractors stop. They fail to use instrumentation or chiropractic thermography to measure what is happening to the nerve system. Anatomical studies cannot show the nerve system dimension of the vertebral subluxation complex.

The doctor of the future will be educated as to the value and necessity on outcomes measurement of the impact a chiropractic adjustment has on the vertebral subluxation complex. The doctor who is not using instrumentation, such as thermography, will not be able to document improved results on patients, whether it be musculoskeletal or viscerosomatic.

The technology of chiropractic thermography is helpful in two ways:

1. Chiropractic thermography provides visual documentation of the patient before and after care, as an outcomes measurement.

2. Because it is visual, it also becomes a very effective method in patient education. The patient will be able to see the need for care before the doctor does anything. Follow-up thermograms will also reveal how well the problem is being corrected. This is probably of most value to many doctors and patients.

Efficient case management is obtained when you know your procedures are effective and the patient can "see" the results.

The old adage, "Let's try this and see how you feel," is replaced with objective scientific documentation.

PRACTICALITY OF CHIROPRACTIC THERMOGRAPHY TO PATIENTS

Most doctors don't realize it, but they and their patients are already reading similar technology on CNN and other network weather reports, when they observe the color weather maps of the U.S. or other parts of the world. You don't have to wait until the reporter points out the weather

CASE HISTORY

27-Year-Old Female

Auto Accident:
Neck and shoulder pain
Right leg pain
Numbness and tingling of both hands

Chiropractic Adjustments:
Right Positive Ilium
Forward motion headpiece - C5
Forward motion headpiece - C6
One Atlas - Palmer Toggle Adjustment
Pelvic corrections

Pierce-Stillwagon Technique (PST)
Thompson Table

Total Care:
8 months

patterns, you already know where the hurricane, the snow and the rain are.

Thermal patterns, by color, can also be viewed on the human body, when you have the equipment to measure it. Now, you and your patient will be able to see when they need care, when there is trouble and when it is corrected.

Chiropractic is lagging behind in using this technology. Chiropractors continue to tell anecdotal stories and extol tales about the wonders of chiropractic, but they lack the visual proof of what is happening with the nerve system. You've heard most of the stories over and over again. However, when you ask the doctor for documentation of their results, they have none.

No wonder the scientific community, the decision makers and the public look at chiropractors as "bone doctors." We haven't educated them as to the fact that chiropractors work with the nerve system.

Is chiropractic ready to take up the challenge?

Is chiropractic ready to give visual proof of what we do?

Or, are we going to let more time go by and let someone else do it and claim that they found something new?

It's time for chiropractors to take this new technology, apply it to what we do, establish the proof of what we do to the nerve system and claim it for chiropractic.

Even though many chiropractic thermographers are seeing these results in their offices every day, why isn't it growing faster?

We believe there are two reasons for this:

1. Most doctors in the field were never taught the neurophysiology behind the relationship of skin temperature and the vertebral subluxation complex, so we can't blame the doctor for that.

2. Doctors tell us they decided not to use instrumentation because, even though instrumentation was in the curriculum, their instructors didn't seem to know that much about it and didn't use it in their own practice.

The solutions to these two problems are obvious. Colleges need to provide this technology to students and clinicians in their training. Field doctors will need to seek out continuing education programs through chiropractic colleges and learn it on their own. Doctors, who have already graduated, need to look at these issues and

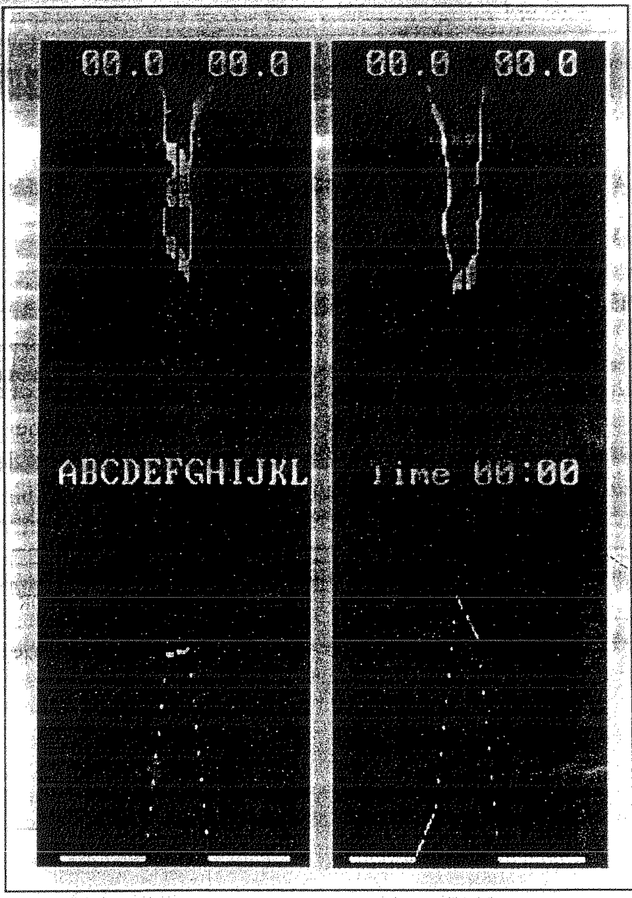

Figure 4: Back Scan - Segmental Graphs (Pre and Post)

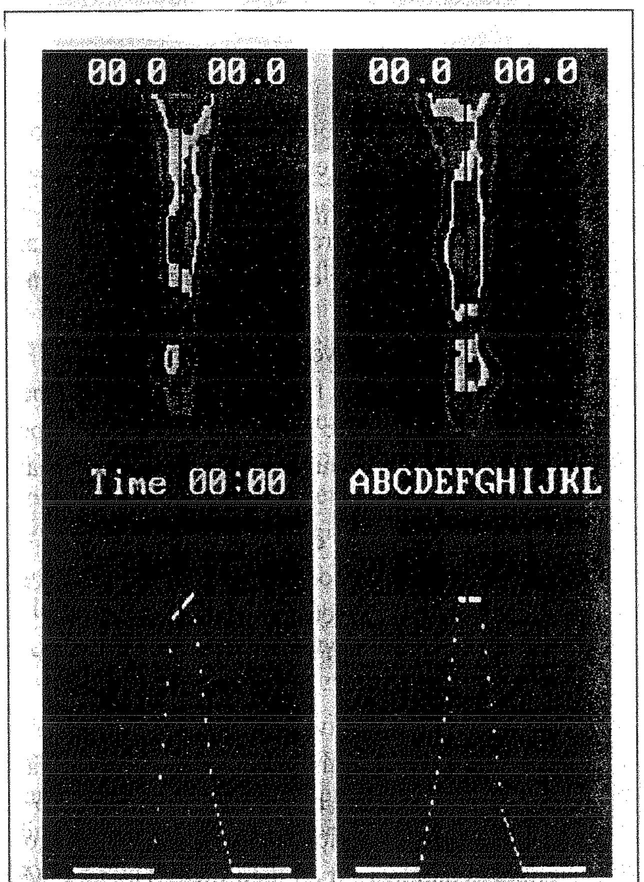

Figure 5: Posterior Arm Scans - Horizontal Graphs (Pre)

take the action steps necessary to address the problem.

The following overview of Visi-Therm chiropractic thermography will help you to understand what has been done over the past years in research.

On Figure 1, there are 15 different colors in the color scale viewed on the screen. Warmer temperatures are at the top of the scale, and cooler temperatures are at the bottom.

The objective of the chiropractic thermographer, during case management, is to maintain a balance in temperature of less than 0.5° C from one side of the body to the other.

In traditional medical thermography, the following statistics indicate the importance of surface temperature in disease:

Extensive research involving several thousand patients has suggested the following data concerning abnormal studies (research conducted by George E. Chapman, D.C. of Clinical Thermography Associates, Chula Vista, Calif.).

Standard Deviation	Temperature	Percent Correlated With Pathology
1	0.3°C	18%
2	0.6°C	64%
3	0.9°C	92%
4	1.2°C	96%

California Thermographic Society Basic Thermographic Manual, page 17.

The chiropractic adjustment can, and will, affect the microcirculation of the skin. Three possible conditions can occur during correction of vertebral subluxation complex:

1. The thermogram will stay the same. In this case, no neurologic correction has been made.
2. Asymmetry of the thermogram will get worse. This indicates that the adjustment did not correct the problem.
3. The thermogram will improve. Your analysis was correct and you have made the proper correction for that visit.

Chiropractic thermography can be used with any technique. It is non-invasive, and there are no contraindications to its use. Regardless of the adjusting technique or examination procedure, the doctor will be able to measure the accuracy of their findings with proper instrumentation. We need to be as precise as possible, because the patient's

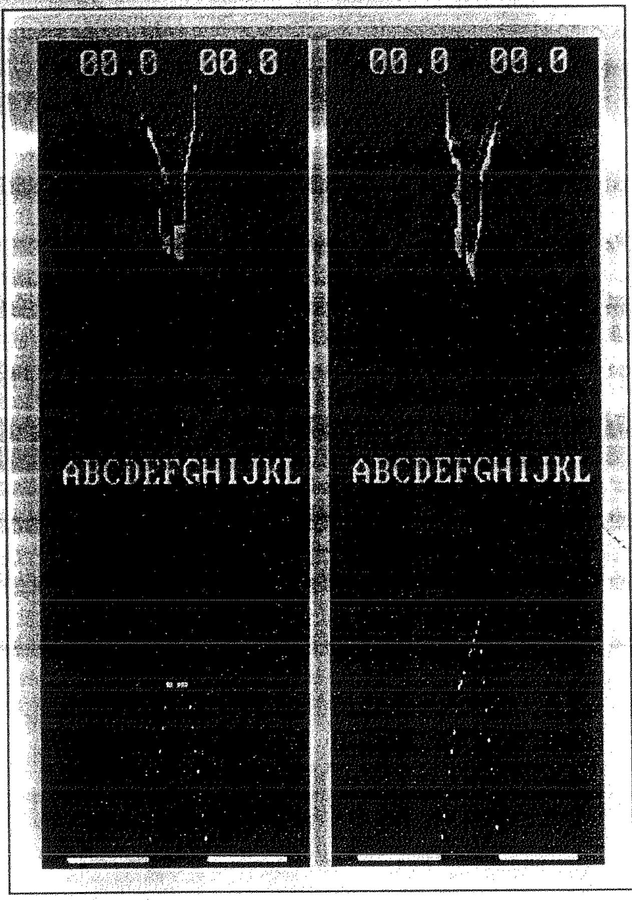

Figure 6: Posterior Arm Scans - Horizontal Graphs (Post)

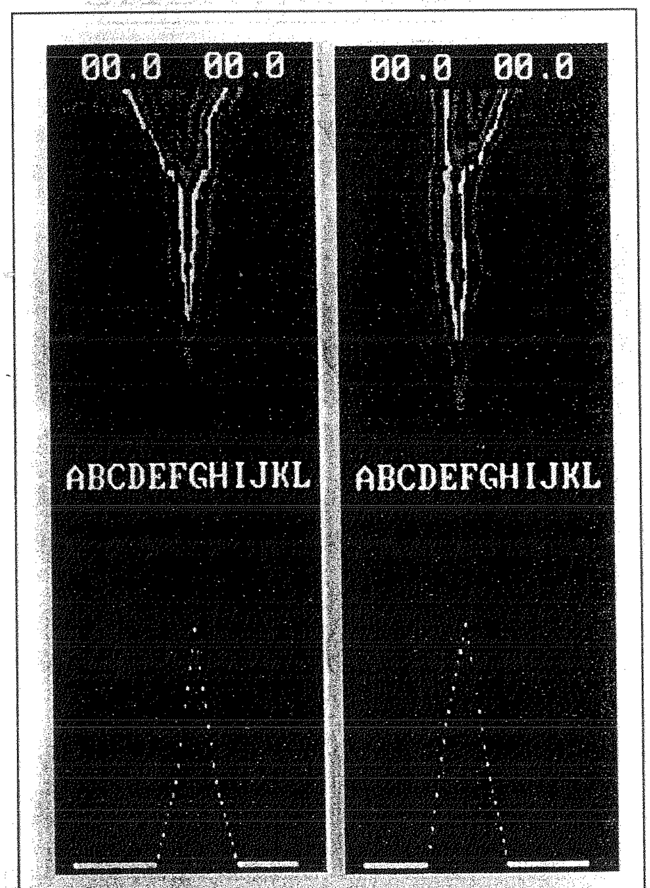

Figure 7: Medial Arm Scans - Horizontal Graphs (Pre)

health depends on it.

While monitoring progress of the patient, the doctor and the patient will see visual evidence of correction of the vertebral subluxation complex. Now the responsibility is on the doctor. You must correct the problem, or the patient will see it.

Statistics in thousands of cases have established that temperatures 0.4°C and greater are found in disease conditions.

In chiropractic thermography, the objective of the chiropractor is to keep the surface temperature less than 0.5°C, from one side of the body to the other.

The Visi-Therm chiropractic thermography system is used as an outcomes measurement assessment before and after the chiropractic adjustment.

To follow the effects of the VSC throughout the body, thermograms can be taken of the extremities to show the temperature differential of dermatomal patterns as seen in circulatory disturbances, RSD, etc.

Thermography is a fast procedure to determine whether to adjust or not to adjust. Clinical experience shows that patients do not have to be adjusted on every visit.

Patient improvement is better when the adjustment is only given when necessary. Dr. B.J. Palmer tried to teach this important point to the chiropractic profession in his years at the B.J. Palmer Research Clinic.

The evidence of chiropractic thermography can be seen in pre- and post-case histories. The case history described in the sidebar article is evidence of the impact of chiropractic adjustments of vertebral subluxation complex.

Note: More examples of pre and post thermograms with case histories can be seen on our web site at http://www.stillwagon.com.

About the authors: Glenn Stillwagon, D.C., is a member of the extension faculty at Palmer College of Chiropractic, Life University, Life Chiropractic College West and New York Chiropractic College. A recipient of the D.D. Palmer Scientific Award, he and Palmer College classmate Dr. Walter V. Pierce began research and development of the Pierce-Stillwagon Technique in 1963. Dale Dalesio, product manager for Visi-Therm Electronic Thermography, is an electronic engineer who has been involved with chiropractic thermography for over 11 years. Inquiries should be directed to them at 767 Dry Run Road, Monongahela, PA 15063; call (412) 258-6553; fax (412) 258-5611; or E-mail to info@stillwagon.com.

What Constitutes Clinical Thermography?

There are several parameters which a device must meet to qualify as a clinical thermographic device.

By Howard L. Silverman, Ph.D., D.C.

THERE STILL APPEARS to be a lot of debate as to what constitutes billable, valid, clinical thermography. Part of the problem revolves around the question of the difference between a thermographic device and a thermometric device. Another part of the problem is the fallacious belief that all thermographic devices are capable of performing valid clinical thermographic studies.

The next part of the problem is the false belief that if a device is capable of performing valid clinical thermographic studies, then all studies performed with that device constitute valid clinical thermographic studies. Once these are dealt with, there is the final erroneous belief that the performance of a valid clinical thermographic study means, automatically, that it was clinically necessary and reimbursable.

DEFINING CLINICAL PARAMETERS

First, from a scientific perspective, all thermographic devices are thermometric devices. However, the reverse is not true. A thermographic device is simply a thermometric device which maps temperatures, usually surface temperatures, onto the surface of a display device and utilizes either a gray scale or color hues to represent temperature gradations.

Next, is the question of whether the thermographic device is capable of performing a valid clinical thermographic study. There are several parameters which a device must meet to qualify as a clinical thermographic device. It must have adequate spatial resolution, temperature resolution and temperature stability and must be able to reproducibly scan a reasonable surface area in a single pass and it must scan without significant gaps in the areas being imaged. In other words, without a chance that parts of the region could be missed.

Spatial resolution is typically not a problem in clinical thermography, unless the resolution is directionally dependent. This could occur with a manual scanning device, if the sensors were placed too far apart. Myofascial trigger point activity involves typically the smallest areas which have to be imaged for diagnostic clinical purposes. Therefore, any unit capable of repeatedly imaging them, whether one suspects that they are there or not, has at least the minimum special resolution.

In terms of temperature, the unit must be able to measure to within one degree Celsius, with no more than a quarter of a degree Celsius error. This amount of error would require a no less than a 4:1 signal-to-noise ratio for the device. Temperature drift less than 1 degree Celsius per hour would be required.

Because clinical thermographic studies involve differential temperature comparisons of either one region of the body with the same region on the contralateral side, or a small region of the body with its surrounding region, it is temperature drift, not the absolute temperature, which is the relevant parameter.

A reasonable surface area would be considered to be that which a pillow type of liquid crystal thermographic device could image. While some people study the carotid arteries using thermography and others have studied the female cervix, these are not typical regions on which to formulate criteria.

In general, a minimal reasonable surface would be considered to be the lateral thigh of an obese patient, to the extent that it could be imaged on a liquid crystal pillow type of device. If an electronic device cannot do this entire region in a single pass, then the validity of conclusions based on studies performed on this surface, with such a device, would be considered to be highly questionable.

The reason that the surface has to be scanned in a single pass is because of the problem of registration of image segments formed by consecutive scans, should the device have to be physically moved to produce the scan or to position it for the second or third pass. Devices which touch the skin have even more problems, in that they interact with the skin and could theoretically distort the temperature profile, if multiple parallel scans are required.

Most doctors who bill inappropriately for thermographic services have not fully understood what constitutes a billable clinically diagnostic thermographic study.

Even if a reasonable surface area can be scanned in a single pass, then there is the question as to whether there are any gaps in the scan. This could occur when an electronically scanned array of sensors is utilized. The sensors have to be close enough together so that a small trigger point could not be missed during the scan. In other words, the surface must be adequately imaged.

An instrument with an insufficient number of sensors, or with sensors several inches apart, does not meet the above criteria. A number of years ago, I was asked by one of our national associations to evaluate the Visi-Therm device, as there were questions as to whether it could be used for clinical thermographic purposes.

I personally tested the device and concluded that it did meet the minimum criteria, and that it could be utilized for clinical thermographic purposes. I don't think that anything with less functionality then the Visi-Therm could be adequately used for general clinical purposes, and I don't think that the Visi-Therm is the ideal unit, but it is minimally adequate for these purposes.

PURPOSE OF A THERMOGRAPHIC SCAN

The fact that a thermographic device can be used to perform clinical studies does not mean that the studies performed, using the device, are automatically defined to be clinical studies. Clinical thermographic studies are studies which can be used to formulate a clinical diagnosis of high reliability.

The main diagnostic categories for clinical thermography are nerve fiber irritation, radiculitis, nerve entrapment syndromes, significant vasomotor instability and reflex sympathetic dystrophy syndrome (complex regional pain syndrome).

Myofascial trigger point activity can usually be detected by palpation in conjunction with a pain pattern analysis, and while it would be a valid clinical finding, it would not typically be the primary reason for performing a clinical diagnostic study.

While subluxations, in the chiropractic sense, would also be expected to be reflected in thermographic abnormalities, for thermographic purposes they would be considered to be subclinical conditions until they progressed to the point that they were associated with significant clinical manifestations — in other words, significant nerve fiber irritation.

Let's take as an example a scan of the spine using any clinical thermal device. Various temperature gradients will be noted, but their clinical significance will not necessarily be obvious. For clinical nerve fiber irritation to be diagnosed, at least 25 percent of the nerve path would have to be involved, and the involvement would not necessarily be expected to be continuous. Therefore, for thoracic nerve fiber irritation to be diagnosed or ruled out, not only posterior scans, but lateral and anterior scans would have to be performed.

Lumbar views would not typically be adequate by themselves, but would require additional scans down through the toes to constitute a valid clinical study. Likewise, cervical views would require additional scans down through the fingers to constitute a valid clinical study.

In addition, it is not just one thermatome which has to be scanned, but adjacent thermatomes would need to also be simultaneously scanned to help differentiate between peripheral neurological, general sympathetic, local myofascial, referred myofascial and referred or local sclerotogenous activity.

Assuming that the correct protocol had been followed, and that a valid clinical diagnostic thermographic study had been performed, there is still the question of clinical necessity.

The questions which need to be addressed are the same as those for any other type of clinical study. Documentary studies and general screening studies are generally not considered to be clinically necessary.

The questions which need to be answered are:

1. Why was the clinical study performed? What was suspected? Why was it suspected and was it found? Is the suspected condition significant in the clinical sense?

2. Would there have been a significant change in care protocol if the study had been positive or negative for the suspected condition? Was the protocol after the study congruent with the findings of the study?

3. Could this clinical information have been adequately obtained by other means, or was this the most effective way of obtaining this information?

4. Was the level of the information obtained actually required for the care of this patient or was it more than was needed?

5. Could the patient have been adequately cared for without this information? Would there have been any significant risks to the patient had the study not been performed? If so, what were they?

6. Would a doctor using a different adjusting technique not have felt the need for this study?

7. Would a typical doctor have felt confident in caring for this case without this study?

8. Why was this case so different from other similar cases that the study was mandatory

> ***The fact that a thermographic device can be used to perform clinical studies does not mean that the studies performed, using the device, are automatically defined to be clinical studies.***

the time it was performed, for this patient?

Unless these questions are adequately answered in the case documentation, or unless the answers are obvious to the average doctor across the country, the study would not be considered to be clinically necessary.

MEETING REIMBURSEMENT REQUIREMENTS

The CPT codes which are used to bill for thermographic services are referencing clinical diagnostic services. As indicated, an image on a screen is only the first step in meeting the criteria for such services.

For a clinical diagnostic study to be considered for reimbursement, a detailed report of findings will need to accompany the bill for those services. The report should include a patient-specific statement of the study's necessity, statements referencing the protocol utilized, the specific thermographic findings, the diagnostic conclusions, other possible correlative findings or considerations and case-specific care protocol recommendations.

Many doctors who are using thermographic devices are billing for diagnostic clinical thermographic services, and they do not understand why their studies are being questioned and why they are not getting reimbursed. Other doctors are questioning the ethics of billing for these services.

I seriously believe that most doctors who bill inappropriately for thermographic services have not fully understood what constitutes a billable clinically diagnostic thermographic study. I would like to think that it is a matter of a lack of understanding of the subject, rather than a problem with ethics.

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Part I of II

The Pierce-Stillwagon Technique: Procedures and Analysis

The Pierce-Stillwagon Technique correlates with X-ray analysis, instrumentation and other physical findings to eliminate guess-work from case management.

By Glenn Stillwagon, D.C., and Kevin Stillwagon, D.C.

THE TECHNIQUE DEMONSTRATED in this article represents the culmination of a precise examination and care procedure which is uniquely chiropractic.

The Pierce-Stillwagon Technique is a system of analyzing and adjusting the spine that combines previously understood concepts with a very simplified, logical and effective procedure. It is a full-spine technique that requires the use of a hi-lo table with drop pelvic and cervical pads.

The Pierce-Stillwagon Technique, as described here, is easily and quickly learned and applied, correlating with X-ray analysis, instrumentation and other physical findings to eliminate guesswork from case management.

X-RAY PROCEDURES

Unless contraindicated by pregnancy or other factors, as soon as it is determined that a new patient is a chiropractic case, the D.C. should take the following four X-rays, all in the standing position:

A-P open mouth (8 x 10): This film is taken with the patient in the standing position and the mouth open wide. The tube is locked in at 36" or 40," and tilted cephalad so that the central ray travels through the lower one-third of the open mouth, through the level of the atlas transverse processes, and strikes the center of the film.

Lateral cervical (10 x 12) or (8 x 10): We prefer 10 x 12 film for this view. The tube should be locked in at 72" focal film distance (FFD) with no tilt. The patient is instructed to stand in a normal, relaxed position, looking straight ahead, with the shoes off and the right or left shoulder against the bucky. Turn on the collimator light and raise or lower the tube (no tilt) until the central ray strikes the level of C5. Instruct the patient to move forward to backward as necessary to bring the body of C5 to the approximate center of the film. Then, raise or lower the bucky until the central ray strikes the center of the film.

Note: Extreme care must be taken to make sure the head is not flexed or extended, because it has been shown on X-ray that flexing or extending the head just a couple of degrees can dramatically affect the appearance of the cervical curve. Also, be sure the shoulders are relaxed and the chin is not tucked in, for these factors also affect the cervical curve.

A-P full spine (14 x 36): It is imperative that the view of the pelvis be taken correctly. Preferably, you will take an A-P 14 x 36 full-spine film, however, a 14 x 17 film can be used, but *only* in the manner described below.

Patient placement: The patient is instructed to stand in a normal, relaxed position with shoes off and feet approximately four inches apart. Mask off a line on the floor that is in alignment with the longitudinal center line of the bucky, so that the patient can stand with the feet two inches on each side of the line. The bottom of the cassette (14 x 36 or 14 x 17) should be approximately one inch below the inferior aspects of the ischia, with the buttocks lightly touching the bucky.

The patient should not be leaning backwards against the bucky; however, he should be touching it enough to prevent body movement at time of exposure. The doctor should *not* attempt to square the patient's shoulders or move the head into the center of the film, for we want the patient in his/her normal standing position. As the doctor gains experience, it will become obvious when the patient is assuming an unnatural posture in an attempt to please while being positioned.

Tube distance: The FFD should be 72," 76" or 84." This applies to 14 x 17, as well as 14 x 36 films.

Central ray: For 14 x 36 film, central ray to center of film, no tube tilt; for 14 x 17 film, central ray to top of cassette, no tube tilt. Then lock the tube so it will not move up or down. Tilt the tube down so the central ray strikes the center of the film. Collimate to the 14 x 17 film.

Lateral full-spine (14 x 36): It is advisable to take either a lateral full-spine film or at least a lateral lumbar film to rule out pathology, check the extent of the lumbar curve and note the relationship of the sacrum to the ilia and lumbar spine.

The cervical spine on the lateral full-spine film will usually appear less lordotic or more kyphotic compared to the lateral cervical 8 x 10 or 10 x 12 film. This is because the arms will be positioned in front of the chest on the lateral full-spine film, changing the muscular tension and therefore positions of the neck and shoulder area.

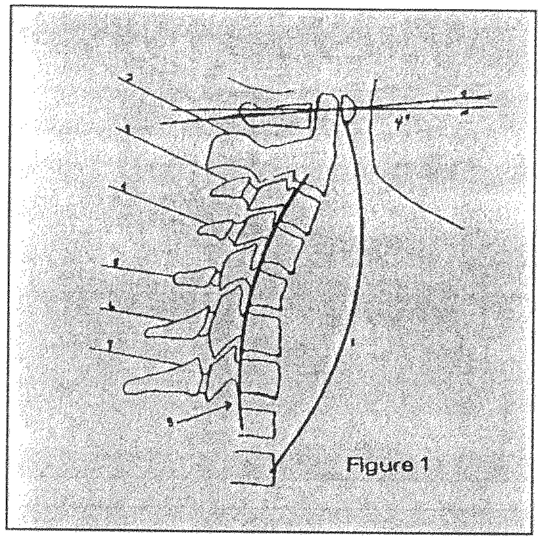


Figure 1

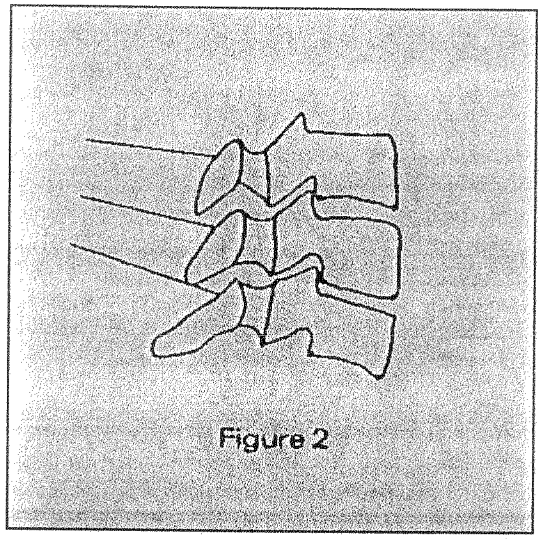


Figure 2

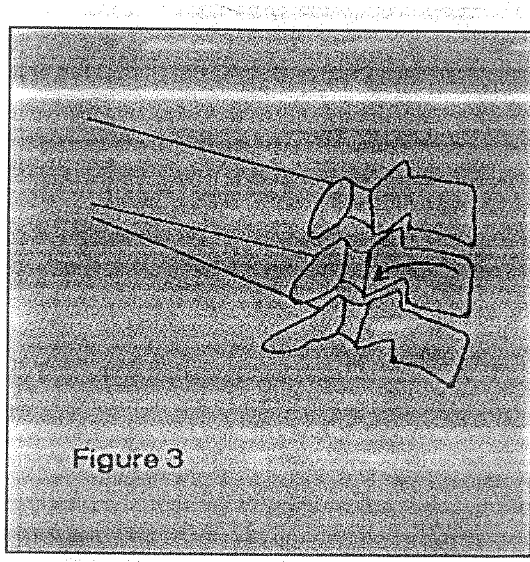
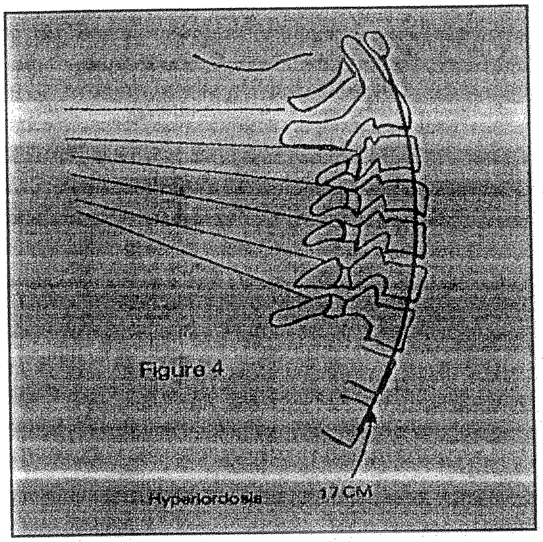
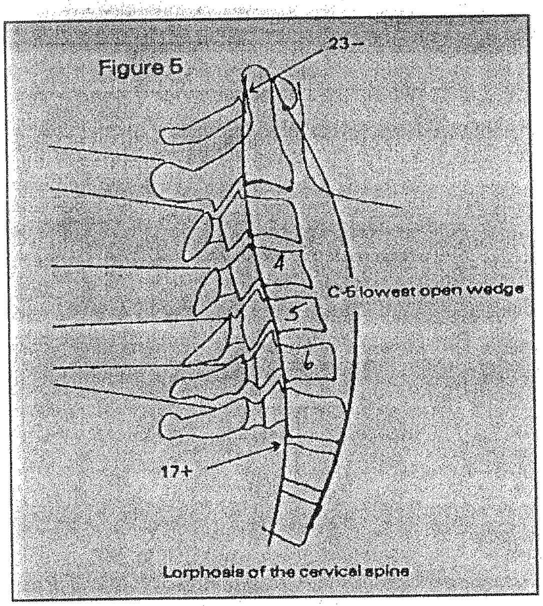
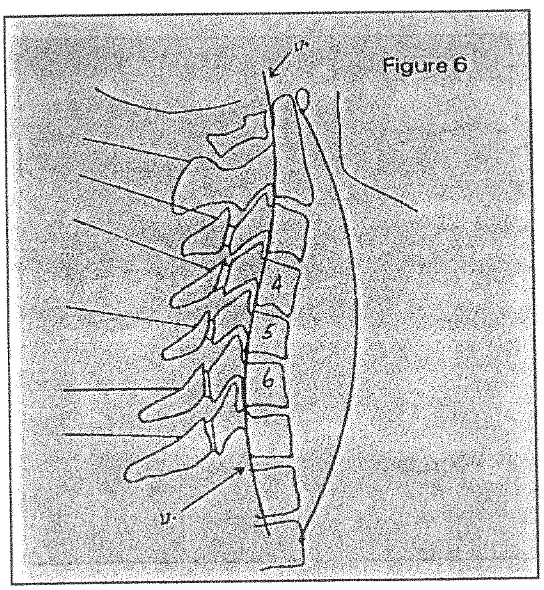


Figure 3







X-RAY ANALYSIS

The first step in analyzing these films is simply to make an on-the-spot visual scan to assess the general situation, determine the ilium misalignment and the side of Logan Basic contact. Immediately after this visual appraisal of the films, the doctor proceeds with the first adjustment or adjustments. Later, a more complete analysis of the films can be made.

The A-P open-mouth view may be analyzed to determine laterality and rotation of the cervical segments using any method with which the doctor is familiar.

To properly analyze the lateral cervical film, you will need a parallel, a protractor and an acu-arc ruler. The ruler enables us to measure the radius of the cervical curve from a maximum of infinity (straight line) to a minimum of 17 cm.

Figure 1 illustrates a completed analysis of a typical film. Line 1 connects the posterior inferior aspect of the anterior arch of atlas with the mid-anterior border of the body of T2. This curve is drawn with a 17 cm radius and is strictly a visual aid for the patient. Lines 2-7 are drawn parallel to the inferior vertebral plates of C2-C7 to determine which of C3-C7 are posterior and inferior. Line 8, or George's line, is drawn along the posterior border of the vertebral bodies. The radius of the cervical curve is measured here and is listed as a positive number if lordotic, and as a negative number if the

> ***The first step in analyzing the X-ray films is simply to make an on-the-spot visual scan to assess the general situation, determine the ilium misalignment and the side of Logan Basic contact.***

curve is kyphotic. This line is used to demonstrate changes made from pre-film to post-film. Line 9 is drawn through the longitudinal plane of the atlas. Line 10 is drawn parallel to the floor. The angle between lines 9 and 10 is used to determine superiority or inferiority of atlas.

The acu-arc ruler gives us an accurate determination of progressive changes from any loss of the normal anterior convexity viewed on the lateral cervical projection. This includes extremes of the cervical kyphosis and the military cervical spine. We can now measure these variations as the chiropractic adjustment begins to move the cervical spine into the normal range.

There are several factors which affect the amount of cervical curve present, including vertebral subluxations, facet angles, pedicle sizes, heights of the articular pillars and sizes of the facet articular surfaces. When the subluxations are corrected, the cervical curve should begin to move into a more normal range, provided the factors just mentioned will allow a correction. In other words, a hypolordosis may be normal in some patients.

Our research at the Stillwagon Chiropractic Offices has established an acceptable range of the cervical curve in the adult. It extends from 17 cm radius to 30 cm radius of curve, provided all wedge lines are closing to the posterior. This range does not apply in children. Because of the decreased linear distance from atlas to T2 (smaller neck), most children will normally have a curve with a radius slightly less than 17 cm. Figure 2 shows the cervical segments in alignment, with the wedge lines closing at the posterior.

When a cervical segment subluxates to the posterior, it also moves to the inferior, due to the articulation at the facets (pre and post zygapophysis). This is a bidirectional movement and will cause an opening of the wedge lines projected to the posterior. In Figure 3 the opening of the wedge is caused by the bidirectional movement of the involved segment marked with an arrow.

Open wedges may occur at more than one level. When such conditions are found, the level of involvement is the lowest segment with an open wedge. Example: If open wedges occur at O3, O4 and O5, adjust O5. If open wedges occur at O4,

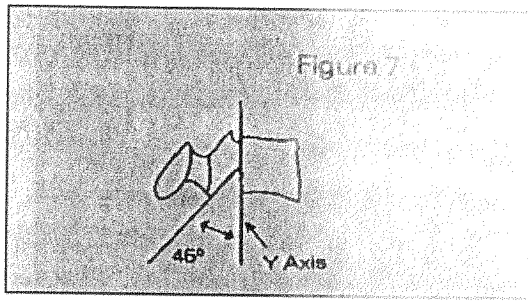


Figure 7

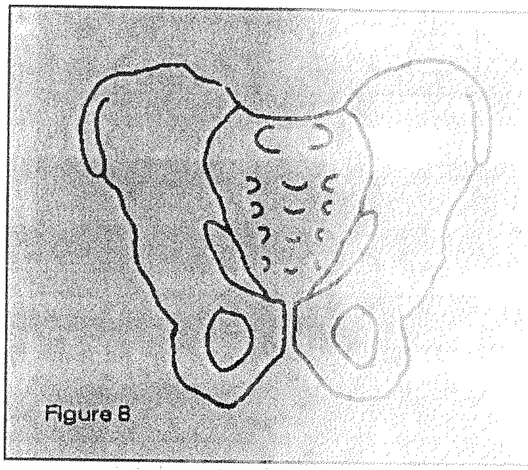


Figure 8

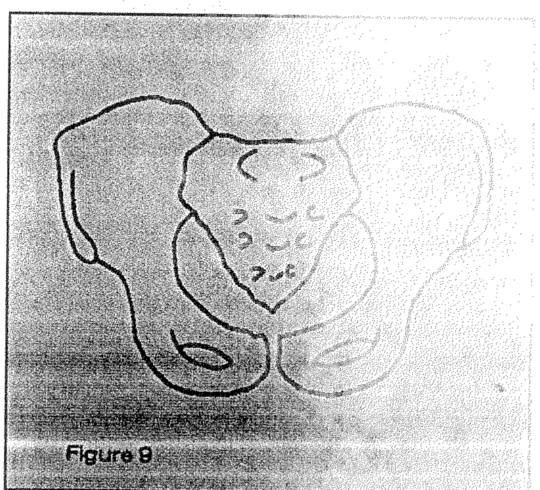


Figure 9

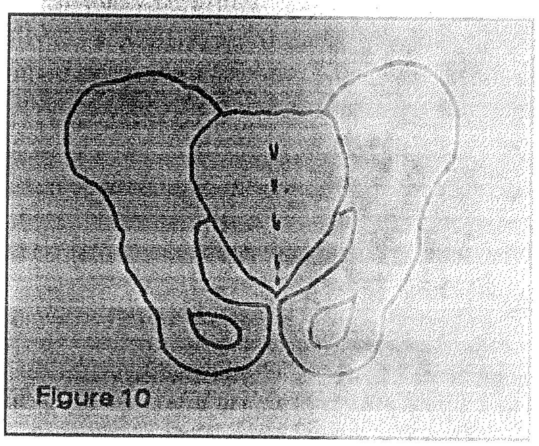


Figure 10

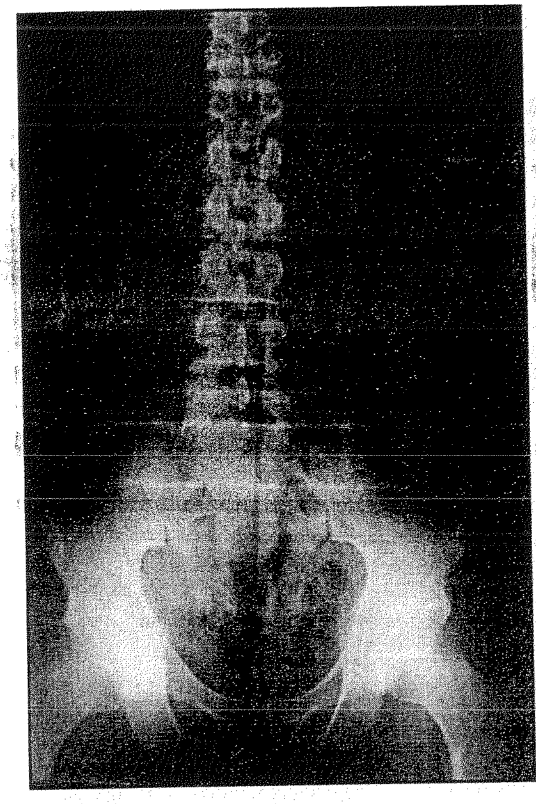


Figure 11

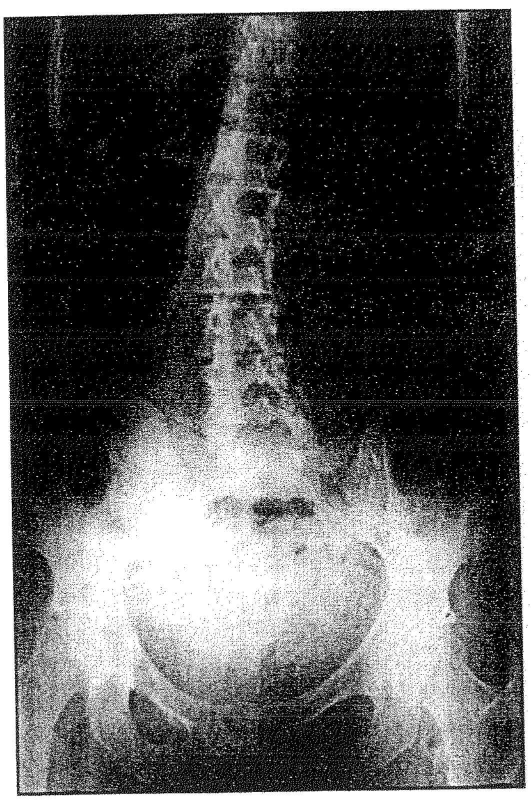


Figure 12

O5 and O6, adjust C6.

On pre X-ray examination, using the open-wedge rule on the lateral cervical films of 1,000 cases, the levels of involvement from C3 through C7 occurred in the following percentages:

No wedges	12%
C3	4%
C4	11%
C5	36.5%
C6	26%
C7	5%
Hyperlordosis	5.5%

The acu-arc ruler gives us an accurate method of determining hyperlordosis of the cervical spine. This condition is present when the anterior portions of the cervical bodies project forward of the 17 cm curve line (see Figure 4). A hyperlordotic cervical curve will have a measurement less than 17 cm radius of curve. A hypolordotic curve will have a measurement greater than 30 cm.

It is not uncommon to find cases with lorphosis of the cervical spine. Lorphosis is seen on the lateral cervical film as a double curvature with an anterior convexity and a posterior convexity. Figure 5 shows an anterior convexity in the lower cervical spine and a posterior convexity in the upper cervical spine. The lorphotic cervical spine in Figure 6 has a superior lordosis and an inferior kyphosis.

In the cervical spine, the inclination or angle of the facet joint plane is approximately 450 to the Y axis (vertical line along the posterior border of the vertebral body). (See Figure 7.) It must be emphasized that these inclinations are only approximate. There are variations within the levels of the cervical spine of the same patient, and of course between different individuals. White and Panjabi in *Clinical Biomechanics of the Spine* state "... these orientations are only approximate. We do not know of any studies where precise measurements have been made."

X-RAY PROCEDURES/ PELVIC ANALYSIS

The analysis of the pelvis from the A-P full-spine X-ray is strictly visual. There are no lines to draw or measurements to make. However, a gravitational center line on the A-P 14 x 36 film can be a valuable visual aid for the patient. This center line should be drawn from the second sacral tubercle to the top of the film, and a transparent nerve chart can overlay this, impressing on the patient that the doctor is working with nerves.

Explain to the patient that you are not attempting to make his/her spine perfectly straight. You are working to get the spine into a gravitational center, which involves positioning the center of the foramen magnum directly above the center of the sacrum.

As you view the pelvis on X-ray, consider the following points in this order:

- The size and shape of the pelvic opening as compared to that of a pelvis in normal alignment. The pelvic opening is heart-shaped and symmetrical when normally aligned.
- The sizes and shapes of the obturator foramina as compared to those of a pelvis in normal alignment. Normally, the obturators are almond-shaped and of equal size.
- The width of the ala of one ilium compared to the other. In a normally aligned pelvis, they are approximately the same width.

X-RAY LISTINGS

Your pelvis listing (taken from X-ray) will indicate the direction that one or both of the posterior superior iliac spines (PSS's) have moved from their normal position in space. The pelvic listings for this technique do not necessarily describe a misalignment of the PSS relative to the sacrum! Herein lies the uniqueness of our system: The entire pelvis structure can misalign as a unit, leaving the sacroiliac joints intact. This is called a bilateral misalignment.

There are two bilateral pelvic misalignments possible:

Bilateral PI: Both PSS's have moved PI (posterior and inferior) from their normal position in space (see Figure 8).

The analysis of the pelvis from the A-P full spine X-ray is strictly visual. There are no lines to draw or measurements to make. However, a gravitational center line can be a valuable visual aid for the patient.

Bilateral AS: Both PSS's have moved AS (anterior and superior) from their normal position in space (see Figure 9).

When a PI or AS occurs unilaterally, one side of the pelvis will appear normal, and the other side will demonstrate the characteristics of a PI or AS. Obviously, one of the SI joints must be disrupted for this to occur. However, the disrupted SI joint could be on either side, therefore the listing PI or AS cannot always describe a sacroiliac misalignment on the side of PI or AS as seen on X-ray. The listings PI and AS describe the direction the PSS has moved in relation to its normal position in space; the listings are not intended to describe a misalignment between the PSS and the sacrum.

Example: Look at Figure 10. The right ilium has moved PI from its normal position in space. If the sacrum followed the right ilium, the disrupted SI joint is on the left, and the right ilium is not PI in relation to the sacrum. If on the other hand, the sacrum did not follow the right ilium, the disrupted SI joint is on the right, and the right ilium is PI in relation to the sacrum.

You cannot tell which condition exists by looking on the X-ray. This is done by performing a spine-in-motion study.

Refer to Figures 11 and 12 to see the IN and EX misalignments.

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About the authors: Glenn Stillwagon, D.C., is a member of the extension faculty at Palmer College of Chiropractic, Life University, Life Chiropractic College West and New York Chiropractic College. A recipient of the D. D. Palmer Scientific Award, he and Palmer College classmate Dr. Walter V. Pierce began research and development of the Pierce-Stillwagon Technique in 1963. A noted seminar and convention lecturer, he may be contacted at (412) 258-6506 or (412) 258-6553 and by E-mail at drglenn@stillwagon.com. The Stillwagon Seminars website address is www.stillwagon.com. Kevin Stillwagon, D.C., a 1979 Palmer College graduate and co-valedictorian, has co-authored several articles with the senior Dr. Stillwagon.

Part II of II

The Pierce-Stillwagon Technique: Procedures and Analysis

Just because one exhibits symptoms does not necessarily mean an adjustment is required. This is where instrumentation becomes most valuable — it can help the doctor know when not to adjust.

By Glenn Stillwagon, D.C., and Kevin Stillwagon, D.C.

IN THE FINAL PART OF THIS article, instrumentation analysis and care procedures for the Pierce-Stillwagon Technique are examined.

The technique is a system of analyzing and adjusting the spine that combines previously understood concepts with a very simplified, logical and effective procedure. It is a full-spine technique that requires the use of a hi-lo table with drop pelvic and cervical pads.

The Pierce-Stillwagon Technique, as described, is easily and quickly learned and applied, correlating with X-ray analysis, instrumentation and other physical findings to eliminate guesswork from case management.

INSTRUMENTATION

Outcomes measurements using instrumentation and thermography are reliable methods of monitoring patient reaction to the adjustment immediately, not days later.

If the doctor relies on the patient's symptoms as a monitor of the adjustment, he/she can easily fall into the habit of overadjusting. Just because one exhibits symptoms does not necessarily mean an adjustment is required. This is where instrumentation becomes most valuable — it can help the doctor know when not to adjust.

The instrumentation used in the Pierce-Stillwagon technique is the DTG (Derma Therm-O-Graph), which monitors patient progress. It can be used with any technique. Early DTG models used thermocouples to determine skin temperature variations relative to a calibration point on the body.

In 1975, we began using an infrared sensor to record the actual temperature differences in degrees (Fahrenheit). This eliminated the need for a calibration point and permitted spot temperature readings anywhere on the body.

The majority of heat loss from the body is in the form of infrared radiation. According to Guyton's *Physiology*, (in chapter 72), "A nude person in a room at normal room temperature experiences 60 percent of his/her total heat loss in the form of infrared heat rays. All mass in the universe that is not at absolute zero temperature radiates such rays."

The DTG simply picks up this radiation without actual skin contact and converts it to a temperature readout. This readout is registered on a dial built into the pickup unit, and also on a strip of graph paper if the graph model is used.

Why use body heat for an indication of subluxation?

Heat production in the body is maintained within limits by the processes of vasoconstriction and vasodilation. In a cold environment, the superficial blood vessels constrict to keep heat inside the body. In a hot environment, the vessels dilate to radiate heat from the body. The sympathetic nervous system regulates this action. Stimulation of the sympathetic fibers causes vasoconstriction.

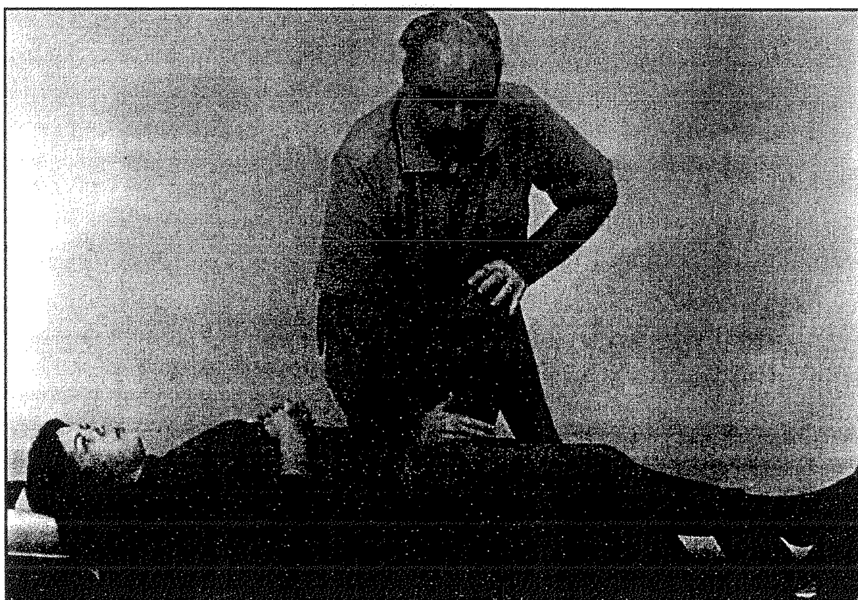
The center of the sympathetic nervous system is in the intermediolateral cell column of the spinal cord, levels T1 to L2 or L3. The lateral cell column is another name for the intermediolateral cell column. A vertebral subluxation causes the lateral cell column to be maintained in a state of hyperactivity, thus stimulating the sympathetic nervous system to constrict the blood vessels, resulting in a colder surface temperature somewhere in the body. Vasoconstriction can also affect organs, resulting in ischemia, which is usually the first step involved in pathology. The DTG will record this colder temperature.

How does a subluxation stimulate the lateral cell column?

Vertebrae are surrounded by many sensory fibers in the small muscles and ligaments, especially the capsular ligaments at the zygapophyseal articulations. When a vertebra is subluxated, the ligaments and muscles around it are stretched, and the sensory nerve endings are stimulated. Many of these fibers are proprioceptive and are unconsciously interpreted by the cerebellum. These stimulated nerves enter the cord through the dorsal sensory root and will do one, some or all of the following:

• Ascend to the brain in sensory tracts to be interpreted as pain. Pain is a manifestation of

The PI Adjustment: Special Web Contact



The PI Adjustment: Superior Hand Contact

The PI Adjustment: Inferior Hand Contact

The EX Adjustment

subluxation.

• Ascend to the cerebellum in proprioceptive tracts. (You cannot feel this.)

• Synapse with motor neurons in the anterior horn, causing a sustained contractile muscle reflex. This results in the classic taut and tender muscle fibers.

• By a multisynapse with interneurons, eventually synapse with cells of the lateral cell column, resulting in sustained sympathetic stimulation and vasoconstriction at certain levels. The mechanism of this reflex is called a polysynaptic reflex arc.

The level or levels of vasoconstriction may not be at the same level as sympathetic stimulation due to ascending and descending postganglionic and preganglionic fibers of the sympathetic chain.

So, a subluxation can actually cause interference with the nervous system without physically "pinching" a nerve. We chiropractors get so caught up in the term "pinched nerve," from explaining subluxations in simple terms to our patients, that we sometimes forget about the true neurophysiological mechanisms of the subluxation.

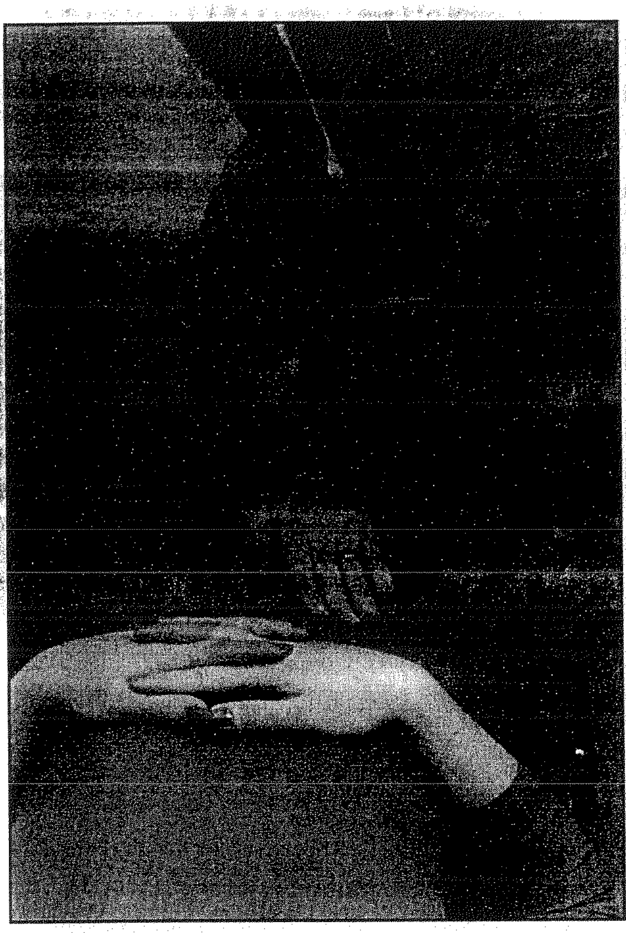
According to Stevenson's textbook, a subluxation is the condition of a vertebra that has lost its proper juxtaposition with the one above or the one below or both, to an extent less than a luxation, which impinges nerves and interferes with the transmission of mental impulses.

Does impinge mean pinch? Not necessarily.

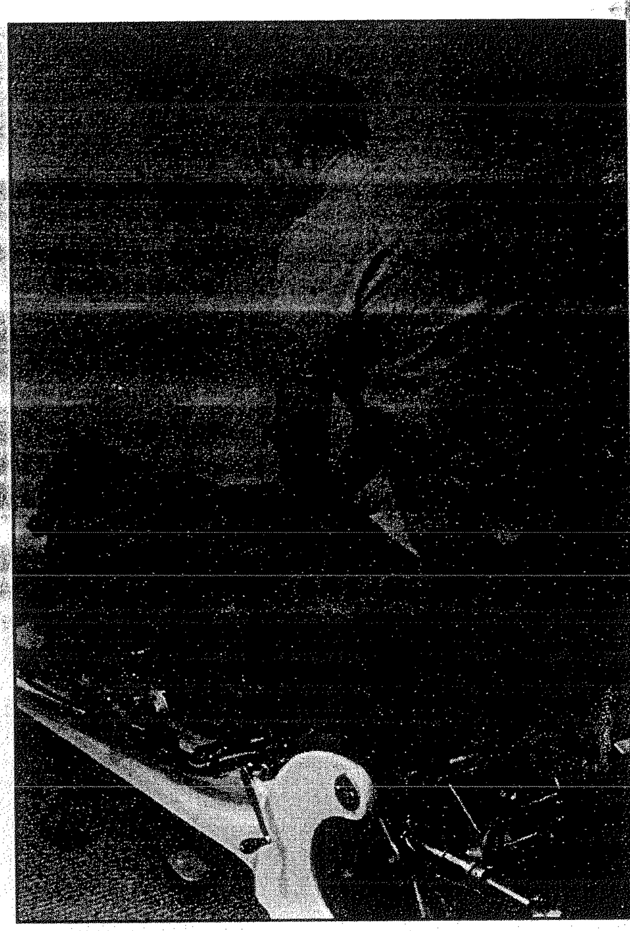
An impingement can be interference of any sort. There are two main categories of nerve impingement or interference: disturbances in afferent input; and physiochemical disturbances in neuronal excitation and conduction as a result of direct biomechanical insult to nerves (nerve compression).

These two categories are different in mechanisms, but may contribute to one another and be present at the same time.

Nerve compression or pinching occurs when the intervertebral foramen is reduced in size, or pressure on the nerve exists



The PI Adjustment: Involved Side Stance



The AS Adjustment

from disc swelling, protrusion, etc. This type of impingement does not usually initially decrease the flow of impulses along the nerve, but instead causes hyperexcitability at the compression site. If it becomes a chronic condition, the flow of impulses may decrease.

Disturbed afferent input causes the lateral cell column to be maintained in a state of hyperactivity, resulting in vasoconstriction or other reactions (e.g., somatovisceral reflexes, viscero-visceral reflexes or viscero-somatic reflexes).

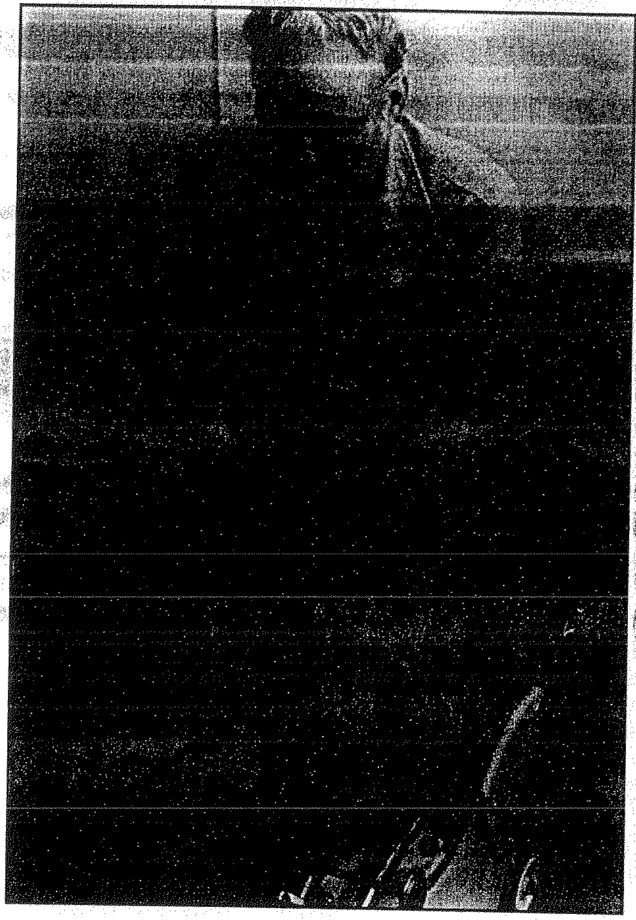
To take a DTG reading, begin at approximately the second sacral tubercle level. Press the switch on the DTG and wait until the temperature stabilizes to give you a base line.

Now glide up either side of the spine to the base of the occiput. The average time from sacrum to occiput should be 15 seconds. Keep your glide speed constant and also keep the cone perpendicular to the skin.

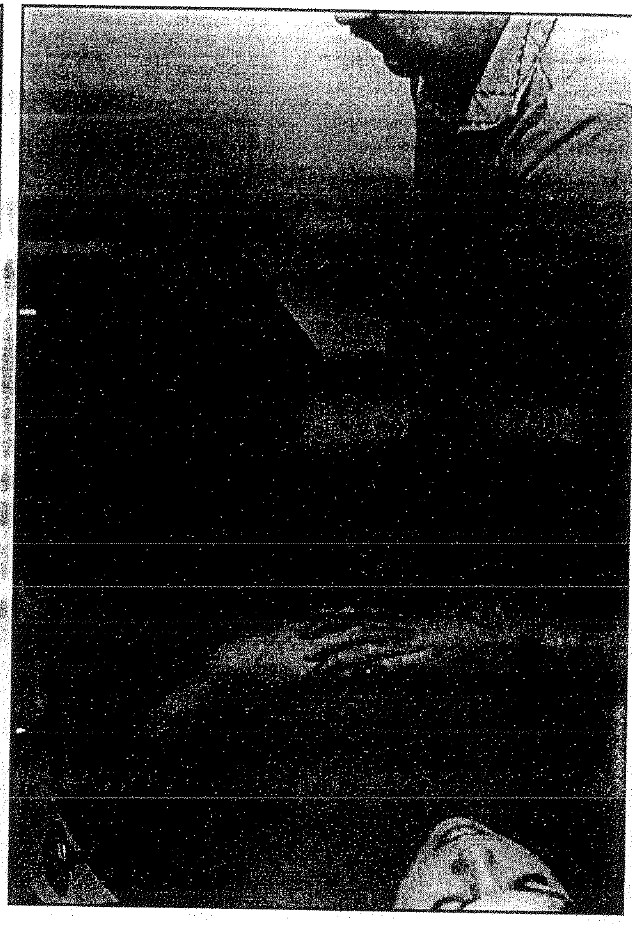
Next, check the temperature on both sides of the atlas. Direct the cone into the fossa anterior to the mastoid and posterior to the mandible. Hold the switch in for 2 to 3 seconds to obtain an accurate reading. You should check the left side first, then the right, but keep it constant in your office to avoid confusion.

To interpret the graph, the following concept is extremely important: Just because a cold reading exists in an area of the spine does not necessarily mean an adjustment is needed in that area.

Why? Because of overlapping ascending and descending sympathetic fibers. A subluxation at the level of T6, for example, may cause sympathetic stimulation of those fibers at T6. But, the fibers at T6 level may not immediately exit the spine at that level. They enter the sympathetic chain and may ascend or descend several levels before exiting and influencing blood vessels. So, a cold area at T6



The Bi-Lateral AS Adjustment



The IN Adjustment

could be the result of a subluxation much higher or much lower.

Your objective will be to "clear" the reading. This "clearing" may at first be only a slight change (especially if the condition is chronic), but eventually a generally improved reading can be expected in most cases. This involves four factors:

- Removal of cold spots or areas;
- Reduction of the large swings in either direction;
- Equalizing to less than 1°F, the temperature difference from one side of the atlas to the other; and
- An improved overall reading from sacrum to occiput, bringing a relative uniformity to the entire reading.

For examples of case reports with before and after thermography scans, look on our Internet web site (www.stillwagon.com); new case reports are added each week.

THE SPINE-IN-MOTION STUDY

The positive ilium can only be identified by performing the spine-in-motion study, a maneuver of short duration consisting of two simple tests: the cervical rotation test and the leg flexion test.

These tests are an integral part of the analysis and must be performed on every patient, on every visit.

The patient should be lowered from a normal standing position to a prone position using a hi-lo table. The patient should not shift his or her body in an attempt to get more comfortable, as this will usually induce false readings. When the patient reaches the prone position, look at the leg lengths with the legs fully extended (ankle rest down). The leg lengths should be compared at the medial malleoli, or the point where the heel of the shoe meets the sole, keeping the shoes flush against the bottoms of the feet.

If the legs are balanced, there is no need to do the cervical rotation test, and there is no need to do the leg flexion test.

The patient should not receive a pelvic adjustment at this time. however a cervical adjustment may be required. depending upon DTG and X-ray findings.

If the legs are not balanced. the cervical rotation test must be performed as follows.

Cervical Rotation Test: Keep your hands off the feet and instruct the patient to keep their shoulders still: not to move their shoulders at all but turn their head to one side. (pause to compare the leg lengths). the other side. (pause to compare leg lengths) then to the center. The shoulders must not move. the legs must be fully extended. and you must not touch the feet during this test.

If the legs balance with the head turned to either side or even both sides. you have a positive cervical rotation test. This means that a subluxation is present in the cervical spine that takes priority over any other subluxations in the rest of the spine or pelvis. The cervical spine must be adjusted first.

Correlate DTG and X-ray findings to determine the involved segment. If the DTG shows a temperature difference of more than 1° F at the level of the atlas, and you have a positive cervical rotation test, adjust the atlas. If the atlas reading is within limits, adjust C2, C3, C4, C5, C6, or C7 as determined by X-ray.

If the legs did not balance with the head turned to either side, you have a negative cervical rotation test, and you must proceed to the leg flexion test.

The Leg Flexion Test: With the patient prone and legs fully extended, note the side of the short leg. Grasp both ankles lightly and flex the legs past 90° of flexion. Keep your plane of flexion along the longitudinal midline of the body, and do not veer off to one side.

If the short leg remains short past 90° of flexion, you have a negative ilium on the short leg side. A negative ilium can be any of the following, and it should be adjusted accordingly: bilateral PI (major on the short leg side), bilateral AS (major on the short leg side), PI, AS, IN, EX, combination (PIIN, PIEX, ASIN, ASEX).

When a PI or AS occurs in combination with an IN or EX, the rotation does not have to be adjusted unless the short leg when the patient is prone becomes the long leg when the patient is supine.

Example: Left short leg prone, right short leg supine. Adjust the right ilium for rotation as indicated on X-ray.

If the short leg crosses over to become the long leg past 90° of flexion, you have a positive ilium on that side. A positive ilium is a unique fixation within the SI joint. You cannot see a positive ilium on the X-ray. A positive ilium may occur with any of the possible pelvic X-ray listings in this technique.

A patient may have a negative ilium one day and a positive ilium the next day, or vice versa. When a positive ilium is found, it must be adjusted. When you correct a positive ilium, one of two things will happen:

- The legs will balance in the fully extended position. When this occurs, there is no need to perform additional leg flexion or cervical rotation tests.
- The legs will not balance, however you will now have a negative ilium instead of a positive ilium (the short leg will remain short past 90° of flexion). Do not adjust that negative ilium. Never make a positive and negative ilium adjustment on the same visit.

THE POSITIVE ILIUM

As a review, your pelvis listing taken from the X-ray (PI, AS, etc.) describes the direction that one or both of the posterior superior iliac spines (PSS's) have moved from their normal position in space. The pelvic X-ray listings for this technique do not necessarily describe the misalignment of the PSS relative to the sacrum. An AS or PI can occur without disturbing the sacroiliac joint (the sacrum can move with the ilium).

We are specifically dealing with a misalignment between the PSS and the sacrum when a positive ilium is present. A positive ilium is a posterior inferior fixation of the PSS relative to the sacrum. You cannot see this on the X-ray. If we look at the pelvis from the side, we see that the ilium moves on the sacrum around a pivot point somewhere near or inside the sacroiliac joint. There are several theories as to where the pivot point is located, and the exact movements of the ilium on the sacrum have not been well documented.

We have found that the location of the pivot point is highly variable. This explains why some patients are likely to have a positive ilium and others are not.

If the pivot point is high in the SI joint, this allows the ilium to move around the sacrum on that axis, but prohibits the PSS from moving PI in reference to the sacrum to any great extent. This case will not get a positive ilium.

If the pivot point is lower in the SI joint, this permits the PSS to move in relation to the sacrum. When the PSS is posterior and inferior in reference to the sacrum and fixed there, you have a positive ilium.

A positive ilium is a posterior inferior fixation of the ilium on the sacrum. This has nothing whatsoever to do with the movement of the ilium from its normal position in space. A positive ilium is not a PI in this technique!

A PI in this technique means the ilium has moved posterior and inferior in relation to its normal position in space, not necessarily in relation to the sacrum. Remember, a positive ilium can occur with any pelvic listing.

THE LEG CROSSOVER PHENOMENON

Obviously, the only possible way that a leg can be short with the legs in the fully extended position is for the knee on the short side to be more superior on the table. We are excluding the rare occurrence of anatomical deficiencies.

When you flex the legs past 90° and the knee on the short leg side stays more superior on the table than the other knee, a crossover in leg length occurs as viewed at the ankles or feet. If you cannot visualize this happening, try using two pencils or pens of the same length, one end representing the knee and the other end representing the foot.

A positive ilium causes the muscles of flexion (biceps femoris, semitendinosus and semimembranosus) to spasm slightly, thus pulling the knee superior and the leg appears short on that side. During the leg flexion test, the muscles of flexion keep the knee superior on the table, resulting in the leg length crossover viewed at the feet.

PI ADJUSTING PROCEDURES

The PI adjustment can be accomplished via the following procedures:

The Involved Side Stance: The table is set for the pelvic and lumbar sections to drop down. The patient is positioned supine, with the leg on opposite side of involvement flexed. The doctor's setup is on the involved side, inferior and close, and contact is made with the fleshy pisiform of the superior hand, with a secondary contact at the pubic arch lateral to the symphysis pubis. Stabilization is made on the knee of the flexed leg on the opposite side. The line of correction is anterior to posterior with very slight torque toward the midline, with three light (shallow) thrusts. (Note: If a bilateral PI exists, a PI adjustment must be given to each side separately.)

Inferior Hand Contact: The table is set for the pelvic and lumbar sections to drop straight down, with medium to light tension. The patient is positioned supine, with the leg on the opposite side of involvement flexed. The doctor's setup is on the opposite side, inferior and close, and contact is made with the fleshy pisiform of the inferior hand. The line of correction is anterior to posterior with the focal point the pubic arch, not the leg, opposite the involved side. It is directed anterior to posterior with very slight torque toward midline, with three light (shallow) thrusts.

Superior Hand Contact: The table is set for the pelvic and lumbar sections to drop straight down, with medium to light tension. The patient is positioned supine, with the leg opposite the side of involvement, flexed high. The doctor's setup is on the opposite side, straight away and in close. Contact is made with the fleshy pisiform of the superior hand, and a secondary contact is at the pubic arch. Stabilization is made on the knee of the flexed leg on the uninvolved side. The line of correction is anterior to posterior with very slight torque toward midline, with three light (shallow) thrusts; it may also be accomplished by one firm thrust.

Special Web Contact: This

contact is especially helpful with children and in the case of an adult with an inguinal hernia (especially when wearing a truss). The table is set for the pelvic and lumbar sections to drop straight down. The patient is positioned supine, with the leg on the involved side flexed. The doctor's setup is on the same side, inferior and close, and contact is made with the thumb web of both hands. The thumb web of the inferior hand is directly on the pubic arch, while the superior hand is around the patient's leg, with the thumb overlapping the thumb of the inferior hand. The secondary contact point is the pubic arch. There is no stabilization; both hands thrust. The line of correction is anterior to posterior, with the pubic arch being the focal point.

OTHER APPLICATIONS

The Pierce-Stillwagon Technique can also be applied in the following ways:

The IN Adjustment: The table is set for the pelvic and lumbar sections set to drop straight down. The patient position is supine with the leg on the involved side flexed high. The doctor's setup is straight away on the side of involvement. Contact is made with the inferior hand, with the secondary contact the lateral thigh on the involved side, eight inches distal to femur head. The lumbars must be stabilized. The superior hand is flat on the abdomen (soft tissue) just above the pubic arch and just lateral to midline on the involved side. Fingers may run S-I or lateral to medial. There is no thrust at all.

The Bi-Lateral Adjustment: The table is set for the pelvic and lumbar sections to drop straight down, with medium tension. The patient is prone, with the doctor setting up inferior and in close (on either side). Contact is made with the thumb web or base of each hand, and secondary contact is made on both ischia. There is no stabilization; both hands thrust. The line of correction is posterior to anterior and some I-S (in a slight "rocking" motion).

The EX Adjustment: The table is set for the pelvic and lumbar sections to drop straight down. The patient is positioned supine, with the leg of the involved side flexed and crossed over the other leg, and the doctor's setup is on the opposite side of involvement, slightly inferior. The contact is made with the base of the inferior hand, and a secondary contact is made anterior superior iliac crest of the involved side. Stabilization is made on the opposite ilium (just hold, no thrust), and the line of correction is anterior to posterior, with one firm thrust.

The AS Ilium Adjustment: The table is set for the pelvic and lumbar sections set to drop straight down, with medium tension. The patient is prone, and the doctor's setup is inferior and in close on the side of involvement. The contact is made with the thumb web, knife edge, or the base of the inferior hand, with the superior hand superimposed as a "hammer hand." The secondary contact is the ischium of the involved side. There is no stabilization; both hands thrust. The line of correction is posterior to anterior and I-S in a slight "rocking" thrust.

About the authors: Glenn Stillwagon, D.C., is a member of the extension faculty at Palmer College of Chiropractic, Life University, Life Chiropractic College West and New York Chiropractic College. A recipient of the D.D. Palmer Scientific Award, he and Palmer College classmate Dr. Walter V. Pierce began research and development of the Pierce-Stillwagon Technique in 1963. A noted seminar and convention lecturer, he may be contacted at (412) 258-6506 or (412) 258-6553 and by E-mail at drglenn@stillwagon.com. The Stillwagon Seminars website address is www.stillwagon.com. Kevin Stillwagon, D.C., a 1979 graduate and class co-valedictorian of Palmer College, has co-authored several articles with the senior Dr. Stillwagon.

Diagnosis

Chiropractic - Instrumentation

Thermography

Part II

Chiropractic Instrumentation — Let's Get It Straight

Diagnostic imaging

In using any instrument, the chiropractor must be aware of its advantages and limitations, because each is designed to perform a specific task.

By Pinchas Noyman, D.C.

42-47

THE DERMA THERM-O-Graph (DTG) is an infrared heat-sensitive instrument which measures skin surface temperature by detecting the infrared rays radiated from the body without skin contact. The DTG uses the principle of surface thermometry, collecting the radiated heat from one spot of the skin to which it is applied with an infrared-sensing device.

When moved along any side of the spine, it produces a graph line. As no skin contact is required, the DTG is less influenced by skin blemishes, scar tissue and other such abnormalities.

The readings are also not influenced by the pressure that is so essential to skin contact instruments. The angle of the probe must be maintained at all times at 90 degrees to the skin's surface, since infrared rays are emitted from any surface at 90 degrees. Decreasing the angle of the probe while performing a scan will alter the readings. Constant speed is also essential for consistency and accuracy of pre- and post-readings. A clinician must maintain the same scanning time throughout care in order to monitor if a patient responds favorably to the adjustment.

A traditional approach requires 25 to 35 seconds of scanning time, but Dr. Glenn Stillwagon found, in his clinical experience, that 15 seconds is the optimal time. Chiropractors may find that in order to fit a patient to such a time frame of 25-35 seconds, they have to stall the glide. A delay of the glide at different segmental levels at each scan promotes inconsistent graph lines and unreliable readings.

One of the greatest advantages of the DTG is the ability to detect vertical (segmental) heat differences as opposed to thermocouple instruments, which can only compare one side to another.

Using thermocouple principles the DTG can be used most effectively when scans are taken bilaterally on both sides of the spine. When utilized in this manner, the DTG gives the chiropractor essential data that cannot be collected if the scan is performed unilaterally. Time consistency is critical since at the end of scanning, the graphs can be placed on top of one another and vertical (segmental) and horizontal (side-to-side) analysis can be performed.

Figure 1

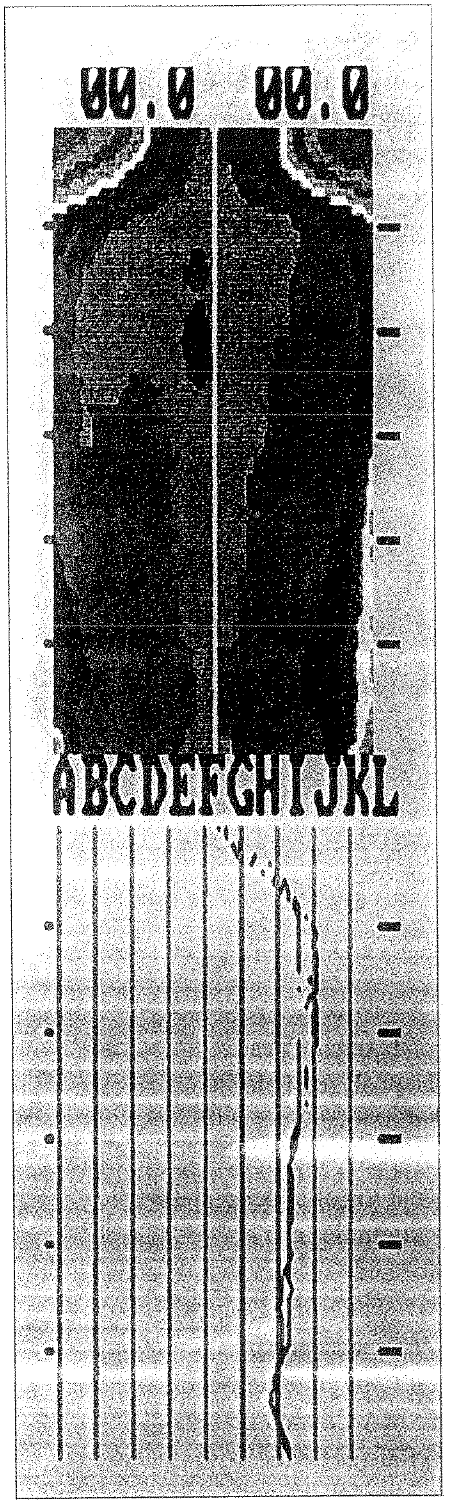


Figure 2

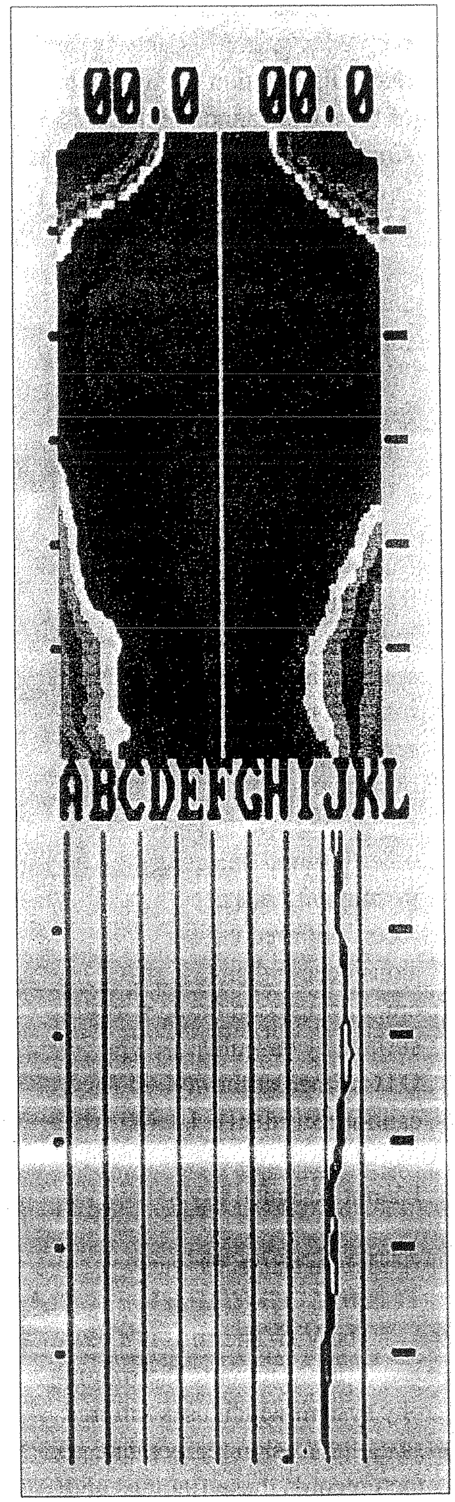


Figure 3

What we are trying to achieve is thermal symmetry, which is a traditional concept associated with the use of the DTG stating that the atlas temperature reading is associated with atlas laterality. Engel stated that inflammation of small joints of the spine cannot be detected, since the articular blood drainage is not directed toward skin surface.

Low back X-ray and CT studies performed on asymptomatic individuals revealed an abnormality rate of 36 to 50 percent, although thermographic findings were normal. It should also be noted that structural abnormalities, including spinal misalignments, may not necessarily present a physiological dysfunction.

The DTG, or any other infrared detecting instrument, will not record infrared emissions deeper than 0.5 cm, having been brought to the surface by vasculature. The DTG aimed at the styloid fossa cannot record atlas laterality or any other spinal misalignment. It's not designed to do that.

CHIROPRACTIC THERMOGRAPHY

The Visi-Therm II is a low-resolution electronic thermography system which uses infrared scanning of skin temperature and then records these findings and transforms them into images by using computerized high-technology sensory devices. It is the most significant advance in recent chiropractic history.

The Visi-Therm II consists of a scanning paddle containing 12 primary infrared sensors and one auxiliary sensor. The 12 primary sensors are used for scanning the back and upper and lower extremities, while the auxiliary sensor is used for spot temperatures anywhere on the body.

A clinician must maintain the same scanning time throughout care in order to monitor if a patient responds favorably to the adjustment.

Three full regional color mappings of scanned areas can be analyzed in terms of segmental or bilateral temperature graphs. A horizontal temperature analysis of upper and lower extremities can also be performed.

The *AMA Council Report — Thermography in Neurological and Musculoskeletal Conditions* (AMA Council on Scientific Affairs, Thermology, 1987) stated the following:

1. "Central control of skin temperature affects both sides of the body uniformly and simultaneously, resulting in symmetry of thermal patterns. The presence of significant temperature difference between corresponding areas of opposite sides of the body is suggestive of nerve impairment."

2. "Thermography can detect sensory/autonomic nerve dysfunction."

3. "Thermography also contributes to the evaluation of possible autonomic nervous system dysfunction and of spinal disorders."

The Visi-Therm II measures differences in temperature by comparing anatomically identical areas of opposite sides of the body or opposite extremities. In any areas of concern, a temperature difference of more than 0.5 degrees Celsius is considered significant and will be indicative of possible neurological dysfunction.

The Visi-Therm II presents a regional thermographic mapping of the scanned area of the body (a thermogram). The thermogram is a color scan which can be displayed on the screen. Each thermogram can be analyzed in terms of bilateral (thermocouple) and segmental (DTG) temperature graphs.

The Visi-Therm II is on the cutting edge of today's technology and its greatest advantage over any other chiropractic heat detecting instrument is that it is the only instrument that can collect thermographic data outside the paraspinal area. A scanning procedure over the back takes 14 seconds, and the information is displayed immediately on the screen.

A further evaluation can be performed at this time. Line graphs can be displayed on the screen, and they show what each of the 12 sensors detected in its path. Each sensor on one side can be compared to its "mate" sensor on the opposite side. By doing so, the doctor can detect the presence of thermal symmetry or asymmetry. This collected data may indicate the presence or absence of a vertebral subluxation complex.

At times, you may find that the paraspinal area does not show significant temperature changes, while outside of that area there is a significant change. Paraspinal heat-detecting instruments are limited in revealing such data. This may affect the chiropractor's decision on whether to adjust or not.

The advanced technology of the Visi-Therm II allows the chiropractor to document the results of each adjustment through the thermographic mapping and the graph lines. It shows whether the patient is responding favorably to the adjustment. A printout of the color scan and the graph lines can be used for documentation of patients' progress and also for patient education.

> ***A temperature difference of more than 0.5 degrees Celsius is considered significant and will be indicative of possible neurological dysfunction.***

CASE STUDY

A 26-year-old female presented with ear pain, repeated ear infections, sinusitis and urinary tract infections, and an increase in white blood cell (WBC) count was revealed upon urine analysis lab tests (see note). X-rays of the cervical, thoracic and lumbopelvic spine were taken. Chiropractic analysis revealed a vertebral subluxation complex at the spinal levels of C3, C6 and the sacrum.

Low-resolution chiropractic thermography revealed asymmetrical patterns of the cervical, thoracic and lumbar areas. Paraspinal line-graph temperatures demonstrated thermal asymmetry of over one degree Celsius (C) in the cervical spine. The lower dorsal spine revealed a horizontal temperature difference of one degree C and a vertical temperature difference of three degrees C between the lumbar and dorsal spine (Fig. 1).

A back scan, post adjustment of C3 and C6 (Fig. 2), utilizing a Thompson drop table, revealed elimination of the temperature splits in the cervical spine and the lower dorsal spine. The vertical temperature difference between lumbar and dorsal spine was reduced to one degree C, with elimination of the cold reading in the lumbar area. There was a significant restoration of thermal asymmetry in the cervical, dorsal and lumbar areas.

A back scan, post adjustment, of C3 two days later revealed elimination of temperature splits and a restoration of thermal symmetry (Fig. 3). The patient's presented symptoms and complaints, which had existed for months, were all gone after eight days of care. The patient still gets checked on a regular basis, and chiropractic thermography is a valuable component of each exam.

SUMMARY

In using any instrument, the chiropractor must be aware of its advantages and limitations, because each is designed to perform a specific task. Expectations or interpretations cannot change the instrument's design and function. The chiropractor should also be knowledgeable about the physiology of the human body and the neuropathophysiology of the VSC in order to prevent false statements and claims which may exceed the purpose and performance capacity of a particular instrument.

Documentation of results is a real benefit and should be the primary concern of each chiropractor. We take X-rays based on the assumption that structure may affect function, but the question is: To what extent is function affected? Measurement of function and physiology is the key to assess and document the results of each adjustment. Our responsibility is to know if the patient is responding favorably to our care.

[Note: The case study was taken from the paper, "Chiropractic Thermography — Proof of Correction of the V.S.C.," presented by Dr. Noyman at the Chiropractic Centennial Celebration in Washington, D.C., on July 7, 1995.]

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Objective Analysis of N

By William C. Amalu, D.C., and Louis H. Tiscareño, Jr., D.C.

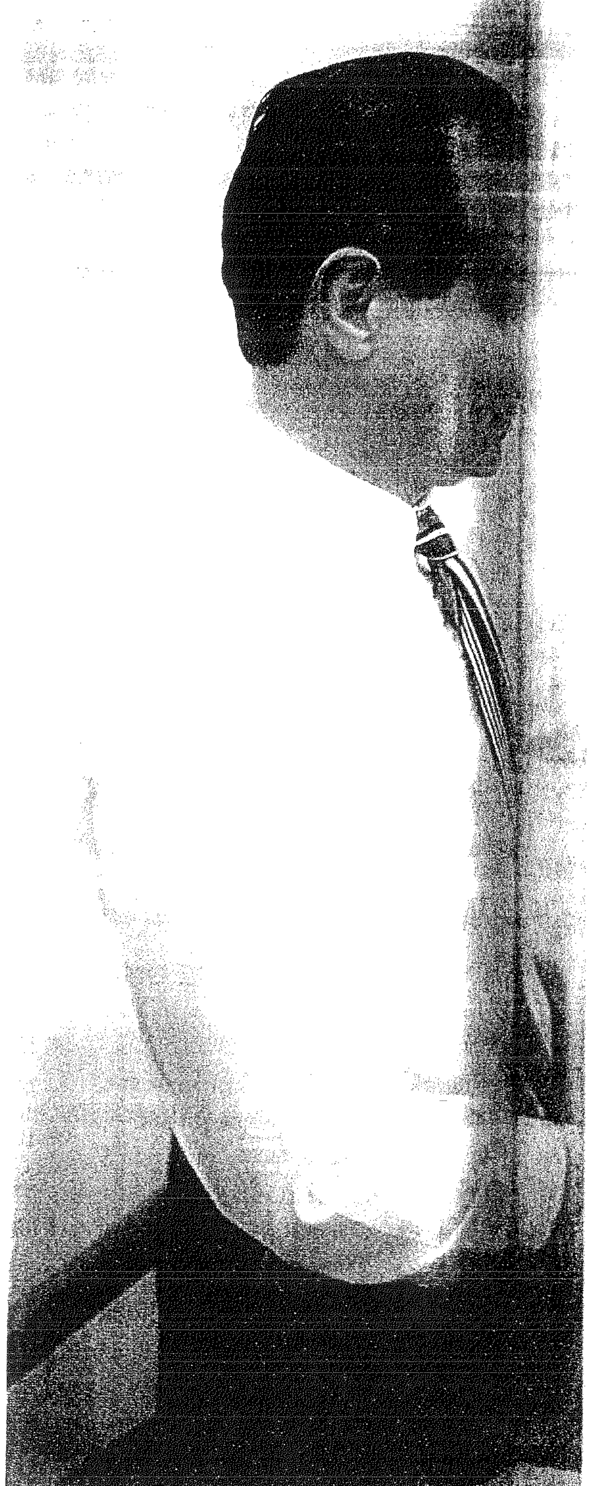
As chiropractors, we tell our patients that we improve nervous system function. Don't you think that we should be able to prove it?

How many patients fail to understand explanations of subluxations and their care plan because there is nothing tangible demonstrated to them about the neurological damage produced by their subluxations?

How do we know if patients enter our offices with neuropathophysiology? Do they leave with improved neural function after the adjustment, or is it worse? How do we know which adjustment is most efficacious? These are questions that practitioners face each day.

How are we to answer these questions? Should we address them by doing such vague tests as leg length, postural analysis, motion or static palpation? We stand on the core principle that our forefathers developed, that both health (homeostasis) and disease are nervous system dependent. Our profession's foundation relies upon our ability to improve the health of our patients via restoration of neural function.

As chiropractors, we tell our patients that we improve nervous system function. Don't you think



Part I of II

Neuropathophysiology

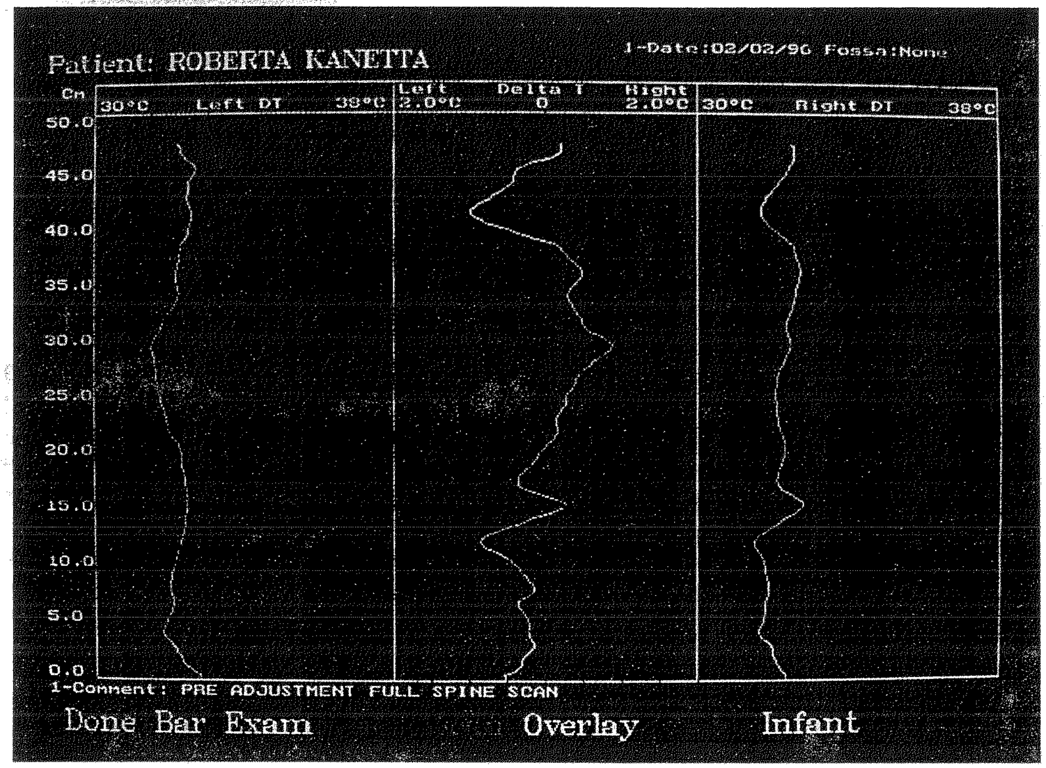


Figure 1

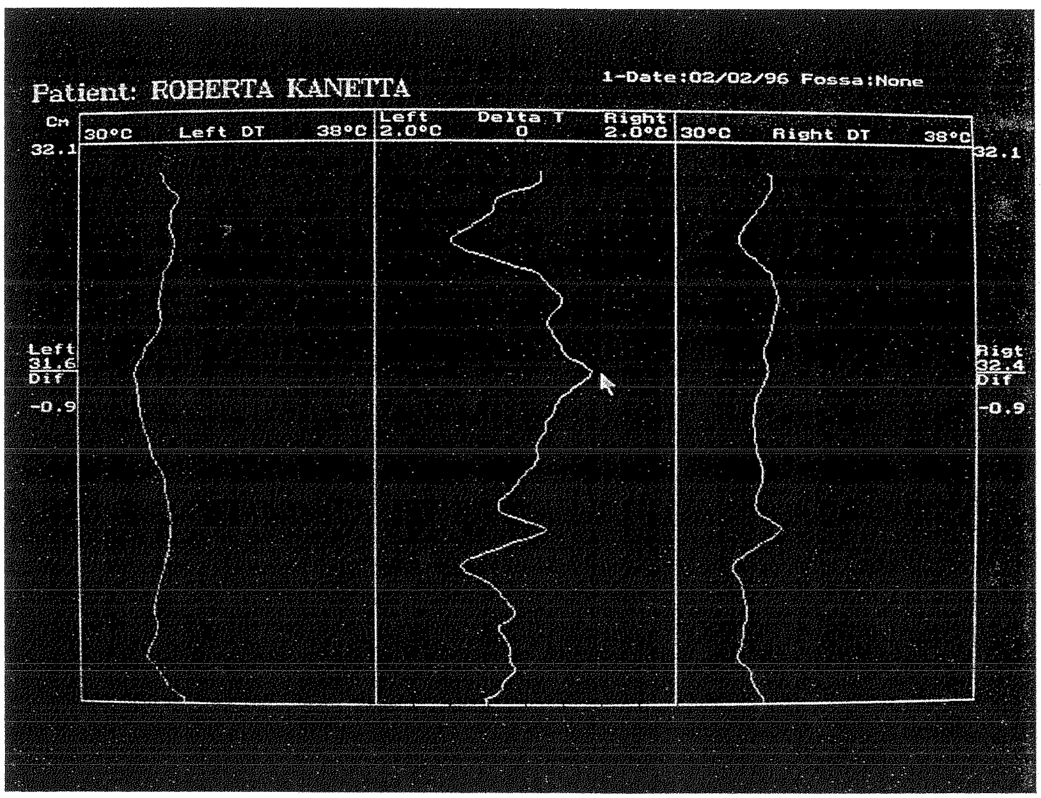


Figure 2

that we should be able to prove it? Isn't it about time that we focused on objectively monitoring the neurophysiology of our patients on a pre- and post-adjustment basis?

NEUROPHYSIOLOGY AND THE VERTEBRAL SUBLUXATION COMPLEX

There is no longer any doubt in the health sciences about the importance of the nervous system. *Gray's Anatomy* states that, "Homeostatic responses are innate in all living organisms, but with increasing size and complexity of structure, the range and flexibility of responses has steadily increased in parallel with the evolution of the nervous system. Its structure and activities are inseparable from every aspect of life — physical, cultural and intellectual."

Cutting-edge research into the exact level of control the nervous system exerts has uncovered processes that stagger the imagination. The discovery of brain cell hibernation stunned the research community with the knowledge that nerve cells could actually remain dormant for decades, awaiting awakening by a slight increase in blood supply.

Recent studies have also found a direct two-way communication system between the brain and every cell in the body. The amount of research supporting chiropractic's core principle is enormous. All of these technological advances in neurobiochemical and neurophysiological research have established the nervous system's dominance in controlling and coordinating all bodily functions. It seems that science has finally caught up with our 100 years of clinical observations.

THE APPLICATION OF NEUROPATHOPHYSIOLOGY

Then, what are we doing to objectify neuropathophysiology in our patients? What are we doing to measure what science has determined to be the most detrimental of all system malfunctions? Surely, a majority of us, can agree that our first and foremost role as chiropractors is the restoration of proper nervous system function through correction of the subluxation.

However, we have established a more modern and complex definition of the subluxation — the vertebral subluxation complex (VSC) with its five basic components (neuropathophysiology, kinesiopathology, histopathology, myopathology and biochemical changes). Some believe that all of the components must be present for the subluxation to exist.

If patients present with one component missing, are they without subluxation? Aren't neuropathophysiology and aberrant arthrokinematics (a subcategory of kinesiopathology) the two components that must be present at all times for a subluxation to exist? Can't all of the other components be completely absent with a subluxation still present? Yes! Yet, field practitioners are currently using a plethora of instruments in an endeavor to monitor as many of the components of the VSC as possible. Why?

> ***As chiropractors, we should focus on the direct measurement of the prime component, neuropathophysiology.***

Apart from neuropathophysiology and aberrant arthrokinematics, the rest of the components are *effects*. Aren't we supposed to get to the cause? Why are we measuring the effects of the subluxation and not its core element? These other instruments are luxuries and merely yield adjunctive measurements of the subluxation.

It seems, that with this evolution of the VSC, we are losing sight of who we are and what we do. As chiropractors, we should focus on the direct measurement of the prime component, neuropathophysiology. Once this is corrected, all the other components will follow; or do we "treat" something else?

Today, there are an overwhelming number of instruments available, such as needle EMG/NCV, surface EMG, somatosensory evoked potentials, computerized muscle strength, current perception threshold, computerized inclinometers and many others are currently used in patient examination.

However, one must be careful of manufacturers claiming that their instruments measure neurological function. Many of these instruments do not. Some of these instruments do test for neurological function, but fail to do so on a broad scale.

Measurement of a segmental neural pathway is not enough to make a determination of global neuropathophysiology. Most of these devices are also not sensitive enough to detect minute neurological changes. Moreover, the time involved in the actual performance of many of these tests is usually prolonged.

However, the greatest problem encountered with the majority of these instruments is patient compliance. If any analytical system must incorporate much more than the physical presence of the patient, errors will ensue. If the accurate use of the instrument necessitates that the patient move, sit extremely still, or register a verbal confirmation, the validity of the test comes into question. Many of these tests carry up to a 60 percent error rate.[1] How objective can an examination truly be when the subjectivity of patient compliance is involved? We cannot afford errors such as these when the patient's health lies in the balance.

AN INSTRUMENT FOR THE CHIROPRACTIC PROFESSION

What we need is a truly objective analysis of nervous system function. We need an analysis that will be able to remove human biases and tell the doctor with certainty when neuropathophysiology exists and when the proper adjustment has corrected it. An instrument is needed to validate the science, aid in the art and support the philosophy of the chiropractic profession.

To suit our needs, the device must meet certain criteria. First, it must be able to fulfill the founding principle of our profession, the detection of subluxation via measurement of *global* and *segmental* neurological *function*. Since we also claim to affect visceral function, we will need an instrument that analyzes the autonomic nervous system. The device must also be sensitive enough to detect the first signs of neuropathophysiology — a minimum requirement for preventative care. It must be easy to use and fast enough to perform daily pre- and post-adjustment tests.

> ***What we need is a truly objective analysis of nervous system function***

Finally, the device must have ample research behind it to support its accuracy, repeatability, stability, sensitivity, specificity and validity in the area of neuropathophysiological analysis. Research must also determine a standard for normal neurological function, thus providing a normative database to which the patient can be compared.

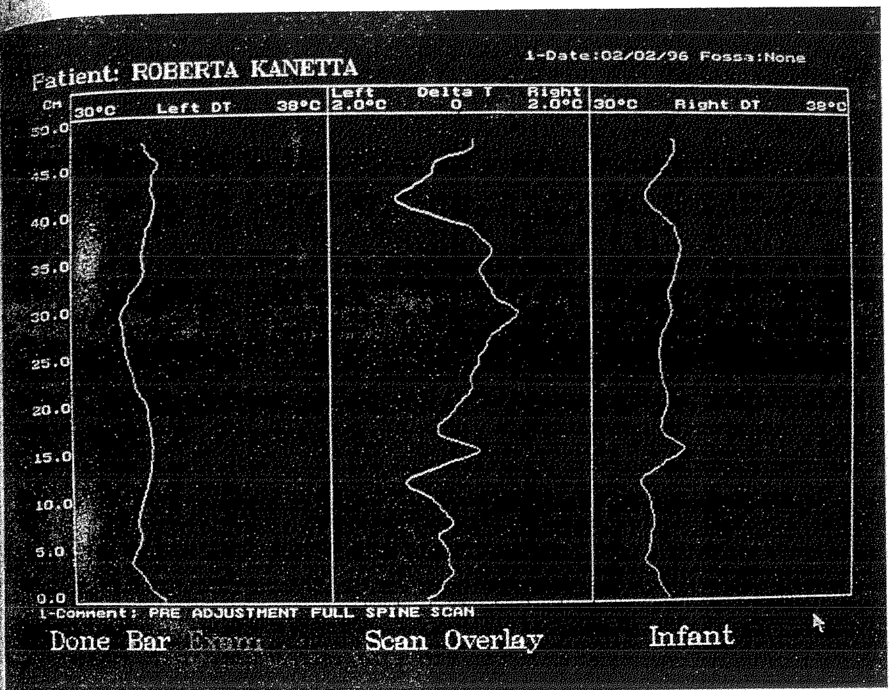


Figure 3

The only instrument available which meets every one of these criteria is computerized paraspinal infrared thermography. This does not mean the expensive camera systems popular in the 1980s. Current technology makes computerized paraspinal thermography very affordable and within the reach of every chiropractor.

When we say we are able to improve the function of the nervous system, now we can prove it! With the advent of modern computerized paraspinal thermography, the chiropractor has the means of monitoring nervous system function on a pre- and post-adjustment basis, thus, fulfilling the needs of modern outcome-based care.

Both the chiropractor and patient can *see* when neuropathophysiology is present and when the adjustment has corrected it. For the first time, the patient and the doctor are both able to determine objectively how much neurophysiological improvement has been made and when more care is indicated.

The device, which meets the stringent instrument standards required by the international thermographic community, is the Tytron C-3000 Computerized Paraspinal Infrared Thermographic Imaging System.

Today, the Tytron C-3000 has taken paraspinal thermography to its highest level, while addressing all of the limitations associated with the devices of the past. The Tytron C-3000 incorporates extremely sensitive (up to 1/100th of a degree F) and stable infrared sensors, high-resolution thermal data collection, fiber optic communication, beam collimating lenses, travel distance encoders and computer processing.

This new paraspinal scanner houses its sensors in a solid block of aluminum, which allows them to maintain their peak efficiency throughout each scan.

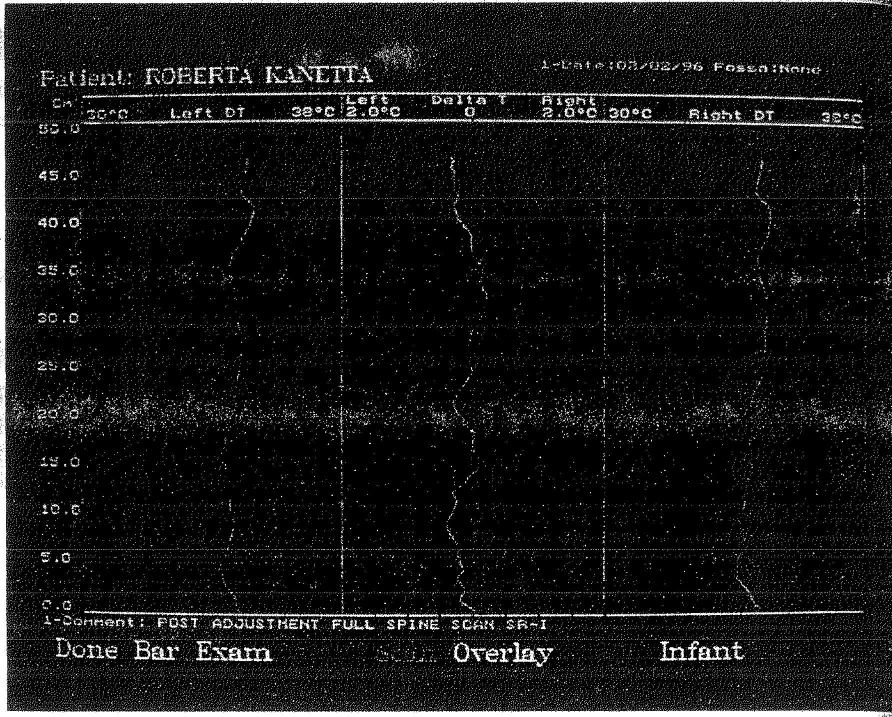


Figure 4

Additionally, the Tytron C-3000 has the unique ability to record thermal differentials (right to left thermal asymmetries) on the horizontal scale, and to record direct temperatures on the vertical scale (independent right and left absolute temperatures), both at a very high resolution (Fig. 1).

This is a critical feature for proper "pattern" analysis, because it is possible to have an identical differential and the patient not be in "pattern." Computer processing also allows the doctor to quantify the exact temperatures of all the thermal shifts, or "breaks," within the pattern (Fig. 2). Pre-adjustment (Fig. 3) and post-adjustment full-spine scans (Fig. 4) dramatically demonstrate to the patient their nervous system's improvement with care.

Part II of this article will be published in the July/August issue.

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Part II of II

Objective Analysis of Neuropathophysiology

Current technological advances have also brought manufacturing costs down to a point that paraspinal thermography is now within the reach of every field doctor.

By William C. Amalu, D.C., and Louis H. Tiscareño, Jr., D.C.

WHEN THE CORRECT access point to the nervous system is used, normalization of neuropathophysiology will occur. The scans may also be displayed as color bar graph images with green representing normal and yellow, orange and red as 1-3 standard deviations from the norm. (Figure 5 shows pre-adjustment full spine abnormal, and Figure 6 shows post-adjustment "green.") Past office visit scans may also be displayed as a multiple comparison image for tracking patient improvement and the need for future care (Figure 7).

Moreover, the Tytron C-3000 has the ability to display pre- and post-adjustment scans as an overlay graph or side-by-side bar graphs. This new paraspinal scanner is also designed to read accurately into the hairline and up to the occiput without thermal distortion. Another plus is that the instrument is extremely easy to use and can be mastered in a clinical setting in less than a week.

The incorporation of all of the above cutting-edge technology insures that the practicing field doctor can produce accurate, repeatable and valid paraspinal thermographic scans. Consequently, these images allow the doctor to objectively demonstrate to the patient a clear picture of their improvement and any need for future care.

With the increasing costs of running a practice concerning many clinicians today, incorporating computerized paraspinal thermography into patient care becomes an important issue. With the use of many other types of instruments, the time needed to perform the test can be quite prolonged. This can cause office problems such as the need for extra personnel, increased use of space and reduced patient flow. With the combined use of computer processing and fast-stable infrared sensors, the Tytron C-3000 can produce full-spine scans in less than 15 seconds. Current technological advances have also brought manufacturing costs down to a point that paraspinal thermography is now within the reach of every field doctor.

RESEARCH AND COMPUTERIZED PARASPINAL THERMOGRAPHY

We have a responsibility to the patient and ourselves to monitor the nervous system's function due to its unique role in the maintenance of global bodily function.

More than 30 years of research and 6,000 peer-reviewed and indexed journal papers have confirmed thermography as a valid means of analyzing neurophysiology. Both the chiropractic and medical professions have issued policy statements confirming thermography's validity as a neuro-diagnostic imaging tool. The medico-legal system has allowed thermography to be introduced as evidence in court for more than two decades.

Thermographic imaging is used across the U.S. and overseas in almost every major medical center. It is also accepted by federal agencies and departments as being valid and useful. The weight of the evidence lends overwhelming support to thermography as a valid procedure for the analysis of neuropathophysiology.

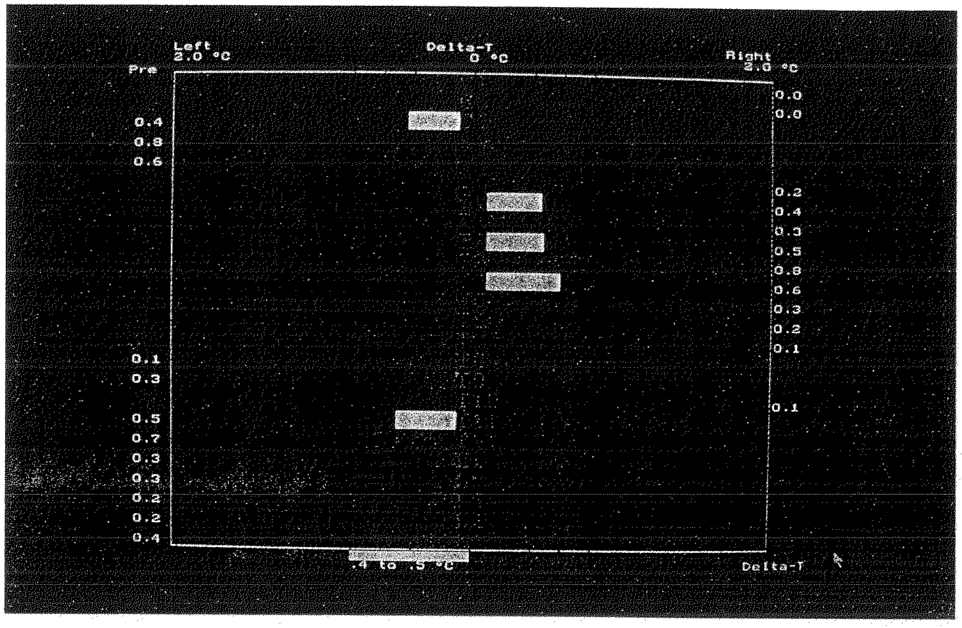

Figure 5

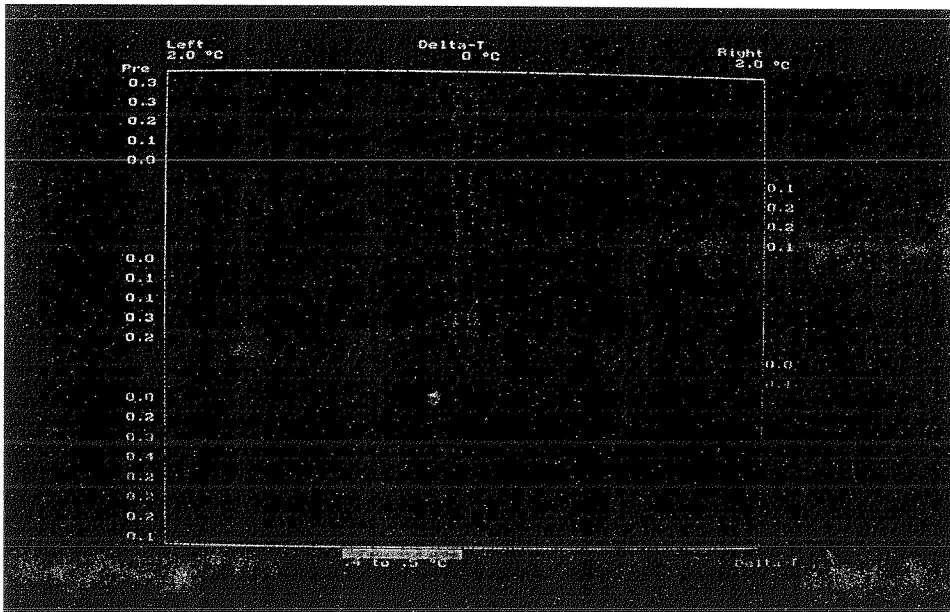

Figure 6

The guiding principle of our profession rests upon our ability to improve the health of our patients via correction of abnormal neural function. Since there is no longer any dispute over nervous system dominance, what are we doing to measure the most deleterious of all system malfunctions? Why we are using instruments and tests which ana-

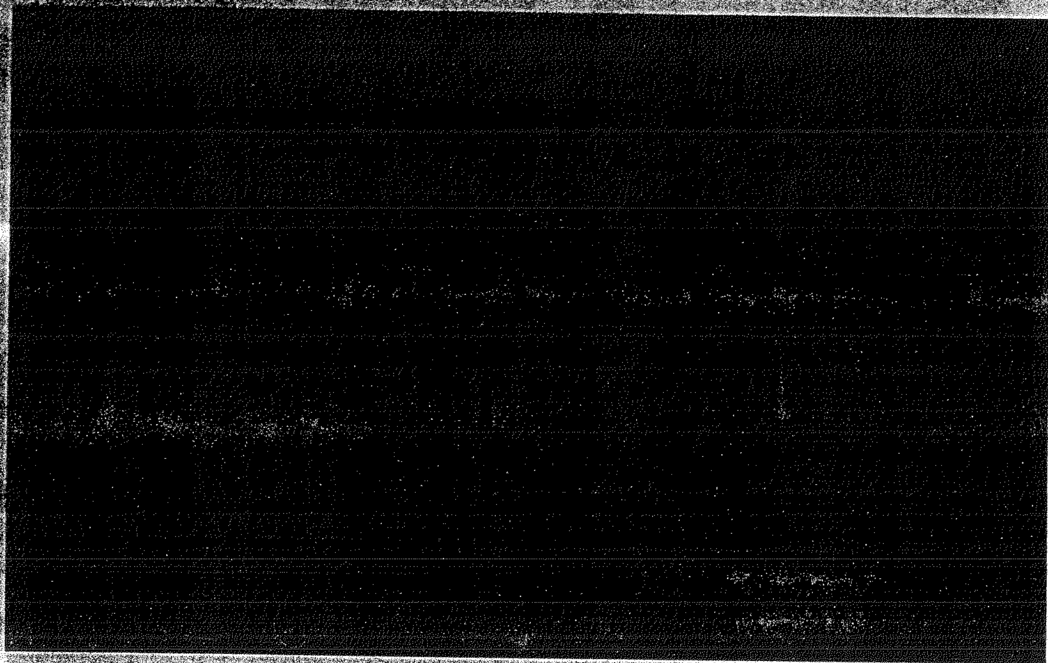

Figure 7

lyze the component effects of the subluxation? How are we to use devices which cannot, under any circumstances, directly establish an objective analysis of neuropathophysiology?

There is nothing wrong with testing for other VSC components, so long as it is understood that the findings are adjunctive to the cause. With the use of quality paraspinal thermography, the field doctor is finally able to tell when neuropathophysiology (subluxation) is present and when the correct adjustment has been rendered.

The International Upper Cervical Chiropractic Association (IUCCA), through its Applied Upper Cervical Biomechanics Certification Program, is making an effort to bring this level of care to the profession. Extensive research into computerized paraspinal thermography has determined normal paraspinal thermal values, and thus, normal neurophysiology.

The IUCCA was the first to incorporate this normative database as a guideline for neuropathophysiology and a standard for the correction of the subluxation. If results-oriented (outcome-based) care is to become a reality, then objectifying our profession's core premise becomes a necessity.

A CHALLENGE

Do patients really enter our offices with neuropathophysiology on a regular basis? Do we know that we corrected their subluxations and they are leaving our offices with normalized neural function? Are we absolutely sure they have not been made worse by our care? How do we know which adjustment is most efficacious? Can we truly answer these questions without objective instrumentation?

Research has established computerized infrared thermography as the new standard in subthreshold neurophysiological analysis. If the chiropractic profession is going to continue to stand on its core principle that the subluxation, and its adjustment, does affect the neurophysiology of the body, then it becomes absolutely necessary to monitor its function using the best technology the world has to offer.

Regardless as to whether or not you *believe* in any particular technique, we must insist on the highest standards possible in objective neurophysiological outcome measurements. Only then will we truly discover what works and what doesn't. Do we need to be challenged, or is it a challenge to do what we profess as a principle?

About the authors: William C. Amalu, D.C., and Louis H. Tiscareño, Jr., D.C., are the vice president and president, respectively, of the International

Upper Cervical Chiropractic Association. Both are certified chiropractic upper cervical specialists, having completed over 300 hours of postgraduate course work. Inquiries should be directed to them at IUCCA at 621 Middlefield Road, Ste. A, Redwood City, CA 94063; or call Dr. Tiscareño at (510) 757-9200 or Dr. Amalu at (415) 361-8908. For information on the Tytron C-3000 computerized paraspinal infrared imaging system, call Tytronics R & D Corporation at (800) 705-2307.

Note: Following is a condensed list of references. For a complete list of 206 references, provided by the authors, contact *Today's Chiropractic*.

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Letters to the Editor

THE THERMOGRAPHY DEBATE

This letter is regarding Dr. Pinchas Noyman's article in the September/October issue of *Today's Chiropractic* about electronic infrared thermography. With all due respect, we, as well the entire medical thermography community, know that he is not doing thermography.

It is chiropractic thermal analysis, and any falsification of a CPT code for the benefit of fraudulent reimbursement cannot be tolerated in either profession. Hopefully, innocent chiropractors who inadvertently bill the wrong CPT code, because they were misinformed, will not get punished.

Charles R. Solano, D.C., D.A.B.C.T.
Indianapolis, Ind.

[Having received a copy of Dr. Solano's letter, Dr. Noyman responds as follows.]

DEFINING THERMOGRAPHY

It seems that the issue of thermography vs. thermometry (temperature gradient study) needs to be addressed. I have learned in the past that the number one rule in preventing confusion is to define our terminology.

In his letter, Dr. Charles Solano refers to my article, "Chiropractic Instrumentation — Let's Get It Straight" (Part I), from the September/October issue, and he states that it is about electronic infrared thermography. Anyone who reads the article will notice that there was no discussion anywhere of thermography, although

I was attacked on it.

I do agree with Dr. Solano that chiropractors use different instruments for thermal analysis which may produce graph lines or graph bars. These lines/bars are a presentation of differential temperature measurements and/or absolute temperature measurements. Instruments like the Nervoscope, Neurocalometer, Derma Therm-O-Graph, Tytron C-3000 and Insight 7000 with their recording devices, use the principles of differential thermography and/or absolute thermography. They are not thermography units. The accepted standard for thermography includes thermograms of the body, including extremities.

Instruments that make use of line graphs and bar graphs cannot produce thermograms on extremities and can only be used for thermal analysis at the paraspinal area. Any presentation or advertisement for these instruments as thermography is misrepresentation and false advertising. I support Dr. Solano and strongly agree that the use of these instruments should not be placed under a thermography CPT code, but under temperature gradient study for the benefit of reimbursement.

Dr. Solano suggested that I am not doing thermography, but he has no knowledge of what I am doing. I do not know what kind of thermography he is referring to or what his definition of thermography is. If he refers to the use of thermography in medical applications, it is true that I am not doing *medical* thermography. There are thousands of references in the scientific and medical literature which demonstrate the use of thermography in conjunction with other diagnostic methods to evaluate and verify medical pathological conditions. I should emphasize that diagnosis and treatment of disease is not the specific training of the chiropractor, hence we do not use thermography for this purpose.

The *non-medical* uses of thermography extend to many other areas, and chiropractic is one of them. Thermography has been used for years in numerous applications, including satellite weather forecasting, industrial insulation evaluation, heat build-up in electrical and electronic components and so forth. Evidence shows that thermography is not a field limited to medicine.

Chiropractors who use the Visi-Therm II, a low-resolution electronic infrared thermography system, refer to it as *chiropractic* thermography, which is separate and distinct from medical thermography. Like many other thermography systems, it allows accurate color mapping of temperatures emitted by means of infrared rays from the surface of the body.

Thermography systems may differ, however the greatest difference is in *how we interpret the data* we collect through them. Both medical doctors and doctors of chiropractic take X-rays. Whether the X-rays are taken with an old single-phase unit or with a high-frequency unit, an X-ray is still an X-ray. The insurance companies do not ask doctors how old the equipment they use is, nor which model it is. The emphasis is put on the interpretation and diagnosis. The definition of X-ray is not determined by the equipment, its model or by the person who uses it. Different specialists may look at the same X-ray and come up with different findings. That is not unusual. It is the intent of the analysis and the doctor's interpretation that makes the difference.

The same rule applies for thermography: A thermogram is a thermogram whether it is taken with a liquid crystal system, telethermography system or low-resolution electronic infrared system. These thermography systems produce a regional temperature mapping of the studied surface area. The main difference between them is the way in which the doctor interprets his/her findings. Medical doctors use thermography for study and diagnosis of different conditions, such as bone tumors, psoriasis, migraine headaches, rheumatoid arthritis, RSD and many other pathological conditions. Chiropractors should be the experts in the detection and correction of the vertebral subluxation complex (VSC).

The VSC has a destructive effect on the nervous system, and it modifies the physiological and structural integrity of the body. With our training in different techniques, the use of X-rays and the use of low-resolution infrared thermography, we can observe the structural, biomechanical and physiological changes that are the result of a VSC. Chiropractors who use a low-resolution infrared thermography system, do not use it for the diagnosis or management of any medical problem.

In medicine, a test is helpful if it assists in the diagnosis of a medical condition or if it aids in the management of that condition. If a diagnosis of a condition has already been established, the indication for thermography may or may not be needed. With chiropractic analysis, a thermographic study is needed and should be indicated at all times before and after an adjustment. This advanced technology can assist the chiropractor in determining a patient's care program.

Although I agree with some of Dr. Solano's statements, it is important to mention that he has never attended any of the courses that offer training in chiropractic thermography, nor has he had any training with the Visi-Therm II thermography system. No professional should criticize chiropractic thermography without prior training in this type of analysis.

Dr. Solano and I may have a difference of opinion, but we should remember that our obligation is to serve the public. In order to do this, we should best use the technology that is available to us.

Pinchas Noyman, D.C.
Kennesaw, Ga.

SUBLUXATION RESEARCH

I wish to offer congratulations to, and thank, Dr. Sid E. Williams for placing in print his firsthand account and interview of Dr. Chung-Ha Suh in the July/August

Letters to the Editor

issue of *Today's Chiropractic.*

The interview and report are notable and vital for the much-needed response to the current-day scientific community's insistence on "scientific research proof" of the significance of the human spine in health and disease.

Thank you for making it available for the entire chiropractic profession and world to read and consume.

W.W. DeVore, D.C.
Arcadia, Mo.

[Editor's Note: Dr. DeVore, now retired, is former chairman of the Missouri State Chiropractors Association's Committee on Research Studies.]

CATEGORIZING THERMOGRAPHY

Monitoring neurophysiology with temperature sensing instrumentation has been a primary and unique procedure utilized by the chiropractic profession to determine the presence and correction of the vertebral subluxation complex since 1924.

Advancements in infrared temperature sensors, and computer enhancement of the data they gather, have greatly improved the information available to the doctor of chiropractic. These advances in the science of skin temperature analysis have necessitated updating the procedure protocols and description of the various levels of instrumentation applied by this science.

The area of surface temperature measured by a particular instrument is the determining factor in defining and describing its capabilities as a diagnostic versus a non-diagnostic tool. The category of information that the instrument is congruent with establishes the level of temperature analysis it produces.

Let us review the various levels of information gathered by today's temperature sensing instruments and correlate their appropriate categories. This will provide clarification for those who deal with this aspect of chiropractic science by eliminating confusion and misapplication of terminology.

There are two major categories of skin temperature instrumentation currently in use by the chiropractic profession: thermometry and thermography. Each of these categories may be further divided into sub-categories to provide specific capabilities of each type of instrument. We will not delve into the specifics, but we will differentiate the major categories according to the data received from the study performed.

Thermometry includes all instrumentation systems without the capability of producing a thermogram. The earliest of this type of instrument applied in chiropractic was the Neurocalometer (NCM), invented in 1924 by Dossa Evans. The NCM is a dual-probe, skin-contact instrument which measures bilateral (paraspinal) temperature differences. It does not measure actual temperature. When connected to a graph, it produces a single line-graph print.

Another thermometry instrument is the Derma Therm-O-Graph (DTG) developed by Drs. Walter V. Pierce and Glenn Stillwagon in 1963. It measures spot temperatures segmentally along the spine and also produces a line graph printout. Since the introduction of the NCM, there have been numerous skin temperature instruments developed and used by our profession in the thermometry category. Some of these produced graphs and some indicated temperature differences, and all of them measured spot temperatures.

Currently, there are instruments that work on the same principle of the bilateral and/or segmental temperatures, except they employ modern infrared non-contact sensors and may display their spot temperature graph readings on a computer monitor along with printout capabilities. Examples of this type of instrumentation are the Accolade, STI System 120 and TyTron C-3000. These instruments all provide valuable skin temperature information, but none are capable of producing thermograms. Some proponents of these

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systems continue to use misleading terms such as paraspinal thermography, and computerized infrared thermography (CIT) in their descriptions, even though they are inaccurate.

Thermography is the category of skin temperature analysis by means of a thermogram, which is a color picture of heat. It is a temperature map of an entire surface area of the body with temperatures represented by a corresponding color scale. Thermography provides the doctor with a much greater surface area of temperature and the ability to compare like sides of the body for symmetry. These instruments provide the doctor with the ability to map entire dermatomal distributions, whereas line-graph instruments do not.

There are different levels of thermographic instruments available in regard to resolution. In the thermographic community, they are referred to as contact, non-contact, electronic, telethermography, non-computerized and computerized thermography.

The Chiropractic Institute of Thermography is an organization whose goal is to provide objectivity for the chiropractor through the use of modern chiropractic thermography technology. It focuses on a specialized low-resolution, non-contact, electronic computerized thermography system developed specifically for chiropractic by Drs. Kevin and Glenn Stillwagon. Their Visi-Therm II thermography system produces full-color thermograms of both the trunk and extremities, while also providing traditional line-graph studies like the NCM and DTG.

It is important for both the chiropractic profession and the insurance industry that proper application of terminology, procedure description and CPT coding be followed to avoid confusion and an overall rejection of skin temperature studies. Avoid gray areas; don't gamble with juggling CPT codes. Misapplication of coding and terminology has caused problems in the past and can be avoided in the future by providing an accurate description of the information received from a specific instrument, along with the proper billing code for that level of service.

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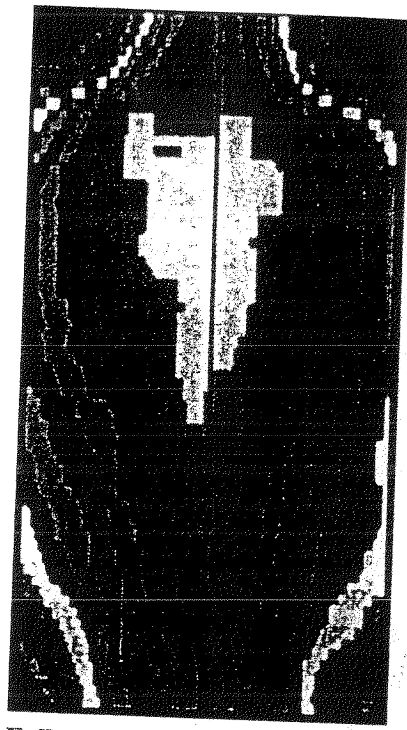
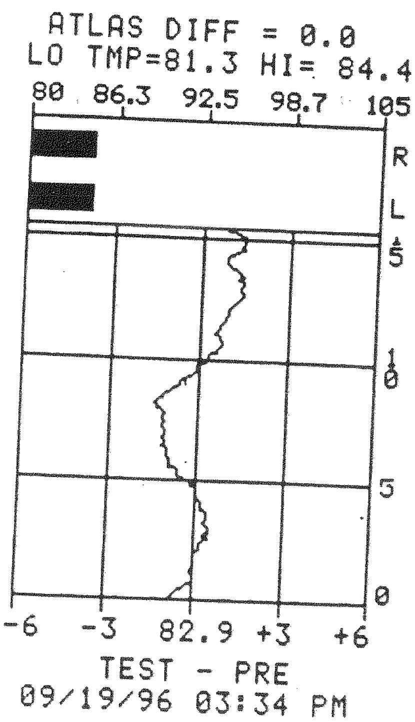
[Note: Drs. Hether and Story are president and secretary/treasurer, respectively, of the Chiropractic Institute of Thermography. For CIT membership information, call Dr. Story at (717) 676-9833 or write to P.O Box 71, South Sterling, PA 18460.]



Full-spine thermogram



Full-spine line-graph DTG thermometry

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Letters to the Editor

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Thermography

SPINAL THERMOGRAPHY

I have always enjoyed reading Today's Chiropractic. However, the July/August issue with Part II of Drs. William C. Amalu and Louis H. Tiscareño's article on spinal thermography, "Objective Analysis of Neuropathophysiology," was not enjoyable.

Let me explain. Both doctors sent me tapes and literature demonstrating their TyTron C-3000. I teach postgraduate clinical thermography at New York Chiropractic College, and I'm a board member of the International Thermographic Society. They wanted our board to review their work to see if it can be termed thermography. It isn't and now, with them publishing that it is, it leaves us in a very awkward position.

Both myself and James Christianson, Ph.D., postgraduate, clinical thermography, National College of Chiropractic, agree that they are doing thermal analysis, but it is not thermography.

We're afraid that some misinformed field doctors will inadvertently bill for spinal thermography and possibly get entangled in legal problems with the patient and possibly the third-party payer, who may deem this somewhat irregular. Seemingly, there is no CPT code for spinal thermography. Subsequently, to bill thermography, they would use a billing code which does not apply to the TyTron C-3000.

We suggest Drs. Amalu and Tiscareño use an unspecified CPT code, not a thermography CPT code.

Charles Solano, D.C.
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IS IT THERMOGRAPHY?

This letter is in reply to the article titled, "Objective Analysis of Neuropathophysiology," published in the May/June and July/August 1996 issues of *Today's Chiropractic.*

Drs. William C. Amalu and Louis H. Tiscareño are correct when they explain that we need to have objective documentation to support the presence and correction of the vertebral subluxation complex. However, they say that the TyTron C-3000 computerized paraspinal imaging system is the *only* instrument available which meets the criteria that they state. I believe that upon investigation one would find that the DTG (Derma-Therm-O-Graph), developed in 1983 by Dr. Vernon Pierce and Dr. Glenn Stillwagon would meet those criteria.

Drs. Amalu and Tiscareño then stated that the TyTron C-3000 "meets the stringent instrument standards required by the international thermographic community." I was unaware that there was such a standard.

Lastly, I have a problem with Dr. Amalu and Dr. Tiscareño calling the TyTron C-3000 "thermography." According to the literature, thermography is a color heat picture of the temperatures on the surface of the body as shown on a thermogram. The

TyTron C-3000, which Drs. Amalu and Tiscareno have called "thermography," appears to be thermometry, which is a paraspinal temperature reading. It is a comparison of the temperatures from one side of the spine to the other at a particular level, similar to an NCM instrument reading.

The TyTron C-3000 also appears to give a segmental temperature reading, which is what a DTG instrument reading would give you. The color bar graph (shown on page 63 of the July/August 1996 issue) appears to be bilateral temperature comparisons in color — in essence, an NCM reading in color.

My concern is this: If doctors who are using the TyTron C-3000 believe that it is thermography, and bill it to the insurance companies as thermography, what happens when the insurer requests copies of records? The protocol would be to send copies of the *thermograms*. The TyTron C-3000 user would not be able to send a thermogram. Does that not position the insurer to then claim insurance fraud against the doctor?

If the answer is yes, then this could result in all thermographers having difficulty getting paid for their services. I believe this is a potential problem that must be avoided. If I am incorrect, I would appreciate seeing documentation that refutes these points.

Francis C. Zulka, D.C.
McMurray, Pa.

[Editor's Note: Having been provided with copies of the above letters, Dr. Amalu responds as follows.]

DEFINING TERMS

This letter is in reply to the above letters to the editor. As someone who has spent many years in mechanical engineering, a member of the International Thermographic Society and a recent board-eligible diplomate in thermography, I would like to address the comments regarding our article in the May/June and July/August issues of *Today's Chiropractic*.

The comment regarding the TyTron C-3000 as being "the only instrument (hand-held scanning, of course) available which meets every one of these criteria" is valid. All other instruments that we know of in this category, including the DTG, are not. These instruments contain so many inherent design flaws that they are rendered incapable of meeting accepted standards of thermal analysis. Unstable sensors, thermal drift, sensor cross-talk, stem-effect (thermocouple instruments), improper calibration, inadequate thermal resolution and many other engineering problems plague these units. Current technology and manufacturing methods have replaced these outdated instruments. Consequently, there are no other instruments of this type that are built to the accepted standards of thermal analysis like the TyTron C-3000.

In regard to the issue of "thermometry" and "thermography," confusion in this area must run rampant based upon the amount of calls I receive. Thermometry is defined as the basic science of temperature measurement. The graphic rendering of temperature is defined as thermography. Consequently, thermography falls under the broad heading of thermometry. The international thermographic community concurs with this. I would like to know where, in the literature, is found the "color heat picture" definition of thermography. It is ridiculous to consider than an image must be in color, represent a picture, or any permutation of this type in order to define it as thermography.

If a color heat picture is necessary, then the initial (pre-computed or pre-colorized) black-and-white images produced by IR camera thermography units, and routinely read by thermographers, must not be thermography. It is unfortunate that some are unaware that the resolution of these black-and-white images are superior to color, since they are not subject to the error inherent in color images. Any device that measures temperature and produces some form of graphic rendering of such is defined as thermography. Consequently, the use of the TyTron C-3000 is thermography and the images produced are thermograms.

As far as billing is concerned, there is no problem whatsoever. The TyTron C-3000 owner's manual lists in bold text that under no circumstance should anyone bill for this procedure using IR camera CPT codes. I agree this would be fraud. The IUCCA courses clearly stress that this form of billing is

Letters to the Editor

not to be done. As one who uses telethermography, I am well aware of the expertise, time, education and laboratory environment needed to take IR camera thermograms. Consequently, billing and coding are very specific to this end.

Please look to the 6,000-plus peer-reviewed thermography articles available. It is the hope of all devoted to the truth that this debate over thermometry, thermography, outdated instruments and billing can be put to rest. The science of thermal analysis continues to advance, and so should we.

William C. Amalu, D.C.
Redwood City, Calif.

ARTHRITIS/RHEUMATISM SERIES LAUDED

I want to offer my compliments on publishing Dr. Paul Goldberg's excellent series, "Arthritis/Rheumatism Sufferers: The Forgotten Patients."

Articles of this professionalism and depth are badly needed from within our profession. We have, for far too long, depended on second-hand information from other sources in the scientific sectors. While this is not bad, or even undesirable, it is high time that we chiropractors, who claim so much, back up those claims with quality work such as Dr. Goldberg's. Only then will chiropractic receive professional respect from others — respect that is badly needed if chiropractic is ever to be regarded for what it is, a truly unique health-care system.

Keep up the good work, and we need more authors like Dr. Goldberg.

W.M. Holland, D.C.
Caseyville, Ill.

SERVICE-MINDED CHIROPRACTORS

The feature article "A Service Mission in the Dominican Republic," by Martin Finkelstein, D.C., in the September/October 1996 issue reminds me of the loving spirit we all possess that is so important in our work.

I am grateful for the Marty Finkelsteins, the Pat and Mike McLeans and the Frank Gilberts in our wonderful profession who constantly, relentlessly, live the message (a message so big that my mind has difficulty allowing it in), and present it to me more by living example than anything else.

The consciousness of the "healing facilitator" needs attention and focus to better serve. I am proud to know these great chiropractors and to experience their love, integrity, commitment, intention and spirituality. I know it is doctors such as these, along with Dr. Sid Williams and his great vision, that will bring us all closer to unity with our spirit and will ultimately be responsible for the evolution of mankind.

Steven D. Erde, D.C.
Brooklyn, N.Y.

CHIROPRACTIC INSTRUMENTATION

Congratulations on the time[illegible] article by Pinchas Noyman, D[illegible] "Chiropractic Instrumentation[illegible] Let's Get It Straight" (September/October 1996) dealing with chiropractic tem[illegible]ature instrumentation.

I am in full agreement wi[illegible] author, who stated, in his fi[illegible] article, that temperature ins[illegible]mentation "is still the most [illegible]tive method in assessing th[illegible]iology of the nervous syst[illegible]

Knowing when *not to* gi[illegible] spinal thrust is just as imp[illegible] if not more so, as knowin[illegible] *to* give a thrust. Tempera[illegible] instrumentation is tremen[illegible] important in answering [illegible] practic question.

John F. Hart, D.C.
Chesnee, S.C.

PI Cases

Thermography, Pre-Existing Conditions, Emotional Injury and More

By C. Jacob Ladenheim, Esq.
and The Honorable Louis K. Campbell

Few diagnostic modalities have had the tumultuous history of thermography. From the heights of optimism when the American Medical Association's (AMA) Council on Scientific Affairs issued its report sprinkled with words such as "useful in documenting" and "safe," to the depths of despair when the AMA's house of delegates repudiated the council's recommendations, the modality's advocates have faced serious challenges on many fronts. Thermographers, however, persist and the clinical and forensic benefits of thermography remain evident. The Supreme Court of Alabama recently has approved a chiropractor's thermography testimony in a case yielding a jury verdict of $200,000.[1] The details of the case are significant and may have important ramifications on the profession throughout the United States.

Rear-End Auto Crash

When Wayne Lawrence stopped at a traffic light, he was struck from behind by another vehicle. He sought no medical care that day, but upon feeling back pain the next day he visited an MD who recommended Ibuprofen. When his discomfort increased over the next several days, Mr. Lawrence made an appointment with Robert Hollis, DC.

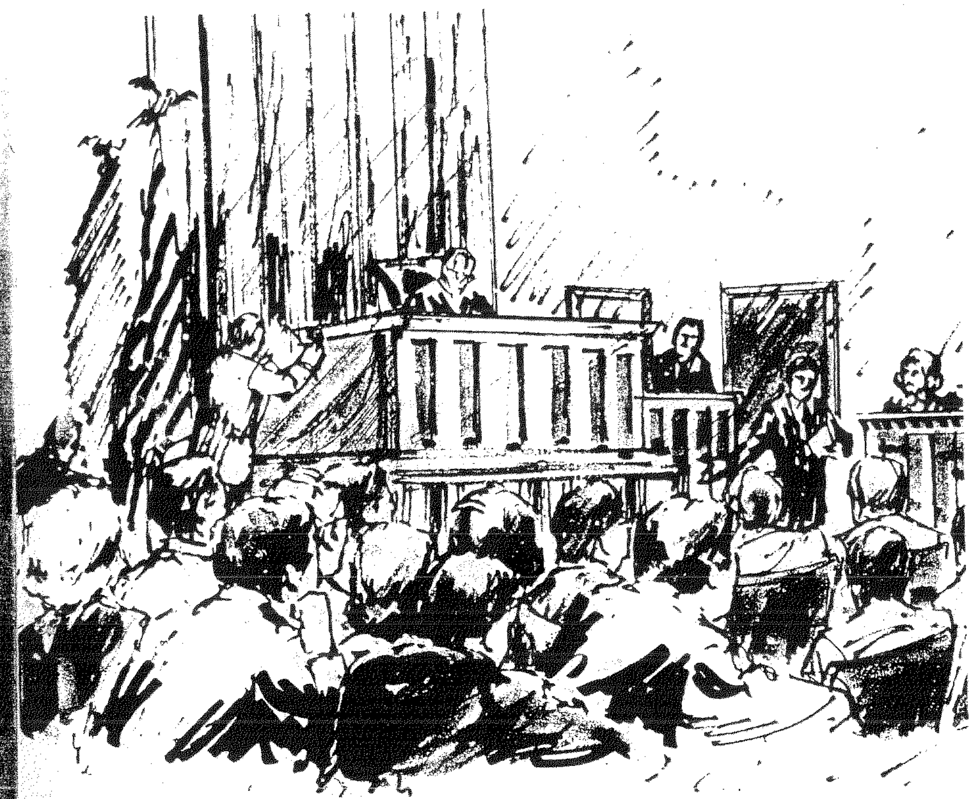
Dr. Hollis' treatment included spinal manipulation, traction, ultrasonic massage and electrical stimulation. Several months later, the doctor performed a thermographic exam, which, he maintained, confirmed his initial diagnosis of brachial neuritis/radiculitis. Subsequent treatment involved 130 visits to Dr. Hollis over approximately two and one-half years.

In the ensuing personal injury (PI) litigation, Dr. Hollis attempted to testify about the results of the thermography and volunteered that the technique was "an acceptable diagnostic tool within the medical community" (the standard test for admissibility of "scientific evidence"). The defendant's lawyer objected, arguing that Dr. Hollis was not qualified to make such a pronouncement since he was not an MD. The trial court overruled the objection, and Dr. Hollis went on to show the jury the thermogram and testify as to his interpretation of it.

Pre-Existing Condition—Surgery Before Collision

This trial contained many of the problems DCs frequently face when treating patients injured in automobile collisions. Many doctors and patients are paranoid about a previous accident or condition which may have contributed to the patient's post-trauma symptoms. Doctors fear that confusion about "which accident 'caused' the problem" will make them appear uncertain or will diminish the lawyers' chances for a possible victory.

Actually, however, the general



The duty and responsibility of an expert witness is not to "help the patient win."

legal rule is that "you take your victim as you find him." When lecturing to groups, these authors use the example that one who kicks a person in the shins ordinarily is responsible only for his damages, which would be minimal, if he suffered only a bruised leg and ego (OK, you legal types—ignore the possibility of punitive damages). The total would perhaps reach $100.

If, on the other hand, the victim happens to suffer from hemophilia and the same battery results in two weeks of hospitalization, the assailant will be responsible for his victim's medical bills and related damages, even though the act was no more egregious than in the first example. You take your victim as you find him. It's not his fault that he suffers from hemophilia. If anyone is going to suffer from the unfortunate convergence of a particularly vulnerable person and a tortfeasor, we as a society have elected not to place the loss on the blameless victim.

The case involving Dr. Hollis is just such a situation. Mr. Lawrence had undergone surgery for lower back problems five years before his accident. Dr. Hollis testified that the collision exacerbated the preexisting condition. He further testified that Mr. Lawrence had a permanent impairment and would experience pain and require treatment for the rest of his life. However, the defendant cannot expect to escape liability for the permanency, just because a "more sound" victim would have been less seriously injured.

Emotional Injury

With defense lawyers already arguing theories of malingering, hysterical conversion reaction and exaggeration of complaints, many plaintiff's attorneys have shied away from psychological workups, fearing that a positive finding could hurt their cases more than help them. Apparently, it did not hurt the plaintiff in the Hollis case, who reportedly had suffered no previous emotional problems. His pain and activity limitations were declared to be responsible for the onset of his severe clinical depression, which eventually required him to undergo drug therapy. His upset was also cited as a contributing factor in the deterioration of his relationship with his wife of seven years and their stepchildren.

What Does the Jury Think?

When the jury returned a $200,000 verdict in this case, the defense asked the judge to reduce that amount as being clearly excessive, given the evidence of only $8,000 in medical bills. Such a motion for "remittur" asks the judge to give the plaintiff the option of agreeing to a lesser amount or submitting to a retrial. Denying the motion, the judge in this case emphasized that the evidence of Mr. Lawrence's suffering was "extremely convincing." In addition to a 20 percent whole-man impairment, his continuing pain was reported to have sharply curtailed his physical activity. Walking or driving a car for any length of time aggravated his injury. Mr. Lawrence testified to having foregone his normal routine, including sports and family activities.

DCs Testify About "Medical Acceptance"

One issue on appeal in the *Brown v. Lawrence* case was the judge's ruling that the DC in this case could testify about the medical acceptance of thermography. The appellate court noted that the trial court's discretion in admitting expert testimony is traditionally broad and will not be disturbed, absent an abuse of discretion. The trial court had evidence that Dr. Hollis was serving on the American Board of Medical Infrared Imaging and that he had administered the board's examination to candidates, including medical doctors, seeking certification in thermography. Moreover, he testified that over 4,000 articles published in medical and other journals, as well as statements issued by several distinguished medical boards, supported the validity of thermography. That evidence was deemed sufficient to warrant admission of his testimony.

Since, contrary to the practice in many practitioner's offices, the court's understanding of the modality and its uses is noteworthy: "A thermogram is usually conducted several months after an injury, when any initial swelling has receded and the true severity of the damage is more apparent."

Appellate Court Says Jury Not Unreasonable

A court may not "substitute its judgment for that of the jury when the jury has returned a compensatory verdict that clearly is supported by the evidence, nor may it conditionally reduce a jury verdict merely because it believes that the verdict overcompensates the plaintiff." Following that precedent, the appellate court in this case echoed the trial judge's opinion that the testimony concerning this plaintiff's suffering was "particularly compelling," and affirmed the jury award.

What it Means for the DC

The authors of this article often remind chiropractic seminar attendees that they are not advocates. The duty and responsibility of an expert witness is not to "help the patient win." In theory, doctors should rise above such partisanship and be interested only in fully and accurately reporting what they observed, what they did, what results they achieved, what they believe caused the injury and whether permanency may result, and what care is required.

In reality, of course, the expert witness wants to do a good job. Certainly, Dr. Hollis' reputation in the community (particularly in the plaintiff's community) was not hurt by this jury award. Whether that reputation has translated into referrals or other measurable benefits we will leave to more investigative spirits. For our purposes, we will assume that such an outcome is good for the doctor. Why did it happen?

In refusing the remittur, the trial judge and appellate court each emphasized the particularly convincing nature of the testimony about this patient's suffering.

Indeed, a doctor's handling of

The chiropractor is not, and should not strive to be an advocate in the legal sense.

the history, patient progress reports, self-help recommendations, re-examinations and thorough documentation can enable him or her to more vividly convey to the jury the severity of the patient's condition. We're not talking about embellishing or exaggerating, but rather avoiding oversight and trivialization.

Strategies for the Expert Witness

When serving as an expert witness, it is the chiropractor's duty to apply his or her expertise to give an accurate reading or opinion about the case at hand. The chiropractor is trained in a healing art and not in legal strategy; it is never appropriate for the DC to attempt to cross the line or to take on the position of a legal advocate. However, there are many steps which the chiropractic expert witness may take in order to be seen as a more credible and effective witness before the jury.

In many cases, the chiropractor can take measures to make the plaintiff's injury more comprehensible to the average juror. For example, in our book titled, *The Chiropractic Form and Sample Letter Book*, these authors present a form labeled "activities of daily living," which emphasizes the persuasiveness of relating to the jurors the real, everyday implications of an injury. The typical juror (if there is such an animal) may not appreciate the significance of a loss of "20 degrees of cervical rotation," even given the most skillful scientific explanation. However, that same juror is likely to be moved after learning that the victim can no longer lift her grandchildren.

Among the categories of daily activities included in our book are housework, yardwork, personal grooming and travel. Falling in the category of "general activities" are walking, standing, running, sitting, lifting children, bending, climbing stairs, reading, lying in bed, chewing, swimming, sports, getting in and out of a car, playing the piano, using a typewriter or computer, kneeling, sexual intercourse, exercising, sleeping, using the telephone and sitting in a recliner.

Jurors also are impressed by people who do their best to recover. A doctor's recommendations for strengthening exercises and rehabilitation, when coupled with an accurate account of the patient's scrupulous adherence to the regimen, can have a great impact. First, it demonstrates that the plaintiff is not just a "dead-beat," out to make a quick buck off of the insurance company; there are easier scams than spending an hour a day working out. Second, it raises the specter of how seriously the patient still is suffering. Information such as this demonstrates to the jury that the patient's injuries might have been much worse, had he or she not devoted so much time and effort toward recovering.

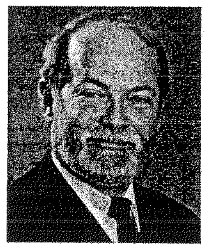
Similarly, DCs should include in their records a notation of those home activities which can help alleviate the patient's symptoms. Whatever activities may help—applying ice or heat, sitting or lying down, stretching, taking frequent breaks, etc., should be recorded. Again, such details convey to average, everyday jurors what a disruptive effect the needless collision has had on this innocent victim.

While the chiropractor is not, and should not strive to be an advocate in the legal sense, he or she should be an advocate through providing the kind of expert testimony that fully, fairly and accurately conveys to the jury the condition of the patient. ■

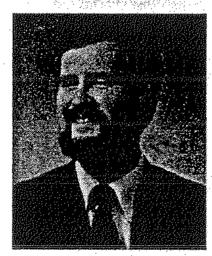
References

1. *Brown v. Lawrence*, 632 So.2d 462 (Ala. 1994).

C. Jacob Ladenheim, Esq. is a practicing attorney with "hands-on" experience representing DCs in malpractice and disciplinary matters around the country. As a member of the postgraduate faculties of Logan College, National College and Cleveland College of Chiropractic, Los Angeles, he has presented license renewal seminars and is the co-author of the textbook Risk Management in Chiropractic. *He is the editor of* Chiropractic Showcase *magazine and editor-in-chief of the newsletter "The Chiropractic Legal Update."*



The Honorable Louis K. Campbell is a graduate of the College of William and Mary and the Marshall-Wythe School of Law. As an attorney, Judge Campbell contributed significantly to the brief before the U.S. Supreme Court in its ground-breaking Pireno *chiropractic antitrust decision. He has lectured extensively to state associations and other groups on chiropractic risk management and personal injury, and he is a postgraduate faculty member at two chiropractic colleges. In 1988, Judge Campbell received a full-time judicial appointment to serve on the bench in Virginia's 25th judicial district.*



Operational Definitions of Vertebral Subluxation: A Case Study

Purpose: Literature and methods for reliability and validity for identification of vertebral subluxation are reviewed. To date, subluxation research has been hampered by the lack of accepted operational definitions. Procedures used at Sherman College of Straight Chiropractic (SCSC) are described and an approach for framing operational definitions is proposed. **Method:** Qualitative review of literature and description of current clinical procedures used at SCSC. **Summary:** The two main elements for assessment of vertebral subluxation in use at SCSC include: (1) the detection of neurological involvement and (2) the location of a specific associated vertebral segment. Assessment of neurological involvement includes a battery of palpation, leg length checks, and thermographic readings to assess clinically observable muscle activity and asymmetries and skin temperature. The methods for locating misaligned segments include leg checks to provide a general location, followed by more detailed analysis for X-rays and palpation. These approaches can form a basis for standardizing subluxation identification for clinical and research purposes. Key words: *chiropractic, leg length inequality, neurologic examination, palpation, spine, thermography, X-rays*

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INTRODUCTION

In a previous issue of *Topics in Clinical Chiropractic* (7:1), Dr. Bill Meeker did an excellent job of laying out some of the challenges in researching the concept of subluxation, particularly in reference to its relationship to health.[1] Much of the problem still lies in our ability to define subluxation and health in operational, researchable terms. General definitions of subluxation and the vertebral subluxation complex derived from a consensus process show that there is agreement on the broad concepts.[2] Still, these definitions are not operational in the sense that particular measurements of anatomic or physiologic parameters are not included in the definition.

As noted by Meeker, there seems to be an inverse relationship between our ability to agree on a term or concept and the extent to which we are willing to specify exactly what we mean by it. Meeker concludes that at this time we have no "useful operational definition" of subluxation. From a clinical perspective, however, there is certainly no lack of operational definitions for the vertebral subluxation based on technique-

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The authors thank Dr. David Koch who, during his term as president of Sherman College of Chiropractic, created an environment where critical study of phenomena associated with the vertebral subluxation was encouraged. His vision helped guide the current work, and his manuscript review was quite helpful.

Edward F. Owens, MS, DC, Sherman College of Straight Chiropractic, P.O. Box 1452, Spartanburg, SC 29304; telephone: 864-578-8770, ext. 1279; e-mail: eowens@sherman.edu.

specific models. Most of the 200 or so chiropractic techniques incorporate analytical methods including assessments of articular alignment or mobility, global postural alignment, or neurologic function. Many of these methods are operationalized and taught in detail, sometimes in chiropractic college programs and often in postgraduate technique seminars.

Any of these technique-specific analytical models should be useful in a research setting, in addition to the clinical setting, as long as the methods are well defined and provide measurements. For research purposes, consensus at the operational level may not be necessary. A single, narrowly defined definition of subluxation may not be as useful as several models that approach the subluxation from different viewpoints. "Whatever measure is chosen will reflect only certain characteristics of the construct, and thereby influence our interpretation of changes."[3(p100)]

Our search for knowledge regarding the subluxation is somewhat analogous to the old story about the blind men feeling an elephant in different locations. Each observer reported very different findings depending on his location. For our purposes, it is better to collect information from various perspectives to form a clear picture of vertebral subluxation. Also, certain perspectives, as the story goes, may be more desirable than others.

For scientific use, there should be certain criteria that describe a proper operational definition from a methodologic viewpoint. Likewise, there should be certain criteria, perhaps derived from a philosophical viewpoint, that describe a proper definition of vertebral subluxation. The criteria should be clearly enough defined to be able to say what is and what is not an adequate subluxation model for study purposes. The presentation of a vertebral subluxation hypothesis tree at the Research Agenda Conference IV in 1999 and its subsequent publication were attempts to show how any number of operational definitions could be derived from a common philosophical base.[4] The base suggested by Owens and associates is general enough to perhaps be acceptable by a large group of subluxation-centered chiropractors, although it has not been subjected to a consensus process.

This article develops criteria for operational definitions of vertebral subluxation based on the approach presented by Owens et al[4] and offers as an example the analytical methods taught in one chiropractic college and used in the health center there.

DISCUSSION

According to Meeker, "Operational definition is simply the description or delineation of the exact procedures for measuring or observing the concept whether it is a thing, an event, a behavior, or something else."[1(p67)] In this case, the concept being defined is a clinical observation of abnormality in the structure of the spine that is presumed to be related to neurologic dysfunction. This conceptualization bears strong resemblance to the consensus definition produced by the Association of Chiropractic Colleges: "A subluxation is a complex of functional and/or structural and/or pathological articular changes that compromise neural integrity and may influence organ system function and general health."[5(p34)] If we restrict the discussion to the articulations of the spine, then the term "vertebral subluxation" should be used.

At the very minimum, the operational definition for vertebral subluxation should consist of ways to measure spinal structure or function and neural integrity. At Sherman College, the process of analysis and location of vertebral subluxation requires two steps and meets this criterion. The initial focus is on determining the presence of signs of neural dysfunction. After neural dysfunction is found, the clinician determines which segments of the spine, if any, show signs of having inappropriate juxtaposition with neighboring segments. The vertebral subluxation is present only when the combination of neural involvement and vertebral misalignment is found.

SUBLUXATION DETECTION—THE NEUROLOGIC ASPECT

The methods of neurologic assessment used at Sherman College involve determining the degree of adaptability of physiologic function, which is presumed to be mediated by neural activity. In this model, it is theorized that when the nervous system is functioning properly there will be constant subtle changes in physiologic function in response to changes in the internal and external environments.

Abnormality, in and of itself, is not considered a sign of neurologic dysfunction in this scheme of subluxation detection. The approach reflects an acknowledgment of an innate intelligence as being a prime director of the physiologic functions of the body. In other words, physiologic abnormality might be a necessary adaptation for a specific patient at a specific time. Only when the abnormality is fixed or persistent over time is it considered a sign of neurologic dysfunction or maladaptation.

While many physiologic phenomena could be monitored within this framework, a battery of six tests has been developed for use in the Sherman College curriculum and health center. The six tests are as follows:

1. Paraspinal skin thermographic pattern analysis
2. Atlas fossa temperature difference
3. Supine leg length difference
4. Derefield-Thompson prone leg length tests for pelvic function
5. Prone leg length difference test for cervical syndrome
6. Prone leg extension for sacral restriction

Ideally, these tests are performed for three successive days at the outset of care, and the results from each day's evaluations are compared to determine if a static pattern exists in the patient's responses to the tests. Detailed descriptions of the methods of measurement for each of the tests listed above are needed to show how each provides an assessment of the neurologic aspect of vertebral subluxation. These descriptions, along with the criteria used to decide whether a test is "positive" for the occurrence of neural dysfunction, constitute an operational definition for the neural component of the vertebral subluxation.

Paraspinal skin thermographic pattern analysis

The assessment of paraspinal thermographs at Sherman College currently makes use of the TyTron C-3000 infrared thermal scanner (Titronics Research & Development, Oxford, Iowa) interfaced to a Microsoft Windows–based computer. For the procedure, the patient is seated in a special backless chair equipped with a facial support for stability. The patient's back is exposed, and a full spine thermogram is recorded in one long smooth glide from the second sacral tubercle to the base of the occiput. Hair at the base of the neck and skull is lifted out of the way, and the barrels of the thermographic instrument are held at a uniform close distance from the skin during the glide. The TyTron is equipped with a position sensor incorporated into one of its rollers that tracks the vertical position as the temperature recording is made.

The temperature profile of the skin can be observed, indicating the change in skin temperature on the left and right sides of the spine with respect to vertical location along the spine. Another way to look at the temperature information is to view the calculated side-to-side difference in temperatures. Interpretation of the thermogram is made either with visual inspection, looking for similarity in successive recordings, or using recently developed objective methods. Visual inspection provides a subjective determination of whether two thermograms are similar enough in character to be considered "in pattern" based on the location of left-to-right swings of the trace and the location of peaks and valleys characteristic of the traces.

Atlas fossa temperature difference

The atlas fossa temperature is recorded in a separate procedure using the TyTron. The temperature of the skin overlying the left atlas transverse process is measured, followed by the right fossa temperature. The test is considered positive if there is a temperature difference of more than 0.5°. The temperature difference and the warm side are recorded for comparison to previous measures.

Supine leg length difference

The supine leg length test is a visual inspection of the leg length inequality (LLI). In this test, the patient is supine on an adjusting bench. The examiner cradles one foot in each hand, applying gentle headward pressure on the heels. Some pressure may be needed to remove dorsiflexion or inversion of the feet so that planes formed by the soles of both feet are parallel. The examiner then assesses the relative lengths of the legs by comparing the position of the shoe welt, or some well-defined line above the sole of the shoe. A difference of more than 1/8 inch is considered a significant finding.

Derefield-Thompson prone leg length tests for pelvic function

The prone leg checks are done following the two-step procedure developed by Derefield and later modified by Clay Thompson.[6] The patient is lowered to the prone position on a hi-lo table. In the first step of the test, the feet are cradled in the examiner's hands so that the lower legs are lifted slightly off the table. Gentle headward pressure is applied, and any dorsiflexion or inversion of the feet is removed. The LLI is estimated to the nearest 1/8 inch. A difference of more than 1/8 inch is considered a positive finding. In the second step of the Derefield-Thompson test, the patient's legs are flexed at the knee to past 90°. The relative lengths of the legs are assessed in the second position, again looking for a difference of more than 1/8 inch.

Prone leg length difference test for cervical syndrome

With the legs in the extended position, the patient is asked to turn his or her face to one side, back to center, and then to the other side. Any change in relative leg length in response to head rotation is recorded.

Prone leg extension for sacral restriction

With the patient still prone on the hi-lo table, the examiner stabilizes the sacrum with one hand and requests the patient to extend one leg up off the table while keeping the knee straight. One leg is extended, and the examiner marks the height of the leg lift by holding his or her hand in the air at the highest location the leg reached. The other leg is then extended in the same manner, and the relative height is assessed by comparison to the mark reached by the other leg. Discrepancies of more than 1 inch and the height of the lower side are recorded.

Test battery results

The results of all six tests are tallied in the patient record and compared with the findings of previous visits. If more than half of the tests produce the same or similar findings on successive visits, then the patient is considered to be "in pattern" and perhaps in need of adjustment. All of these tests, including the cervical syndrome and sacral leg checks, are considered screening tests for the presence of stress on, or lack of adaptability in, the nervous system. Some tests, such as the cervical syndrome check and sacral restriction test, also give a general idea of where to begin looking for vertebral subluxation in the next stage of the chiropractic assessment.

SUBLUXATION LOCATION

Locating the specific level of vertebral subluxation involves the integration of information from three different types of analysis: the leg checks, palpation, and X-ray analysis. Descriptions of how each of these tests is performed and the use of the information gained constitute the operational definition of the subluxation location component of the Sherman College vertebral subluxation definition.

Leg checks

The leg check methods are described in the above section on the neurologic evaluation. The leg checks provide information about which general area of the spine or pelvis might be involved in the subluxation. It is used to devise a strategy for further investigation as follows:

- *The supine leg length difference.* It is used as a sign that subluxation may be located in the upper cervical spine. This assessment is commonly used in the Grostic/Orthospinology and Sweat/Atlas Orthogonal techniques.
- *Derefield-Thompson prone leg length.* The results of the prone extended and prone flexed leg checks are compared to produce one of two indications. When the side of the extended LLI switches to the other side on knee flexion, it is called a Derefield positive or pelvic positive. The pelvic positive is taken as an indication that there may be posterior and inferior misalignment of the posterior inferior iliac spine (PI-PSIS) on the side to which it crossed over, or an indication of rotation of the L5 spinous process to that side. When the LLI is on the same side, whether the legs are extended or flexed at the knee, it is called a Derefield negative or simply pelvic negative. It serves as an indication that the PSIS has misaligned anterior and superior (AS-PSIS).
- *Prone leg length difference test for cervical syndrome.* A change in relative leg length in response to head rotation is taken as an indication of a lower cervical or occiput misalignment as in the Thompson technique.
- *Prone leg extension for sacral restriction.* Any discrepancy of more than 1 inch may be an indication of a posteriorly rotated sacrum on the side of restriction.

The leg check information does not serve as the final word for determining vertebral listings or for making a decision where to adjust. The palpations and X-ray findings must be used to corroborate or refine the listings.

Palpation

A three-step approach to palpation is taught at Sherman College, including muscle palpation, static bony palpation, and motion palpation (MP) of the suspected region(s). Anatomic anomalies are always kept in mind and are rechecked with X-ray examination.

Muscle palpation is done first with the understanding that a muscle with increased tone can indicate a working muscle attempting to correct a misaligned vertebra, a contracted muscle causing a vertebra to misalign, or a combination of both. Recognizing that vertebrae are passive, being acted on by the active muscle system, and that the muscle system is ultimately controlled by innate intelligence, Sherman College embraces muscle palpation from the "working muscle facilitating correction" approach.

Based on the leg check findings, particular sets of muscles, as shown in Fig 1, are first located by palpating bony attachment points, then contacted lightly in the muscle belly to detect side-to-side differences in consistency or tension. A particular bilateral set of muscles may be determined to be balanced, hypertonic on one side, or hypertonic on both sides. Hypertonicity, based on the theory above, is taken as a sign that innate intelligence is attempting to move the attached segment in the direction the muscle is pulling. Hence, groups of muscles that attach to particular vertebrae are used to determine a listing. Fig 1 presents the muscle profile form used by clinicians to record their findings. The muscles palpated and the segmental levels at which they may be found also are shown.

Static bony and MP are routinely assessed together. Each vertebra in areas of suspected subluxation is palpated to determine if noticeable misalignment is present. Each motion segment also is motion palpated with gentle impulses to induce movement and test the end-feel of movement in flexion, extension, and rotation.

The general understanding of the biodynamics of specific joints is kept in mind as an aid in interpretation of palpation findings. Certain precepts that are used include the following:

- C1 as it relates to occiput can misalign in lateral flexion, rotation, or flexion/extension.
- C2 to L5 as each vertebra relates to the vertebra below can misalign in lateral flexion, rotation, and flexion/extension.
- The sacrum and pelvis can misalign with respect to each other and to L5 in lateral flexion, internal and external rotation, and flexion/extension.

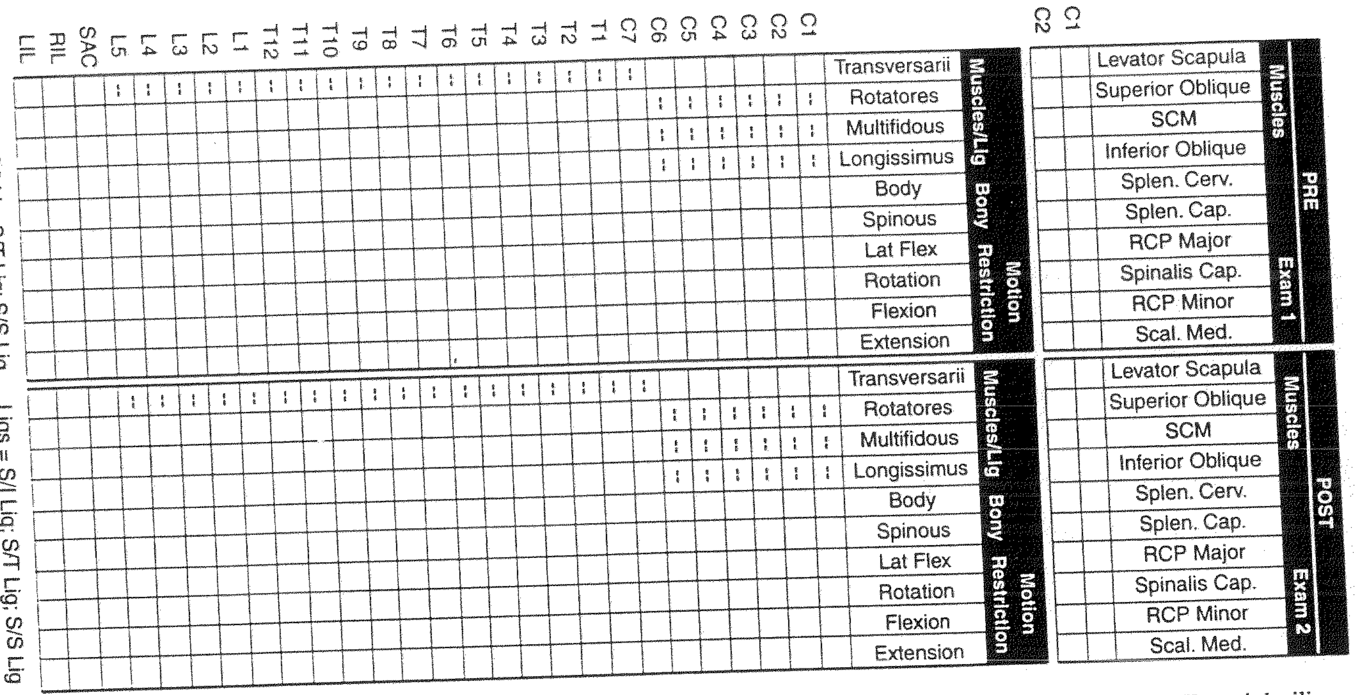

Fig 1. Muscle profile form for recording palpation findings. Note: LIL = left ilium; RCP = rectus capitis posterior; RIL = right ilium; SCM = sternocleidomastoid; S/I Lig = sacroiliac ligament; S/S Lig = sacrospinous ligament; S/T Lig = sacrotuberous ligament. Courtesy of Sherman College of Straight Chiropractic, Spartanburg, South Carolina.

- If a vertebra is misaligned in a particular direction, then motion in that same direction will be restricted. (The movement is restricted because the joint is already fixed in that position and cannot go further into it.) For example, if C1 is misaligned in lateral flexion to the right in relation to the occiput, then the right transverse process will not be felt to approximate the occiput when the head is flexed to the right.

The combination of muscle, static bony, and MP results in a listing for one or more segments, indicating the direction of misalignment.

X-ray analysis

X-rays of the indicated areas are then taken. If the cervical area were the area in question, the following four views would be routinely taken in an effort to get the most comprehensive viewing of the area:

1. Neutral lateral taken for the assessment of the superiority/inferiority of C1.
2. Nasium taken for the assessment of laterality of C1. (This view is taken with the central ray placed directly in line with the plane line of the atlas, as measured from the lateral view.)
3. Base posterior/vertex taken for the assessment of the rotation of C1.
4. Anterior-posterior open mouth (APOM) taken for the assessment of laterality and rotation of C2, and for the rotation and disc wedge assessment of C2 through C7.

X-ray analysis is done using a combination of visualization and line drawing techniques. The precise methods used are a collection of techniques described in class notes and technique manuals. Those documents are available from the college, but are too lengthy to reproduce here.

Each view is analyzed for the patient's position when the X-ray was taken. Since head rotation and head tilt affect the segmental biodynamics, head position must be taken into consideration when determining a listing. For example, the presence of head tilt on the lateral cervical view would cause a superior misaligned C1 to appear less superior than it actually is or a slightly superiorly misaligned C1 might even appear inferiorly misaligned. On an APOM, right head rotation would make a C1 that is slightly misaligned posterior on the left appear to have no rotational misalignment. The integration of body position when the X-ray was taken and the apparent misalignment of each suspected area is considered in this intricate analytical system.

CRITERIA FOR USEFULNESS IN RESEARCH

The above-described clinical approach to assessing neural involvement and locating vertebral misalignment has been in place at Sherman College since its development 25 years ago. While some elements of the assessment methods are taught only at Sherman College, most are in common use throughout the chiropractic profession. The approach has passed the test of time, but does it meet the criteria for an operational method useful for research?

To be accepted as a tool for research, any assessment method needs to meet certain minimum criteria. First, the phenomenon must be measurable in an objective fashion. In this case, the subjective features of the assessment methods must produce reliable, repeatable results at the very minimum. Several questions need to be satisfied in preliminary studies of the elements of the subluxation assessment, for instance:

- Can independent assessors observe the measures?
- How stable are the measurements?
- How precisely can measures be taken?

After satisfactory reliability is demonstrated, a second set of questions needs to be investigated having to do with the validity of the measures. These questions are as follows:

- Do the measures really reflect what they are supposed to?
- Is the system self-consistent?
- How accurate are the assessments?
- Do the measures change with adjustment (ie, Is the assessment sensitive to change?)?
- Are changes in a measurement due to errors in the system of measurement, random fluctuations, or true changes in the patient's status?

Several elements of the proposed subluxation definition have been tested for reliability in published studies. Reviews of systems of chiropractic patient assessment have not generally shown promising results. The most recently published systematic review of chiropractic measures used a rating scale to judge the quality of studies published between 1976 and 1995 pertaining to the reliability and validity of tests for the lumbo-pelvic spine.[7] While some high-quality studies were found, the authors concluded that no tests had been established as valid and reliable measures of a manipulable lesion in the lumbar spine. Since that time, there have been studies that show promise and have taken into account some of the methodologic issues raised by Hestboek and Leboeuf-Yde.

Leg length inequality assessment

Manello[8] reviewed the available evidence for quick leg checks similar to the supine leg check and Derefield-Thompson leg checks used in the assessment of neural involvement in the Sherman College system. While several reliability studies were found, some with promising results, there were challenges to the statistical methodology in most cases, which made a strong conclusion impossible to reach. More recently, however, Nguyen et al[9] tested the activator method's prone leg check using methodology that specifically addressed the problems encountered in previous studies. They found acceptable reliability between two experienced examiners assessing 34 subjects in a blinded setting (Kappa = 0.66). The activator method's prone leg check bears a strong resemblance to the Derefield-Thompson leg check described earlier.

Hinson and Brown[10] carried out a reliability study of the supine leg check often used in specific upper cervical chiropractic techniques. The study involved nine experienced practitioners and nine subjects; it also used a blinded assessment. Again, the measure was found to be reliable, with 60% of the measures agreeing to within 1/8 inch and 80% agreeing to within 1/4 inch. The measure of concordance used by Hinson and Brown was the intraclass correlation coefficient (ICC). The overall interexaminer ICC was 0.94, indicating good agreement between doctors.[10]

Palpation

Chiropractors traditionally use three different palpatory methods as indicators of the need for chiropractic adjustment: static palpation of vertebral alignment and tenderness, MP for passive movement characteristics, and muscle palpation to detect muscle tone imbalances. Of these, MP has been the most frequently studied. While MP seems to have good face validity, it is considered to have limited objectivity. Keating[11] performed a meta-analysis of the available literature on MP in 1989 and concluded that no strong claims for the objectivity of lumbar MP could be made at that time. Studies of MP reviewed by Keating showed very little reliability, a limited number of examiners, and overreliance on asymptomatic students as palpatory subjects.

An interesting finding from reliability studies is that while inter-examiner reliability is typically low, intra-examiner agreement is generally good (ie, assessors often agree with their own measures). Breen[12] suggested that some of the error could be traced to examiners simply misnaming the involved segment. Panzer[13] reached similar conclusions in a more recent review of the MP literature and recommended that improved standardization of palpatory techniques be achieved.

The other forms of palpation used by chiropractors also appear to have good face validity (ie, they make good sense), but there are few if any reports on their objectivity. Without demonstrated reliability, claims relative to a method's objectivity or validity cannot be made. However, a survey[14] of chiropractors showed that these methods are commonly used and relied on for making clinical decisions relative to patient care.

A specific type of muscle palpation technique is taught at Sherman College as one of the methods used to detect subluxation. Spano[15] teaches advanced muscle palpation (AMP), a similar method. AMP has been the subject of one validity study in which listings from palpation were compared to X-ray findings using the Grostic procedure of upper cervical X-ray analysis. Since only one palpator was used in that study, reliability could not be confirmed; however, the almost perfect concordance between the methods is encouraging.

Paraspinal thermography

Literature reviews describe the use of thermography in chiropractic practice. Thermography can be a diagnostic tool for a variety of radiculopathies, entrapment neuropathies, and the vertebral subluxation complex.[16,17] A wide array of information from the basic science literature relates paraspinal skin temperature control to neurologic function.[17]

B.J. Palmer and researchers (including Lyle Sherman) at Palmer College developed a "pattern analysis" for use in assessing dual-probe thermograms of the paraspinal skin. Differential thermograms were generated with the Neurocalometer that showed the side-to-side temperature difference along the skin adjacent to the spine. In pattern analysis, the detailed character of the differential thermograms was compared day to day, looking for the emergence of recognizable patterns. When no pattern was present, the patient was presumed to be adapting normally. The presence of the same pattern on successive days was taken as evidence of the need for an adjustment.[18–20]

The inter- and intra-examiner reliability of a hand-held temperature differential instrument was investigated by Plaugher et al[21] in 1991. They used a "break" analysis to locate sharp changes in side-to-side temperature balance. Inter-examiner and intra-examiner agreement were rated as fair to substantial using the Kappa statistic. Better agreement was found in the mid-thoracic spine than in the C4-T2 scans.[21]

Clinical case studies using pattern analysis of thermograms have been presented recently in the literature, including those of Hart,[22] Hart and Boone,[23] and Kessinger and Boneva.[24,25] Hart and Boone[23] developed a method for assessing the degree of similarity between thermograms using a manual measurement. Stewart et al[26] and Owens et al[27] developed computational methods that make use of digitized thermograms. Computer-aided pattern analysis is useful because it quickly provides a numeric assessment of the degree of similarity of thermograms and allows clinicians to detect patterns in an objective fashion. The computer-aided analysis is still being tested for reliability at multiple sites and has not been incorporated into the Sherman College system yet.

X-ray analysis studies

Radiography has had a long and contentious history in chiropractic. Its use for screening of pathology is well accepted. Less well recognized are its applications for assessing vertebral misalignment. One review of the use of line drawing methods for assessing cervical spine alignment was published in 1992.[28]

Early studies of upper cervical line drawing analyses showed that there were changes in alignment evident from radiographs taken before and after specific upper cervical adjustment.[29,30] Reliability studies centered on determining whether the marking systems could be used with enough precision to measure the 1.5° to 2° changes in alignment thought to be associated with upper cervical subluxation. Sigler and Howe[31] concluded from their study that X-ray analysis was not reliable enough to be used as an assessment for misalignment. More recent studies[32–34] have been promising, showing that inter-examiner reliability is sufficient to allow a precision of ±1.5° for certain line drawing methods, including the Grostic procedure and the Harrison listing system. Keating and Boline[35] provided a review of the studies of upper cervical listing systems, showing the mixture of findings. They concluded that the measurement system was sometimes accurate enough to detect small changes in atlas laterality. Rochester and Owens[36] performed a follow-up of Keating and Boline's review, pointing out that, of the 15 doctors tested in various reliability studies, 80% had achieved precision adequate to detect 1.2° of atlas laterality.

Full spine and lumbo-pelvic listing systems have been studied less often, but recent studies[37,38] are demonstrating good reliability of measures. While reliability studies have been performed using blinding and randomization, usually having multiple examiners analyze the same set of films, there has been only one study assessing the stability of the X-ray procedure itself. Hosek and Owens[39] used a triple-blind design, including two control groups that were X-rayed twice with no intervening adjustment. In the group where subjects were placed on the adjusting table in the side posture position used for adjustment, but with no thrust applied, the changes seen in the before and after X-rays were similar to those seen in the adjustment groups. In the other control group, where subjects were not placed on the table, or adjusted, the X-ray analysis showed slightly less change in vertebral alignment in serial radiographs, but no statistically significant difference.[39] This study is not likely to be repeated, due to questions regarding the exposure of patients to serial radiographs where no intervention is provided.

Other studies[40,41] have demonstrated changes in vertebral alignment between pre- and post-adjustment X-rays in practice settings, but these have not employed blinding of the examiners. It may be possible to test X-ray analysis systems using moveable X-ray phantoms, as demonstrated by Grostic[42] in a pilot study. Computer modeling also can be used, but X-ray views simulated from computer models have not produced acceptable images to date. Computer models show the shell of the bone only, representing the bone as if it had uniform cortical thickness and no internal structure. Modeling the bone surface as a semitransparent glass can produce simulated X-rays, but some of the landmarks that are used in X-ray analysis are not well represented.[43]

SUMMARY

The technology of reliability studies has largely been worked out, including methodologic issues and statistical analysis. It is recognized that concordance statistics such as Cohen's Kappa and ICC are the methods of choice when assessing reliability. While experienced examiners should be used, they are encouraged to compare methods in a consensus-building procedure before study initiation. It also is recognized that randomization and blinding are important parts of the study protocol, along with the use of naive, new patients who are more likely to exhibit positive findings on the tests. Further, it is important to avoid performing too many tests on the same patient in the same session since the testing itself may change the status of the patient. With these issues in mind, the door is open to more productive research on chiropractic methods.

The patterning method described in the neurologic component of the Sherman College system tends to enhance reliability in that measures are not considered significant unless they are repeated on multiple occasions. There is recognition that measures may be unstable since the system under examination is not passive; responses may only be repeatable if they are stereotypical, indicating lack of adaptability.

The proposed method has an added advantage in that multiple types of measures are used in clinical decision making. For instance, subluxation is indicated only when at least three of the six neurologic assessments indicate that interference is present, and there are palpatory findings and X-ray findings that concur on the location of misalignment. Keating et al[44] and Haas[45] both noted that combining multiple examination methods in a multidimensional index can produce more reliable indicators for adjustment. Based on mathematical modeling of multitest scores (MTS), Haas[45] suggested that MTS be taken as positive if somewhere near half of the component tests were positive. Straying in either direction, for instance only accepting a positive finding if five of six tests were positive, tends to generate a high likelihood for agreement by random chance. The Sherman College method for detecting nerve interference is in agreement with Haas' model in that maladaptation in the nervous system is presumed present when at least three of the six tests are in pattern.

Assessing the validity of subluxation measures remains a challenge since there is no external reference system or gold standard for comparison. The solution may lie in the philosophic notion that vertebral subluxation has a detrimental effect on the individual's health or physiology. According to Meeker, "A physical attribute can be used to define a subluxation when it can be demonstrated that a certain level of anatomic or physiologic variable is related to a concept of health. Hypothetically, a diagnosis of subluxation can be validated when it reaches a point where there is evidence that health is compromised."[1(p72)]

Thus, an external measure of health may be the best way to validate any definition of subluxation. In that respect, we can ask such questions as: Do patients cared for in such a way as to eliminate the signs of vertebral subluxation experience positive clinical outcomes?

A practice-based study[41] used the RAND SF-36 in combination with pre- and post-adjustment X-rays analysis to show that patients of upper cervical specific practitioners experience an increase in general health while undergoing a course of care aimed at correcting misalignments in the upper cervical spine. X-ray analysis also showed improved alignment in those patients for whom pre- and post-adjustment X-rays were available.

In a broader context it might be desirable to show that the removal of subluxation signs can be correlated with improved function, or increased efficiency or adaptability in the individual. In this way more subtle signs of the deleterious effects of subluxation (or the positive effects of adjustment) might be determined.

CONCLUSION

An operational definition is offered for consideration for general use in chiropractic research. The approach, based on the clinical system taught at Sherman College of Straight Chiropractic, has two parts: (1) the detection of neurologic involvement and (2) the location of a specific segment to be adjusted. The test of neurologic involvement is based on the pattern analysis developed at Palmer College and compares multiple tests over time to detect a static pattern of signs. When at least half of the six tests show the same response on three subsequent occasions, the nervous system is considered to be showing signs of maladaptation and stress. The methods for locating misaligned segments include leg checks to provide a general location, followed by more specific analysis from X-rays and palpation.

Most components of the proposed system of analysis are in common use within the chiropractic profession, and several have been the topic of extensive reliability testing. Although pre-1995 reviews are not promising for any modality, recent studies of LLI and X-ray analysis suggest that these modalities may provide acceptable reliability. It is suggested that combining multiple tests into a subluxation detection scheme as done here will provide enhanced reliability. Validity testing of individual parts of the subluxation analysis method has not generally been done. It may be possible to validate the system as a whole, however, by using clinical outcomes and health measures as external standards for comparison.

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Chiropractic subluxation assessment: what the research tells us

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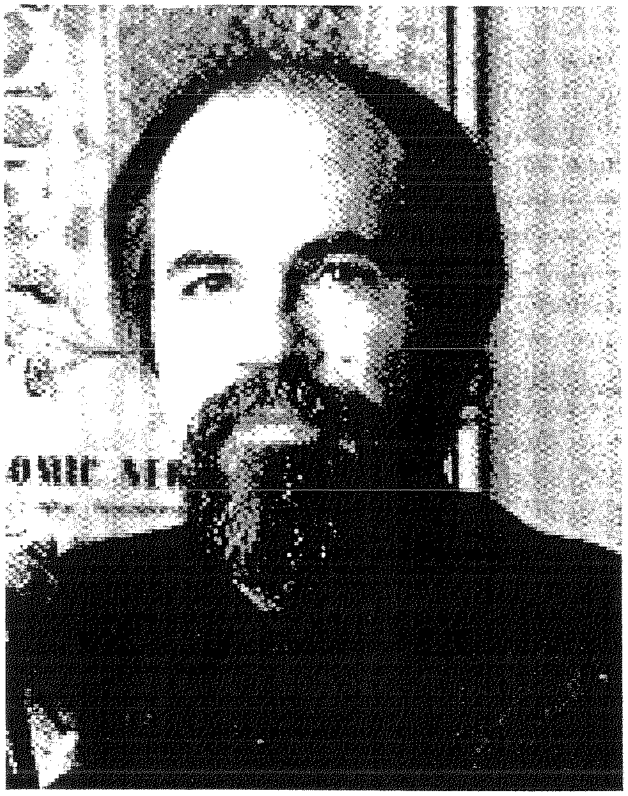

Edward F Owens, Jr.

The chiropractic profession has long had a philosophic attachment to the subluxation concept. Recently, however, the research sector has paid increasing attention to the evidence-base for subluxation. Subluxation Theory has become a topic of discussion at the annual Research Agenda Conferences, since 1999. This article will review several of the recent contributions to the scientific literature that develop subluxation models and evaluate the methods chiropractors use to assess patients for the presence of vertebral subluxation.

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When you speak of subluxation, the first description that often jumps to mind is the traditional misalignment, occlusion of a foramen, pressure on a nerve and interference (MOPI) model proposed by B.J. Palmer.[1] In fact there are several modern models currently in use as well. Some are conceptual models, such as the Vertebral Subluxation Complex model of Faye and Lantz,[2] which proposes as many as nine components interacting in a complex. The profession has also developed consensus models, such as that in use by the Association of Chiropractic Colleges:

> "Subluxation is a complex of functional and/ or structural and/ or pathological articular changes that compromise neural integrity and may influence organ system function and general health."[3]

While consensus models are very broad in order to encompass all their constituents, they are actually fairly useless for research purposes. The definition above posits that subluxation should have an element of articular pathology, but leaves the exact nature of that pathology unspecified. According to this definition, it could be a functional or structural lesion. Is it a fixation, a slight disarticulation or perhaps a change in joint surface area of contact? This definition does specify that the articular change should be associated with a neurological effect in order to be considered a subluxation. Still, the exact nature of the compromise to neural integrity is unclear. Is it compressive or reflexive in nature?

Our greatest need in this area is for an "operational definition" that describes subluxation according to the measurements or procedures you use to locate and analyze it. The operational definition is the model you can test for reliability and validity using the tools of science. Once validated at some level, the operational definition could then be used more widely in outcomes studies.

Nearly any named chiropractic technique has some kind of specific set of procedures you use to assess the patient, either from a structural or functional point of view. Very few of these models have been subjected to scientific scrutiny, however. There are some recent models that do describe operational definitions and the evidence base that exists in support of that definition. (See Table 1.) Each of these models represents a different view of what the authors consider a subluxation to be; however, there are some overlaps, particularly in the clinical methods described.

Osterbauer proposes an integrated model where regional measures such as palpation and intersegmental range of motion are combined with assessments of pain, physical capacity and physical performance to arrive at a comprehensive diagnosis.[4] He performed a literature review to identify the usefulness of several assessment procedures, some were survey instruments and others were manual assessments. In general the manual assessments such as Leg Length Reactivity and palpation had high quality studies available, but did not rate as highly as clinical measures of patient symptoms or function, such as the Visual Analog Scale (VAS) for pain or the Neck Disability Index. Osterbauer advocates using physiologic measures as indicators of normal function and relating those measures to subluxation measures in future studies of validity.

Bergman and Finer describe a system of diagnosis called the P.A.R.T.S. system. The acronym stands for

Table 1
Several articles published in the past 6 years describing operational definitions of subluxation

- Paul Osterbauer "Technology Assessment of the Chiropractic Subluxation"[4]
- Tom Bergmann, Bradley Finer "Joint Assessment – PARTS"[5]
- Bob Cooperstein, Anthony Lisi "Pelvic Torsion: Anatomic Considerations, Construct Validity and Chiropractic Examination Procedures"[6]
- Ed Owens, Val Pennacchio "Operational Definitions of Vertebral Subluxation: A Case Report"[7]
- John Triano "The Functional Spinal Lesion: An Evidence- Based Model of Subluxation"[8]

those modalities evaluated clinically: pain, asymmetry, range of motion, tone and texture and special tests.[5] Like Osterbauer's model, several methods, including palpation, x-ray analysis and ROM are used in conjunction to render an assessment. Bergman and Finer also describe how the P.A.R.T.S. system fits in with a comprehensive patient evaluation scheme, including medical history and physical examination components.

Cooperstein and Lisi focus on the pelvis and develop a model of pelvic torsion based on a review of the literature.[6] They describe the types of pelvic motions observed and ways of measuring them, from instrumented methods on cadaver specimens to manual methods used in patients. Pelvic inclinometry, radiographic methods, palpation and leg checks are considered useful in detecting the presence of abnormality, but methods vary in their accuracy and validity. These methods are often poor indicators of what adjustment is needed to correct the problem. The authors recommend taking a close look at the biomechanical features of typical orthopaedic maneuvers, such as Gaenslen's test, for indications of what care to provide.

Owens and Pennacchio present the operational definition in use at Sherman College for locating subluxations. Like the above, it is a multi-test system, including paraspinal thermography, leg checks, palpation and x-ray analysis.[7] Owens and Pennacchio review the literature regarding the reliability of the methods used at their college. As seen below, some methods have been found reliable to some extent, but very few have been tested for validity. There is also the beginning here of a scheme for defining how individual procedures fit together into a complete package.

Finally, Triano presents a somewhat new model of subluxation, which he calls the Functional Spinal Lesion (FSL), and describes the evidence base for it.[8] This model is more structural in its approach, considering the material properties of the structures that are required to bear loads in the spine. When the tissues are overstressed due to injury or lack of muscle coordination, then instability and buckling can occur, leading to further injury and symptoms. Unlike in the models above, which are based more on procedures and practical methods, Triano does not go into details on the operational definition of the FSL.

Notice that none of the models above goes into the details of how the nervous system might be impacted in the subluxation. They are devoted to the clinical aspects of the subluxation that we can observe from the outside. Some consider the possible regional effects of subluxation on physiological processes such as muscle tone or thermoregulation. None of them posits a particular nerve interference event, as does the classic MOPI definition of subluxation, with its occlusion of a foramen and compression effects. Perhaps it is the more pragmatic nature of operational definitions, what cannot be observed can only be guessed at, so why bother? The exact nature of the neural impact of subluxation might be better evaluated by basic science research, including animal models.

Researching any of these operational definitions typically involves evaluating the evidence for the reliability and validity of the methods used. Reliability is often considered just the repeatability of the measurement, but it involves several principles: Is the thing being measured stable or prone to shift at random? Can the measurement be done in an objective manner so that different assessors can agree on findings? How accurately and precisely can the measurement be made? Intra-examiner reliability tests how well the same examiner can reproduce the same results, while inter-examiner reliability compares results between different examiners. All these components help us understand whether changes that might be seen in measures before and after care are really due to the care provided, and not due to measurement error, examiner bias or spontaneous fluctuations.

Validity is an even trickier condition to demonstrate and determines our understanding of the usefulness or sensitivity of an analysis method. Check any research methods book and you may be surprised to discover that some include 15 or 20 different aspects of validity. In the simplest version, validity is akin to accuracy. Does the method under consideration measure what it says it does? This kind of validity is assessed by comparing a new system of measurement to an existing best method or "gold standard" that allows you to calibrate the new method. At the very least, any system must be reliable to be considered valid, and if there are component measures, they should be internally consistent.

A deeper validity question involves the meaning of a measure. What ranges are considered normal and when is pathology indicated? In chiropractic, we have as yet no established standard subluxation measure to use to validate models, so we are actively looking for alternative methods.[9]

Two interesting examples of how validity tests can come up with different results were presented at the International Conference on Spinal Manipulation this past October in Toronto. B. Kim Humphreys of CMCC and Mitch Haas of Western States Chiropractic College both presented the results of validity studies of cervical end-play assessments.

Their methods were quite different and the results opposite of each other. (No blows were thrown, however.) Humphreys used a simple but elegant method to test whether clinicians could detect the incidence of block vertebrae in three patients.[14] The levels of block vertebrae and presumed absolute fixation were known from radiographic evaluation (a gold standard for end-play). Clinicians did a fairly good job of detecting those abnormalities, indicating that manual end-play assessment does in fact detect what it says it does in those extreme cases.

Haas' test of validity was quite different. In their study, they checked to see whether patients adjusted using the results of an end-play assessment faired any better in terms of pain and stiffness than patients who were adjusted based on a random assignment of adjustment levels.[15] The results showed no benefit to the end-play assessment, suggesting that the test provides no useful information for patient care and questioning the validity of the method. Stay on the lookout for full-length articles of both of these studies in the next year or so.

Reliability testing has been going on in chiropractic since at least the mid 1970s. Much of the work appears in conference proceedings and some in peer-reviewed journals. A good way to find citations is to do a literature search in an electronic database. The easiest database to access is MEDLINE, a service of the National Library of Medicine. Since MEDLINE indexes only a few journals of interest to chiropractors, it is more productive to search one of the commercial specialty sites like MANTIS or CINAHL. A search of MEDLINE in April, 2002 using the keywords palpation, leg length inequality, X-ray analysis and thermography produced 11 citations, all to articles in JMPT. A second search of CINAHL using those same keywords, along with a special term in CINAHL's word list "chiropractic assessment", produced an additional 22 citations. The CINAHL search was restricted to "Expert Peer Reviewed" journals, to eliminate several references found in trade journals, rather than research journals.

If you want to follow along this trail yourself, a good place to start is with the critical review article published by Lise Hestbaek and Charlotte Leboeuf-Yde.[10] They evaluated studies that were published between 1976 and 1995 on measures used to assess the lumbar spine. Their review also looked at the methods used in each study and judged the results based on the quality of those methods. None of the tests they studied reached a very high degree of both reliability and validity, although palpation for tenderness had the best results.

In my literature review, I also found a number of studies that were published in peer-reviewed journals that either had more recent data or looked beyond the lumbar spine. In compiling a list of methods used to assess subluxation, they can be divided into "local" or "remote" methods. Local methods look at joint alignment or muscle tone just in the area of a suspected vertebral subluxation (Table 2). Remote methods look at more global responses to the spinal problem, such as postural distortion or range of motion (Table 3). The citations listed in the tables refer to articles in the reference list that report on reliability or validity of the methods. I've rated the reliability and validity of each measure according to what I found in the literature review. If the most recent studies were showing results in favor of reliability or validity, I rated that measure as a "+" in the table, indicating moderately positive findings. If the preponderance of data was negative, the rating was simply "-." In those cases where the references were equivocal, some positive and some negative, the rating "+/-" was given. In some cases, articles with very differing opinions, or long sequences of letters-to-the-editor suggested to me that the measure is more than just equivocal, but actually contentious; those are denoted with a '!" in the table.

Conclusion

Progress is being made on several fronts toward operationally defining subluxation. Most new models combine commonly used manual assessment methods into a system for rendering a subluxation diagnosis. Researchers performing reliability studies have learned from the mistakes of the past and are using more valid methods of investigation. Perhaps as a result, more subluxation assessments

Table 2
Local methods of subluxation assessment. Citations are indicated by reference number.
Reliability and validity are rated: "+" = fair to moderate, "+/–" = equivocal,
"–" = poor to nonexistent, "!" = contentious, " " = no data found.

Local Methods	Citations	Reliability Intra-examiner	Reliability Inter-examiner	Validity
Palpation – pain/tenderness	10	+	+	
Palpation – alignment	10	–	–	–
Tissue Compliance	11	+	+	
Motion Palpation – active	10	+	+/–	!
Motion Palpation – end play	10, 12–15	+	–	+/–
Static X-ray – Cervical	10,16–22	+	+	!
Static X-ray - Lumbar	23, 24	–	–	!
Surface EMG	25–27	!	!	+/–
Para-Sp Thermography	28–30	+	+	

Table 3
Local methods of subluxation assessment. Citations are indicated by reference number.
Reliability and validity are rated: "+" = fair to moderate, "+/–" = equivocal,
"–" = poor to nonexistent, "!" = contentious, " " = no data found.

Remote Methods	Citations	Reliability Intra-examiner	Reliability Inter-examiner	Validity
Visual inspection	10, 23	–	+/–	
LLI – Prone	10, 31, 32	+	+	+
LLI – Supine	10, 33–35	+	+	+
LLI – Reactive	10, 36–38	+/–	+/–	+/–
SOT tests	10	+/–	–	+

are being found reliable in current studies, including palpation for pain/tenderness, paraspinal thermography, prone and supine functional leg length inequality and cervical x-ray line drawing analysis. New methods, such as computerized tissue compliance measurement and computer-aided thermographic pattern assessment are being developed, and initial results have been positive for reliability. Still, we are hampered in our ability to test validity of the measures and systems. As local phenomena, several tests appear to measure what they claim to measure, but the meaning of the findings, in terms of an external measure of health or function is mostly unknown.

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The Chiropractic Journal

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Thermography -- A valuable tool in differential diagnosis of pain patterns

by Dr. David J. BenEliyahu

The Chiropractic Journal recently published a two-part presentation by Stephen M. Perle, D.C., CCSP, on myotomal and scleratomal pain patterns. The purpose of this article is to educate the practicing chiropractor as to the benefit of thermography in differentially diagnosing dermatomal, scleratomal and myotomal origins of pain.

As most know, the embryological somite is divided into three segments: dermatome, myotome, and scleratome. Each of these structures can cause referred pain in a different type of referral pattern.

Scleratomes include structures such as bone joints (facet) and ligaments. Kellgren injected hypertonic saline into interspinous ligaments of various cervical, thoracic, and lumbar segments. Very definite patterns of pain referral were seen. [15] Typically, L2 referred pain to the groin; L3 to the upper anterior thigh; L4 to the anterolateral thigh; L5 to the lateral thigh, calf, and plantar foot; and S1/S2 to the posterior buttock, thigh, calf and lateral foot; [1,2,5] C5 referred pain to the shoulder area; C6 to the radial forearm; C8 to the medial forearm; and C7 to the posterior forearm.

Mooney and Robertson performed a similar study with hypertonic saline and made similar findings. [3] Kellgren also injected saline into the deep and subcutaneous periosteum. The deep periosteal referral patterns were generally distant from the site of injection, whereas the subcutaneous periosteal referrals were in the area of the injection.

Kellgren also injected hypertonic saline into various muscle groups and charted the referral patterns for various muscle groups. The TFL referred pain to the lateral thigh and calf; the gastrocnemius to the posterior thigh and calf; the sartonus to the anterior thigh. Keegan and Keegan did much work with dermatomes, establishing sensory nerve supply to cutaneous segments.

Differential diagnosis of these three different types of structures is often very difficult due to overlapping symptoms and patterns. Thermography is a diagnostic tool that is capable of helping the chiropractor establish an accurate diagnosis and clinical impression.

Thermography measures cutaneous infrared heat emission. It has been shown that equipment only measures heat 0.5 degrees cm deep, so it is not measuring heat from the deep structures due to convection. What is being imaged is a somatocutaneous reflex response. [2] This is usually seen as hyperthermia (increased thermal emission). Thermography is an adjunctive tool in addition to the chiropractor's examination findings and clinical correlation is necessary.

Thermography/myotomal patterns

Typically, muscle spasm and myofascial trigger points are seen as hyperthermic. [12,13] Trigger points are seen as focal hyperthermias, the myofascial referral patterns are seen as hyperthermic, and muscle spasm is seen as bands of hyperthermia along the muscle's distribution. Myofascial referral patterns usually display pain not only in the area of the trigger point, but distal as well. It can mimic a radicular pattern, but are usually hyperthermic. Travell did much work with myofascial referred pain in her work, The Trigger Point Manual. Fischer did much study with trigger points and thermography and found it to be a valuable tool in diagnosis. [5]

Thermography/scleratomal patterns

Scleratomal patterns are seen in thermography as hyperthermia as well, due to somatocutaneous reflex. Facet joints are imaged as focal hyperthermia over the spine of the level involved or adjacent to the spine of the level involved (usually over the TP). Wexler has published much work on lumbar facet joints L4, L5, S1 and their pattern on thermography scans. They usually appear as focal hyperthermia. Chapman also has done much work documenting various scleratomal patterns from facet joints, fractures, spondylolisthesis, degenerative disc disease and shin splints. Chapman has also documented thermal imaging and the subluxation complex which shows focal hyperthermia near the involved motor unit. [14]

Thermography/dermatomal patterns

Dermatomal patterns are usually seen as hypothermic in the extremities. This is due to sympathetic autonic fibers causing a vasospasm. The vasospasm occurs segmentally in the dermatomal territory. The vasospasm will cause vaso-constriction of the precapillary sphincters and peripheral arterioles thus causing hypothermia. Dermatomal maps vary but the most commonly used are those of Keegan and Keegan.

The sinuvertebral nerve is responsible for this vasospasm since it is known that sympathetic fibers are carried by the sinuvertebral nerve. Hypothermia is said to be due to increased postganglionic activity and increased alpha receptor sensitization in the dermal vessels. [2,7] Hyperthermia is said to be due to the reverse.

In order for a hypothermic finding in a dermatome to be considered valid, it must encompass at least 25% of the surface area, must be at least 1.0 degrees C less than the non-affected side and must be consistently present throughout the study. [6] Research has shown that temperature differentials (Delta T) of the extremities do not vary from right to left more than a few tenths of a degree. [8,9,11] When the Delta T exceeds 1.0 degree C, there is a very high statistical probability of pathoneurophysiology.

Thermography and VSC

Thermography is well-suited to the chiropractic patient since it is non-invasive, risk- and pain-free. It also helps document the various components of the vertebral subluxation complex (VSC), kinesiopathology, pathoneurophysiology, myopatholoy, histopathology and pathophysiology. [10]

Kinesiopathology can be documented thermographically due to aberrant kinematics of the spinal joints from subluxations causing abnormal joint physiology. Pathoneurophysiology can be documented since there is a direct relationship of subluxation to the presence of nerve dysfunction.

Myopathology associated with VSC can be documented by recording patterns from musculoligamentous spasm and myofascial trigger points often associated with subluxation. Histopathology can be documented by measuring inflammatory response at spinal and extra spinal joints.

Inflammation and hyperemia is commonly seen in acute trauma. When vasoconstrictive hypothermia is seen, a poorer prognosis can be expected. Pathophysiology can be documented also because it has been shown that certain physiological dysfunctions via viserosomatocultaneous reflexes will display thermal signals at the surface. Examples include appendicitis and McNuney's point, bilary colic and the right scapula, and others. These somatocutaneous reflexes are typically hyperthermic. This thermography is very valuable to the chiropractor in establishing the presence of VSC and documenting the need for ongoing care to correct its effects.

Chapman has proposed that the underlying pathophysiology of the hyperthermic pattern seen in VSC is due to a chemically-mediated response at the local level. There is a release of substance P histamines, VIP and kinins. These substances may inhibit or block the alpha receptor at the dermal vessel allowing a vasodilatory effect or hyperthermia in the area of the injury.

Summary

Dermatomal patterns are typically hypothermic in the extremities. Myotomal and scleratomal patterns are hyperthermic. Thermography is therefore well suited to help in the differential diagnosis. Each has its own unique map of referral patterns and this can be referred to when interpreting a thermography evaluation. Accurate diagnosis and treatment is then possible. Thermography adds a new dimension in diagnostic acumen to the practicing chiropractor and will enable the doctor to make a distinction between dermatomal, myotomal and scleratomal origins of pain.

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The Chiropractic Journal

A publication of the World Chiropractic Alliance

April 1991

Texas doctors join in suit against HCFA

Federal agency recommending halt to Medicare thermography coverage

The Texas Chiropractic Association has joined with the American Herschel Society and other health care provider groups to support New York attorney Victor Yannacone in his class action suit against the Health Care Financing Administration (HCFA), U.S. Department of Health and Human Services.

The lawsuit was filed on behalf of patients to assure their continued access to pluralistic health care. It was filed in the Eastern District of New York of the United States District Court and assigned to U.S. District Judge Leonard Wexler.

It was brought after an Office of Health Technology Assessment (OHTA) report, entitled Thermography for Indications Other than Breast Lesions, recommended that HCFA discontinue Medicare coverage of thermography for the diagnosis of conditions of anatomic areas other than the breast.

The lawsuit claims that discontinuing such coverage would affect more than 100,000 people in the United States and would create a risk to their health care. HCFA established Medicare coverage for thermography in 1972.

Yannacone is one of the authors of the Agent Orange lawsuit against the federal government. The American Herschel Society is a thermographic association made up of neurologists, radiologists, dentists, orthopedic surgeons and chiropractors. It was organized in 1989 and is based in Jacksonville, Fla.

The Texas Chiropractic Association joined the class action lawsuit after the Texas Industrial Accident Commission began limiting the access of chiropractors and other health care professionals to clinical thermography utilizing modern digital thermal imaging technology.

The Texas commission began to effectively preclude chiropractors throughout Texas from utilizing thermography in the diagnosis and treatment of patients who are victims of industrial accidents and occupational disease. This action came after an October 1990 decision by the HCFA to withdraw Medicare coverage of thermography for the diagnosis of conditions in anatomic areas other than the breast.

In addition, Yannacone claims the Texas commission accepted testimony, without the opportunity for cross-examination, from individuals and representatives from certain groups who were contributors to the HCFA's proposed regulation.

Clinical thermography utilizing modern digital thermal imaging technology is a technique used to quantitatively and qualitatively measure and map variations in skin temperature. It uses an infrared imaging radiometer system to record the temperature of skin at resolutions approaching the nearest .05 degrees Centigrade for contiguous areas from one to 10 millimeters square.

The data obtained is converted to a digital image for processing by a computer. The data compares differences in skin temperature between regions of the body which are relatively thermally symmetrical. Changes in skin temperature may occur as a result of muscular activity, trauma or stimulation of sensory and/or autonomic nerves resulting in vasoconstriction or vasodilatation.

Statistically significant thermal asymmetries may indicate neurologic or vascular dysfunction or inflammatory conditions.

OHTA is part of the National Center for Health Services Research (NCHSR) and Health Care Technology Assessment, Public Health Service, Department of Health and Human Services.

OHTA evaluates the safety and effectiveness of new or unestablished medical technologies that are being considered for coverage under Medicare. These assessments are performed at the request of HCFA and are the basis for recommendations to HCFA regarding coverage policy decisions under Medicare.

Questions about Medicare coverage for certain health care technologies are directed to HCFA by such interested parties as insurers, manufacturers, Medicare contractors and practitioners. Those questions of a medical, scientific or technical nature are formally referred by HCFA to OHTA for assessment.

In the class action suit, Yannacone alleged that OHTA did not solicit input from those professionals having practical knowledge of clinical thermography utilizing modern digital thermal imaging technology.

Yannacone also claimed that the report did not represent a detailed analysis of the safety, clinical effectiveness and uses of clinical thermography utilizing modern digital thermal imaging technology.

Robert E. Wren, director of the Office of Coverage Policy of HCFA, said new or emerging medical procedures must be demonstrated to be safe and effective by accepted clinical evidence before Medicare will pay for them under an HCFA interpretation of the Medicare Act.

Wren also said the vast majority of decisions on Medicare coverage are made on a case-by-case basis by HCFA contractors such as fiscal intermediaries, carriers and peer review organizations. These decisions, Wren said, are based on determinations of in-house medical staff and HCFA coverage directives.

Wren said HCFA may be involved in these decisions in several ways. In some cases, Medicare contractors refer questions concerning new medical procedures or technologies to the HCFA regional or national office for an informal judgment. In other cases involving complex or controversial medical issues, HCFA makes "national coverage determinations" that apply in all future cases.

Wren said that in 1982, several Medicare contractors recommended that HCFA consider limiting coverage for thermography, claiming other diagnostic techniques were available. Later that year, OHTA conducted a safety and effectiveness assessment of thermography as a diagnostic technique.

In 1984, the HCFA revised its policy to exclude Medicare coverage for thermography for detection of breast cancer. A year later, OHTA issued a second assessment covering the use of thermography for conditions other than breast disease, but it was withdrawn after OHTA received additional scientific data.

In May 1990, the HCFA instituted another assessment report and ultimately withdrew Medicare coverage of thermography for the diagnosis of conditions in anatomic areas other than the breast in October 1990.

Previously, the HCFA provided Medicare coverage for the following conditions:

*** Peripheral vascular disease including thrombophlebitis, arterial insufficiency and deep vein thrombosis.

*** Musculoskeletal injury involving musculoligamentous soft tissue or discogenic conditions.

*** Extra-cranial vessel disease diagnosis upon demonstration of central nervous system symptoms such as carotid insufficiency.

*** Diagnosis of inflammatory, neoplastic and hyperplastic lesions. Yannacone claims that clinical thermography utilizing modern digital thermal imaging technology satisfies the criteria for coverage under Medicare and meets the fundamental tests of safety, clinical effectiveness and cost effectiveness.

In the lawsuit, Yannacone asserted the following:

*** OHTA failed to apply established analytical criteria in its evaluation.

*** OHTA failed to review all relevant studies and reports concerning the use of clinical thermography.

*** The methodology used by OHTA to review the medical, scientific and technical literature regarding thermography was seriously flawed.

*** OHTA failed to report or discuss differences in the accuracy and reliability of thermography equipment, failing to acknowledge the dramatic improvement in sensitivity and reliability of digital thermographic instruments during the past decade.

*** OHTA failed to consider the reliability of its reference tests and failed to consider risks associated with its reference tests.

*** OHTA failed to consider the cost effectiveness of thermography.

The lawsuit is asking the court to declare clinical thermography utilizing modern digital thermal imaging technology to be a safe and effective technique for the diagnosis or characterization of:

– Nerve root irritation and compression.

– Peripheral nerve injury, whether as a result of genetic, congenital or metabolic factors, trauma, infection, exposure to toxic substances, vascular, neoplastic, degenerative/demyelinating conditions or paroxysmal causes.

– Reflex sympathetic dystrophy

– Occlusive disease of cranial vessels

– Cephalic syndromes (headaches)

– Temporomandibular joint dysfunction (TMJ)

– Neuropathy and neuropathic pain syndromes

– Musculoskeletal pain

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The use of thermography in the diagnosis of V.S.

by Dr. Robert E. Ward

Thermography is a diagnostic tool used to measure the physiological function by recording heat emissions. This heat is a measure of the metabolic activity and microcirculation changes taking place in the skin tissues. This is a byproduct of the chemical reactions taking place in the tissues, but because the radiation wavelength is towards the infrared end of the light spectrum, it is invisible to the unaided human eye.

Thermographic equipment uses colors to reveal the detected heat emissions, depending on the level of infrared energy of the area examined. These colors will differ in various parts of the body, but in a normal individual, the color changes should be symmetrical.

Thermography is non-invasive and a radiation-free method of evaluating certain types of pathology, vascular changes, and nerve involvement.

At present, thermography is utilized to detect a wide variety of health problems. The primary utilization in the last few years has been for the assessment of pain syndromes, most notably by the legal profession, to substantiate personal injury cases. This usage of thermography is justifiable, but represents only a very small portion of the ability to evaluate the human subject.

Thermography is coming into its own as a diagnostic entity for neuromuscular and skeletal disorders, as well as vascular disorders. However, chiropractors need to examine the uses of thermography as it applies to the diagnosis and treatment of the vertebral subluxation, or what Chapman calls, "Biomechanical Impropriety."

Subluxation has two distinct and varied effects: 1) acute -- which is accompanied by inflammation, edema, and pain, which has definite neurological and physiological effects, and which can be detected by the use of thermography; and 2) chronic -- which, if left uncorrected, can propagate symptoms and loss of proper function in peripheral regions of the body, as well as degeneration of the motor units and surrounding soft tissue.

An acute subluxation is more easily detected by thermal imaging, due to increased blood supply, stretching of the surrounding ligamentous structures, stress on the synovia, increased metabolism at the site, and possible slight hemorrhage.

The chronic, static subluxations are harder to image, due to the lack of the initial inflammatory response in the area. This requires a special stress view in order to provide evidence of posterior joint irritation and soft tissue aggravation.

There are numerous established patterns for specific subluxation patterns, such as facet syndrome, laterality, specific segmental dysfunction, decreased inter-osseous spacing, and various other positional misalignments.

Also, referred thermal patterns from affected viscera are established which can be of use in evaluating treatment efficiency.

At this time, more chiropractors are needed to utilize thermography for the evaluation and diagnosis of subluxations, in order to compile more data and correlate specific thermal findings with established subluxation patterns.

Most of the credit for the present work in thermography and subluxation is given to Dr. George Chapman, who, over the last several years, has been instrumental in introducing the use of thermography to the field of chiropractic, as well as establishing much of the present-day research.

(Robert E. Ward, D.C., is a board-certified clinical thermographer and a member of the International Association of Clinical Thermographers, and the International Thermographic Society. A graduate of Palmer College of Chiropractic, Dr. Ward served as a faculty member of that college from 1982 to 1985, and is a member of the post graduate faculty of Pasadena College of Chiropractic.)

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(The following is an excerpt from the article "Chiropractic must stake its claim on vertebral subluxation complex," by Drs. G. and Kevin Stillwagon)

Staking out claim on the VSC

by G. Stillwagon, D.C., PhC and Kevin L. Stillwagon, D.C., DCCT

The chiropractic profession must stake its claim as experts in correcting vertebral subluxation complex based on our professional training. Although chiropractors provide professional services to their patients other than correction of vertebral subluxation complex, this is the **unique** service offered by the doctor of chiropractic which is not presently included under the medical umbrella.

Anyone treating patients for this condition without comparable training of the doctor of chiropractic will be cited as using a treatment procedure in which they lack the education and training. These parties obviously represent a threat to the public health. They will be in violation of the law (Chiropractic Practice Act in each state) and will be charged with "Practicing Chiropractic Without A License."

The courts, in the interest of protecting the public health, will be obligated to uphold the law and support our position.

Medical claim jumpers

Years ago the Saturday afternoon matinee often found many of us at the theater watching western movies. I recall how upset we would get when the good guy/gal found the gold and the bad guy/gal would beat them to the claims office and file the claim first. Many prospectors were cheated out of their claim and fortune when someone else would beat them to it.

Chiropractors have -- in our knowledge of vertebral subluxation complex and its correction – a treasure greater than all the gold in the world. All we need is "proof of claim" and then stake our claim before it is claimed by the medical community.

The medical profession includes in their mode of practice all treatment procedures and remedies which they consider to be in the best interest of welfare of the patient. The only treatment procedure they haven't claimed yet is correction of vertebral subluxation complex. There isn't a single medical school curriculum that has formal training in correction of vertebral subluxation complex.

Just where will chiropractic be when they accidently discover the vertebral subluxation complex and claim it as a part of medical practice?

Objective documentation is vital

The time has come for us to start documenting **objectively** that we change the nerve system when we make a chiropractic adjustment.

In the past, lack of technology prevented us from demonstrating in a pure and simple manner exactly what we are doing when we corrected the vertebral subluxation complex. At the present, we have the technology that ***can provide us*** with this information.

When chiropractic stakes its claim, the difference between subluxation and vertebral subluxation complex must be explained in detail.

The term "subluxation" is not a chiropractic discovery (much to the surprise of many). In truth, it has been discussed in the medical literature for over 300 years. In 1688 The Holmes-Armoury Surgical Textbook talks about the subluxation and describes it as "Putting Out of Joynt." Subluxation defined in the Oxford English Dictionary is a partial dislocation, a sprain.(2) Cockburn defines subluxation as a particular incomplete dislocation. A loss of juxtaposition between two articular surfaces. A misalignment of contiguous joint or articular surfaces.(3)

Palmer has enumerated the following specific criteria for the vertebral subluxation complex:(4)

1. Loss of juxtaposition of a vertebra with the one above, the one below or both... less than a luxation.

2. Occludes an opening.

3. Impinges nerves.

4. Interferes with transmission of mental (neural) impulses between the brain and tissue cells of the body...

Dr. J. Flesia, described the following components:(5)

1. Spinal Kinesiopathology

2. Neuropathology

3. Myopathology

4. Histopathology

5. Pathology

Neuropathophysiology of vertebral subluxation complex

We, the two authors of this article – Dr. G. Stillwagon and Dr. Kevin L. Stillwagon – have amplified and introduced new insight on this subject in our work on the neuropathophysiology of vertebral subluxation complex.(6) We have succeeded in taking a very complex system and making it understandable.

In addition, we have designed the "Objective Chiropractic Model for Research." This model outlines a systematic approach to using both thermography and surface EMG to document the impact of the chiropractic adjustment on correction of vertebral subluxation complex. The use of this model, the first in 99 years of chiropractic, will add credibility to chiropractic research. It can be used with any examination procedure or technique.

Proof of claim

Our "proof of claim" rests in our ability to objectify the vertebral subluxation complex. Every chiropractor needs to have the videotapes on this subject so they can study, know and explain what happens when a chiropractic adjustment is made. We must accept this responsibility and claim it before the medical profession does.

We as chiropractors need to know vertebral subluxation complex and its components in order to stake our claim. One can't very well claim anything if we can't explain it or prove it, anymore than the prospector could stake a claim without having the gold for "proof."

Richard Felten, M.D., Ph.D., Professor of Neurobiology and Anatomy at the University of Rochester School of Medicine(7) has (along with others) reported seeing nerve fibers going into virtually every organ of the immune system and forming direct contacts with the immune system cells. He further says they have seen nerve fibers sitting out among the lymphocytes. Dr. Felten reports that nobody put two and two together and tried to make a story about the brain having a direct influence on the immune system.

In their investigations, these researchers have found that if you take the nerves away from the spleen or lymph nodes, you virtually stopped immune responses in their tracks. Dr. Felten states, "Yes, a constant flow of information goes back and forth between the brain and the immune system." Hmmmm ... isn't that interesting... perhaps the "safety pin cycle"... or maybe "above, down, inside, out"... or even "Brain Cell to Tissue Cell, Theory or Fact!"

Dr. Felten continues... "we have to suspect that the brain is having an impact on the immune system." Researchers, at the present, admit that they don't understand how the mechanisms work.

The mechanisms, in our opinion, are related to the vertebral subluxation complex. The chiropractor can intervene by correcting the vertebral subluxation complex and alter the immune system response.

Researchers are just a step away from the basic premise of chiropractic -- it's only a matter of time, perhaps a short time. Hard-core data: That's what chiropractic needs. We need to show it objectively and we can't afford to delay any longer. The Objective Chiropractic Model is already in place and ready to be used to display the data.

Impingement on nerves can cause numbness, tingling or pain in an extremity. Sever the nerve and paralysis results. Impingement on nerves into the immune system results in lowered resistance. Sever the nerves and you stop immune response in its tracks. Very elementary to the chiropractor, perplexing to others. We only need to document it.

The plan

It is crucial that the chiropractic profession begins to focus on that which we are trained and licensed to do. We have the technology today to enable us to document vertebral subluxation complex, what it is, when it is present and when it has been corrected.

With this kind of hard-core data, we must be aggressive in staking our claim in every state. Every state board of chiropractic should be interested in acting quickly to spell out vertebral subluxation complex as ours by prior rights. We are the experts. Every state has laws which spell out limits of practice for doctors in all branches of the healing arts. These laws are for the purpose of identifying what the practitioner is allowed to do.

Most important of all these laws protect the public health. It is the responsibility of the courts to make certain these laws are enforced. There is a medical practice act in each state which all medical doctors licensed under that act must adhere to. The same is true of all the healing sciences.

Chiropractic is licensed in all 50 states. It's already in the law of each state what chiropractors can do after they have met the requirements of the various licensing boards.

If a person is performing a medical service and is not licensed to do so, the courts in that state must charge them with practicing medicine without a license -- and rightfully so -- because that person represents a threat to the public health. If chiropractors elect to practice medicine. they must further their education, must meet the requirements, pass the boards and they can do so.

If a medical practitioner would elect to practice chiropractic they must further their education, meet the requirements, pass the boards and they can do so.

At the present time the medical doctor isn't taught how to identify vertebral subluxation complex or how to correct it in any medical college curriculum. Therefore, they are not qualified to treat patients for correction of vertebral subluxation complex. They would be in violation of the law and at the same time represent a threat to the public health.

Executing the plan

Our profession can work within the law and have the courts make certain that the public health is protected.

We need to initiate an aggressive campaign through our state licensing boards and the national associations that our objective is to stop anyone who is not qualified by prior education from encroaching into our field. The charge will be practicing chiropractic without a license.

Let's take a bold stand on this issue and see it through. This will include notification to all healing arts licensing boards and courts throughout the land.

We have the legal talents available in the major chiropractic organizations to draw from. With support and requests of the membership they will be able to put their energies into establishing an offensive thrust for chiropractic. We need to establish the ground rules, stake our claim and stick to it.

We are at a crossroads. The chiropractic profession needs a chance to help our nation meet the challenges of the coming years. We can achieve our goals by using the "Objective Model" and establish ourselves as the experts in correction of vertebral subluxation complex. When we do this, patients will enjoy the benefits of chiropractic care for health problems and other musculoskeletal conditions.

When we "Stake Our Claim," the chiropractor will become the "gatekeeper" to vertebral subluxation complex and not be limited to relief of "back pain by prescription."

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Outcome assessments for subluxation-based chiropractic care

by Dr. Christopher Kent

A challenge to the modern chiropractor is objective documentation of a favorable clinical response. The development of standards of care, criteria for the appropriateness of care, and the validation of chiropractic methods all depend upon the availability of reliable outcome assessments.

A variety of methods for validating chiropractic procedures have been proposed. These include decision analysis algorhythms, meta-analysis, consensus, and other methods. (1,2,3,4,5,6,7) Some authors have suggested the use of pain questionnaires as outcome assessments for chiropractic care. (8) Such an approach, however, is plagued with limitations.

There are several significant shortcomings to pain-based models for outcome assessment:

1. Such schemes assume that the objective of chiropractic care is symptomatic treatment of pain.

2. Pain is a highly subjective, private sensation which cannot be directly measured or observed.

3. In some instances, unless the pain is robust enough to restrict activities of daily living, a "false negative" could result.

4. Pain criteria cannot be applied if the patient has symptoms other than pain, or no symptoms at all.

5. Pain criteria are useless in the evaluation of asymptomatic patients undergoing maintenance or reconstructive care.

If the objective of chiropractic care is the correction of vertebral subluxations, criteria must be developed which reliably evaluate their presence and correction. I suggest that the following be used when considering outcome assessments:

*** The procedure should reliably measure a generally accepted manifestation of the vertebral subluxation complex.

*** The information obtained should be useful in the planning of clinical strategies, such as the need for adjustment, frequency of visits, and determination of indications for maintenance care.

Traditional chiropractic philosophy defines the vertebral subluxation terms of four criteria:

1. Loss of juxtaposition of a vertebra with the one above, the one below, or both

2. Occlusion of an opening

3. Nerve impingement

4. Interference with the transmission of mental impulses. (9)

Contemporary definitions have proposed the term "vertebral subluxation complex," which consists of five components:

1. Spinal kinesiopathology

2. Neuropathology

3. Myopathology

4. Histopathology

5. Biochemical changes. (10)

The "vertebral subluxation complex" model also describes tissue specific manifestations, including:

1. Osseous component

2. Connective tissue involvement, including disc, other ligaments, fascia, and muscles

3. The neurological component, including nerve roots and spinal cord

4. Altered biomechanics

5. Advancing complications in the innervated tissues and/or the patient's symptoms. This is sometimes termed the "end tissue phenomenon" of the vertebral subluxation complex. (11)

Many technologies exist to assess the biomechanical and physiological changes associated with the subluxation. Unfortunately, the reliability of many of these procedures has not been adequately explored. In some instances, inappropriate designs leading to improper conclusions plagued many reliability studies. (12)

The following list is illustrative of some techniques used by chiropractors for analyzing manifestations of the vertebral subluxation complex. They have arbitrarily been divided into two categories, biomechanical and neurophysiological. I readily acknowledge that there is overlap in many of these procedures:

Biomechanical

1. Postural analysis

2. Static palpation

3. Motion palpation

4. X-ray spinography
a. static
b. functional (including videofluoroscopy)

5. Computed tomography

6. Magnetic resonance imaging

Neurophysiological

1. Orthopedic examination

2. Neurological examination
– a. reflexes
– b. muscle tests
– c. dermatome testing
– d. functional leg checks

3. Skin temperature examination
– a. thermography
– b. NCM/NCGH, Nervoscope, Thermeter, etc.
– c. DTG, Chirometer, etc.

4. Electrophysiological procedures

– a. electromyography
– b. somatosensory evoked potentials
– c. nerve conduction velocity
– d. EEG, brain mapping
– e. Current perception testing (e.g. Neurometer).

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COMMENTARY

Vertebral Subluxation Correction and its Affect on Thermographic Readings: A Description of the Advent of the Visi-Therm as Applied to Chiropractic Patient Assessment

G. Stillwagon, D.C., Ph.C., Kevin L. Stillwagon, D.C.

Abstract — This paper provides information first presented in 1985. The original context is presented here for its historical value, with references which confirmed the state of infrared thermography at that time. In this article, the application of infrared thermography to chiropractic analysis employed the Visi-Therm instrumentation system, developed between 1983 and 1984. Although considerable advances have been made in regard to infrared thermography, as well as the instrument system itself, the information in this article has been presented in its original context, as it marks the earliest stages, and perhaps the beginning of chiropractic use of computerized infrared thermography as a component of patient assessment. The objectives and value of this technology for monitoring the efficacy of the chiropractic adjustment given for the correction of vertebral subluxation, as well as information which distinguishes it from diagnostic therapy, are presented and discussed.

Key words: Thermogram, Visi-Therm, infrared thermography, vertebral subluxation, chiropractic, chiropractic analysis, chiropractic adjustment.

Introduction

As the spine is altered structurally, neurophysiological changes begin to take place. It is hypothesized that an effective chiropractic adjustment will produce a structural change in the vertebral segments of the spine, and that the body will express an associated neurophysiological response. This response may be manifested in a wide variety of disorders, as has been reported in conjunction with structural alterations of the spine. This paper advances the concept of thermography as a means of visualizing neurophysiological change. This provides a method whereby conclusions can be made as to the efficacy of the adjustment administered by the chiropractor.

The context of this report was presented to the Sixteenth Annual Biomechanics Conference on the Spine, held at the University of Colorado, June 20-30 1985. The Conference was sponsored by the International Chiropractors' Association and the Colorado Chiropractic Association.

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It has been documented, by pre and post x-ray imaging, that anatomical change to the spine does take place following chiropractic adjustments.[1-3] Relative to chiropractic, the monitoring of neurophysiological changes accompanying anatomical changes has not been reported in the literature. In that regard, clinical thermography is becoming known as a relatively inexpensive, non-invasive, accurate and safe method for establishing skin temperature differentials.[4-15] It is believed that infrared thermography may be applied as an assessment of the patient's response to the chiropractic adjustment,[4,16] and is likely to be recording neurophysiologal change.[17-20]

The use of thermography dates back at least as far as Hippocrates.[21] He observed that after smearing mud over a person's body hot areas dried fast and colder areas dried slower. He then began to correlate these areas with disease processes. While technology has changed, the same concept is applied today. Unfortunately, many instruments used in chiropractic currently employ technology of the 1800's, notably those employing thermocouples as heat detectors. This article discusses a heat detection and visualization approach which makes use of infrared sensors, microprocessors, and computer software to provide visualization of the data.

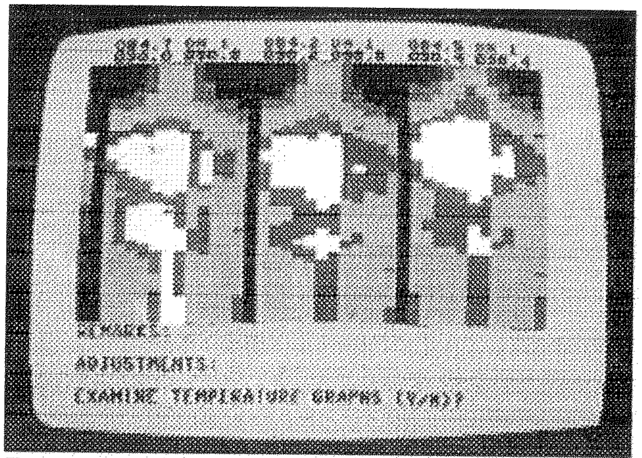

Figure 1: Three thermograms of back.

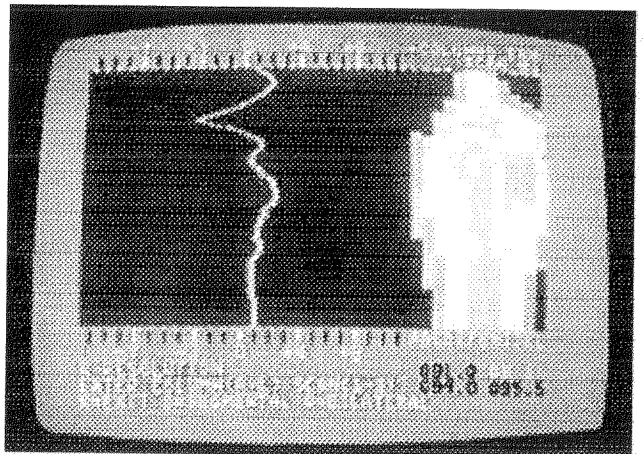

Figure 2: Bilateral temperature graph of back.

Historically, chiropractors have evaluated their patients by some means of temperature assessment. This has ranged from using the hands to detect the "hot-box," (an anatomical region of elevated temperature), to thermocouples with simple galvanometers.[22-31] The advent of thermography has now increased the chiropractic professions' appreciation for the need to measure temperature change as accurately as possible. This can be achieved through thermography. Energy in the form of infrared light is emitted by every object whose temperature is above absolute zero (- 459.7 F). This self emitted energy can be collected, transformed into electrical impulses and converted to visible light to form a heat "picture" or thermogram. A thermogram requires no external illumination or irradiation of the object, and can, therefore, be made in total darkness. Graph analysis of skin temperatures has been a form of patient assessment. It is now possible to evaluate color change as well through thermograms.

Thermography can be used to monitor temperature changes that occur at each patient visit by providing a full color display of the entire back. This non-invasive method of patient evaluation has several objectives and goals. These include (1) finding acceptable normative temperature ranges for the entire back, (2) demonstrating symmetry and asymmetry via the display of temperature (thermogram), and (3) demonstrating the relationship of previously described[32] methods of graph analysis of the paraspinal regions; primarily bilateral and segmental temperature alterations, which occur following structural change in the spine.

Instrumentation and Clinical Application of the Visi-Therm System

The Visi-Therm was developed by the authors between 1983 and 1984. It was reviewed, evaluated, and accepted by the Methods Evaluation Committee at Palmer College of Chiropractic on May 10, 1984. The Visi-Therm system has combined the technology of infrared sensors and analogue-digital conversion to produce a computer software assisted visual display of heat distribution over the entire back of the patient. The Visi-Therm system consists of a scanning paddle containing 12 primary infrared sensors and one auxiliary sensor. The electronic specifications for the system, and specific technique for carrying out the scanning procedure, are described in the patent application.[33] The 12 primary infrared sensors are used for scanning the patient's back, while the 13th sensor is used to take spot temperature readings anywhere on the body.

The scanner is connected to a computer processor by a ribbon cable. The voltages from the infrared sensors are amplified and changed to numerical data by a analogue to digital converter. Specially designed computer software processes and stores the data on floppy disks. Three full color scans can be displayed on the computer monitor at one time **(Figure 1).** Eight colors are used for display, ranging from white-dark red, light red-green, light blue-dark blue, and gray-black. White is the hottest and black is the coldest temperature. Each color covers a temperature range of 1 degree centigrade. However, the practitioner may elect to change the range for each color in 0.10 degree intervals down to a tenth of a degree centigrade.

The scanning procedure requires approximately 14 seconds, after which the color scan is displayed. This is a considerable improvement over the time required to perform a typical contact temperature scan using other methods.

Twelve segmental temperature graphs can be displayed separately for each scan. The Visi-Therm system will also display bilateral temperature graphs **(Figure 2)**. Sensors 5 and 8, while making a scan, approximate where the probes of a dual probed instrument would pass. It is, therefore, possible to display a line graph that shows the difference in contra lateral temperatures of the patient's back **(Figure 3)**. Moreover, the system also permits viewing, for the same scan, of segmental temperature graphs and pre and post adjustment scans of both segmental temperature distribution and contra lateral temperature distribution graphs. This variety of information is derived from data obtained from one, (approximate) 14 second scan of the patient's back.

Implementation and Use of the Visi-Therm

Visi-Therm is a dedicated computer system. That is, the computer will not perform other functions, nor is the scanner interchangeable with other computers. Its operation requires only that the operator activate the system and follow the displayed instructions. The Visi-Therm color logo displayed when the sys-

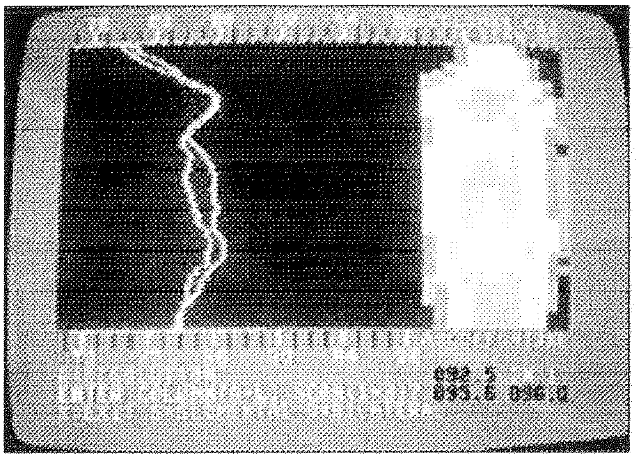

Figure 3: Segmental temperature graphs of back.

tem is first activated is used to make manual color adjustments. Each patient's information is stored on a separate disk. Each disk retains the equivalent of 50 office visits, or a total of 150 scans, plus an entry function that permits practitioner remarks and information on adjustments administered.

Message prompts guide the user through its protocol. For example, the user will be informed, once a disk is inserted, as to the patient's identity and what visit numbers are stored. Once a decision is made to review the disk, options are provided to (1) review previous scans, (2) take a new scan, or (3) calibrate the system. The calibration procedure is performed by directing the scanner at a standardized heat source provided with the system. Calibration is in two steps. The first step is complete when the changing numbers on the screen equals the fixed number displayed on the screen. The second and final step is achieved by pressing the return key and waiting until the numbers match the second time, at which point the return key is pushed again. This is approximately a two minute process. The need to re-calibrate depends on a variety of factors unique to each operating environment, but is generally not a frequent necessity.

If the operator selects option (1), review previous scans, it will be possible to review some or any specific previous scan. Otherwise, the operator can review all previous scans starting with the last scan taken. When the scans appear, the operator has the option to examine both temperature graphs. Change in the resolution of the color patterns is easily achieved to facilitate identification of hot and cold areas.

Selection of option (2), take a new scan; upon pressing any key, five tones will be heard one second apart, followed by a longer intermediate tone. The computer is activated to begin temperature recording the instant the intermediate tone begins. The intermediate tone is followed by six high pitched tones approximately 2.4 seconds apart. The higher tones are provided to assist the practitioner in pacing the scan. For example, when the third high pitched tone is heard, the scan should be half finished, regardless of the starting point of the scan. Thus, a short scan or a full spine scan takes the same time (14.4 seconds). The sensors do not touch the skin, and the roller assembly of the scanner contacts the back of the patient to assist the practitioner to maintain a uniform distance from the skin.

Upon completion of the scan, a full color display will appear. The system informs the user as to the location of the hottest temperature, then offers the option to record "spot" temperatures. Two spot temperatures per scan can be recorded and permanently stored for any part of the body using the 13th sensor, such as the atlas "fossa."

Following the recording of the "spot" temperatures, the examiner is given options to retake, or examine the recorded scans of up to 12 different segmental temperature readings, and one bilateral temperature graph. Resolution can also be changed in conjunction with this option.

If the option to examine the scans and graph was chosen, the system then provides up to two lines of remark entry including the practitioner's comments on such items as the date, patient's complaints, etc. Two additional lines are allowed for commentary relative to the adjustment administered.

Following completion of the commentary option, the computer is ready to take the post scan. All options that pertained to the first scan are once again offered for the post scan. Temperature graphs reviewed for the post scan can be compared to the first, or pre adjustment scan, thus facilitating comparisons of pre to post changes. Since three scans can be presented on the monitor, if the operator wishes, the pre scan can be viewed against an additional post scans, following a second adjustment.

Discussion

The information presented in this descriptive paper was intended to enhance the clinical practice of chiropractic. The purpose of the retrospective publication of this information has been to establish the historical significance of the introduction of computerized infrared thermographic analysis into chiropractic. This has been done with the intent of providing historical information for future reference and to encourage future study to advance the level of "chiropractic thermography" technology available to the profession, and to encourage its use on a broader scale.

Since changes in peripheral temperature have been associated with changes in nervous system activity, and may represent changes in other forms of visceral activity,[34-37] "chiropractic thermography" is an appropriate assessment medium for the profession. While the clinical significance of the data generated by the Visi-Therm system ultimately remains in the domain of the practitioner, the benefit of the system is that it provides reliable data for use in patient assessment before and after the chiropractic adjustment. Moreover, the data provides a documented record of changes occurring in the patient. Temperature patterns reflect physiological changes in the body, and thus contributes to objective versus subjective patient assessment. Thus, "chiropractic thermography" data reflecting physiological change, coupled to imaging studies showing structural or anatomical change, are complementary and offer the broadest spectrum of assessing patient progress.

Summary and Conclusions

A retrospective report has been provided which presents the context of a report presented before the Sixteenth Annual Biomechanics Conference of the Spine (June 20-30, 1985). The significance of this information is that it represents perhaps the first introduction of computerized infrared "chiropractic thermography" into the area of patient assessment. This approach has been discussed in terms of its objective assessment value rather than diagnostic value to the profession. The paper has been presented to establish a starting point for the approximate thirteen years of use of infrared "chiropractic thermography" provided to the profession, and to encourage reports from field practitioners as to its current usefulness in patient assessment. Moreover, as studies published since the advent ofVisi-Therm technology are linked to its concepts, it is believed that an initial reference point for the introduction of this technology to the profession is necessary to appreciate the time frame in which recent advances have been made. Over the past decade plus three years, the Visi-Therm system has been considered a safe, accurate means through which to obtain "chiropractic thermography" information for patient assessment.

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Normative Data

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Quantification of thermal asymmetry

Part 1: Normal values and reproducibility

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The use of thermography in evaluating nerve injury is based on the presence of temperature asymmetries between the involved area of innervation and the corresponding area on the opposite side of the body. However, interpretation of the thermographic image has been troubled by subjectivity. This paper describes a computer-calculated method of collecting data that eliminates subjective biases. Comprehensive normative data are presented on the degree of thermal asymmetry in the human body.

The degree of thermal asymmetry between opposite sides of the body (ΔT) is very small. For example, the value of ΔT for the forehead (mean ± standard deviation) was 0.18° ± 0.18°C, for the leg it was 0.27° ± 0.2°C, and for the foot it was 0.38° ± 0.31°C. These values were reproducible in both short- and long-term follow-up measurements over a period of 5 years. The ΔT's reported here were obtained from 40 matched regions of the body surface of 90 asymptomatic normal individuals. These values can be used as a standard in assessment of sympathetic nerve function, and the degree of asymmetry is a quantifiable indicator of dysfunction.

KEY WORDS · thermography · thermometry · nerve injury

THE skin, one of the largest organs of the body, is equipped with a network of vessels accompanied by dense nerve fibers. It serves as the body's thermoregulator, controlling blood flow within a few millimeters of the body surface.[6] The system is governed by autonomic nerve impulses generated from the hypothalamus and the brain as a whole. The system is both anatomically and physiologically symmetrical.[5] For this reason, localized, asymmetric temperature changes at the body surface have interested physicians as far back as Hippocrates.[8] The recent development of sophisticated thermographic measuring devices that can provide a map of the temperature of the body surface has increased this interest.[7] However, thermography has been criticized for its possible lack of objectivity, arising from interpretation of the colored thermogram. To minimize such subjectivity, it is proposed to use computer-calculated temperature differences (ΔT's) between homologous sections of the body as measures of the degree of thermal asymmetry.[7] This paper summarizes the ΔT's calculated for normal control subjects and discusses their use as a standard for evaluation of sympathetic nerve function in man.

Normal Subjects and Methods

Normal Subjects

The participants in this study were 90 healthy volunteers (38 men and 52 women) ranging in age from 19 to 59 years. All participants gave informed consent for the procedure. None of the participants reported ongoing acute or chronic pain, such as low-back pain, sciatica, recent or old body injury, or surgical procedures.

Study Procedure

All tests were conducted in the thermography laboratory, which is located in a central part of the hospital building, has no windows, and is free from drafts and interruptions. There is only one door in the testing room and conditions are monitored to ensure year-round ambient temperature stability at 23° to 26°C and humidity between 45% and 60%. Recognized thermographic guidelines are strictly followed.[4] Volunteers disrobe and remain in the laboratory for approximately 20 minutes in order to equilibrate their body-surface temperature to the room temperature.

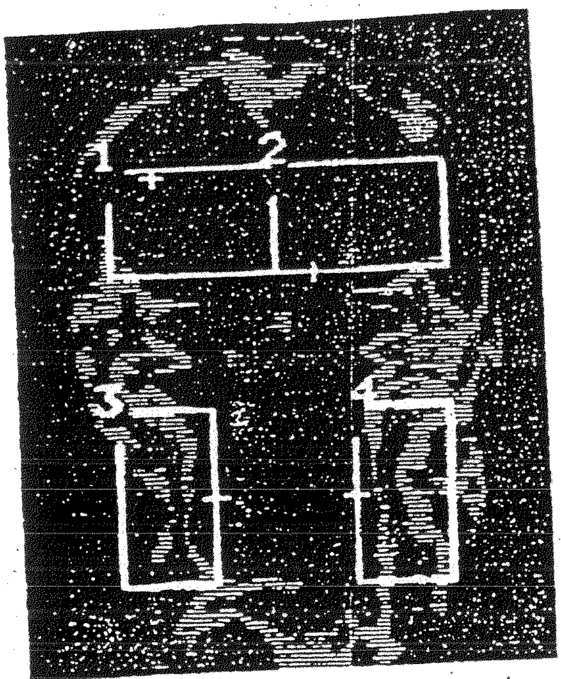

FIG. 1. Facial regions of interest. This close-up photograph reveals the individual picture elements (pixels) within a specified region of interest (ROI). The ROI on the right side of the forehead is labeled, that on the left side of the forehead, 2. The right and left cheeks are 3 and 4, respectively. The temperature of the right side of the forehead is 34.27°C, and that of the left side of the forehead is 34.32°C, so the ΔT for the forehead is 0.05°C. The ΔT for the cheeks is 0, since the cheek temperatures are equal (33.20°C on both sides).

Equipment

From December, 1982, to December, 1983, the work was carried out using the JTG-500 M thermometry system (29 subjects) and thereafter an Infra-Eye-160 thermometry system was used (61 subjects).* Comparable systems are commercially available for clinical use. The equipment consisted of a computer-controlled infrared scanning system designed to scan the body surface (90,000 data points per scan, each point being 1 sq mm in size at a distance of 50 cm between detector and subject) and to provide the information necessary for the computer to construct a temperature map of the skin surface, which was then displayed on a color CRT monitor (Fig. 1). Typical thermographic systems are capable of discriminating differences as small as 0.03°C, and may be used to assess the absolute temperature of specific points on the body; alternatively, by employing one of the system's other features, it is possible to calculate the average temperature of specified regions of the body that are identified for the computer. These specific regions are referred to as regions of interest (ROI's).

* JTG-500 M thermographic unit manufactured by Japan Electronic Optic Laboratory, Ltd., Tokyo, Japan; Infra-Eye-160 thermographic unit manufactured by Fujitsu, Ltd., Kawasaki, Japan.

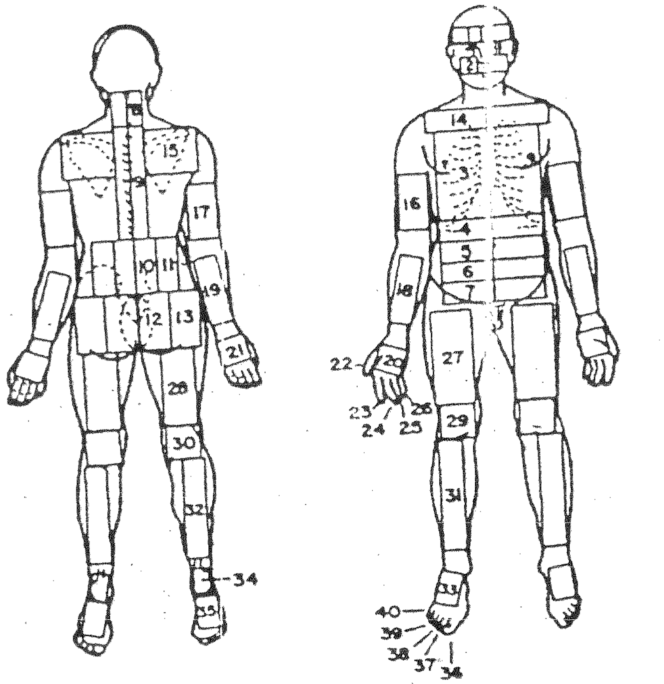

FIG. 2. Body segments assessed by computerized thermography. Each box represents a region of interest (ROI) identified on the computer for analysis. See also Table 1. Some areas, such as hair-covered areas (eyebrows) or moist areas (lips or nostrils), could provide misleading temperature data and are excluded from the ROI.

Each scan lasts 3.7 seconds. Once a scanning image is obtained, the technician maps out the ROI on the image on the CRT screen, dividing the skin surface into one of the 80 sensory segments (Fig. 2) approximating the areas of innervation of the major peripheral nerves and spinal segments.[2] A built-in computer system compiles and analyzes the temperature data and displays the image on the CRT screen at the moment of completion of each 3.7-second scan. The technician notes 10 sequential temperature values for each ROI or point, and the ΔT's are calculated by subtracting the left side value from the right. These data are then used to derive the mean, standard deviation, and other statistical analyses. A well-trained technician can complete routine testing of the lower extremity in less than 1 hour.

In addition to the standard examination, six volunteers were asked to undergo a cold stress (one hand placed in cold water, temperature range 9° to 18°C) while the temperatures of their feet were monitored at 5-minute intervals for 60 minutes. Cold stressors have been shown to enhance sympathetic activation,[3] and thus seemed a reasonable method for assessing the symmetry of response to sympathetic challenge.

Results

The data in Table 1 represent the combined data from each ROI or point, across subjects, and are expressed as the mean ± the standard deviation of the

TABLE 1
Temperature asymmetries of normal control subjects

Region of Interest*	No. of Cases	Nerve (dermatome)	ΔT (°C)†
head			
1 forehead	32	trigeminal (first division)	0.18 ± 0.18
2 cheek	33	trigeminal (second division)	0.30 ± 0.17
trunk (anterior)			
3 chest	49	intercostal (T1–7)	0.20 ± 0.19
4 upper abdomen	43	intercostal (T8–9)	0.22 ± 0.15
5 abdomen I	90	intercostal (T-10)	0.21 ± 0.19
6 abdomen II	90	intercostal (T-11)	0.17 ± 0.14
7 abdomen III	89	intercostal (T-12)	0.20 ± 0.15
trunk (posterior)			
8 cervical	45	cervical (C3–5)	0.23 ± 0.16
9 thoracic	46	post. cutaneous (T2–12)	0.20 ± 0.17
10 lumbar (medial)	90	dorsal div. spinal (T-11, 12; L-1, 2, 3)	0.22 ± 0.19
11 lumbar (lateral)	88	dorsal div. spinal (T-11, 12; L-1, 2, 3)	0.34 ± 0.26
12 sacral (medial)	90	dorsal div. spinal (S-1, 2, 3)	0.28 ± 0.19
13 sacral (lateral)	90	dorsal div. spinal (S-1, 2, 3)	0.26 ± 0.22
extremities, upper			
14 shoulder (anterior)	54	supraclavicular (C-4, 5; T-1)	0.19 ± 0.12
15 shoulder (posterior)	44	dorsal div. spinal (T1–5)	0.31 ± 0.23
16 anterior arm	52	med. antebrachial (C-5, T-1)	0.27 ± 0.23
17 posterior arm	36	dorsal antebrachial axillary (C-7, 8)	0.39 ± 0.26
18 forearm volar	56	med./lat. antebrachial (C-5, T-1)	0.25 ± 0.21
19 forearm dorsum	56	med./lat./dorsal antebrachial (C-7, 8)	0.31 ± 0.22
20 hand	56	median, ulnar (C-7, 8)	0.24 ± 0.23
21 hand dorsum	57	median, ulnar, radial (C-7, 8)	0.31 ± 0.25
fingers			
22 thumb	48	median (C-6)	0.43 ± 0.43
23 index	48	median (C-7)	0.52 ± 0.46
24 middle	48	median (C-7)	0.35 ± 0.46
25 ring	48	ulnar (C-8, T-1)	0.43 ± 0.35
26 little	48	ulnar (C-8)	0.45 ± 0.39
mean fingers	48	med./ulnar (C-6, 7, 8)	0.43 ± 0.26
extremities, lower			
27 thigh (anterior)	71	ant. fem. cutaneous (L-2, 3)	0.24 ± 0.21
28 thigh (posterior)	70	post. cutaneous (S-1, 2)	0.23 ± 0.18
29 knee (anterior)	14	ant. fem. cutaneous (L-4)	0.23 ± 0.17
30 knee (posterior)	14	post. fem. cutaneous com. peroneal (S-1, 2)	0.12 ± 0.10
31 leg (anterior)	70	saphenous sup. peroneal (L-4, 5)	0.27 ± 0.20
32 leg (posterior)	70	sural, saphenous (S-1, 2)	0.29 ± 0.21
foot			
33 dorsum	70	sup. peroneal, sural (L-4, 5; S-1)	0.38 ± 0.31
34 heel	66	tibial (S-1, 2)	0.34 ± 0.21
35 plantar	29	tibial, med./lat. plantar (L-4, 5; S-1, 2)	0.35 ± 0.27
toes			
36 great	43	sup. peroneal (L-4, 5)	0.54 ± 0.44
37 second	43	sup. peroneal (L-5)	0.51 ± 0.48
38 third	43	sup. peroneal (L-5)	0.53 ± 0.48
39 fourth	43	sup. peroneal (L-5)	0.67 ± 0.41
40 fifth	43	sural (S-1)	0.67 ± 0.55
mean toes	36	sup. peroneal, sural (L-4, 5; S-1)	0.59 ± 0.27

* For regions of interest see Fig. 2.
† Mean ± standard deviation of the temperature difference between the left and right regions for subjects tested on the Infra-Eye-160 device.

difference between left and right regions. Longitudinal studies of four individuals were made over a 5-year period from 1982 to 1987. Sample data from these studies are provided in Table 2. Repetitive readings of every 3.7-second scan of major ROI's were also performed in order to investigate intrasession temperature reproducibility. An example of the data obtained is provided in Table 3. The mean and standard deviation of the repetitive readings were 30.8° ± 0.032° C, with a coefficient of variation of 0.1%.

Finally, the effect of the cold-water challenge on ΔT stability was also studied in six asymptomatic healthy individuals. The ΔT for the feet remained stable (within the control value listed in Table 1) throughout the 60-minute cold stress in all six normal volunteers. A typical temperature curve is shown in Fig. 3.

Discussion

Previous investigations have set the upper limit of normal ΔT at less than 1°C.[7] This 1°C norm was applied

TABLE 2

Reproducibility over time of temperature asymmetry for the dorsal foot of a healthy person

Study Date (month/day/year)	Temperature (°C)		Temperature Asymmetry (°C)
	Right	Left	
12/9/82	29.65	29.37	0.28
3/25/83	31.27	31.10	0.17
3/26/84	29.30	29.50	−0.2
12/2/84	31.60	31.60	0
7/2/87	34.50	34.90	−0.4
7/7/87	35.30	35.40	−0.1
7/29/87	31.90	31.40	0.5

TABLE 3

Intrasession measurement variation across 10 repetitive temperature readings

Reading No.	Right Foot Temperature (°C)
1	30.8
2	30.9
3	30.8
4	30.8
5	30.8
6	30.8
7	30.8
8	30.8
9	30.8
10	30.8

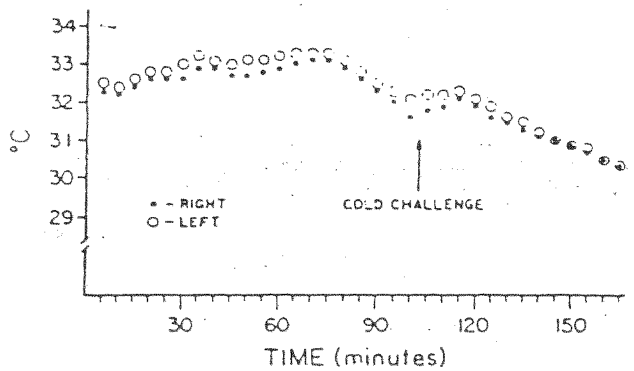

FIG. 3. Sequential temperature readings for the dorsum of the right and left foot for the first 100 minutes while the normal volunteer is sitting in a chair. When the right hand is placed in cold water for the cold challenge, the absolute temperature begins to drop, after an initial mild elevation. However, the ΔT for the feet remains smaller than 0.2°C during the entire 165-minute recording period. There was a similar ΔT stability during rest and a cold challenge in all six normal volunteers tested.

regardless of the body region examined. This value was established in a study of patients with chronic pain and, because a computerized system was not available at that time, the ΔT's were calculated from thermographic readings obtained from a less sophisticated thermographic unit than the one used in these studies.[1] The data reported here represent a more complete form of analysis of thermal asymmetry over the body surface than previously attempted.[8]

With use of the data, an abnormal thermal asymmetry can be defined, based on a statistical criterion, from the normal ΔT for a specific body area, rather than by using a single unit value (1°C) for all comparisons. Because the vasomotor responses may vary depending on underlying conditions, the degree of thermal asymmetry may vary in different underlying pathophysiological conditions. Therefore, in certain clinical cases, a ΔT value of less than 1°C may be significant.

It is noteworthy that our data, derived using different devices (the JTG-500 M system for 29 volunteers, reported earlier,[7] and the Infra-Eye-160 for 90 subjects, listed in Table 1), are similar. As may be expected, while the absolute temperature may vary with time, between nonhomologous regions, and between individuals, the ΔT's obtained from anatomically matched homologous regions are extremely stable and reproducible. It is our belief that the ΔT's we obtained for normal subjects may be used as a reference standard for comparison to ΔT's obtained in most clinical examinations. Deviations from the normal values will allow suspicion of neurological pathology to be quantitated and therefore can improve assessment and lead to proper clinical management.

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Preliminary findings in thermography of the back

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Thermographic studies of the human back along with thermal measurements are presented.

The chiropractic profession has used heat-sensitive devices for many years[1,2] to detect problems in patients. The area viewed has usually been proximal to the spine. Currently, there are a few devices which have come into use in other areas of examination.[3] One device which may prove to be of considerable merit is thermography. Thermography has a rapid scan and photographic recorder to aid in maintaining an adequate record of change, if in fact, any change has occurred. It is not a device that lends itself to offhand use since the equipment is costly. The information which thermography provides is not completely understood, but it is felt that the use of thermographic equipment is efficacious.[4,5] Having used the machinery[6] for some time, this author feels that thermography can provide considerable information to the chiropractor about his patients.

Thermographic scans are rapid and accurate. The area to be scanned can be any heat-producing object. For this investigation the human back was used. No precautions are needed since the device detects emitted heat and does not produce radiation nor is it invasive. No unusual preliminaries are needed since the object to be scanned can be at room temperature, and, as long as the area scanned has not been contaminated by any external temperature alterations, the results should be accurate. This equipment can measure and record variances as fine as .25°C and minimal training is needed to operate the device.

In the following films black is cool and the whitest area is warmest. In Figure 1, a young male is seen with some upper dorsal discomfort because of hyperextension as a result of throwing a baseball. The left low back displays "cool" in the possible outline of the latissimus dorsi but does not produce a symptom. Overall thermal measurement is 2°C from the warmest point to the coolest. Although the right shoulder is warmer, the discomfort is in the left arm and shoulder.

In Figure 2, the right levator scapula and trapezius are the warmest in this male and this is a common finding. That is, there may be a unilateral increase in heat at the upper dorsal area with only moderate variables below.

These two films provide some information worth discussing. First, the spine itself will often be the warmest area of the back and the thermal variance from coolest to warmest is usually 2°C maximum[7] when measurement is made from the sacral to the upper dorsal area. The cervical area is deleted be-

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contracting poorly. Specific muscle testing confirmed that conclusion. The cool pad at the first dorsal may be a result of a mild osteoporotic kyphosis.

Figure 5 demonstrates mottling. The significance is not known. There is an acute neck injury and thermal elevation at the right upper trapezius and levator scapula.

Figure 6 shows unusual coolness of the spine at the dorsal area and the insertion of the rhomboids bilaterally. Patient was severely jaundiced and had undergone cobalt therapy. He died three months later as the result of a hepatic carcinoma.

In Figure 7, the left levator scapula is very tender and 1°C warmer than the right. The fat pads at the lower rib cage distort the thermal patterns but the overall variable was only 2°C. The warmest portion of the spine was of course the sacral area. Some investigators feel that this is a "burned out" sacrum.[8] The author does not hold that thermal gradients can be recognized on these films. The measurement is done prior to taking the film by means of isobaric measurement of the oscilloscopic screen, and the films are made to confirm the general pattern of involvement.

In Figure 8, a female displays a bilateral weak latissimus dorsi upon testing which is also shown on thermography.

Thermographic examination of faulted neurologic dermatomes is not always fruitful. No specific derma-

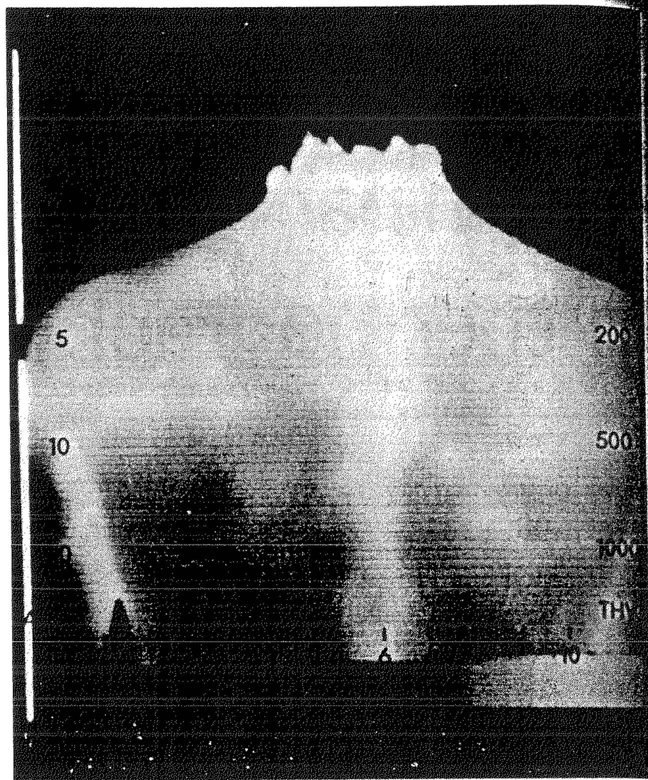

Figure 2

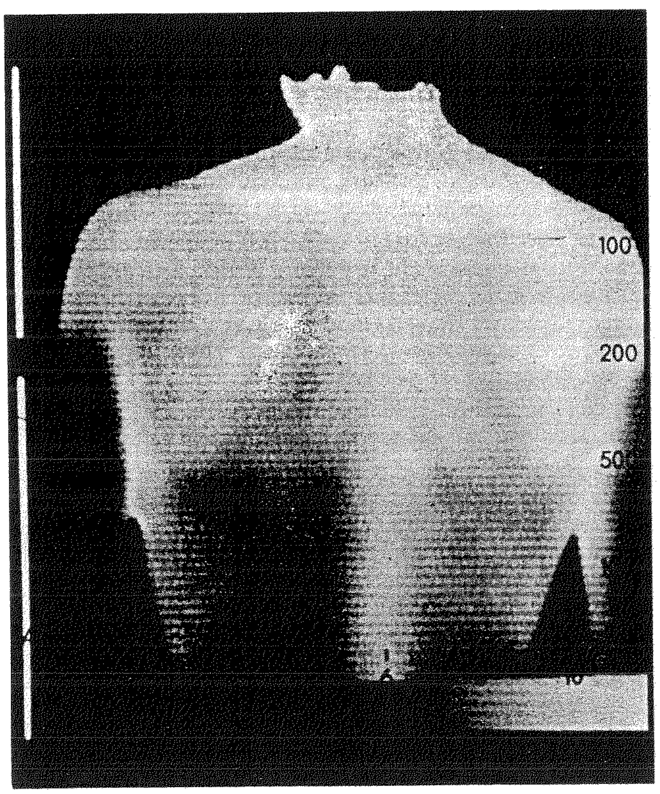

Figure 1

Figure 3

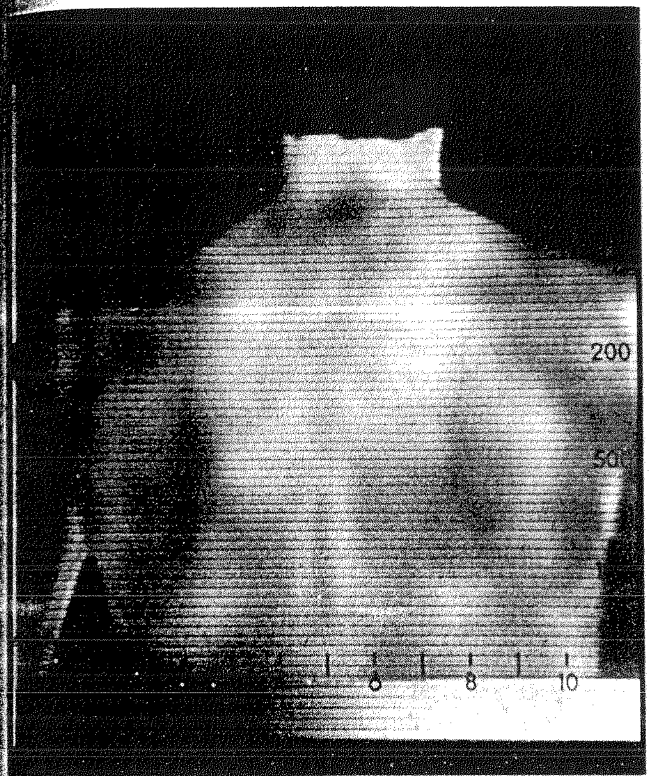

Figure 4

cause of blockage by the hair of thermal measurements. It is not common to note great thermal increases in the spine unless there is underlying pathology of the bone.[8,9]

To examine a human back thermographically and find no variables is uncommon. Since there are stresses, and a person must adjust to those stresses, it would seem to necessitate a change in the muscular contraction and therefore alter any symmetery that would be seen without such stress. Therefore, asymmetrical patterns would be expected.[10]

Figure 3 depicts a young male with no pathology of the bone by x-ray standards, but he has a left scoliosis of the dorsal spine involving the second to the sixth dorsal. The thermal variance or coolness to the right side of the spine could surely be attributed to the non-function of the underlying musculature when compared to the left, and the heat of the left side could be attributed to the additional contraction of the musculature resulting from the scoliotic side. By measurement there is less than a 2°C difference overall. This would seem to confirm the hyper-hypo contraction concept.[11]

In Figure 4, the spinal column of this female exhibits a cool area at the lower dorsal section. The patient complained of pain in the left shoulder and that area is coolest. The coolest area is over the left dorsal but apparently the entire trapezius on the left is

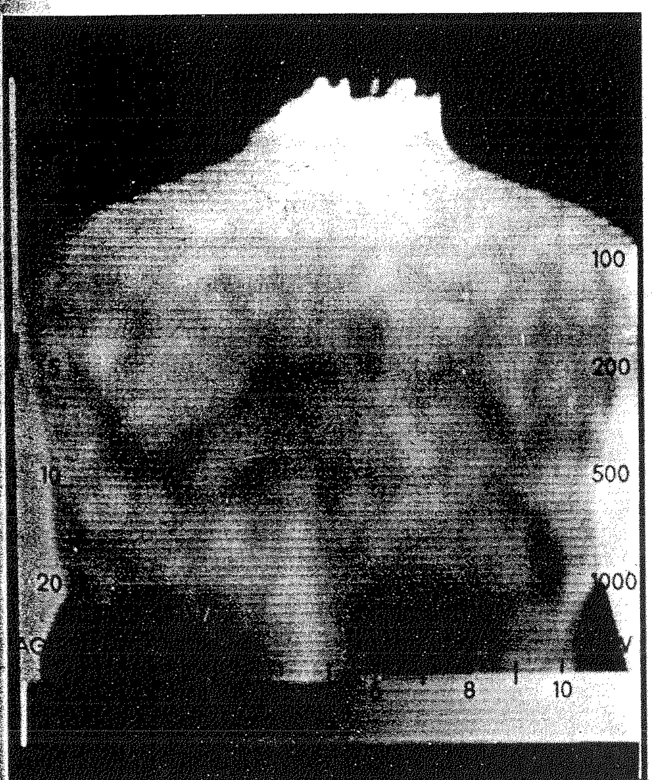

Figure 5

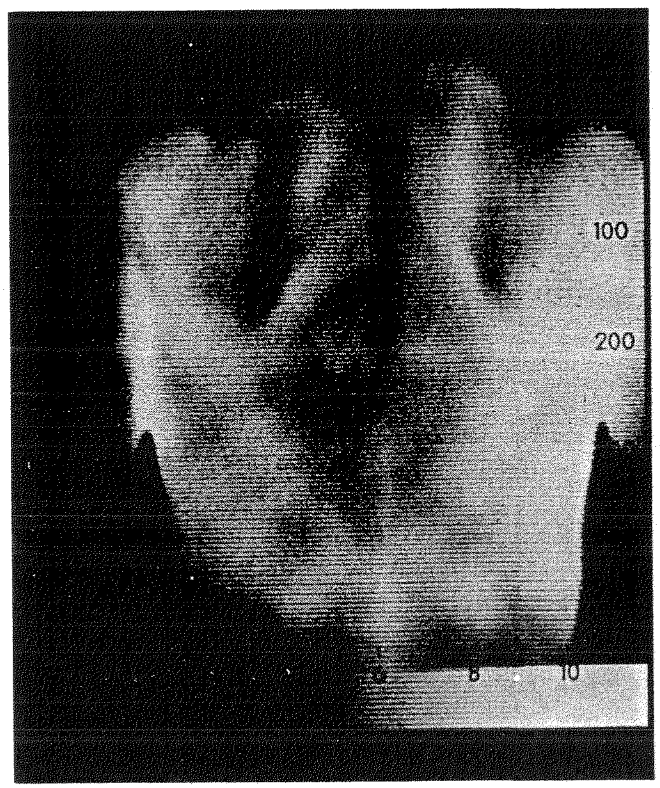

Figure 6

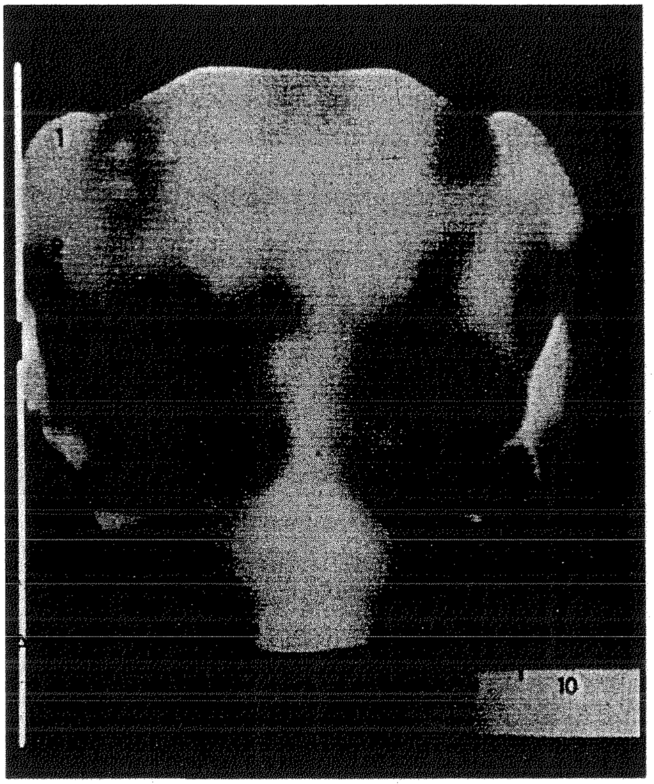

Figure 7

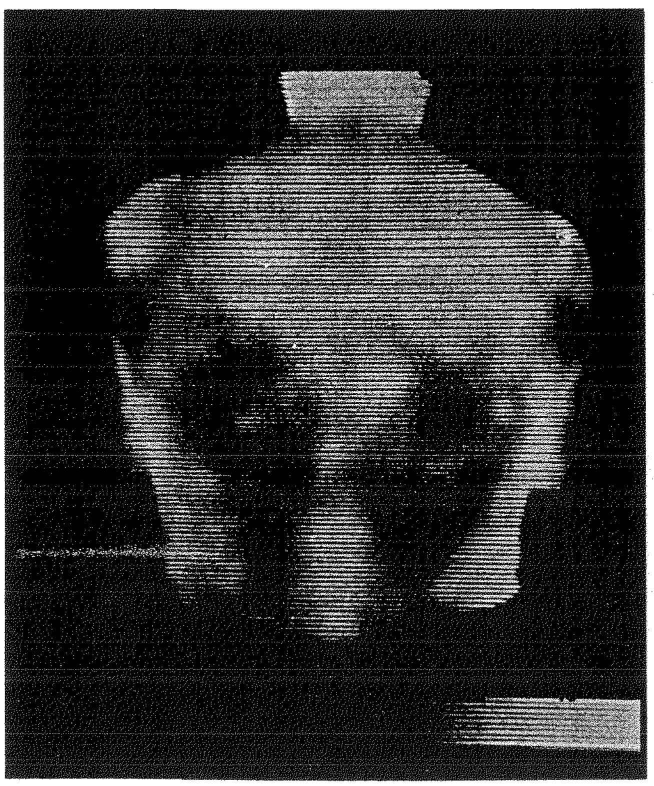

Figure 8

tome can be seen as faulted on thermographic examination of the back which would concur with the neurologic examination. It seems the dermatome must be grossly faulted with extensive involvement into the leg or legs before a thermal variable would show.[5,11] Perhaps innervation of the several muscles that form the dermatome were too varied but at present the attempt was unsuccessful for specific delineation of a dermatome.

When a subluxation exists it causes unequal contraction of the muscles.[10,12] This unequal contraction should be observable by heat-detecting equipment. If thermography has merit it is in this area to determine not the primary subluxation but rather the effects of that subluxation. Then the subluxation can be traced, corrected by an adjustment, and the imbalance of the nervous system arrested. Frequent alteration of the upper dorsal heat pattern has led to other companion signs being noted. For example, the Adsons sign is always positive on the same side as the elevation of temperature of the levator scapula and some parts of the trapezius.[13] If the patient is adjusted to remove the subluxation of the cervical spine and rescanned the temperature would become nearly equal. Therefore, it is easy to note on almost all occasions following adjustments an improvement of the muscular system function and a profound prolonged effect upon the vascular system. □

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Preliminary Report: The Thermal Characteristics of Spinal Levels Identified as Having Differential Temperature by Contact Thermocouple Measurement (Nervo Scope)

PHILLIP S. EBRALL, ANDREW IGGO, PETER HOBSON and GLENN FARRANT

ABSTRACT: *Objective*: To use computer-assisted infrared thermography in an attempt to generate a description of the thermal characteristics of spinal regions identified as having differential temperature by expert users of the Nervo Scope, a contact thermocouple instrument used in chiropractic clinical practice. *Design*: Prospective recording of the infrared thermographic images of prepared, stabilised subjects and then alternate presentation by each subject for blinded assessment by two expert users of the Nervo Scope instrument to identify spinal levels where there was agreement of the existence of a clinically relevant entity (known empirically as a "break") as indicated by the instrument's reponse to differential temperature, and then retrospective examination of those levels by computer-assisted analysis of the infrared thermographic images. *Setting*: Four rooms within a controlled laboratory setting at The Chiropractic Unit of RMIT University, Melbourne. *Subjects*: Eighteen (18) male and 13 female (n = 31) humans with informed consent as volunteers from a late adolescent/young adult student population without any declared clinical symptomatology. *Intervention:* Nil. *Main Observations*: Five (5) subjects were identified where there was agreement for appropriate evidence of spinal dysfunction at a particular spinal level. Thermal analysis of the paraspinal region about the found levels revealed a left/right difference of typically about 0.3°C and no greater than 1.1°C, and a series range on any one side of the spine of typically 1.0°C and no greater than 1.4°C. A particular characteristic was found, namely that an asymmetrical thermal dynamic existed between the paraspinal temperature gradients at these levels, meaning that the skin temperature varied asymmetrically, with one side falling while the other side increased. *Conclusions*: The circular graphs (radar plots) of the data clearly demonstrate the presence of an asymmetrical thermal dynamic which may, if replicated in other laboratories, represent an objective dimension of spinal dysfunction, or in more common terms, the subluxation complex.

INDEX TERMS: (MeSH): SKIN TEMPERATURE; DIAGNOSIS, COMPUTER-ASSISTED; INSTRUMENTATION; THERMOGRAPHY; CHIROPRACTIC; AUSTRALIA.

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INTRODUCTION

Chiropractic instrumentation has been described by Kyneur and Bolton as "the use of electrical devices applied to the spine for the purpose of determining the presence of vertebral subluxation."[1] One such instrument, introduced as the Neurocalometer (NCM) in 1924,[2] has evolved into the Nervo Scope (NS),[3] which today may be used within the Gonstead system of chiropractic analysis as an adjunctive diagnostic instrument contributing, in part, to a chiropractic diagnosis by "aiding in the location of neurologic dysfunction."[4] The validity and reliability of the NS, however, remain in question.[5,6]

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The NS consists of two groups of thermocouples in series with a micro voltmeter. Newer instruments include an amplifier to increase the range of sensitivity. Deflection of the voltmeter needle is such that it points towards the detector receiving the greatest amount of heat,[7] or away from the detector receiving least heat. It is operated by placing the detector probes on the skin either side of the spine and moving the instrument up or down with firm pressure. A level of interest is identified when the pointer deflects and returns to or near its original position within a very short vertical distance being travelled along the spine. The size of the deflection of the pointer may have some significance in the recording of a positive finding. The NS and its derivatives therefore measure paraspinal surface temperature differentials by the use of thermocoupled detectors and an analogue dial. As a temperature differential instrument it does not indicate absolute temperature.

Attempts to assess the validity of any clinical instrument face two hurdles, namely an adequate knowledge of the entity being measured and a known or "gold" standard against

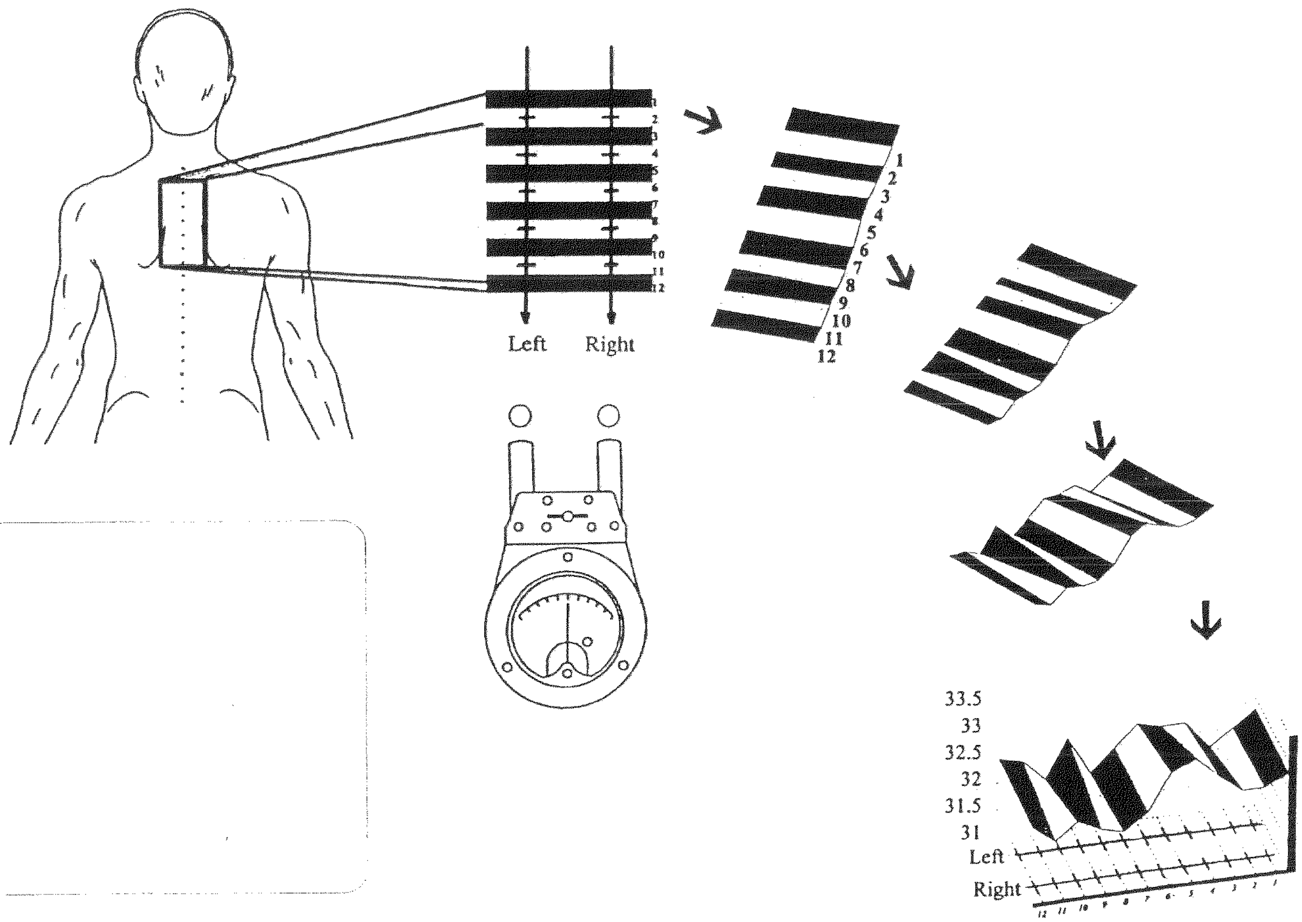

Figure 1. Typical schemata for point temperature collection and graph modelling.

which to judge the instrument under test.[8] There are deficits in both areas regarding the NS, as the literature has yet to adequately describe, in other than subjective terms, the entity of the "chiropractic subluxation" which the NS is claimed to help detect, and as a consequence, we lack any sort of objective characteristic to use as a gold standard.

The purpose of this study was to attempt to find a starting point for future descriptive analyses of the chiropractic subluxation. It was considered that such a starting point could be the generation of a thermal description of those areas of the spine identified by the NS as having a differential temperature reading. The spinal regions were elected to be those areas of the thoracic spine on which two blinded expert users of the NS agreed with respect to the presence of differential temperature, or to use the terminology of NS operators, a "break."

The thermal description was to be obtained by computer-assisted infrared thermography (CAIRT), a non-invasive imaging process able to generate temperature values for selected images of the spine. Most published reports indicate that thermal imaging is an accurate, sensitive method of determining cutaneous temperatures.[9] Further, the American Medical Association's Council on Scientific Affairs[10] reports that thermography may facilitate the determination of spinal root and peripheral nerve dysfunction and of spinal disorders, and may also be useful in documenting peripheral nerve and soft tissue injuries, such as muscle and ligament sprain/strain, inflammation, muscle spasm and myositis.

Thermography has been widely reported in the literature as being a useful indicator in the diagnosis of peripheral nerve injuries,[10-16] radiculopathies,[10,11,17-24] vertebral joint dysfunction,[25-28] reflex sympathetic dystrophy,[10,11,29,30] lumbar/low back pain,[17,20,31,32] headache,[33] myofascial pain syndromes,[10,11,34,35] deep venous thrombosis,[36,37] and spinal cord lesions.[10]

The investigating team felt it appropriate to use CAIRT to generate the thermal description of spinal levels identified by expert users of the NS, however we caution that this is an early attempt to meld contemporary technology with 70-year-old empirical beliefs. We also state categorically that this study is not to be read as any form of inter-examiner trial.

METHODS

The investigating team solicited 31 subjects from a late adolescent/young adult population. There were 18 males (mean age 23.61 yr) and 13 females (mean age 21.08 yr) who participated on one day under controlled conditions with informed consent. All subjects conformed to the standard protocols for infrared thermographic imaging, namely abstaining from smoking and exercise and being suitably gowned and stabilised prior to the readings.

An adhesive aluminium marker (visible on the infrared images) was placed over each of the C7 and L1 spinous processes of each subject. The inferior margin of the C7 marker was used as the datum point for measurement of observations. The first 5 cm of the spine was excluded to limit any potential local skin effects from either the adhesive marker or the mechanics of locating the measuring tape. The section of spine thus examined was typically about 15 cm, ranging from 5 cm below C7, to about 20 cm below C7.

Each subject was prepared and stabilised, and then first presented to the thermographer, where the image of their back was recorded on videotape and computer disc. The thermographic equipment used was a FLIR TVS Model 7300 Clinical Thermography unit, incorporating the Hughes Thermal Image Management System (TIMS) software. The subjects then presented in alternate order to each NS observer, who scanned the spine using a unit called the Skin Temperature Differential Instrument (STDI), manufactured by the Gonstead Clinical Studies Society (Australia) Limited, while an assistant recorded the observations. When a distinctive pattern was noted by the observer and deemed relevant, the assistant measured the distance of that event from the inferior margin of the C7 spinous marker.

The total distance between the two spinal markers was recorded at the time the thermographic image was captured (with the subject seated), and conveyed with each subject as they attended for each NS reading in order to replicate the same seated posture at each of these readings (indicated by duplicating the inter-marker distance). A spinal level was selected for thermal analysis when the measured point of one observer's found effect was within 2.0 cm of the effect found by the other observer. These represented one level from each of five subjects, ranging between 12.4 cm and 16.0 cm caudad to the C7 marker (clinically about the mid-thoracic level).

The thermal description of each level was obtained through retrospective analysis of the stored computerised images. The measured level was termed the "area of interest" (AOI), and a box about 3.75 cm high by about 9.0 cm wide was drawn around it within the image-processing software. Two parallel series of point temperatures in degrees Celsius (°C) were then taken, both commencing above the AOI and ending within the AOI near its inferior border, representing the caudal track of the Nervo Scope. The two vertical tracks were spaced about 5 cm apart to represent the left and right sensors of the instrument. The temperature was sampled at 12 points along each line, covering a vertical distance of about 7 or 8 cm and providing a point temperature at about 0.5 cm intervals. This interval matches the diameter of the sensor, thus providing a series of non-overlapping point temperatures. Point 1 was most cephalad and point 12, most caudad. A representation of how the 3-D graph model was generated from this procedure is shown in Figure 1.

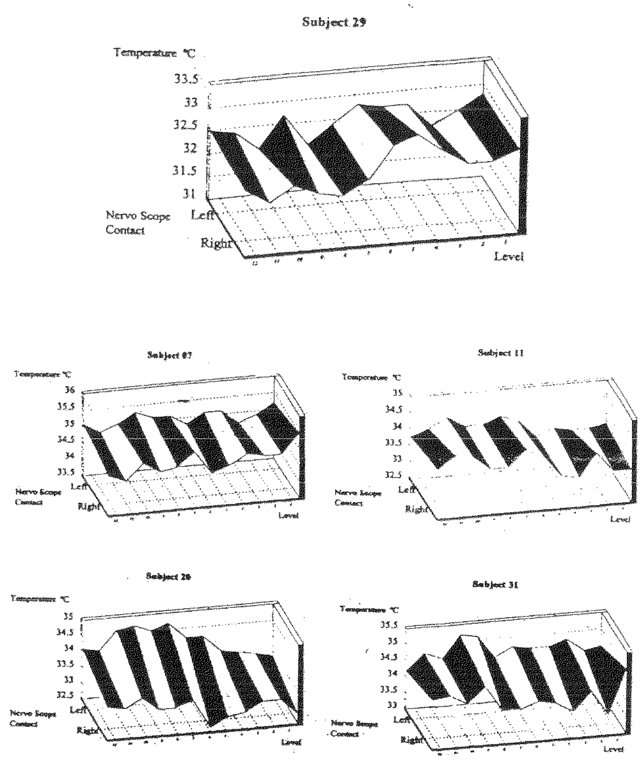

Figure 2. Three-dimensional graph modelling of paraspinal temperatures by subject.

The temperature readings therefore represent the left and right temperatures, sampled about each 0.5 cm, leading into and through the AOI. A number of analyses were conducted on the stored images, including the construction of isotherms and line profiles, however the multiple point method was selected as providing the most appropriate data for the creation of the 3-D graph models (Figure 2).

Each graph model can be considered as representing a "slice of skin" with a length of about 8 cm lying along the X axis and a width of about 5 cm along the Z axis, with temperature shown on the Y axis. Even though the mean temperatures varied between 32.48° and 35.02°C across subjects, the Y axis is shown with a constant 2.5° window.

A second style of graph is used to depict resultant data from this study in order to explore characteristics of the point temperature series beyond simple left/right asymmetry. This graph is a circular or "radar" plot, and reflects the dynamic nature of contact thermocouple assessment, where the concentric rings indicate the size and polarity of the change in °C between one level and the next for the left and right series of point temperatures on each subject (Figure 3). A positive direction indicates the temperature increased as the sensor moved caudad from one point to the next; conversely, a negative value indicates that the temperature fell.

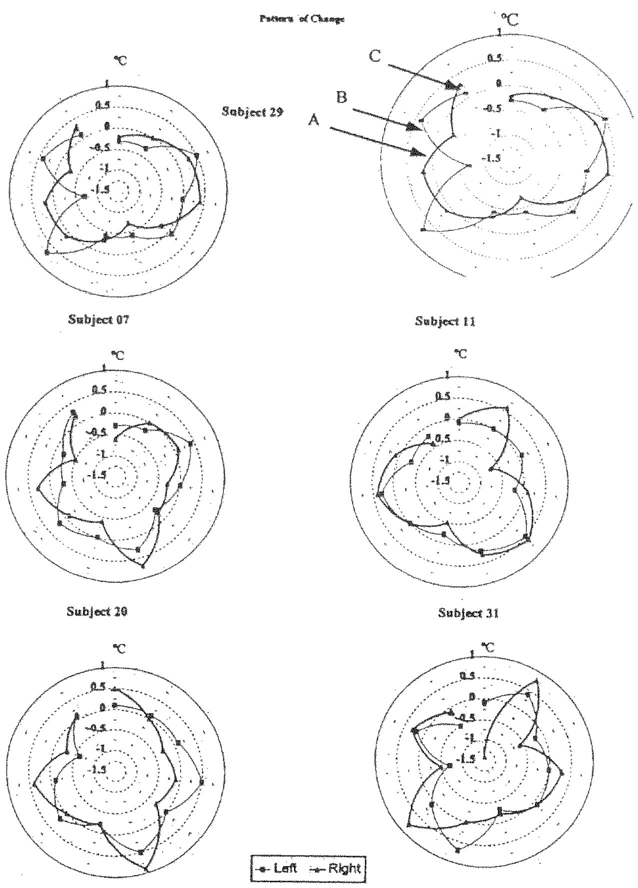

Figure 3. The pattern of temperature change by subject.

RESULTS

Five separate spinal levels are described in the data of this report. The thermal description given for each subject includes:

(i) a series of point temperatures taken at about 0.5 cm intervals in a vertical paraspinal line both to the left and right of the spine (shown pictorially in the graphs of Figure 2 and in Table 1),

(ii) descriptive statistics of the point temperatures (Table 2),

(iii) the temperature difference between the left and right point reading at each of the 12 point levels measured (Table 3),

(iv) the temperature difference between the successive levels on each side (Table 4), and

(v) a dynamic circular graph (Figure 3) of the values reported in Table 4.

The series of point temperatures demonstrate a relatively stable thermal situation in the selected regions on each subject. The mean left and right temperatures of all subjects fell within 2.54°C of each other (Table 2). Similarly both the *minima* and *maxima* were within a 2.7°C range across all these five subjects. The smallest range for any one series was 0.6°C (subject 07, left series), and the greatest was 1.4°C (subject 31, right series) (Table 2).

From the descriptive statistics reported in Table 2, the mean value of the differences between the mean of the left series and the mean of the right series for all subjects is also shown to be quite small, at 0.308°C (mean range 0.05 to 0.88°C). At various levels the individual left/right difference was as great as 1.6°C in one subject (subject 20, point 6, Table 3), however this subject presented with a clearly identifiable left thermal asymmetry indicative of a trigger point. The remaining subjects exhibited a left/right difference no greater than 1.1°C at any one level (Subject 31, point 8, Table 3), and typically less than half a degree (mean = 0.296°C). The temperature difference between successive levels (Table 4) was similarly small, the mean of the means being 0.2955°C (median 0.277°C, Q1 = 0.2273, Q3 = 0.3409°C).

DISCUSSION

The use of the NS within chiropractic clinical practice is described in ambivalent terms by contemporary authors,[4] however earlier writers were more incisive, clearly stating, "...chiropractic instrumentation...will show whether or not subluxations exist..."[7] The NS has been described as identifying the temperature differential or the "warmer side" of the spine,[38] and the principles applied by Gonstead describe heat as radiating away from the area of tissue damage in acute subluxation and towards the area of compression in chronic subluxation,[7] thus reinforcing the simplistic concept of a left/right temperature differential at a specific spinal level. However from an empirical point of view, a "hot reading" may just as likely be due to a dramatic decrease in microvascular circulation on the side opposite the "break" as to an increase on the side of the "break" (Hart C, personal communication, 1994).

The three-dimensional graphs support the empirical concept of a left/right temperature differential at a certain level by depicting a model of the skin temperature in the region of a "break" as determined by two experienced NS operators. With reference to the graph for Subject 29 (Figure 2), the model shows symmetrical temperatures at the start of the sampling (level 1), falling to level 3, then rising to be higher on the right at level 5, a fall on both sides to level 8, then a sharper rise on the left at level 9, a slower rise on the right at level 10 while the left is falling, then about equal temperatures at the end of sampling (level 12).

This pattern appears to be evident in each of the five models, namely an asymmetrical peak following a segment of thermal symmetry, however subject 11 shows an earlier asymmetry (right level 3), and subject 20 shows a more consistent asymmetry over several levels, corresponding with a larger area of thermal asymmetry evident on the original thermograph. These constructs from found data therefore fit the theoretical construct of subluxation being attended by thermal asymmetry, however the question now becomes

Table 1

POINT TEMPERATURE BY SUBJECT

LEVEL	07 Left	07 Right	11 Left	11 Right	20 Left	20 Right	29 Left	29 Right	31 Left	31 Right
1	35.2	35.5	33.7	33.5	33.4	32.8	32.8	32.8	34.5	35.0
2	34.9	34.9	33.6	33.5	33.5	33.3	32.5	32.6	34.4	33.6
3	34.7	34.9	33.6	34.1	33.6	33.3	32.2	32.6	34.8	34.4
4	35.1	35.0	33.7	33.4	33.7	33.0	32.7	32.9	34.6	33.8
5	35.1	34.7	33.5	33.5	34.2	32.9	32.7	33.3	34.6	34.1
6	34.8	34.5	34.0	34.1	34.2	32.6	32.8	33.1	34.7	34.2
7	35.1	35.2	34.2	34.4	34.7	33.5	32.4	32.4	34.4	34.0
8	35.1	34.8	34.0	33.9	34.5	33.3	32.0	32.1	35.1	34.0
9	35.3	34.7	34.0	33.9	34.7	33.3	32.7	32.2	35.2	34.8
10	35.0	35.0	34.3	34.3	34.6	33.7	32.0	32.4	34.5	34.3
11	34.8	34.5	34.0	34.4	34.0	33.4	32.4	32.1	34.7	34.6
12	35.1	34.7	33.8	34.0	34.1	33.5	32.5	32.4	34.2	34.5

T = +C

Table 2

DESCRIPTION OF TEMPERATURE BY SUBJECT

	07 Left	07 Right	11 Left	11 Right	20 Left	20 Right	29 Left	29 Right	31 Left	31 Right
Mean	35.02	34.87	33.87	33.92	34.10	33.22	32.48	32.58	34.64	34.28
SE	0.05	0.08	0.07	0.11	0.14	0.09	0.08	0.11	0.08	0.12
Median	35.10	34.85	33.90	33.95	34.15	33.30	32.50	32.50	34.60	34.25
SD	0.18	0.29	0.25	0.37	0.47	0.32	0.29	0.39	0.29	0.41
Min	34.7	34.5	33.5	33.4	33.4	32.6	32.0	32.1	34.2	33.6
Max	35.3	35.5	34.3	34.4	34.7	33.7	32.8	33.3	35.2	35.0
Range	0.6	1.0	0.8	1.0	1.3	1.1	0.8	1.2	1.0	1.4

T = +C

whether it is simply these levels of asymmetry which are detected by the NS and hence considered indicative of "subluxation." If so, any thermal imaging instrument should be capable of identifying left/right asymmetry and hence, in the view of some practitioners, the subluxation complex.

The data from this study seem to indicate that there is a greater complexity in the thermal characteristics of what may be the subluxation complex than previously thought. For example, the left/right temperature differences are essentially very small, being typically less than half a degree. It is reasonable to question whether the sensitivity of the NS/operator combination (especially with the earliest versions of the NS, as opposed to the later models with amplification) is such that it would reliably detect such small differences. It must be understood that clinically, the NS is used in a dynamic mode, being "glided" over the skin by the operator, thus introducing, as Triano described, a difficulty in standardising pressure and angle of probe contact between operators.[38]

Table 3

TEMPERATURE DIFFERENCE (LEFT-RIGHT) AT EACH LEVEL BY SUBJECT

LEVEL	SUBJECT NUMBER 07 Left-right	11 Left-right	20 Left-right	29 Left-right	31 Left-right
1	-0.3	0.2	0.6	0.0	-0.5
2	0.0	0.1	0.2	-0.1	0.8
3	-0.2	-0.5	0.3	-0.4	0.4
4	0.1	0.3	0.7	-0.2	0.8
5	0.4	0.0	1.3	-0.6	0.5
6	0.3	-0.1	1.6	-0.3	0.5
7	-0.1	-0.2	1.2	0.0	0.4
8	0.3	0.1	1.2	-0.1	1.1
9	0.6	0.1	1.4	0.5	0.4
10	0.0	0.0	0.9	-0.4	0.2
11	0.3	-0.4	0.6	0.3	0.1
12	0.4	-0.2	0.6	0.1	-0.3

T = +C

Table 4

TEMPERATURE DIFFERENCE BETWEEN SUCCESSIVE LEVELS BY SUBJECT

LEVEL	SUBJECT NUMBER 07 Left	Right	11 Left	Right	20 Left	Right	29 Left	Right	31 Left	Right
2-1	-0.3	-0.6	-0.1	0.0	0.1	0.5	-0.3	-0.2	-0.1	-1.4
3-2	-0.2	0.0	0.0	0.6	0.1	0.0	-0.3	0.0	0.4	0.8
4-3	0.4	0.1	0.1	-0.7	0.1	-0.3	0.5	0.3	-0.2	-0.6
5-4	0.0	-0.3	-0.2	0.1	0.5	-0.1	0.0	0.4	0.0	0.3
6-5	-0.3	-0.2	0.5	0.6	0.0	-0.3	0.1	-0.2	0.1	0.1
7-6	0.3	0.7	0.2	0.3	0.5	0.9	-0.4	-0.7	-0.3	-0.2
8-7	0.0	-0.4	-0.2	-0.5	-0.2	-0.2	-0.4	-0.3	0.7	0.0
9-8	0.2	-0.1	0.0	0.0	0.2	0.0	0.7	0.1	0.1	0.8
10-9	-0.3	0.3	0.3	0.4	-0.1	0.4	-0.7	0.2	-0.7	-0.5
11-10	-0.2	-0.5	-0.3	0.1	-0.6	-0.3	0.4	-0.3	0.2	0.3
12-11	0.3	0.2	-0.2	-0.4	0.1	0.1	0.1	0.3	-0.1	-0.4

T = +C

Further, the dynamic movement of the sensors along a glide path means that the instrument is responding to any segmental left/right asymmetry after being conditioned by the preceding temperature on each side. In other words, the NS may not show thermal asymmetry if held against the skin in a static manner, but may detect asymmetry through a comparison of the *rate of thermal change* on one side compared with the rate of change on the other.

Support for this concept is found in the radar graphs which demonstrate the size and nature (rising or falling) of the difference between sequential temperatures at each level on each side of the spine. The graphs as presented in this paper therefore demonstrate what may come to be acknowledged as a characteristic of the spinal level detected by the NS, namely that while the temperature is changing in one direction on one side, it is varying in the opposite direction on the other side.

For example, Figure 3 includes an enlargement of a part of the radar plot for subject 29. Arrow A indicates the right-side temperature was falling by 0.5° (from a between-point value of +0.2° generated by the rise from 32.2° at point 9 to 32.4° at point 10, to a between-point value of -0.3° generated by the fall from 32.4° at point 10 to 32.1° at point 11), while Arrow B indicates the left-side temperature was rising by 1.1° (from a between-point value of -0.7° generated by the fall from 32.7° at point 9 to 32.0° at point 10, to a between-point value of +0.4° generated by the rise from 32.0° at point 10 to 32.4° at point 11). The left side then fell again, while the right side increased to a point of approximate symmetry (arrow C). This effect is more complex than the simple left/right asymmetry which is depicted in the 3-D model for subject 20, and is dependent on the dynamics of sensor movement.

If the observations found in this study are valid, then it may be that we need also to consider the thermal changes which fall in a linear manner parallel to the spine as well as the traditionally considered left/right asymmetry at segmental levels. The data from this study demonstrate that the paraspinal temperature varies symmetrically within a very small range (< 0.5°C) in certain spinal regions, and at a particular level will vary asymmetrically, with one side falling while the other side increases. This effect has been shown in the radar plots for each of the five subjects, namely subject 07 at 9 o'clock, subject 11 at 2 o'clock, subject 20 at 8 o'clock, subject 29 at 10 o'clock, and subject 30 at 7 o'clock (clock positions given with reference to Figure 3). The plot for subject 20 does not strongly exhibit this crossover characteristic, however this is the subject with the objective evidence of a localised heat source on the left at these levels, which could act as a confounder.

These data give rise to an alternate hypothesis which states, "The spinal region to which the contact thermoscope is sensitive is that region where an asymmetrical thermal dynamic exists between the paraspinal temperature gradients." If this study is replicated and the hypothesis supported, it will present us with an objective dimension which may well be a parameter of the subluxation complex, given the empirical use of the NS to assess the spine for evidence supportive of the need for chiropractic adjustment. Further, if we can identify such an objective dimension, then we can more fully investigate why clinical instruments such as the NS do not have stronger concordance (fair as incidentally noted in this study, but substantial as found by Plaugher *et al.* in a comparable spinal region[5]).

It may be that CAIRT could gain greater utility in chiropractic practice if it can be used in a way to more easily identify these objective characteristics. This could be done by obtaining a line profile of the skin temperature along either side of the spine, generating the progressive thermal differential values and then, by overlapping the two data sets, identifying levels where the asymmetrical thermal dynamic existed. This is an area for future study in our chiropractic laboratories at RMIT.

CONCLUSION

This study of 31 subjects identified five subjects where two blinded, experienced operators of a traditional chiropractic instrument, the NS, agreed there was appropriate evidence of spinal dysfunction at a particular spinal level. A description of these five levels was generated by CAIRT and the data plotted in a series of graph models. A particular characteristic was found, namely that an asymmetrical thermal dynamic existed between the paraspinal temperature gradients at these levels, meaning that the skin temperature varied asymmetrically, with one side falling while the other side increased. These events happen within a relatively small window, as the thermal description of these spinal levels revealed a left/right difference of typically about 0.3°C and no greater than 1.1°C, and a series range on any one side of the spine of typically 1.0°C and no greater than 1.4°C.

The radar plots of the data clearly demonstrate the presence of an asymmetrical thermal dynamic which may, if replicated in other laboratories, represent an objective dimension of spinal dysfunction, or in more common terms, the subluxation complex. If this objective dimension can be reliably and repeatedly identified, we will have evidence in support of the validity of the contact thermocouple in chiropractic clinical practice. Alone, this study can be read as demonstrating that the clinical entity found by use of the NS exhibits more than simply a left/right thermal asymmetry.

ACKNOWLEDGMENTS

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Reliability

Inter- and intra-examiner reliability study of paraspinal infrared temperature measurements in normal students

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Abstract

Paraspinal temperature measurements were made on 24 normal students in order to evaluate variability of temperature measurements, both within and between examiners. A dual probe IR spectrometer, which measured absolute temperature accurately over a very small (approximately 1/4 inch) skin area, was used on all subjects. Three experienced chiropractic clinicians, using a controlled environment and standardized procedures, independently measured subjects from L5 to T1 on two occasions, separated by no more than one hour. Both right and left side paraspinal temperatures were recorded on graph paper each time. Degree of concordance of the absolute temperatures along the spine from one reading to the next and also one examiner to the other was evaluated by Intraclass Correlation Coefficient (ICC). Overall ICC R values ranged from .639-.998 and in all possible inter- and intra-examiner comparisons were statistically significant. In only 14 of the 24 subjects however were all of the readings statistically identical. These results indicated that temperature recordings can, with difficulty, be reliably measured at least over the short term.

Key words — Infrared, paraspinal temperature, reliability study, concordance.

Introduction

Temperature variations along the spinal column have long been thought to hold diagnostic and therapeutic implications, especially for chiropractors. To the chiropractic profession, in fact, goes credit for first recognizing and explicitly postula that paraspinal temperature readings may be rela to health and disease.[1,2] Various subdiscipli within chiropractic have, over many decades, hig developed the rationale and protocols for taking interpreting such temperature readings.[3,4] The jor reason chiropractors may favor tempera readings is that if local temperature variations properly interpreted, they may help localize chiropractic subluxation.[5,6] Thus, it is often as an adjunctive diagnostic tool for subluxatio along with palpation or x-ray.[7] Similarly, the teopaths also have occasionally used tempera variations as possible indicators of osteopa lesions.[8,9]

The usual chiropractic diagnostic thermograp procedure is to measure paraspinal temperature ferences between left and right sides at each segm A rapid onset (i.e. high frequency), relatively la temperature variation between left and right sid is interpreted as a "break", indicating the site possible subluxation.[10] Contrarily, a "locked" non-varying temperature pattern along the two of the spine, or the existence of a stable tempera pattern, is sometimes also taken as indicative possible subluxation.[11,12]

Unfortunately, no reliability study has been conducted to adequately assess either (a) the de of temperature symmetry which exists norm along the spine or (b) the test-retest stability of temperature patterns one encounters over ector et al[13] found that two repeated asurements of paraspinal temperatures by the e type of infrared thermographic (IR) equipment d in the present study yielded Pearson correla- coefficients hovering around 0.9. High correla- coefficients of the Pearson type, however, not necessarily good indicators of reliability.[14] and and Gizzoni[15] used a similar IR device and und that no significant temperature changes oc- red between right and left sides at either T1, T8 or L5, following an adjustment. Additionally, ng an electrical thermovision apparatus on the ole back of 35 normal young males, they found t no particular pattern of temperature along the ne could be identified from one subject to another. emperature range of 2-3.5 degrees C was normal er the back in an individual subject. They claimed t very stable temperature patterns occurred thin specific sites in a given individual subject, en after nine months. Their data, however, were ite general, poorly defined, and non-quantitative, the meanings of their temperature measurements, possible conclusions about reliability of perature measurements are not conclusive. dew et al[16] measured paraspinal skin perature bilaterally over C7, T6, L1, and L5 in ormal, male chiropractic students with four dif- ent chiropractic temperature measuring devices, uding an IR "gun" like the one used in our pre- t study. Two test-retest measurements were made h each instrument and also with combinations he various instruments. These authors, like Spec- et al,[13] reported that Pearson correlations of ater than 0.9 were usually obtained from one surement to another. Lack of details of the blin- g procedures and the weak statistical analysis, es their conclusion of high temperature measure- t reliability uncertain.

ott et al[17] tested the popular chiropractic heat or instrument, the Nervo-Scope, for accuracy eliability. They found the instrument itself was ly accurate but concluded that temperature aks" (which was the only parameter they ured) did not correlate with putative clinically ted spinal lesions. They did no reliability study, ever, and their patient selection and evaluative ia were very poor.

begin to document the validity of the diag- c tools used clinically by chiropractors, there- we set out to evaluate some of the variability ed in taking temperature readings. We wished if the temperature measured along the spine epeatable, even over a short time period, under controlled conditions. The purpose of the present study was specifically to evaluate the replicability of paraspinal temperature measurements, in a test-retest situation, by three typical chiropractic clinicians, using typical chiropractic clinical procedures and normal human subjects.

Method and Materials

Paraspinal temperature measurements were made along the whole spine by a procedure that was modelled after a typical chiropractic clinical practice. A few minor modifications were made so that more uniform control could be maintained to enhance statistical validity of the results. A basic premise was made that paraspinal temperature readings taken along either side of the spinous processes would remain fairly constant in a given normal individual over the period of one hour. Therefore, multiple readings taken by the same doctor, using the same equipment and same procedure, should yield identical results over this time period. By these means we obtained estimates of the intra-examiner reliability. Similarly, by the same rationale, consecutive readings from the same subject using the same equipment, procedures, etc., by three different doctors should also yield three identical readings that can be used to test for inter-examiner reliability.

These hypotheses were tested using a sample of 24 normal, healthy, Palmer College of Chiropractic freshmen. Subjects were recruited for the study to receive credit for research. Subjects were unfamiliar with the specific aims or underlying theory of the experiment as well as the equipment and procedures used. Also, the clinical co-investigators were unknown to the subjects. After volunteering for the study, subjects were administered a short medical history and given a cursory physical examination to rule out severe concurrent infectious or other disease, chronic neuromusculoskeletal disorders or deformities, or previous back surgery. After being apprised of the general nature of the experiment, which was limited to a single episode of one hour duration for any given subject, they were asked to sign an Informed Consent form approved by the Palmer College of Chiropractic Institutional Review Board. All subjects were males, in good health, in the age range of 21-40.

The 24 subjects accepted into the study were then used to obtain identical full spine IR thermographic recordings. Each of three different chiropractic clinicians recorded the paraspinal temperatures on each subject at two different times, within one hour of each other. These clinical co-investigators were all licensed doctors of chiropractic with experience in chiropractic use of temperature measurements with apparatus similar to the one used in this study. Several practice runs using the equipment were made beforehand by the clinicians to assure more uniformity and expertise.

For temperature measurements, subjects were assigned to a common examination room, maintained at 65-70 degrees and free of drafts. The subjects' backs were exposed and a harmless water color pen was used to mark the spinous processes of S2, L1, T1, and C2. The subjects were asked to sit upright without smoking, eating, walking or touching anything for at least 15 minutes in order to attain adequate temperature equilibration[18] before beginning temperature measurements.

Temperature measurements

The temperature measuring device which was used throughout the study was a slightly modified IR spectrometer (Decade III R, Exergin Co., Natwick, Massachusetts) of the type used extensively by Pierce and Stillwagon[3] and many other chiropractors. Two of these IR sensors were purchased and the two separate "guns" fixed together one and one-half inches apart so the two sensors could be handled by the doctor as one unit. Figure 1 is a photograph of the two IR measuring devices which have been wedded into one unit for use. Each IR device had a window of 5/32 square inches and measure radiation of wavelength 2-10 microns wit Bismuth-antimony detector. The time constant than 0.10 sec. and maximum sensitivity of the de tor alone, as stated by the manufacturer, is degree C.

The output of the IR detectors were lead to Linear Instrument Corp. (model 91107, Re Nevada) recorder running at a constant sensit and paper speed of 18 cm/min. The IR sens recorder unit was calibrated before and after the periment, by precision thermistors, to record solute temperature to a measured accuracy of degrees C. The output was linear between 86 deg and 98 degrees F. The paper used in the reco came premarked with temperature lines in this ra which made it relatively easy to maintain calib tion and facilitate data reduction and analysis

For making the clinical measurements, the cli cian simply positioned the sensor heads about quarter of an inch off the skin of the subject, w one head on either side of the spinous process. distance was maintained as closely as possibl the skilled eye of the clinician. Neither the sen nor the doctor touched the subject's back. Be ning always at the S2 tubercle, the sensor was mo slowly up the spine to C1. To maintain a unif speed, the IR sensor was attached by a chain to electrically driven arm that moved upward at a stant rate of 28 cm/min. (Consta-glide, Murdoc San Leandro, CA). Since the typical spine wa cm long, the total measurement time was typic

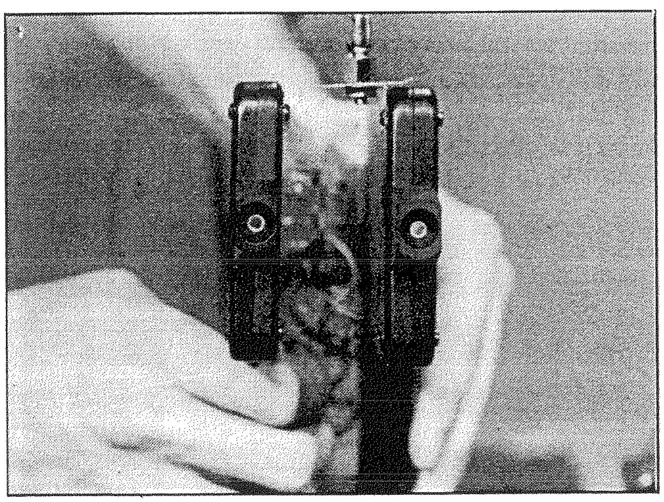

Figure 1.

Close-up photograph of the infrared sensing guns, showing spacing of the 2 windows for obtaining simultaneous right and left paraspinal temperatures.

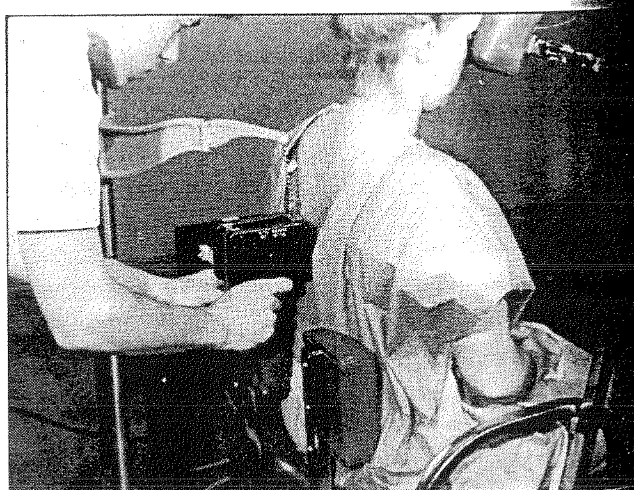

Figure 2.

Photograph of a temperature measurement in pro gress. Note IR sensors chained to the Consta-Gl for speed control and also the subject positioned the constant posture chair. (Chart recorders attac to each IR sensor not shown, behind doctor) about 2.5 min. The clinician activated a single switch which simultaneously turned on or off the IR sensor, the motorized arm and the paper recorder. Figure 2 is a photograph of the apparatus in use.

To reduce biological variation in temperature and other variables, each subject was maintained for 15 minutes in a constant temperature, draft-free clinic exam room which was adjacent to the testing room. Student assistants called the appropriate subject, in random order, into the temperature recording room and sat the subject onto a backless, constant-posture chair. The patient's head was rested against the headpiece of the chair which was fixed in position once the subject had assumed a correct, natural posture so that as much stress was off the spine as possible (see Fig. 2).

Only after all these preliminaries had been accomplished was the doctor called in to do the actual measurements. The doctor never saw the subject's face and no speaking was allowed. After manually positioning the sensor, the doctor began taking the temperature reading on the subject. As the sensor head passed the marked vertebrae levels, the doctor called these out to another assistant who marked them on the chart recorder paper. Each temperature measurement resulted in continuous absolute temperature recordings along each side of the whole spine. When the reading was completed the doctor left the room and the student assistant released the subject and called in another subject, as well as another doctor, for similar measurements. Measurements were continued until each subject had been measured twice, at random interval, by each doctor.

Data analysis

After each session, the senior author collected each chart record of the temperature measurement, consisting of simultaneous left and right side paraspinal readings. All data analysis was made from these charts. Each chart was digitized, using a DEC Pad digitizer and stored on disc in a DEC VAX 11/750 computer. Data was input for each subject separately, for each visit and for each doctor. Right and left sides were digitized and treated separately since each side represented independent absolute temperature readings.

The computer was programmed to fit each digitized plot to a curve-fitting equation so that differences in digitized points would be standardized from subject to subject for statistical analysis. Ten equally spaced data points were made at each vertebral segment. A plotting routine was developed so that the fitted curve, from multiple charts, could be viewed on a Tectronix graphics terminal. The fitted curves were visually compared to the original paper charts to ensure their comparability. In every case the plotted curve turned out to be a satisfactory reproduction of the original chart recording, which was not surprising since the curve-fitting routine forced the line through each actual digitized data point. Because of technical difficulties of obtaining good temperature readings from the cervical spine, as well as the sacrum, due to hair, fat, etc., data from only the lumbar and thoracic spine was used for statistical analysis.

Three types of statistical analysis were carried out by local programs to evaluate whether there was agreement in temperature measurements between and among clinicians. The statistical desiderata for studies such as this, as has been previously pointed out,[19] is to determine the *relatedness, or sameness* of values from different readings. This is statistically measured best by concordance,[14] and for the type of data obtained in this investigation, the concordance statistic of Intraclass Correlation Coefficient (ICC)[14,20] is most appropriate. Rationale and calculation details of ICC may be found in the above references as well as in another paper by the principal investigator.[21]

Therefore, as the primary basis for deciding whether there was adequate intra- and inter-examiner agreement of temperature findings in the present study, we calculated various ICC's. Separate ICC's were necessary to determine inter- and intra-examiner concordance. For inter-examiner concordance an ICC was calculated for all three examiner pairs, for visit 1 only, of each subject separately and also over all subjects. The data for each of these analyses was taken from the ten evenly spaced, data points from each of the 17 vertebral segments (i.e. L5-T1). To reduce chance of type B error, ICC's were only calculated for the first visit of subjects and for only the left side.

The effect of visits within a given doctor (intra-examiner reliability) was assessed by separate ICC calculation. The same ten data points for each segment were used as data input as described above. (Again only the data from the left side of the subject was analyzed.) Separate ICC's for every doctor were then calculated using visit 1 versus visit 2. Temperatures taken by each doctor from all 24 subjects were used for one combined ICC calculation, but in addition, an ICC calculation was also made for each subject to try to estimate subject variability.

Temperature "break" analyses were also made for each subject. Breaks are generally defined as large temperature variations within 1-2 vertebrae.[17] One method we used to determine existence of a "break" was to simply subtract each data point from the mean spinal temperature of that subject. All these values (and their segmental location) which exceeded 0.5 degrees F over three consecutive data points were determined by computer program and printed out. These values represented possibly biologically significant local deviations from the average and might be taken as an indication of a "break" or subluxation. Inter- and intra-examiner agreement on the location of these breaks was assessed by a Reliability Test for Dichotomous Items.[22] This statistical test produced a correlation (Ro) value which, if high enough, indicated there was a greater than chance level of sameness of, or agreement on, location of these breaks by two doctors (for inter-examiner agreement), or from Visit 1 vs. Visit 2 for intra-examiner reliability.

Another method for temperature "break" analysis was to subtract right side from left side temperatures from each subject's corresponding paraspinal sites. The location of left-right absolute temperature differentials which exceeded 2.0 degrees F for three consecutive data points was determined as described above. This kind of left-right temperature differential is what is normally carried out in chiropractic clinical practice. The same concordance statistics as above were performed to determine if agreement was reached on the number and location of these "breaks" based on segmental temperature variations from side to side. The mean temperature of the whole spine, over all doctors and subjects, was also calculated for visit 1 and visit 2 and then compared by T-test to determine if any systematic temperature change could be ascribed to the passage of time alone.

Results

The mean paraspinal temperature (from L5 to T1) over all subjects and all doctors was 87.1 ±2.55 degrees Fahrenheit (F) for visit 1 and 87.7 ±2.56 for visit 2. These temperatures are not significantly different (determined by unpaired t-test) and indicates that there was no temperature change due simply to passage of time between measurements. The standard deviations were quite large compared to the surprisingly low variability of replication within the ten data points making up a spinal segment (SD's ranged from 0.03 to 0.97, mean = 0.34). Temperatures along each side of the back often varied (within a single measurement) by 3-4 degrees F, ran[ging] usually from about 86 to 90 degrees F. The [tem]perature variations were not visibly stable from [one] subject to another but were instead appar[ently] idiosyncratic to each individual.

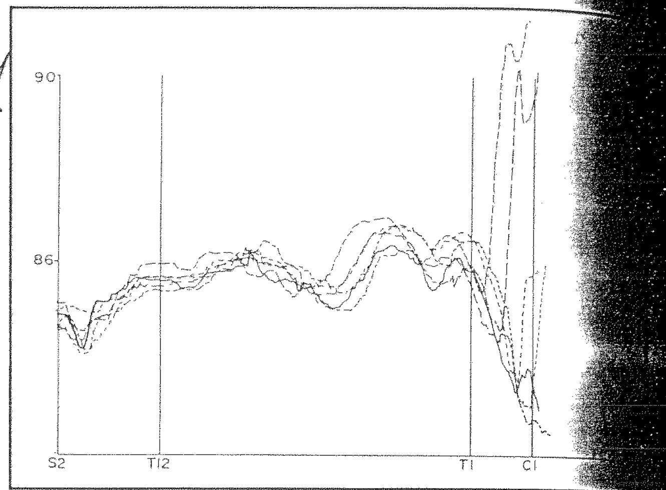

Figure 3.

A typical computer generated plot of the paraspi[nal] temperatures plotted at 10 equal intervals with[in] each vertebral segment from a single subject. Al[l] independent measurements from the left side a[re] overlaid. Ordinate is the actual temperature in degrees Fahrenheit. Note the high concordance, bo[th] in terms of close agreement in absolute temperat[ure] values and also in pattern, except for the cervical region.

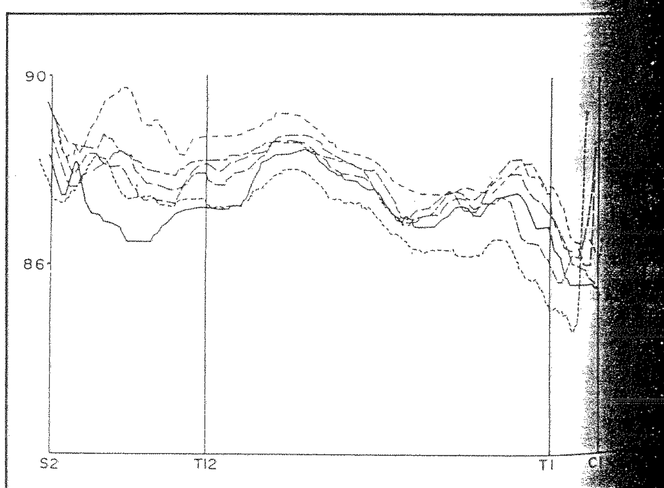

Figure 4.

A typical computer generated plot of the paraspi[nal] temperatures, plotted at 10 equal intervals with[in] each vertebral segment, from a single subject. Al[l] independent measurements from the left side a[re] overlaid. Ordinate is the actual temperature in degrees Fahrenheit. Note the rather wide diverge[nce] of absolute temperatures between different measurements but still the pattern, overall, excep[t] the cervical region, is highly concordant.

The pattern of temperature readings along the ne was compared visually by overlaying on a mputer graphics terminal all of the readings for th visits for each subject and all three doctors. sually the patterns looked quite congruent, hough the absolute temperature values were often fferent from doctor to doctor or visit to visit. gures 3 and 4 show typical temperature plot verlays to illustrate the general similarities in mperatures.

Statistically, the evaluation of inter-examiner con- rdance was made for all 24 subjects and all three octors using temperatures for visit 1, at all segments the spine. The inter-examiner ICC was r = .657 = 5.09, $p < .05$) and indicated overall statistically gnificant inter-examiner reliability. Intra-examiner liability was likewise assessed separately for Doc- r A, Doctor B and Doctor C. The respective r lues for these calculations were 0.591, 0.699, and 799 ($p < .05$) indicating that the intra-examiner liability was also statistically significant for all 3 ctors. Table 1 summarizes the various correlation efficients.

CC's were also calculated separately for each sub- t to examine the inter- and intra-examiner reliabil- The critical F value for significance was 1.30 and alue less than this (indicating non-reliability) was n in only 32 out of the total 184 possible com- isons. There were 15 intra-examiner pairs and 17 rs of inter-examiner ICC which were not reliable. nalysis of temperature differentials (i.e. breaks) ween left and right sides, and also local perature variations from the mean along the e side at corresponding segments, indicated that e local variations often occurred, sometimes as ch as 4 degrees. No consistent pattern of tem- ature differences were noted at any particular site g the spine. On temperature recordings from 16 jects (out of 24) there was at least one local perature difference greater than .5 degrees F from mean of the subject. In the majority of cases only or two spinal segments exhibited greater than grees F variations. These local deviations were preted for this paper as being possible "breaks" ere analyzed for repeatability of these findings within and between doctors. For purposes of tical analysis, "breaks" (temperature deviation segment > .5 degrees F from the spinal mean) counted as agreements if the location was n one segment above or one vertebral segment The mean inter-examiner agreement overall 48/199 (75%) while the intra-examiner agree- was 148/200 (74%). Statistical analysis by

Table 1.

Summary of Intraclass Correlation Coefficients (R) and Dichotomous Item Reliability (Ro) test analysis for inter- and intra- examiner reliability of paraspinal temperatures.

Doctor Comparison	Intraclass Correlation (ICC) (a)	F Value (b)	Reliability Coefficient Ro (c)	Percent Agreement (d)
A vs A	.700	6.50*	.298	69.6%
B vs B	.791	10.43*	.393	80.8%
C vs C	.696	6.21*	.348	75.5%
A vs B	.726	6.44*		
A vs C	.764	7.54*		
B vs C	.866	14.05*		
A vs B vs C (total inter-examiner)			.744	

(a) ICC based on all 24 subjects, using absolute temperatures for left side only, and for visit 1 only for interexaminer analysis.

(b) F = MS (rater) / MS (error); Critical F = 1.300; * = $P < .05$

(c) Ro = Dichotomous Item Reliability Coefficient, based on agreement on semental location of left-right temperature differentials > 2.0 degrees F ("breaks").

(d) Percent agreement calculated for "breaks" as defined in text.

dichotomous item reliability test gave high inter-examiner Ro's, but relatively low intra-examiner Ro values (Table 1).

Similar calculations for breaks defined as temperature differences within a segment of greater than 2.0 degrees F between left and right sides were made. Inter-examiner agreement was 147/198 (74%), while intra-examiner agreement was 147/199 (74%). Dichotomous item reliability test values (Ro) are given in Table 1 and show almost identical results to the "break" analysis based on deviations from the mean spinal temperature.

Discussion

The results presented here tend to show that chiropractic use of paraspinal temperatures may be justified, at least to the extent that a given clinician might have confidence that if he repeated the measurements, he will get essentially the same results. Figures 3 and 4, which show repeated temperature tracings in the same subject, provide quite encouraging visual evidence that, while absolute temperatures may vary slightly from measurement to measurement, the general pattern of temperatures appear quite congruent. Each subject, in other words, appears to have his own individual pattern of temperature values along his back and these do not change drastically, at least within the short term. These differences, even in the same subjects, often exceeded 1 degree, so in a particular case, attempting to make too much of a small (< e.g. 1.5 degrees F.) temperature difference would not seem to be warranted.

The validity of taking paraspinal temperatures measurements was not under test in this experiment. Obviously, the next question immediately arises as to what use can be made of these measurements. It would appear that, if a given clinician assiduously attempts to standardize his equipment and procedures, he should be able to obtain temperature readings that may be used for comparative purposes on a given patient. How these temperature readings are to be used for diagnostic or therapeutic evaluation needs now to be intensively studied. Previous chiropractic use of these for precise interpretation and aid in diagnosis of subluxations should provide a good guide for further development of this theory and practice.[16]

Medical usage of thermographic data of the spine has been less precisely defined. Recently, the use of pattern analysis of temperature variation using thermovision over the back has been shown useful in diagnosing certain spinal pathologies, nerve root compresion, sciatica, etc.[23,24,25,26,27,28,29] Along with mammography,[30] and screening for other forms of cancer or pain,[31] this and other uses of medical thermography have been a rapidly evolving and accepted clinical tool.[32] Wexler[33] and others[31] have shown, using sophisticated electronic IR devices to display temperature over large areas of the body, that reliability and stability of the temperature pattern over a normal spine or a patient's back were very high, although no rigorous quantitative test-retest data was presented.

Few medical investigators have measured the degree of temperature symmetry at various body sites. Silberstein et al[34] used an IR thermeter similar to the one used in the present study to measure unspecified sites on the right and left sides of both (a) the "posterior chest" and (b) "posterior lumbosacral" areas. On any given day, using ten male subjects, they found a mean temperature right-left difference of .4-.6 C at these sites. Intrasu
variation at these same sites, over two days
.9-1.5 C. They suggested that temperature varia
of < 1 C at local sites was insignificant
unreliable. Our data tend to corroborate this eva
tion. Doust[35] found that temperature change
axillary regions occasionally varied up to 2.5
normal subjects at rest and in fact, there was
minute cycle to this phenomenon. Unfortuna
no bilateral measurements were done, so it is
possible to determine if both sides varied at the s
time. Presumably, a stable temperature differe
between right and left sides could have been pre
Newman et al[28] found high (96 percent) inte
server reliability of back temperatures using li
crystal thermography.

Feldman and Nickoloff[36] also found that m
normal subjects had symmetric (< 1.0 C differe
tial) temperatures on both sides of the cervical sp
Furthermore, painful sites in some of their patie
had either hot or cold states. They stated "Asy
metry may, therefore, be indicative of a subclin
abnormality or of a currently silent pathologic
cess which will subsequently surface." Patients w
painful pathologies involving C6, C7 or C8 ro
were distinguishable thermographically in m
cases. Normell and Wallen[37] provided di
evidence that not only is skin temperature due
sympathetic nervous system activity, but lo
changes in both nerve activity and temperature fl
tuated (.3-.8 degrees) within two-five minute peri
in response to stress, noise, draft, etc. Lo
showed that local perfusion and, to a degree, lo
metabolism govern local skin temperature,
dicating further that local pathology might be e
pected to alter local temperatures.

Tichauer[39] found qualitative analysis of therm
graphs superior to quantitative analysis and he co
differentiate between which of 22 patients ha
and which did not have[8] back pain. In norm
subjects he found that back temperature was usua
symmetric (< 1.0 C) and also that right and left
ferences were only ±.5 C in both normal subje
and in patients. Kelso, et al,[40] used a thermovisi
system to evaluate back skin temperature patt
in 35 normal subjects. Temperature variation o
the back was 2-3.5 C. One of their subjects ha
putative osteopathic lesion and there was an a
of stable temperatures in that region. They a
reported that even within an hour, "warm areas
this often appeared and disappeared. These da
taken together with the chiropractic literature a
experience, indicate the definite possibility o

place for thermography in the clinical arsenal. ability of IR temperature readings appears to be ptable at this point, but further work, as well aution, is obviously warranted.

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To doubt everything or to believe everything are two equally convenient solutions; both dispense with the necessity of reflection.

— Jules Henri Poincaré
La Science et l'Hypothese, (1903)

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The Inter- and Intraexaminer Reliability of a Paraspinal Skin Temperature Differential Instrument

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ABSTRACT

An experiment was undertaken to determine the intra- and interexaminer reliability of a paraspinal skin temperature differential instrument. Nineteen pain-free female chiropractic college students participated as subjects for the investigation. Three separate areas of the spine (C4-T2, T4-T8 and L2-L5) were examined for concordance between two examiners. Additionally, intraexaminer reliability was tested by having each examiner repeat the scanning procedure. Concordance for whether a temperature differential existed in a particular area was evaluated with the Kappa statistic. Kappas ranged from 0.034 to 0.6591 and were all statistically significant ($p < 0.05$). This represented slight to moderate reliability in the area C4-T2 and substantial agreement in the region T4-T8. The lumbar region could not be evaluated with the Kappa statistic due to limited variation. Following agreement for a positive finding in a given area, the numerical ratings were evaluated for agreement with the intraclass correlation coefficient (ICC). The first observation between examiners indicated fair agreement (ICC = 0.2756, $p = 0.0478$). The second observation between examiners had substantial agreement (ICC = 0.6402, $p = 0.042$). Intraexaminer agreement was moderate for one examiner (ICC = 0.5078, $p = 0.0016$). The other examiner showed an excellent level of agreement (ICC = 0.8588, $p < 0.001$) between observations. (J Manipulative Physiol Ther 1991; 14:361–367).

Key Indexing Terms: Chiropractic, Skin Temperature, Thermography.

INTRODUCTION

The use of skin temperature instrumentation to detect evidence of nerve root compression or irritation and myofascial inflammation is common (1–7). Usually skin temperature instrumentation has taken the form of liquid crystal or infrared thermography for the assessment of trunk or extremity skin temperature (8). Hand-held devices, more common to the chiropractic profession, have been evaluated and shown to have moderate to excellent interexaminer reliability over short time durations (9, 10); however, one study (9) incorporated a weak statistical analysis, making its results uninterpretable. These instruments use infrared technology for assessment of skin temperature.

Hand-held thermocouple instruments have received less attention in the literature (11, 12). One report (11) demonstrated little value of the Nervoscope (hand-held thermocouple) as a diagnostic instrument. It is interesting to note that the Nervoscope was evaluated for concordance with other tests of unknown reliability or validity. Another report (12) demonstrated excellent test-retest reliability of a Nervoscope, but failed to address the reliability of the instrument for dynamic scanning of the paraspinal tissues. Additionally, the details of the blinding procedure and the weak statistical analysis employed makes the results uninterpretable (10).

Although criticisms of hand held thermocouple instruments have surfaced in the literature (13), these are mostly based upon inferences of presumed inaccuracies due to the technologically primitive design of the instruments rather than on any scientific data.

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This investigation was therefore undertaken to determine the intra- and interexaminer reliability of a thermocouple paraspinal skin temperature differential instrument (Nervoscope) by testing it under dynamic scanning conditions.

MATERIALS AND METHODS

Nineteen female chiropractic college students gave informed consent and participated as subjects for the study. Participants with skin lesions or febrile conditions were excluded. They were instructed to not smoke and not ingest caffeine at least 24 hr prior to the start of the investigation. The subjects were gowned and had three sections of their spines marked with a surgical ink pen. Four vertical 2-cm marks were drawn over the spinous processes for each section, separated by a 1-cm clear zone. At the top and bottom of the section, a 3-cm horizontal mark was drawn. Section one corresponded to spinal levels T2 to C4 and was scanned with a cephalad glide with the subject's head slightly flexed in the seated position. Section 2 corresponded to spinal levels T4 to T8. The third and final section corresponded to spinal levels L2 to L5. Since the lumbar spinous processes are much larger than other regions, the vertical markings were lengthened to 2.5 cm for this area. The clear zone between the vertical marks remained 1 cm. These areas were chosen to decrease the amount of time for each examination. Had the entire spinal column been used, observer fatigue could become a problem. Typically, the instrument is used to scan small sections of the spinal column, one after another, rather than one continuous glide from C1 to L5. The subjects were seated and the glide was caudal for sections two and three. The instrument is commonly used to scan a small region of the spinal column, rather than assessing an individual motion segment.

A nonamplified Nervoscope served as the instrument for the experiment (Figure 1). The instrument consists of two low impedence thermocouples connected to a 124 microammeter. The device has a jeweled movement, adjustable probe widths and a high/low sensitivity switch. The instrument was maintained on the high sensitivity setting throughout the investigation.

Two practicing chiropractors participated as examiners for the experiment. Each had approximately 9 yr of clinical practice experience using thermocouple instruments similar to the one tested in this study. The examiners considered themselves well versed in the usage of the instrument. One examiner (examiner 1) used an electronically amplified version of the Nervoscope in practice and therefore may have been less familiar with the more subtle nature of positive findings

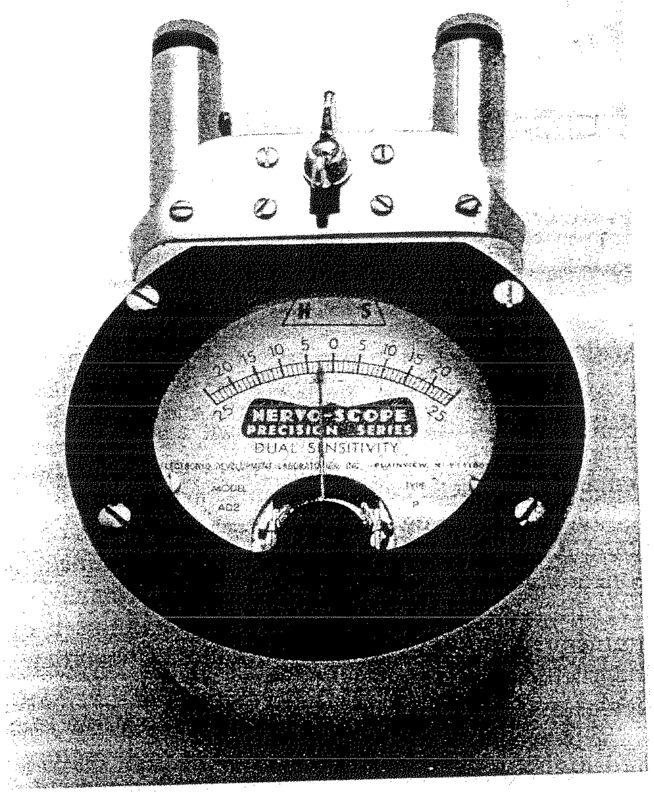

Figure 1. The Nervoscope.

encountered with the nonamplified type. Preceding the trial, the examiners met for 1 hr in order to practice the scanning procedure and to coordinate agreement for a typical positive finding.

A positive finding ("break") was established when the meter needle moved briskly in one direction followed by a brisk movement in the opposite direction. To be considered positive these two movements must occur over the length of one vertebral segment. A mark was placed on the data sheet at the level of the center of the thermocouples when the needle indicated a change in direction of movement. The data sheet had corresponding numerically calibrated marks identical to that on the subject's skin. The recorder then showed the examiner where he placed the mark in relation to the lines and the examiner agreed to this location before proceeding to the next section.

A break was considered only if it was present for at least three out of four successive glides. Only one break, the largest, was noted. This was an arbitrary assignment for the purposes of the study and does not necessarily reflect how a small or large temperature differential would be interpreted in a clinical setting. An examination was considered negative if any of the above criteria were not met. In the case where two or more equally obvious breaks were present, the first break encountered in the direction of the glide was noted. If the glide path was too short to complete an analysis of a suspected needle movement no break was recorded. If a break gradually diminished after successive glides it was considered less significant than if the break remained stable or was accentuated by repeated scans.

Some examples of meter needle movement patterns can be seen in Figures 2–4. Note the differences in the needle movements with progressive glides over the same area in Figures 2 and 3.

Separation of the instrument probes containing the thermocouples was 4 cm, and was kept constant for all subjects and all scans. The speed of the glide for each scan was approximately 0.5–1.0 cm/sec. The thermocouples contacted the skin surface. The probes were kept in contact with the surface of the skin with a very light pressure sufficient enough to prevent air gaps forming at the skin/thermocouple interface.

Three "prescan" glides of each area to be examined were performed with an instrument similar to that used

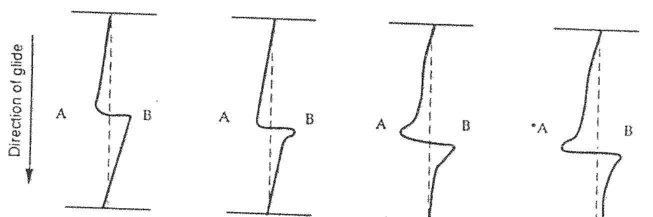

Figure 2. Successive scans with a caudal glide. In the fourth scan A and B are of equal magnitude, but A is recorded since it is the first encountered in the direction of the globe.

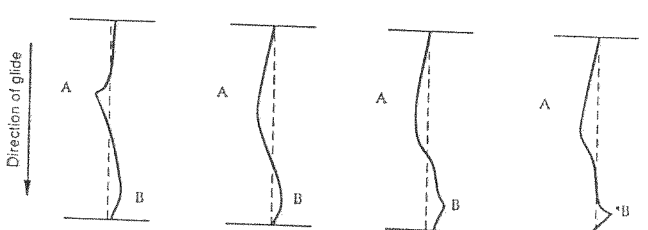

Figure 3. Successive scans with a caudal glide. B is recorded due to its accentuation following successive glides.

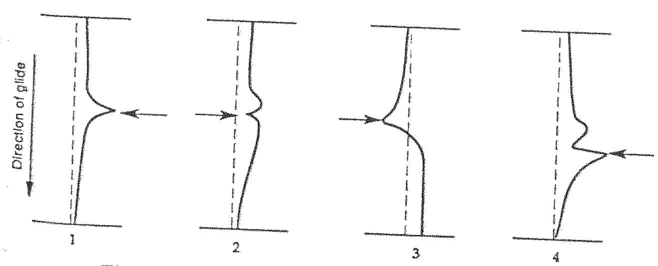

Figure 4. Examples of different "break" patterns.

during the actual scan. The meter was covered to prevent any prejudgment of subsequent scans. These prescans served to stimulate the skin in the area of analysis. It has been hypothesized, based on uncontrolled clinical observations, that a true break will be brought out by successive glides and that frivolous skin temperature fluctuations are minimized (14). A separate instrument was used for the prescans to lessen any heat-loading effects on the thermocouples of the testing instrument. Probe widths and glide protocol were the same for both the prescan and the examination scan.

The actual evaluative scans were initiated with the thermocouples in contact with the skin at the beginning of the glide path, with a 2-sec delay before initiation of the glide. At the end of the glide the instrument was held on the skin for 2 sec to allow for the completion of any needle movements on the meter. Five seconds elapsed between scans to minimize the heat-loading effects of the thermocouples. Four scans were performed in each area. The instrument was allowed to cool in front of a fan while prescanning the next area to be examined. This also prevented heat loading.

The scanning took place over a period of 3 separate days. Due to the involved protocol of the experiment, each session lasted approximately 5 hr. The subjects remained in a separate room and were brought to the scanning area through a randomization process. The subject was seated on a stool inside of a large cardboard box. A narrow section was cut out of the box which allowed access to the patient's skin over the spinal column. The tightly enclosed area of the box made identification of the patient by the examiner difficult. Additionally, to further blind the examining doctor for intraexaminer scans the subject had black tissue paper attached to the spinal column just lateral to the scanning area to hide any identifying landmarks unique to that subject. The paper was attached to the subject's skin for two of the four scanning sessions. A shower cap was used to cover the subject's hair so that identification could not be made.

Each subject underwent two scanning sessions with each doctor. One subject only underwent one examination with each doctor because her cervical section was excluded from analysis due to a skin lesion. Intraexaminer patient identification would have been easy with this particular subject since this was the only time where just two sections were scanned.

Through an oddity that occurred with the randomization process, one subject was examined twice by the same doctor in succession. In this particular case, the examiner noted different findings. We believe, therefore, that the examiners were not attempting to remember the subjects being analyzed and/or the process of covering all portions of the spine not being examined effectively blinded the examiners to subject identification on repeat scans. Additionally, the recorder checked the examiners' findings on the instrument meter to make sure there was, in fact, a break present.

Concordance was measured in two ways. First, to determine whether there was agreement that a break existed in a given area, Cohen's Kappa was used. Agreement between observations for each examiner was scrutinized as well as agreement between examiners for each observation. The next method of concordance used was the intraclass correlation coefficient (ICC) which is based on the Model II one-way ANOVA. The ICC was used to determine numerical location consistency for ratings with the instrument between examiners for each observation as well as location consistency between observations for each examiner. The ICC statistic was computed after it was agreed that a break existed either between examiners, or between observations with the same examiner. The ICC was chosen to analyze numerical location consistency since the patient's spinal column was calibrated in cm intervals. Additionally, the mean measurement difference between examiners and the mean intraexaminer disagreement was computed.

RESULTS

For observation 1 between examiners for the first area (C4-T2) the Kappa was 0.03 ($p < 0.0124$). Observation 2 (C4-T2) yielded a Kappa of 0.13 ($p < 0.003$. The second area (T4-T8) had higher levels of agreement: observation 1 had a Kappa of 0.57 ($p < 0.002$) and observation 2 had a Kappa of 0.65 ($p < 0.015$). The third area (L2-L5) had limited variation (high proportion of yes/yes) and therefore could not be evaluated with the Kappa statistic. Intraexaminer agreement for examiner one had a Kappa of 0.35 ($p < 0.003$) for area one (C4-T2) with examiner two having a Kappa of 0.43 ($p < 0.002$) for the same area. The second region (T4-T8) showed higher levels of agreement for both examiners. Examiner one had a Kappa of 0.66 ($p < 0.016$) and examiner two, also had a Kappa of 0.66 ($p < 0.011$). Area three (L2-L5) had a high amount of agreement confined to only one cell of the 2 × 2 matrix (yes/yes), making the Kappa statistic unusable. Limited variation creates instability in the Kappa statistic and makes it unsuitable as a concordance statistic (15). Table 1 summarizes the results obtained from the Kappa statistic.

Table 2 lists the raw data used to derive the statistics in Table 3. The data in category A refers to examiner one's consistency between observations. The calculated ICC here is 0.8588 ($p < 0.001$) indicating an excellent level of agreement of location between examiner one's observations. Category B refers to the agreement be-

TABLE 1. Summary of Kappa values

Interexaminer concordance:
Area one (C4-T2)
Observation 1 = 0.03 ($p < 0.014$)
Observation 2 = 0.13 ($p < 0.003$)
Area two (T4-T8)
Observation 1 = 0.57 ($p < 0.002$)
Observation 2 = 0.65 ($p < 0.015$)
Intraexaminer concordance:
Area one (C4-T2)
Examiner 1 = 0.35 ($p < 0.003$)
Examiner 2 = 0.43 ($p < 0.002$)
Area two (T4-T8)
Examiner 1 = 0.66 ($p < 0.016$)
Examiner 2 = 0.66 ($p < 0.011$)

TABLE 2. Raw data used for the intraclass correlation coefficient

	A		B		C		D	
	x	y	x	y	x	y	x	y
1.	5	4	2	8	5	6	4	8
2.	3	4	6	1	3	4	4	1
3.	4	4	4	5	6	5	4	5
4.	4	5	5	5	2	10	3	5
5.	11	10	4	4	5	2	5	5
6.	5	5	3	3	6	2	4	1
7.	7	4	2	6	10	5	4	5
8.	9	9	3	3	4	3	5	3
9.	11	11	5	5	11	2	10	6
10.	6	10	6	6	5	3	5	3
11.	12	12	7	6	7	6	4	5
12.	7	6	7	5	10	7	4	6
13.	6	5	9	11	6	5	6	6
14.	2	4	11	6	6	6	5	6
15.	5	2	12	12	6	8	5	2
16.	10	10	7	7	3	3	4	5
17.	4	5	5	5	4	5	9	11
18.	7	7	10	1	7	5	11	6
19.	6	6	5	5	7	11	10	12
20.	7	7	5	6	7	7	6	7
21.			6	6	12	6	6	8
22.			12	8	9	9	12	11
23.			11	11	11	11	6	12
24.			6	12	6	12	6	7
25.			7	7	12	7	12	12
26.			12	12	7	7	6	9
27.			8	9	10	12	6	7
28.			5	2	7	11	7	8
29.			6	7	6	6		
30.			6	8	6	7		
31.					12	12		
32.					6	8		
33.					11	4		
34.					6	6		
35.					7	6		
36.					8	8		

A = Examiner 1, observation 1 vs. observation 2; B = Examiner 2, observation 1 vs. observation 2; C = Observation 1, examiner 1 vs. examiner 2; D = Observation 2, examiner 1 vs. examiner 2.

TABLE 3. Summary of statistics

	A	B	C	D
Xa v	6.525	6.483	6.847	6.339
MSB	14.814	13.327	10.052	13.595
MSW	1.125	4.350	5.708	2.982
ICC	.8588	.5078	.2756	.6402
1-ICC	.1412	.4922	.7244	.3598
F	13.1684	3.0638	1.7609	11.2099
p	<.001	.0016	.0478	.042
df	19, 20	29, 30	35, 36	27, 28
SD	1.4266	2.9952	3.376	2.465
Dm	.8421	1.7667	2.3056	1.9643

Xa v = sum Xi j/nm
MSB = Mean Square Between Groups
MSW = Mean Square Within Groups
ICC = Intraclass Correlation Coefficient
F = MSB/MSW
p = probability of rejecting a correct decision
df = degrees of freedom
SD = $\sqrt{[\text{sum}(d-dm)^2]/(n-1)}$ = standard deviation of disagreement
Dm = sum $|y-x|/n$ = mean interexaminer disagreement

tween observations in determining the location of a break for examiner two. The ICC here is 0.5078 ($p = 0.0016$) indicating a moderate level of concordance. Group "C" refers to the consistency between examiners for observation one. Here the ICC is a low 0.2756 ($p = 0.0478$) indicating that there is only a fair probability in determining the location of a break consistently from the first observation. Group "D" refers to observation two between the examiners. The ICC value is 0.6402 ($p = 0.042$) indicating a substantial level of concordance between examiners for observation two. The mean measurement difference ranged from 0.84 cm to 1.77 cm for the intraexaminer data and from 1.96 cm to 2.3 cm for the data between the two examiners.

DISCUSSION

Although the neurocalometer (Nervoscope) has been used by chiropractors since 1924 following its introduction by Evans (16), it has received little attention in the literature. It would seem prudent, therefore, for chiropractors to know how much confidence they can place in the information obtained from this instrument. The fact that data derived from the use of this instrument is at least in some way reproducible on a patient is important in determining the clinical significance of the presence or absence of a skin temperature differential.

Ultimately the testing of examiner concordance must consider how the instrument is used in actual practice. Perdew et al.'s work (12), which demonstrated high test-retest reliability of the instrument, is of limited value since it does not duplicate actual clinical use of the instrument. Perdew et al.'s statistical analysis was also an inappropriate use of the Pearson correlation coefficient since good correlation does not necessarily mean good concordance (15). The only other published work in the literature directly involving this instrument is that of Trott et al. (11). They attempted to assess the diagnostic value of the instrument. Their results could have been more interpretable had they used examiners with practical experience, not assessed concordance of the instrument with variables of unknown reliability or validity and analyzed the data with appropriate statistics of concordance. The current investigation is an attempt to expand on previous published studies and to evaluate the reliability of the Nervoscope as it is commonly used by experienced practitioners.

The results of this study are mixed. Interexaminer test concordance for determining whether or not a break existed in area one yielded only slight levels of agreement. The first area was technically more difficult to scan since the instrument must first be glided vertically up the thoracic spine and then tilted forward to remain perpendicular to the skin over the flexed cervical spine. In contrast, the second area (T4-T8) had moderate to substantial levels of interexaminer agreement. We used the arbitrary guidelines put forth by Landis and Koch (17) for evaluation of the Kappa statistic, which are as follows. Value of κ strength of agreement:

< 0 Poor
0 - 0.20 Slight
0.21 - 0.40 Fair
0.41 - 0.60 Moderate
0.61 - 0.80 Substantial
0.81 - 1.00 Almost perfect

Due to the high level of agreement confined to the yes/yes category for the third area (L2-L5), Kappa could not be used as a statistic of concordance. This high level of agreement may be a result of the high likelihood for detection of a skin differential in the lumbar spine, possibly due to the biomechanical stress in this region or other factors.

Intraexaminer test concordance for determining whether or not a break existed in a particular section of the spine was fair to moderate in the first area (C4-T2) and substantial in the second (T4-T8). The difficulty in scanning the region from T2-C4 may have been a factor in the lower levels of agreement seen in area one. Again the lumbar region could not be evaluated with the Kappa statistic due to limited variation.

It must be noted that this type of concordance is regional and not segmentally specific. Haas (15) points out the difficulties with regional concordance designs, citing a clinician's attempt to diagnose specific vertebral levels. He poses the important question, "of what value is regional concordance if examiners cannot concur on the fundamental decision of what needs to be adjusted?" Haas correctly asserts that pooling segments into regions yields inflated reliability; however, it could be suggested that regional concordance is of clinical value if the region is specific enough to eliminate large portions of the area being examined. For example, isolating a problematic area to the lower lumbar vs. the lower thoracic spine is of value in eliminating the number of vertebral levels involved in spinal analysis. Kirkaldy-Willis and Tchang (18) have suggested that "manipulation" is diagnostic since the results of manipulation influence the diagnostic impression. For example, in the event of an unsuccessful response following a manipulation, it would appear unreasonable to continue manipulation in that region or to reason that the patient's symptoms are caused by a manually reversible lesion. This implies, of course, that the type of maneuver is appropriate and is being applied correctly. If treatment resulted in an unfavorable response at a particular motion segment, then this would lead the practitioner to another spinal level. In combination with a diagnostic test which can isolate the level of involvement to only two or three functional spinal units, the diagnostic aspect of "manipulative procedures" may help the doctor to isolate the actual lesion.

While it is true that most diagnostic tests affect the subject being tested in some way (e.g., radiography utilizes ionizing radiation), the interaction between a patient's skin and a thermocouple device represents an unusual variable. It is well established in infrared thermographic protocol that the thermogram is easily affected by a physiotherapeutic intervention, perspiration or excoriation of the patient's skin. The application of the Nervoscope involves skin stimulation. Indeed, this stimulation is thought to be desirable (14). The skin stimulation causing erythema can be equated to the red response described by Lewis (19). Wright et al. (20) investigated the effects of sympathetic tone by analyzing the red response, skin temperature (thermocouple) and vascular coloration of the skin with a photoelectric measurement device. Reproducibility of the different phenomena on different dates with the same individual was considered high. However, statistical analysis of the data is not presented, nor is any blinding procedure reported. Correlations between the results of the three examinations was reported, but no data is presented (20). We suggest that future studies should investigate the Nervoscope skin stimulation on the red response and skin temperature. Infrared thermograms of patients following a scanning session may be of help in determining correlation, if any, between a temperature differential detected by a Nervoscope and one determined through infrared thermography. The ICC values are low for the interexaminer data for observation 1 and higher for observation 2. This may imply that the differentials become more stable and are more easily detected as the skin is repeatedly scanned. This is an important consideration for future investigations.

For the second observation between examiners and the intraexaminer data, moderate levels of reproducibility are shown. Fleiss and Cohen (21) have demonstrated that the ICC is mathematically equivalent to weighted Kappa; therefore we use the arbitrary guidelines put forth by Landis and Koch (17) for the evaluation of the ICC.

Efforts should also be made in the future to incorporate actual symptomatic patients and/or patients with diagnosed root lesions since the symptomatic profile of our subjects was negligible.

A possible flaw in the design of this study may have been the criteria used to determine a positive finding by an examiner. Too much emphasis may have been placed on the examiner's ability to determine the most obvious break when more than one was observed or whether a break decreased or was accentuated after successive glides in a given area. As can be seen in Figure 4, the diversity of the types of needle movements commonly observed lends considerable potential for variances of levels to be marked. Future studies may more effectively evaluate the reliability of the instrument with less subjective interpretation, if a simple yes/no categorical response were required of the examiner at each individual motion segment.

The ICC statistic shows higher levels of interexaminer agreement with the second observation. After the first observation, the examiners were allowed to communicate for a few minutes on the types and subtle variations of temperature differentials encountered. This may have lead to improved interexaminer concordance with observation 2. It is possible that interexaminer concordance could be improved in future studies by spending more time prior to the examinations on differentiating suspect needle movement patterns. Again, a yes/no distinction at a motion segment would lessen this problem.

Extrapolation of the results seen in this investigation to the clinical setting is difficult. It is unlikely that actual clinical usage of the instrument is as strict as the protocol outlined in the methods of this experiment.

CONCLUSION

The results of this investigation are mixed. Regional concordance, evaluated with the Kappa statistic, was slight for interexaminer agreement for area one (C4-T2) and moderate to substantial for area two (T4-T8). Intraexaminer agreement was fair to moderate for area one (C4-T2) and substantial for area two (T4-T8). Area three could not be evaluated with the Kappa statistic due to limited variation. Following agreement of a break's existence, agreement of ratings on the location of the differential across different subjects was evaluated with the intraclass correlation coefficient. Interexaminer agreement was fair for the first scanning session, but substantial for the second. Intraexaminer agreement was moderate for one examiner and excellent for the other. Reliability of the Nervoscope for evaluation of the cervicothoracic junction is not suggested by the results of this experiment. Reproducibility of the Nervoscope across all three spinal regions appeared to be greatest with a repeat scanning protocol. This is evidenced by the increased levels of agreement when comparing the second observations. If the area of examination is not prescanned, results should be viewed with caution.

Future studies should evaluate the correlation between the red response, thermocouple derived temperature differentials and temperature differentials assessed with infrared thermography. A larger and more symptomatic population would strengthen the conclusions of future investigations as well as a dichotomous choice design for each individual motion segment. This might lessen the subjectiveness of examiner interpretation. Extrapolation of the results of this study to the reliability of the Nervoscope in an actual clinical setting should be done with caution due to the involved protocol of the experiment.

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EQUILIBRATION TIMES FOR DIGITIZED THERMOGRAPHIC EVALUATION

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INTRODUCTION: A chief technical concern in conducting thermographic examinations is reliability of the results. Patient equilibration in a temperature controlled environment is essential. Standard thermographic protocol requires a 15 minute equilibration period before the first thermograph is recorded.(1) Three scans are taken of the same area at intervals of 15 to 20 minutes between scans. Each subsequent scan is compared to the previous to decide whether the patient is completely equilibrated. Using these guidelines, the minimum time required for triplicate studies would be 45 minutes.

The object of this study is to determine the length of time needed for a patient's thermographic scan to become stable, not necessarily with respect to overall temperature, but with respect to clinically significant patterns.

METHODS: The Visi-Therm II computerized electronic thermography system (Stillwagon Seminars, Inc., 767 Dry Run Road, Monongahela, PA) was used to take a series of twelve thermograms, each three minutes apart on 25 subjects, as they equilibrated to ambient room temperature. The Visi-Therm II is a non-contact electronic infrared thermography system that uses twelve individual optical sensors mounted into a hand-held scanner to measure infra-red emissions in twelve bands up the spine.(2) The scanner is moved by hand up the back, from S2 to the Occiput, and has rollers that are kept in contact with the back to maintain uniform distance from the skin. The results of each scan were stored on floppy disks for later analysis.

Data analysis consisted of combining the serial data files into larger files which could be plotted and investigated using statistical methods. It was very difficult to compare whole scans over time using color changes to represent temperature, since the average temperature changed between scans.

cont....

Individual whole back graphs were normalized over time by calculating a color scale based on the warmest spot on the back. This method produced more similar scans, but did not provide a method for determining the amount of change between scans.

For more detailed analysis, programs were written in BASIC on an IBM Compatible computer that could plot bands of data, representing the thermal scan produced as a single sensor was moved up the back. It was then possible to compare adjacent scans on a column by column basis, looking for similarities in the locations of hot and cold deviations in each band.

A special algorithm was generated to shift adjacent scan plots by the average temperature of the scan, then calculate the square of the difference between adjacent scans. The result of this calculation was used as a measure of the amount of change that occurred over time in each thermal scan.

RESULTS: The average temperature of the back was found to decrease smoothly from 35 to 32 degrees Celsius during the course of the 33 minute data collection period. A plot of the squared difference between adjacent thermograms with respect to time shows an approximately linear decrease from 6 units to 2 units over the first 12 minutes. After 12 minutes the plots level out, indicating that adjacent data is as uniform as it will get after 12 minutes.

CONCLUSIONS: It was found that after 12 minutes, on the average, the scans were very consistent. Even though the patients continued to equilibrate for more than 36 minutes, as evidenced by an overall decrease in temperature, the significant features of the columnar scans were consistent after 12 minutes.

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Pattern Analysis

ASSESSMENT

Pattern Analysis of Paraspinal Temperatures: A Descriptive Report

John Hart, D.C.,[1] and William R. Boone, Ph.D., D.C.[2]

Abstract — A thorough analysis of vertebral subluxation requires assessment of its minimum four components; bony alignment, foraminal encroachment, nerve pressure, and interference of information flow via the nervous system. A method of determining patterns within paraspinal skin temperature readings is described as one means of evaluating the neurological interference component of vertebral subluxation. The method is described from the standpoint of its ease of use, and its potential to provide quantifiable data that can be further evaluated for inter- and intra-examiner reliability. The report emphasizes why pattern analysis of paraspinal temperature differentials has application in chiropractic patient evaluation on a visit to visit basis, as well as assessing the efficacy of the chiropractic care administered for the correction of the nerve interference component of the vertebral subluxation.

Key Words: Pattern analysis, thermography, vertebral subluxation, paraspinal skin temperature, chiropractic.

Introduction

The Concept of Pattern Analysis

Pattern analysis is based on the concept that the body, as regulated by the nervous system, should demonstrate adaptability by responding to changes in the external and internal environment.[1-3] It is assumed that if the nervous system is experiencing interference to the transmission of information, then adaptive changes will be less likely to occur, hence revealing static patterns from one evaluation to the next. A number of evaluations, believed to be associated with vertebral subluxation, can be analyzed through patterns, i.e., leg length differences,[4] palpation for muscle tone, and temperature instrumentation findings.[4] For example, if a leg length evaluation reflects a short leg on one visit but on a subsequent evaluation, the contra-lateral leg is short, then this particular test does not confirm the presence of vertebral subluxation.[4] That is, no pattern of repeated short leg is present. Alternatively, if the short leg remains short, under the conditions described above, then the patient's neurological response is viewed as not being adaptive. This evaluation would then contribute to the total analysis, as one positive indicator of interference to the neurological component of the vertebral subluxation.

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Evolution of Pattern Analysis of Paraspinal Temperature Readings

Since the usefulness of thermography, or temperature detection, has been discussed elsewhere,[5-9] it is not the intent of this report to survey the evolution of its clinical application. However, methods of interpreting the graphic displays in a manner that can be of the greatest use to the practitioner have not been widely investigated.[9]

The dual probe thermocouple heat recording instrument was first introduced to the chiropractic profession in 1924.[10] Since the early days of clinical use of the dual probe thermocouple heat detecting instruments, some chiropractors have employed what is termed the "break" analysis for interpreting paraspinal heat readings. A "break" is defined as a heat deflection to the right or left of the centerline of the graph. Advocates of this system often consider that a "break" in and of itself, even on a single evaluation, should be considered an indication of the presence of vertebral subluxation. Following the concept of pattern analysis, however, the heat deflection to the right on one visit and to the left on the subsequent visit would not be sufficient to indicate interference to the nervous system. Hence, a break could not be taken as adequate information upon which to draw the conclusion that vertebral subluxation was present. Consequently, the approach of interpreting a "break," in and of itself, as being indicative of nerve interference, or in the absence of other findings to conclude that vertebral subluxation is present is contradictory to pattern analysis.[11] Because of the multi-component nature of vertebral subluxation, it is apparent that any examination should consider as much clinical information as is obtainable.

The first discussion of evaluating the patterns of paraspinal heat readings over time was reported in the early 1950's with case files from the B.J. Palmer Chiropractic Clinic[10] and was further developed by Sherman.[12] According to Kent,[3] modern methods of pattern analysis of paraspinal temperatures employing infrared detection devices are based principally upon the following three concepts:

1. Skin temperature is governed by the nervous system.
2. Normally, skin temperature patterns change as a reflection of the body adapting to its environment.
3. When vertebral subluxation is present, the nervous system does not evoke adaptive change optimally. Evidence of this phenomenon is presumed if paraspinal temperature differentials are static.

This report focuses on interpretation of differential paraspinal temperature readings. In particular, one method for detecting the presence of patterns in skin temperature readings is presented.

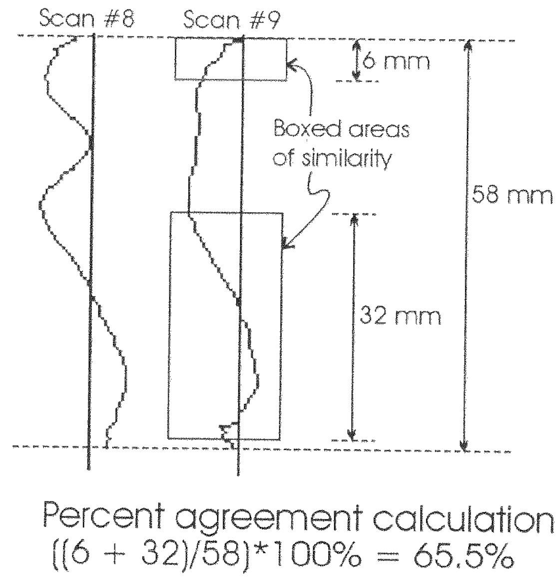

Figure 1. The method of pattern analysis using cervical readings 8 and 9. The two boxed-off areas represent areas of similarity on graph 9 when compared to "template" graph 8. The similar areas are determined by horizontally positioning a ruler and sliding the ruler down from the top of the two readings being compared. A horizontal line is drawn marking the beginning and the end of areas that have the same direction of slope (pattern). On reading graph 9 the boxed-off areas measure 38 mm (6 + 32) in a reading that has a total measurement of 58 mm. Dividing the area in pattern by the total area reveals a 65.5% similarity of graph 9 when compared to graph 8.

Methods

The first author of this article served as the subject. A colleague in the Sherman College Health Center performed paraspinal temperature scans using the dual probe TyTron C-3000 infrared instrument [Titronics Research & Development, Oxford, Iowa]. Full spine scans were performed by starting as close as possible to the fourth lumbar vertebra and ascending to and stopping near the T1 level. A cervical reading then was performed from the T1 area up to the occipital shelf. Thus, theoretically, for purposes of comparison, the full spine graphs were expected to be of uniform length, as were the cervical readings.

The temperature information obtained from this instrument was recorded graphically as a plot of temperature differential with respect to position along the spine. The differential plot deviates to the side of highest temperature at each point along the spine. Ten such graphs are depicted in Figures 2 and 3. The sequentially numbered scans were recorded between 4/9/98 and 5/13/98. One chiropractic adjustment was given on 5/12/98.

Pattern analysis was used to compare each cervical graph to all other cervical graphs and each full spine graph to all other full spine graphs. The method of manual analysis described in this report is a modification of a hypothetical computer assisted evaluation of temperature patterns previously reported by Stewart et al.[9] When graph 1 was used as the template, it was affixed by tape to a flat surface with the remaining graphs, one at a time, affixed parallel to it and aligned evenly at their respective terminal points. The vertical length of the template was measured and recorded in millimeters (mm). The ruler was then placed across the top of two readings, corresponding to the level of T1 for the full spine readings and the occipital shelf for the cervical. The ruler was then brought slowly downward, in a parallel fashion, to compare both graphs in short segments. Each section where the graphs deviated in the same direction was blocked off and designated as a "constant."

Two comparisons were derived from this approach. The first involved the total percentage of any two graphs that were similar, determined by measuring the vertical distance of each constant then dividing that measurement by the total vertical length of the template. These numbers were expressed as percentages and then summed as the total vertical area of agreement (Fig. 1). The second comparison was calculated from data that indicated the "number" of areas of two graphs that were deviating in the same direction (constants). It was possible for two or more graphs to exhibit the same total percentage of agreement but have different numbers of constants.

A third factor was calculated from the measured parameters as an assessment of the quality of agreement. Since, for any given percentage agreement between two graphs, the lower the number of constants, the greater would be the continuous vertical areas of agreement (continuity of pattern). Consequently, for a given percentage of agreement, the lower the ratio of constant(s) to overall percent of agreement, the greater the continuous vertical consistency of the two graphs, and hence the greater the "quality" of agreement. Thus, graphs were not only evaluated according to how similar they were, but also to what extent the similarity was continuous in a vertical manner ("quality").

For purposes of this study, it was considered that any two graphs which would yield a ratio of constant(s) to the total percentage of agreement equal to or less than 0.10 would constitute "good quality," or high level of continuous vertical area of agreement. Moreover, it was concluded for any two or more graphs to have clinical relevance there must be a minimum of 65.0 % total agreement (quantity) to distinguish the percent of agreement as being above a chance phenomenon.

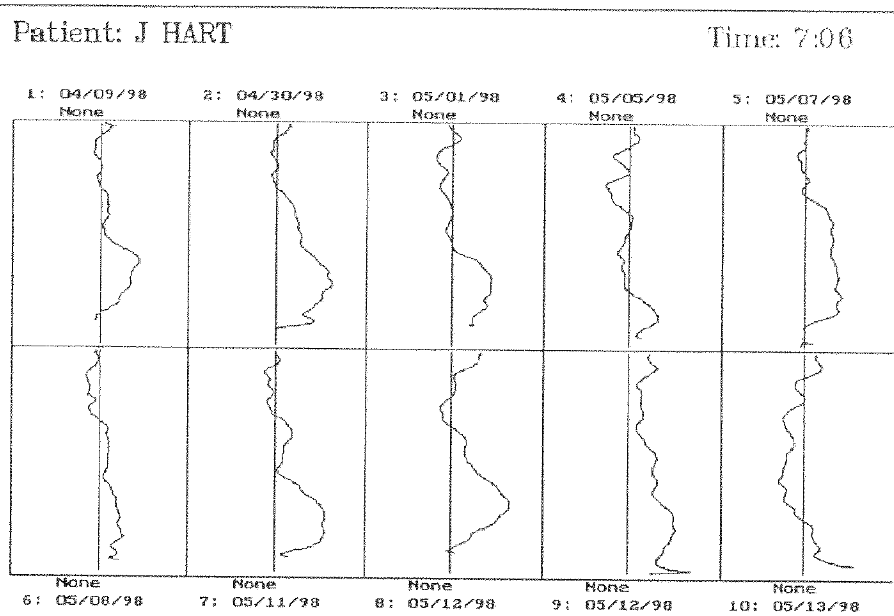

Figure 2. A computer screen capture of full spine graphs taken between 04/09/98 and 05/13/98. These plots show the temperature differential between the left and right sides. The temperature plot deviates toward the warmer side with the centerline representing balanced temperature. The span of these plots is from L4 to T1, with L4 at the bottom. The word "none" on the top of the readings indicates a visit where the atlas fossa reading was omitted.

Results

In order to ascertain if the graphs could be compared vertically, the overall lengths of each of the ten graphs were measured in mm. They ranged in length from 58.0 mm to 64.0 mm, with a median of 60.0 mm and a mode of 60.0 mm for the full spine readings. The mean and standard deviation for the full spine readings was 60.4 ± 2.07. The standard deviation was only 3.4 % of the mean value. The cervical readings ranged in length from 56.0 mm to 68.0 mm. (median 59.0, mode 58.0, mean 60.9 ± 4.31 [7.0% of the mean value]). Thus, all graphs were close in length, with only a very small variation within the population of ten.

Using the pattern analysis method described above, each graph served as a template to be compared to the other nine. Thus, there were a total of nine group comparisons, each designated by the number of the graph chosen as a template; Template 1 – Template 9. Table 1 shows the pattern comparisons for the full spine readings and the cervical readings are shown in Table 2.

Full Spine Analysis

Comparison of the ten sequential full spine temperature graphs (Fig. 2, Table 1) revealed that patterns were apparent when compared against graph 1 as the template. Graphs 1, 2, 3 and 8 exhibited the greatest overall similarity of any of the Template groups, especially when compared to graph 1. Compared to graph 1, graph 2 exhibited a total agreement of 71.0% with a constant(s) ratio of 0.04, while graph 3 exhibited a total agreement of 68.1%, and a constant(s) ratio of 0.10. Graph 8 exhibited a 66.3% overall agreement with graph 1, with a constant(s) ratio of 0.09.

When other temperature graphs were compared, using graph 5 as template, graphs 5 and graph 6 were considered to be in pattern, but no pattern was evident with graphs 1, 2, or 8. Graph 6 was 67.8% in agreement with graph 5, with a constant(s) ratio of 0.09.

Cervical Analysis

Figure 3 and Table 2 show that patterns appeared when either graphs 4, 5, or 6 were used as templates. The greatest extent of pattern, relative to other graphs, occurred using graph 4 as the template. In this instance, graphs 5, 6, and 8 were in pattern with graph 4 (83.6%, 79.5%, 77.9% agreement respectively). All three graphs were above 65% agreement, and exhibited low constant(s) ratios of 0.02, 0.01, and 0.01 respectively. Graph 6 was also in pattern with graph 5 as the template (67.0% agreement, 0.02 constant(s) ratio). Graph 8 was also in pattern with graph 6 as template (74.5% agreement, 0.01 constant(s) ratio). Table 2 under reading 10 shows zero values for the comparison to template 2 because there was no similarity between these two readings.

Discussion

This report recognizes that paraspinal temperature analysis is but one measure of the neurological component that can be considered in conjunction with other assessments. As with all assessments, however, they are most valuable if their validity can be demonstrated. Thus, the present method of pattern determination has been introduced to provide a quantifiable method

Table 1. Pattern Analysis of Ten Consecutive Full Spine (L4 to T1) Temperature Graphs

	Graphs Compared Against Templates*								
	2	3	4	5	6	7	8	9	10
Templates									
Graph 1 (length 58.0 mm)									
% agreement	**71.0**	**68.1**	15.0	32.0	22.4	51.7	**66.3**	24.0	26.7
no. of constants	3.0	7.0	5.0	7.0	4.0	5.0	6.0	4.0	7.0
ratio of constants/ %	**0.04**	**0.10**	0..33	0.22	0.18	0.10	**0.09**	0.17	0.26
Graph 2 (length 60.0 mm)									
% agreement		40.8	28.4	55.9	26.7	45.0	60.1	60.1	27.6
no. of constants		6.0	8.0	8.0	5.0	8.0	9.0	9.0	7.0
ratio of constants/ %		0.15	0.28	0.14	0.19	0.18	0.15	0.15	0.25
Graph 3 (length 59.0 mm)									
% agreement			48.0	41.7	19.5	55.4	45.9	45.7	50.9
no. of constants			6.0	7.0	6.0	5.0	7.0	4.0	4.0
ratio of constants/%			0.15	0.17	0..31	0.09	0.15	0.09	0.08
Graph 4 (length 62.0 mm)									
% agreement				36.3	37.2	28.4	18.6	34.2	45.1
no. of constants				7.0	6.0	6.0	2.0	6.0	7.0
ratio of constants/%				0.19	0.16	0.21	0.11	0.17	0.16
Graph 5 (length 59.0 mm)									
% agreement					**67.6**	26.4	55.1	27.1	23.9
no. of constants					6.0	6.0	6.0	6.0	5.0
ratio of constants/%					**0.09**	0.23	0.11	0.22	0.21
Graph 6 (length 62.0 mm)									
% agreement						50.0	33.9	24.1	48.5
no. of constants						4.0	6.0	5.0	4.0
ratio of constants/%						0.08	0.18	0.21	0.08
Graph 7 (length 60.0 mm)									
% agreement							36.6	44.6	50.0
no. of constants							6.0	6.0	7.0
ratio of constants/%							0.16	0.14	0.14
Graph 8 (length 60.0 mm)									
% agreement								32.8	23.0
no. of constants								7.0	6.0
ratio of constants/%								0.21	0.26
Graph 9 (length 65.0 mm)									
% agreement									33.8
no. of constants									4.0
ratio of constants/%									0.12

* See Methods for description. Numbers in bold meet the criteria of 65.0% total agreement between graphs, and a constant(s) ratio of 0.10 or less

Table 2. Pattern Analysis of Ten Consecutive Cervical Readings

	Readings Compared Against Templates*								
	2	3	4	5	6	7	8	9	10
Templates									
Graph 1 (length 58.0 mm)									
% agreement	36.7	19.6	58.9	40.9	52.6	23.5	35.5	15.2	22.0
no. of constants	3.0	2.0	2.0	1.0	2.0	1.0	2.0	.02	2.0
ratio of constants/%	0.08	0.10	0.03	0.02	0.03	0.04	0.05	0.13	0.09
Graph 2 (length 68.0 mm)									
% agreement		44.2	32.1	13.1	36.2	44.1	27.1	32.2	0
no. of constants		2.0	2.0	1.0	2.0	2.0	2.0	.3.0	0
ratio of constants/%		0.04	0.06	0.07	0.05	0.04	0.07	0.09	0
Graph 3 (length 61.0 mm)									
% agreement			26.7	57.3	58.6	36.7	22.0	32.2	16.9
no. of constants			4.0	1.0	1.0	1.0	2.0	2.0	1.0
ratio of constants/%			0.14	0.01	0.01	0.02	0.09	0.06	0.05
Graph 4 (length 56.0 mm)									
% agreement				**83.6**	**79.3**	42.6	**77.9**	45.7	20.3
no. of constants				2.0	1.0	2.0	1.0	2.0	1.0
ratio of constants/%				**0.02**	**0.01**	0.04	**0.01**	0.04	0.04
Graph 5 (length 61.0 mm)									
% agreement					**67.2**	33.8	59.3	44.0	23.7
no. of constants					2.0	3.0	2.0	3.0	1.0
ratio of constants/%					**0.02**	0.08	0.03	0.06	0.04
Graph 6 (length 58.0 mm)									
% agreement						47.0	**74.5**	45.7	28.8
no. of constants						3.0	1.0	2.0	1.0
ratio of constants/%						0.06	**0.01**	0.04	0.03
Graph 7 (length 68.0 mm)									
% agreement							32.2	35.5	20.3
no. of constants							2.0	2.0	2.0
ratio of constants/%							0.06	0.05	0.09
Graph 8 (length 59.0 mm)									
% agreement								**65.5**	59.3
no. of constants								2.0	1.0
ratio of constants/%								**0.03**	0.01
Graph 9 (length 59.0 mm)									
% agreement									55.9
no. of constants									1.0
ratio of constants/%									0.01

* See Methods for description. Numbers in bold meet the criteria of 65.0% total agreement between graphs, and a constant(s) ratio of 0.10 or less.

that can be easily tested for clinical utility, accuracy, and validity.

Other analyses (i.e., static and motion palpation and radiographic analysis) are directed to the vertebral misalignment/fixation component of the vertebral subluxation. However, skin temperature analysis is used to assess the neurophysiological component.[13] Of course, the integrity of the nervous system must be analyzed as a separate component, since not every misalignment/fixation may represent a vertebral subluxation.[10, 14] Moreover, Palmer believed that to adjust a vertebra that is merely misaligned could result in the formation of nervous system malfunction.[10] Leach, citing others, also offers support to the idea that not every misalignment results in neurological insult, thus highlighting the need to test the nervous system separately rather than assuming there is a neurological component present when misalignment exists.[15] Furthermore, the Council on Chiropractic Practice Clinical Practice Guideline recommends both a biomechanical assessment of the patient as well as a neurological assessment.[13] As part of fulfilling this recommendation, the reliability of temperature instrumentation recording devices and the measurements obtained from them, having been shown to be generally acceptable,[16, 17] should be coupled to a method of analysis which can also be shown to be acceptable. Verification of the utility of the method of pattern analysis is, therefore, essential in order to distinguish it as having a valid clinical application for the detection of vertebral subluxation.

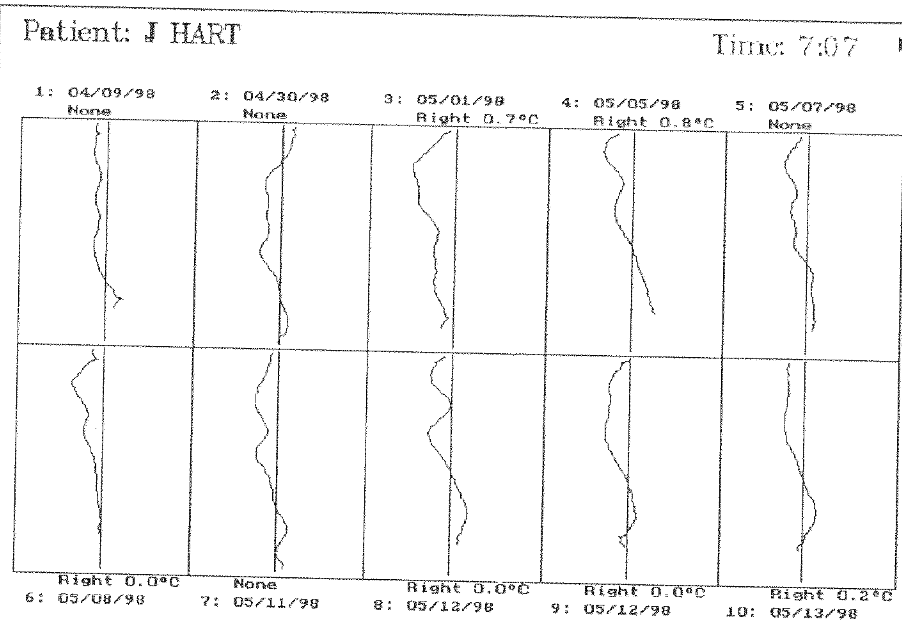

Figure 3 A computer screen capture of cervical spine graphs taken between 04/09/98 and 05/13/98. The span of these plots is from T1 to the occipital shelf, with T1 at the bottom. The word "none" on the top of the readings indicates a visit where the atlas fossa reading was omitted.

Analyzing paraspinal temperature graphs for patterns can be done in at least two different ways: (1) visual, without any form of measurement, and (2) marking and measuring constant(s). The second approach can be embellished by calculating the total percentage of agreement between graphs, and further establishing the quality difference between graphs that exhibit the same total percentage agreement. This study chose the second method, with the embellishment of quality estimation. While the visual method is subjective and difficult to quantify, method (2) can be readily investigated for inter- and intra-examiner reliability due to its ease of application. Of course, a computer-program, as suggested by Stewart[9] would be helpful in this regard, but the current method does not depend upon high level technology.

In the present report, the consideration of the "quality" of any given graph relative to its template was believed to be important. For example, if two graphs were identical, both could have very few or even one constant area. This would be considered a high quality of agreement. However, in clinical practice, it is unlikely that readings would be identical. It is more likely, however, for two or more graphs to have the same or different percentages of agreement spread out over several areas of similarity. It is, therefore, proposed that if two different graphs were compared to the same template and exhibited identical total percentages, the graph that was comprised of the larger areas of vertical similarity (fewer constants), would be considered a higher quality of agreement relative to the template. Such a pair of graphs would be considered more relevant from the standpoint of clinical significance as it would have exhibited greater continuity (quality) of static pattern. A set of graphs, although expressing a high percentage of agreement, with many frequent but separate constants would bring into question whether the similar areas were chance alone or truly representative of a continuous static pattern. It is of interest that the model of Stewart et al.[9] considered this problem. In their model, constants were evaluated by a correlation analysis to determine if the distance from centerline was of statistical significance. This component was not introduced into the current method, but should be considered in future studies.

The parameters of 65.0% total agreement between graphs, and a constant(s) ratio of 0.10 or less as limits to assigning pattern, were based on the authors' desire to achieve a realistic level of agreement and quality, rather than more rigorous limits not likely to be experienced in the practice setting. Other researchers or practitioners may choose more rigorous or liberal criteria for defining pattern between graphs.

The purpose of the present report has been to present a method of pattern analysis, rather than to interpret the clinical significance of the findings presented. As noted above, several clinical measures need to be considered to determine clinical significance. Even in a situation where temperature pattern analysis is used, it should be a discretionary matter for the practitioner to determine the best applications of his/her findings. However, since this approach has not been introduced before, it is necessary to elaborate on how these findings could be used clinically. In terms of temperature patterns (an assessment of neurophysiology) it would be necessary to establish criteria which provide a standard for interpretation of the significance of the findings. The first step in this approach would be to establish a minimum standard for attributing clinical significance to the temperature patterns. This could be done by removing the evaluation of static temperature pattern from the realm of chance occurrence alone. In the absence of a suitable form of statistical analysis, confidence that the data was indicating the presence of neurological interference should be otherwise established. This could be accomplished by requiring a minimum of three sequential graphs, each fulfilling the "quantity" and "quality" requirements as described in the present report. To reiterate, even if this finding was to occur, in and of itself, it would not be considered justification to conclude that the patient was subluxated, but is evidence for the presence of neurological interference. Thus, the findings could be logically used to conclude that nerve interference was present, although they do not assess the biomechanical or anatomical aspects of vertebral subluxation. Since nerve interference can occur in the absence of vertebral subluxation (severing a nerve for example), it remains essential to evaluate both neurological and biomechanical aspects of vertebral subluxation prior to making a decision to adjust the patient.

Moreover, as demonstrated in the present report, even if three successive graphs meet the criteria to conclude that a temperature pattern exists, it is plausible that the static pattern can dissipate without a chiropractic adjustment. This was evidenced in the Template 1 group of full spine analyses (Table 1) where graphs 2 and 3 were in pattern with graph 1, but the pattern dissipated for graphs 4 - 7 even though no adjustment was given. Graph 8 also exhibited pattern with graph 1, but the pattern dissipated in graph 9. Interestingly, full spine graph 9 was a post adjustment graph. Moreover, there appeared to be a dissipation of pattern in the cervical readings after graph 6.

Thus, in the full spine instance, the pattern dissipated both with and without an adjustment. It will be necessary to conduct further study to see to what extent dissipation of pattern can be directly associated with the chiropractic adjustment as opposed to spontaneous loss of pattern. Also, a secondary pattern among graphs can occur, as was also evident between full spine graphs 5 and 6. Thus, it would be important to regularly evaluate each graph against the first, as well as against all others in order to detect the emergence of a new temperature pattern. It is imperative in this type of study that researchers or practitioners develop a skill level to insure a very close starting and stopping point when obtaining the temperature scan. This skill level was evident in the present study, as demonstrated by the low standard deviation among the lengths of the graphs.

When several evaluations for vertebral subluxation are employed, as is customary during a thorough examination, it is not unusual for less than 100% of the evaluations to yield positive findings. Perhaps the best application of information derived from clinical evaluations is to establish how data from different assessments can be used collectively to form a larger picture of the patient's overall biomechanical and/or neurophysiological status. We suggest that findings should be clinically significant for the presence of vertebral subluxation only when more than 50% of the findings from all assessments conducted are positive.

Examination of the vertebral subluxation should minimally include: (1) a biomechanical assessment, and (2) a neurological interference assessment.[13] When several tests are employed to evaluate the full spectrum of subluxation components, an overall pattern may present that otherwise would be missed if only one component was assessed. This possibility emphasizes the importance of analyzing both the biomechanical and neurophysiological aspects of vertebral subluxation.

Further Study

Based on the feasibility of testing the present method of evaluating temperature patterns, further study should include evaluation of inter- and intra-examiner reliability.

Once established, it will be important to evaluate the findings of temperature pattern in conjunction with other findings related to vertebral subluxation. This should be done both retrospectively and longitudinally. Retrospective study can establish if the decision to adjust a patient was based on the accumulation of information from biomechanical and neurological assessments, and how successful that strategy was in correcting the subluxation. Longitudinal studies could focus on determining how often static paraspinal temperature patterns are supported by positive findings regarding biomechanical and anatomical aspects of vertebral subluxation. This type of information will serve to enhance the level of assessment that is required to avoid unnecessary adjustments to the patient, and still provide chiropractic adjustment when appropriate.

Summary and Conclusions

This report has presented a new method of discerning the presence of static temperature patterns from differential paraspinal temperature graphs. The method is easy to perform, being independent of high level technology, and provides quantifiable data for analysis. Its clinical utility will best be appreciated when it is studied in conjunction with other assessments which collectively provide information leading to the conclusion that vertebral subluxation is present or absent.

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SKIN TEMPERATURE PATTERNS OF THE POSTERIOR NECK USED IN CHIROPRACTIC ANALYSIS
A Case Study

John F. Hart, D.C.

ABSTRACT

The persistent skin temperature pattern can be viewed as an indicator of spinal nerve interference induced by the vertebral subluxation. This premise is based on two generally agreed upon principles: 1) Skin temperature is almost entirely under the control of the nervous system and 2) the intact nervous system (no interference) tends to display paraspinal skin temperature patterns that adapt to internal and external forces. This paper attempts to review the premise and to present a case where chiropractic temperature instrumentation was used.

Key Words: Chiropractic; Thermography; Chiropractic/instrumentation; Neural transmission

INTRODUCTION

Chiropractors were the first to recognize that paraspinal temperature readings may be related to health and disease.[1] The first chiropractic instrument used to help detect spinal nerve interference, the neurocalometer (NCM), was introduced to the profession by B.J. Palmer at the Palmer School Lyceum in 1924.[2] Prior to this the profession analyzed only one-half of the subluxation - structure by palpation or x-ray. But as our definition goes, the other half - function went unanalyzed, at least objectively. The NCM received favorable ink in the lay press[3,4] but sustained mixed reviews from the profession,[5] as it does today.[6] Indeed some of the Palmer School of Chiropractic faculty resigned in protest at its introduction. Most probably there were NCM supporters and NCM detractors then just as there are today, 67 years later. The NCM is still in use and is the forerunner of other similar chiropractic instruments also in general use today such as the ones described in the present report.

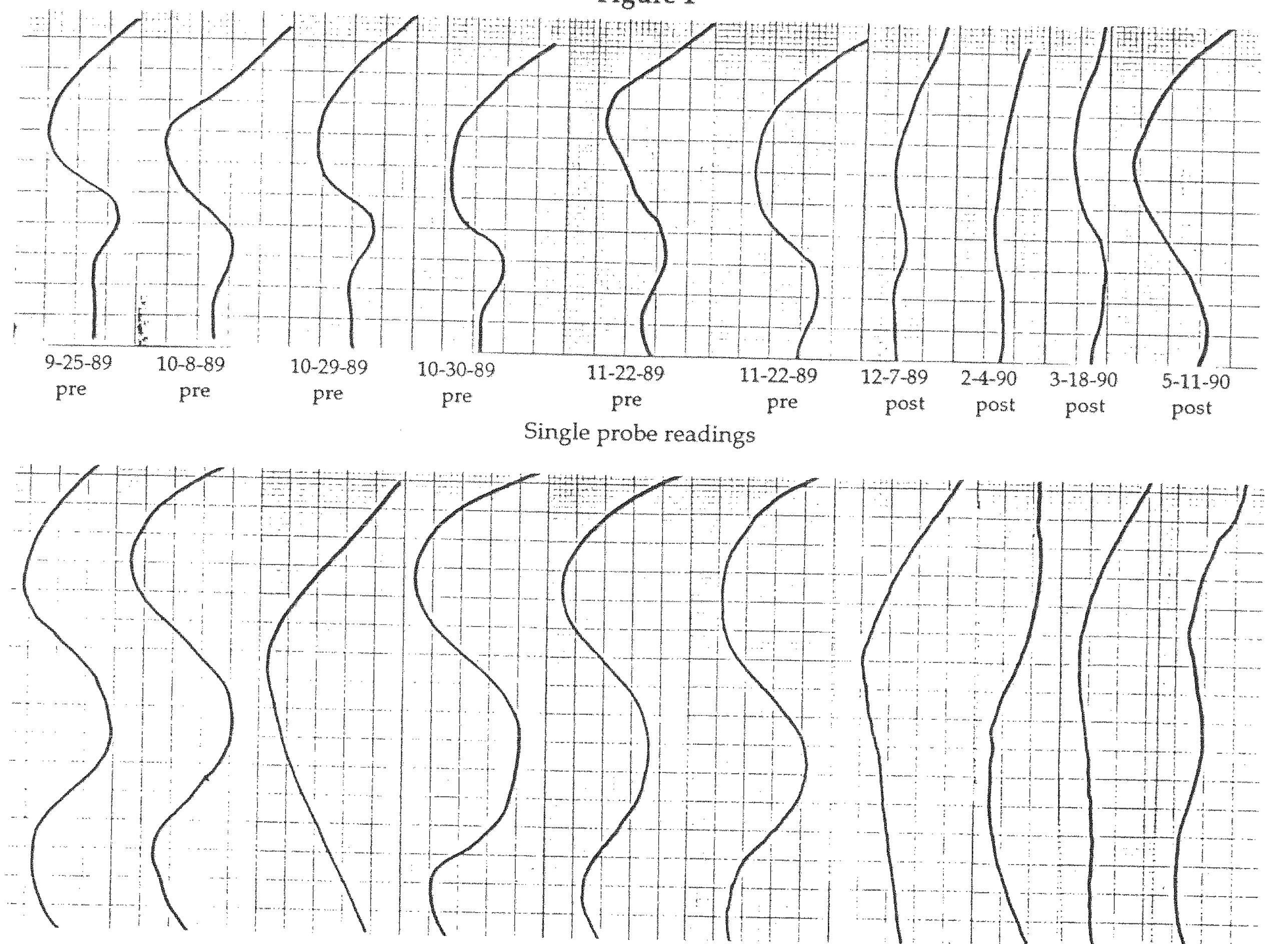
The primary objective of the chiropractor is to ascertain the presence or absence of the vertebral subluxation with its associated neurological interference.[7] Chiropractic thermometry assists the chiropractor in making that determination. Many chiropractors use the "break" system[8] to analyze subluxation while others use the "pattern" system. The latter was used in analyzing this case. Pattern work is based on the assumptions that the skin temperature is primarily under the control of the nervous system, rather than local regulation[9] and that a paraspinal skin temperature pattern should be changing in a nervous system free of interference. A patient with a static, repeatable paraspinal skin temperature reading is said to be "in pattern".

Continuous demands are placed on the nervous system so that adaptation of the organism can take place. Adaptation equals change. Adaptation of bodily function is preceded by the nervous system itself changing, initiating the adaptive response[10] which is viewed through the "window" of changing skin temperatures, absolute as well as differential (i.e., pattern). A nonadaptive, or less than optimally adaptive nervous system will therefore tend to show static paraspinal skin temperature patterns that should otherwise be changing both vertically and horizontally, with a tendency toward symmetry.[11-19]

THE CASE

Derm-o-thermo-graph (DTG, Exergen, Natick, MA), Thermoscribe (Kale/Murdoch, Spartanburg, SC), and the Analagraph (EDL, Hauppauge, NY) were used to analyze this case. The Thermoscribe and Analagraph are both dual-probed contact instruments that measure temperature differences along the sides of the spine and neck. The DTG is a single-probe infrared scanner that measures absolute temperatures and is used for analyzing vertical temperature differences along the spine. All readings were of the posterior neck using an inferior to superior glide (T-1 to C-

Figure 1



1) straddling the spinous processes. The patient was acclimated briefly prior to the reading with the neck bare and was seated with his face resting in a posture-constant apparatus at the time of the glide.

A 39 year-old male presented himself to the author's office initially on 09-25-89 for a "check-up". This was his first chiropractic encounter. He was relatively asymptomatic so there was no urgency for intervention and it was agreed that he would return periodically to determine pattern stability. Subsequent pre-adjustment readings for both the single and dual probed instruments displayed a persistent pattern (Figure 1). The first six graphs (from left to right) for both the single (top row) and dual probe (bottom row) are all pre-adjustment readings. Before initiating the glide on 10-29, a reddened area in the path of one of the detectors on the dual probed instrument was noted. The resultant differing pattern apparently was a false reading because of the reddened area, as subsequent readings showed the familiar pattern.

The patient was relatively asymptomatic up until November 1989, when he began to experience bowel trouble of which he had reported a history. On 11-22-89 a Thermoscribe reading was taken at 7:00 p.m. and an Analagraph reading at 7:02 p.m. One might expect this second reading to be somewhat of a different pattern because of probe-induced hyperemia from the glide two minutes before, and variability of a different make of instrument. But the pattern came through. Confident a subluxation/nerve interference pattern was established, the patient was x-rayed. An axis subluxation was detected and adjusted using Palmer toggle-recoil. This was his first and so far, only adjustment. The post-adjustment readings on subsequent days revealed a clearing of pattern for both the single and dual probe, suggesting a restoration of normal nerve communication. On the last check-up, however, the single probe graph pattern was returning, suggesting a return of neurological interference.

Clinical improvement was realized two weeks after the adjustment. It was recommended to the patient that he be checked periodically in case the subluxation should return, as the 5-11-90 single probe reading is suggesting.

DISCUSSION

This is not a typical case in my office though I would like to say it is. This is however the type of chiropractic care I strive for - doing more by doing less. One may argue legitimately that the clinical improvement may have occurred anyway without an intervening chiropractic adjustment for who can deny the possibility of time bias in any condition's improvement? It is the chiropractor's objective to look for those signs of subluxation which will not seem to go away on their own. It was becoming apparent after two months (September to November 1989) that this patient's apparent subluxation, evidenced by the persistent pattern, was not going to go away with time alone.

It has been my experience that the fewer the number of adjustments, the quicker and more permanently temperature patterns clear out. The first post-adjustment reading (12-07-89) showed only minimal improvement, but improvement just the same. Had I been hasty and given another adjustment that visit, the original interference pattern quite possibly would have returned. When such an iatrogenic manipulation is given, it is difficult to regain even the minimal pattern improvement. This has been an unfortunate occurrence in my office more often than I care to admit.

In the case whose subluxation is suspected to be one of long standing, it seems best to not adjust when there is only (seemingly) slight improvement on post-adjustment readings.

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COMPUTER-AIDED ANALYSIS OF PARASPINAL THERMOGRAPHIC PATTERNS: A TECHNICAL REPORT

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ABSTRACT

Paraspinal skin temperature measurements are commonly used by chiropractors as part of their assessment for vertebral subluxation. One way to interpret paraspinal thermograms is to look for characteristic patterns in the contour of the graph. Although this method is subjective, there have been attempts to develop analytical methods that might provide objective determination of the presence of patterns in the temperature information.

This report describes the development of specialized pattern analysis software that accepts temperature data exported from the TyTron Thermographic instrument. The TyTron is a dual probe infrared thermographic instrument that provides temperature information for the skin on the left and right sides of the spine. The user can compare scans from the left side, the right side, and the delta or side-to-side difference. The newly developed software provides tools for manipulation and visualization of two overlapping plots and for calculation of congruence between thermographs taken on different occasions.

Using the pattern analysis software, the user can shift and crop the thermographs to produce the best subjective overlap before calculating congruence factors. After the scans are prepared for analysis, five congruence factors are calculated using a variety of algorithms. All of the calculations are scaled to produce factors from 0 to 1, where 1 is perfect congruence. The calculated factors are area ratio, slope comparison, correlation coefficient, and slope and amplitude comparisons using methods similar to those of Stewart and Boone. The pattern analysis software is being used in studies of thermographic pattern stability at Sherman College and Life University.

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Key Words: Chiropractic, Skin Temperature, Thermography, Pattern Analysis

INTRODUCTION

Paraspinal skin temperature assessment has a long history in chiropractic, beginning with the introduction of the Neurocalometer in 1924 (1). B. J. Palmer and researchers at Palmer College developed a "pattern analysis" for assessing dual probe thermograms of the paraspinal skin. Differential thermograms generated with the Neurocalometer showed the side-to-side temperature difference along the skin adjacent to the spine. In pattern analysis, the practitioner compared the detailed character of the differential thermograms from day to day, looking for recognizable patterns to appear. As long as a certain fixed pattern was absent, the patient was presumed to be adapting normally. The presence of the same pattern on successive days was taken as evidence for vertebral subluxation and the need of an adjustment (2). Clinical case studies using pattern analysis of thermograms have been presented recently in the literature, including those of Hart (3), Hart and Boone (4), and Kessinger and Boneva (5,6,7,8).

Chiropractors and medical thermographers have developed differing methods for interpreting paraspinal thermograms. Detailed scans of whole regions, as provided by liquid crystal or video thermography can be used to locate unusually warm or cool regions. The approach to interpretation in this case is to compare like locations along the back, looking for symmetry of temperature. Here, asymmetry is considered abnormal in proportion to the magnitude of the temperature difference. Wallace, Wallace, and Resh surveyed the extensive literature on paraspinal thermography and described the thermoregulative physiology behind its use as a clinical assessment tool (9).

Chiropractors often use paraspinal thermograms from dual probe devices. These devices provide temperature information only on thin strips of skin on either side of the spine. Commonly, these devices only provide information on the difference between side-to-side temperatures without plotting the actual skin temperature. One method of analysis is to locate the presence of "breaks," where there is a sharp side-to-side swing of the temperature trace. DeBoer et al. (10) and Plaugher et al. (11)

tested the inter- and intra-examiner reliability of differential paraspinal temperature recording and analysis. Plaugher used a thermocouple device that made contact with the skin and tested the ability of operators to detect the same breaks. DeBoer, using a noncontact infrared thermal device, was able to digitize the thermograms and compare temperature data statistically. In both studies, the authors found agreements ranging from fair to substantial by using the Intraclass Correlation Coefficient as a basis for comparison.

Other methods have been devised for analyzing differential thermograms, including the counting of "constants" or similar regions of the graph that reappear over time (12). In this type of pattern analysis, the contour or character of the temperature plot is considered more important than the magnitude of the temperature swing from the centerline. Recently, Hart and Boone developed a method for assessing the degree of similarity between thermograms by using a manual measurement system where the proportion by length of regions of the temperature pattern that had similar slopes was used to calculate a percentage of pattern (4). In this method, the degree of similarity of thermograms is based largely on the analyzer's judgment, although some measurement or counting is also involved.

In 1989, Stewart, Riffle, and Boone noted the need for an objective assessment of temperature pattern, especially to produce reliable measures for research (13). They developed mathematical methods for analysis of digitized thermograms, although, at the time, no such digitized temperature patterns were available to them. In the intervening years, digital thermographic systems that provide numeric output of skin temperature profiles have become widely available. Owens et al. developed computational methods that make use of such digitized thermograms (14). Computer-aided pattern analysis is useful and convenient because it quickly provides a numeric assessment of the degree of similarity of thermograms and allows clinicians to detect patterns in an objective fashion. This report describes the pattern analysis software developed at Sherman College of Straight Chiropractic.

METHODS AND DISCUSSION

Data Acquisition

Paraspinal thermographs for this project were recorded using the TyTron C-3000 Infrared thermal scanner (Titronics Research & Development, Oxford, Iowa) interfaced to an MS-Windows-based computer. The TyTron is a hand-held dual probe scanner with wheels to keep it a uniform distance from the skin during data collection. One of the wheels is equipped with a position sensor that tracks its location along the spine as the temperature is recorded. For scans, the patient is seated on a special backless chair. The full spine thermal scan is a continuous glide from the second sacral tubercle to the shelf of the occiput. A typical full-spine scan can be collected in 15 seconds. Thermal data are stored in a patient database for later viewing and interpretation. For the purposes of this study, Titronics Research & Development provided us with a special export routine from their software that saves the centigrade temperature data in a comma delimited text file.

Software tool development

Our goal in developing software to help interpret thermal scans was to provide an objective and efficient method for comparing any two scans. The temperature file consists of two columns of temperature data, one for each side of the spine. The number of records depends on the length of the patient's spine and varies generally between 300 and 500 data pairs. (The TyTron collects data at a rate of 6 points per centimeter.) Temperature comparison, therefore, could involve comparing the left temperature profiles on two occasions, the right profiles, or a calculated left/right difference, called the delta profile.

We developed the software tools for this project in Microsoft Visual BASIC 6.0 (VB6), which combines good graphing capabilities and mathematical command libraries. Our approach was to provide general graphing and calculation tools, but to let the operator control the flow of the program. The initial steps of preconditioning, in particular, involve the operator's judgement and visual interpretation. The intent was to use the operator to produce the best visual overlap of data files before congruence is calculated.

Preconditioning: Normalization

Previous studies showed that the temperature of the back changes with time, depending on how long the patient is allowed to equilibrate to room temperature. In one study, the back temperature was seen to change continuously for 30 minutes, although certain features of the scans became stable after 9 minutes (15). For analysis purposes, we desired to remove artifacts from the data that might have to do with the amount of time the patient was allowed to equilibrate with differences in ambient temperature. We developed a preconditioning algorithm, normalizing the temperature file on the basis of the range of temperatures found in the data file, to remove variability due to absolute temperature differences between scans. Essentially, before the comparison of similarity occurs, the data points are all shifted so that the highest and lowest temperatures are normalized between the two files. Hence, a new data set is calculated from the temperature file wherein the range of temperatures between highest and lowest covers the same span in both data sets. The left probe, right probe, and delta (difference) information are each normalized separately. Normalized data files are graphed in a vertical orientation from the cervical to the sacral spine. Color-coding is used to distinguish data files from each other. The two data files that are being compared are referred to as File1 and File2.

Sliding and clipping

Early observation of the thermal scan data indicated that TyTron operators did not always begin scans at precisely the same level of the spine or end them at the same spot. Hence, temperature scans performed on the same patient are not usually precisely the same length, and the locations of characteristic peaks do not always occur at the same record in the data set. Two more preconditioning stages were developed to handle artifacts having to do with starting and ending regions of the scans. A clipping tool can be used to crop off areas of the traces at the beginning and end if necessary. The operator decides where to crop the files. Cropped areas are not considered in normalization or congruence calculations. A sliding tool was also developed to enable the operator to move one trace up or down with respect to the other in an attempt to visually produce the best overlap of the traces. After graphing the normalized plots, the operator can observe certain characteristic peaks where the traces overlap well. If the peaks clearly do not line up, the operator uses the sliding tool to move one trace up in increments of one step with respect to the other. Because the TyTron has a built-in position sensor, the number of data points in successive scans varies little and seems to vary only when the starting and stopping points are different. Hence, we saw no need to scale or normalize the data sets with respect to length.

Smoothing

In some cases the temperature plot shows erratic changes. The delta plot in particular, because it is the difference between two changing profiles, is prone to this effect. We added a smoothing tool to the software to make comparisons between plots easier when the information is erratic. The smoothing tool calculates a new data set with a moving average algorithm that sets the value of each data point equal to the average of the four data points on each side of it in the data file. Certain of the congruence calculations described below are sensitive to the slope of the temperature plot and produce calculation errors when the temperature plot is perfectly vertical. Smoothing is necessary in those cases to allow the calculation to proceed through that segment.

Congruence Calculations

The software operator uses the congruence calculation tools after he or she is satisfied that all the preconditioning steps have produced a pair of traces that are most likely to provide the best similarity.

Several different analytical methods are used to detect patterns in thermal scans by chiropractors. Similarly, a wide variety of mathematical methods might be used. We decided to provide a sampling of different methods, some of which compare the temperature scans on a global basis, and some of which compare small adjacent sections to each other. All of the calculated congruence factors are scaled so that perfect congruence provides a factor of 1.00.

Area Ratio

The simplest mathematical calculation of congruence involves simply taking the area between the two curves. The first step is to sum the absolute value of the difference between the normalized temperature values (between file1 and file2) at each vertical location in the trace. In the second step, the area æ bounded by a rectangle as tall as the length of the files, and as wide as their range æ is calculated. The area ratio is the area of the difference between the files subtracted from the total area of the bounding rectangle and divided by the total area. Perfectly congruent curves will have no area between them and produce an area ratio of 1.00; the area ratio will decrease from there, as curves become more disparate.

Slope Comparison

The slope comparison algorithm calculates the instantaneous slope at each point along the temperature profiles and compares the slope of one file to the other at that point. The instantaneous slope for point i along the data file is calculated as:

$$Slope(i) = (NTemp(i+1) - Ntemp(i-1))/3$$

where NTemp is the normalized temperature.

The slope of the ith point of File1 is compared with the slope of the ith point of File2. If the slopes are within a threshold value (Slope Sensitivity) set by the operator, then the two temperature files are considered congruent at that point. The comparison is done for every point on the temperature plot, and the number of congruent points is tallied. The slope comparison reported to the operator is the ratio of the number of congruent points to the number of points in the data file. Hence, a slope comparison on identical files produces a value of 1.00. The slope comparison can be made as stringent as desired by varying the Slope Sensitivity value. The default value of 1.00 makes a very sensitive test for congruence.

Correlation

The correlation coefficient calculation is another global comparison of temperature profile congruence. The equation used is that for Pearson's product moment r:

$$r = (n\sum XY - (\sum X)(\sum Y)) / \sqrt{(n\sum X^2 - (\sum X)^2)(n\sum Y^2 - (\sum Y)^2)}$$

where X and Y are the normalized temperature values for File1 and File2 respectively and n is the number of points in the data file.

A scattergram plot of File1 versus File2, displayed as the calculation is performed, shows how well the two files compare. Very similar temperature scans show a tight grouping of (x,y) pairs along a diagonal line.

Stewart/Boone methods

Stewart, Riffle, and Boone developed two statistical methods for comparing temperature scans (9). They used a piecewise comparison wherein segments 10-data-points long were compared on the basis of amplitude and slope. This statistical method uses tests to determine the probability of two segments being from the same population, and has a confidence interval of 95%. We used two similar methods in developing our software and dubbed them Stewart/Boone Methods r% and t%. In our adaptation of these methods, we also used 10-data-point-long segments of the temperature data files. The algorithm steps through the data file and compares overlapping 10-data-point segments. The ith segment will compare data points i-4 through i+5. Hence, each segment overlaps with the next adjacent segment by nine points.

In the slope comparison (r%), the Pearson product moment (r) is calculated by comparing 10-data-point segments of File1 with 10-data-point segments of File2. The value of r is evaluated for significance by comparison to a statistical table. (In this case, the degrees of freedom (df) = 8 and $r > 0.632$ are significant at the 0.05 level.) All the overlapping segments are tested for congruence in turn and the proportion of the data file that is congruent is presented as a fraction, where 1.00 represents perfect congruence. In the amplitude comparison (t%), the

Student's *t*-test is used to compare 10-data-point segments of File1 with the same segment of File2. The calculated value of '*t*' is compared with values in a table to determine significance. (For df = 8, $t > 1.734$ is significant at the 0.05 level.). Again, the proportion of the data files that are congruent is presented as a number from 0 to 1.00.

Interpretation of congruence calculations

Because this method of analysis is new, we do not yet know how to interpret the congruence values. Already we can see that some factors are more sensitive than others: the same input files produce a range of congruence factors. For instance, the area ratio tends to produce high values whereas the slope comparison is more sensitive.

One way to test the sensitivity of the calculations is to use specially prepared test files. In one set of experiments, actual temperature scan files were reversed, i.e., the left and right probe data were swapped. Switching the input order in this way produces delta plots that are the reciprocals of each other. Figure 1 shows a screen capture of the pattern software with one of the switched files plotted and analyzed. The resulting congruence factors for a set of seven runs on switched data files produced an area ratio on these files, which are about as different from each other as can be accomplished, averaging 0.53 (Table 1). The Correlation coefficient shows a value of negative 1, as expected. The Stewart/Boone methods show an interesting result. The calculation based on slope similarity (r%) produced 0 for all 7 files tested, whereas the calculation based on amplitude was less sensitive, producing a range of values between 0.41 and 0.69 (avg 0.53).

A second test of the sensitivity was performed by testing the effects of sliding on the congruence factors. In this experiment, congruence factors were calculated when each of three actual data files was compared to itself, i.e. the same file was loaded into File1 and File2. In the experiment, File1 was translated six steps up with respect to File2 in increments of one step at a time. The congruence factors were calculated at each step.

The area ratio and correlation factors were relatively insensitive to sliding (Table 2 and Figure 2), decreasing from 1 to 0.93 when one file was slid six steps with respect to the other. Slope comparison and the Stewart/Boone methods were more sensitive to sliding, decreasing from 1 to 0.54 (0.38 for slope comparison) with six steps of sliding. Six steps in the data set represents one centimeter of travel of the scanning gun along the patient's back.

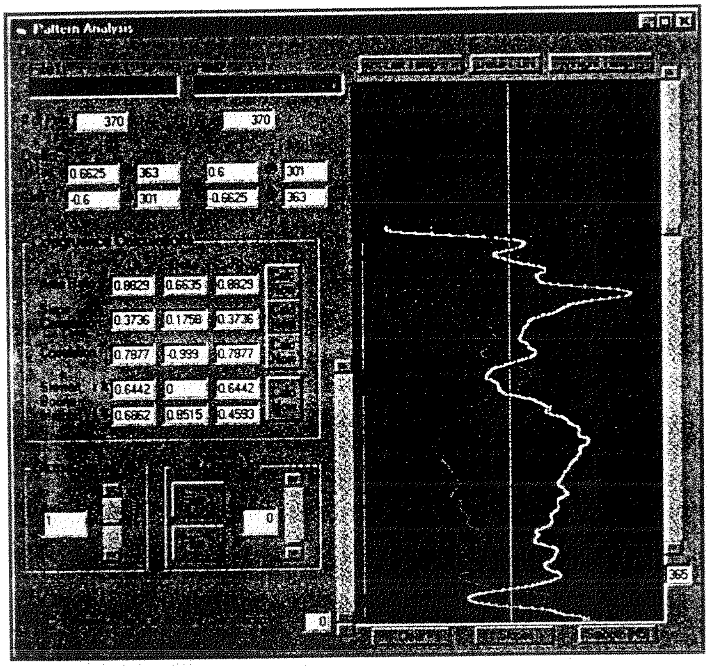

Figure 1. *A screen capture of the pattern software being used to calculate congruence factors for a switched data file. The right and left probe data have been swapped in the data set, producing a delta channel in which the File1 and File2 data sets are reciprocal. This method was used to determine the relative sensitivity of the different congruence factors.*

Table 1. Summary table of calculated congruence factors for 7 files where the left and right probe data are switched, producing reciprocal delta values.

	Area Ratio	Slope	Correlation	r%	t%
Avg	0.532	0.148	-1.000	0.000	0.526
Max	0.773	0.202	-0.999	0.000	0.691
Min	0.361	0.006	-1.000	0.000	0.407

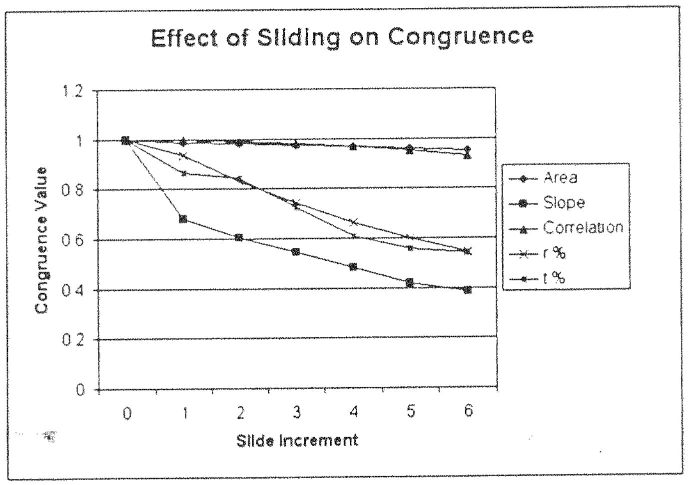

Figure 2. *The effect of sliding on congruence. Identical files were tested for congruence, then slid in increments of one step with respect to the other. The TyTron records approximately six data points per centimeter of travel so that six steps in the data set would represent one centimeter of displacement of the temperature profile. The slope comparison shows the greatest sensitivity to sliding, while area ratio and correlation vary very little.*

Table 2. The effects of sliding on the congruence factors. Identical files were tested for congruence, then slid in increments of one step with respect to the other. This table shows the average values for three different data file sets. The slope comparison shows the greatest sensitivity to sliding, and area ratio and correlation vary the least.

Slide	Area	Slope	Correlation	r%	t%
0	1.000	1.000	1.000	1.000	1.000
1	0.987	0.678	0.998	0.936	0.864
2	0.982	0.605	0.992	0.831	0.841
3	0.975	0.550	0.982	0.741	0.725
4	0.967	0.482	0.968	0.662	0.607
5	0.960	0.419	0.952	0.600	0.558
6	0.952	0.386	0.933	0.547	0.542

In clinical use, this software would be used to determine the degree of similarity of temperature profiles to help determine when an adjustment is needed. We still need to determine which congruence factor works best in the clinical setting and what range of values tell us when "pattern" is present. Reliability studies of the software are currently being carried out at Sherman College and Life University. Serial thermographic readings will show how much change occurs in the temperature patterns over the short term and what changes can be expected with adjustment. The calculated congruence factors will lend an element of objectivity to the results of those studies.

Another possible use of the system and a way to "calibrate" the congruence factors would be to have a panel of experts compare the calculations subjectively to determine if a pattern exists. Thermograms can be printed on paper and distributed to a group of experienced chiropractors for analysis. The chiropractors can use their own preferred method to indicate which scans show the presence of pattern, and perhaps to what degree pattern is present. With that information, it should be possible to calibrate the congruence factors, or provide cut-off values, so that novice chiropractors can use the objective numbers generated as an indication of the presence of pattern in their patient's thermograms.

CONCLUSION

Software has been developed that uses as input the temperature profile data from the TyTron C-3000 infrared thermography system. The software allows for preconditioning of the temperature data to remove artifacts associated with the recording technique, including normalization to remove effects of ambient temperature and equilibration, and provides clipping and sliding tools to remove artifacts associated with inconsistent beginning and ending points for the scans. The ability to calculate five different congruence factors provides an objective way of comparing thermograms over time. The congruence factors are based on calculations of the area between the temperature plots, the slope of the plots and correlation coefficients. Area and amplitude calculations appear to be less sensitive to changes in the temperature profile than do the calculations based on slope. At this time, the software is being used to evaluate the results of reliability studies to help determine which congruence factors are most useful and what range of values can be used to detect the presence of pattern or neurological effects associated with vertebral subluxation in clinical studies.

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Computerized Paraspinal Skin Surface Temperature Scanning: A Technical Report*

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ABSTRACT

An interfaced microcomputer-thermister device was developed by which real-time paraspinal skin surface temperature differentials may be measured simultaneously at 58 points (29 bilateral levels) for the purpose of establishing the basis and possible parameters for the present-day chiropractic use of such findings as they may relate to the chiropractic subluxation complex. It was found that such a device may be constructed from relatively low cost state-of-the-art circuitry and computer components, was simple and efficient to use, and was accurate to 0.1 degrees C. It was concluded that this system provides an effective and reliable means for monitoring temperature changes that may occur following chiropractic spinal adjustments. (J Manipulative Physiol Ther 1982; 5:117–121)

Key indexing terms: thermography, microcomputers, skin temperature, instrumentation, chiropractic.

INTRODUCTION

Surface skin temperatures are measurable quantities that may vary with degree of subcutaneous vascularization, physiological skin response to heat or cold, inflammations, or metabolic muscle activity. That one or more of these may be relatable to spinal subluxation complexes, perhaps through some neurological mechanism of subcutaneous vasomotor affect, is the basis for the development and present-day use of chiropractic paraspinal skin temperature differential measuring devices.

Typical chiropractic units in current use are relatively inexpensive hand-held galvanometers with single or double thermocouple sensors which are glided up one or both sides of the patient's spine. However, these devices present a number of problems, particularly with regard to their use in research: they induce temperature aberrations due to "p[illegible]ction," do not permit simultaneous sampling of the entire spinal/skin temperature profile, and cannot be adapted for use under dynamic conditions; such as, during a manipulative adjustment.

While there are instruments available that are capable of simultaneous measurement of surface skin temperature at all points along the spine, they are expensive to purchase and operate. These devices are generally based on infrared scanners that use sensors which require liquid nitrogen, which makes them financially impractical for wide scale research or clinical use.

In this article we describe an electronic device comprised of a computer interface and two flexible bands of 29 thermister sensors which are placed in stationary contact with the skin on both sides of the spine. By this means, we are able to simultaneously monitor 58 different points along the entire spine, horizontally or vertically, under static or dynamic conditions, at a relatively low cost.

A cost-effective way of sampling these sensors and connecting them to a recording device involves state-of-the-art electronic and computer circuitry. Such circuitry can be constructed using easily available electronic integrated circuits interfaced to a low cost microcomputer controller. This arrangement gives the research much flexibility in designing experiments, as sampler and display can be under specifically designed software program control. This device is reliable, easy to construct, inexpensive, and yet capable of measuring skin surface temperatures to within 0.1 degree C.

MATERIALS AND METHODS

Hardware

An Apple II+ microcomputer is used to control which thermistor is sampled and is also used to collect and process the temperature data from each thermistor. The Apple system we used has 48K of RAM memory with

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an autostart ROM and two disk drives. We also use a 12" color video monitor (Sanyo) and a printer with graphics capabilities (Paper Tiger, Integral Data Systems 440). The printer requires a parallel printer output port (Apple) to interface it with the microcomputer. The initial cost of this computer equipment is about $3000. In addition to the above equipment, this particular application requires two additional hardware boards that fit into the Apple and interface it with the external equipment.

The first board is an AIO parallel/serial interface (SSM Microcomputer Products, 2190 Paragon Drive, San Jose, Ca., 95131), which allows the computer to send and receive binary signals from outside the computer. In our system these signals are used to control electronic switches that sequentially sample each thermistor by connecting it into a measurement circuit.

The second board is an analog to digital (A/D) converter, (Tecmar Inc., 23414 Greenlawn Ave., Cleveland, Ohio 44122). This device inputs the measured signals and sends them back to the Apple as a binary number.

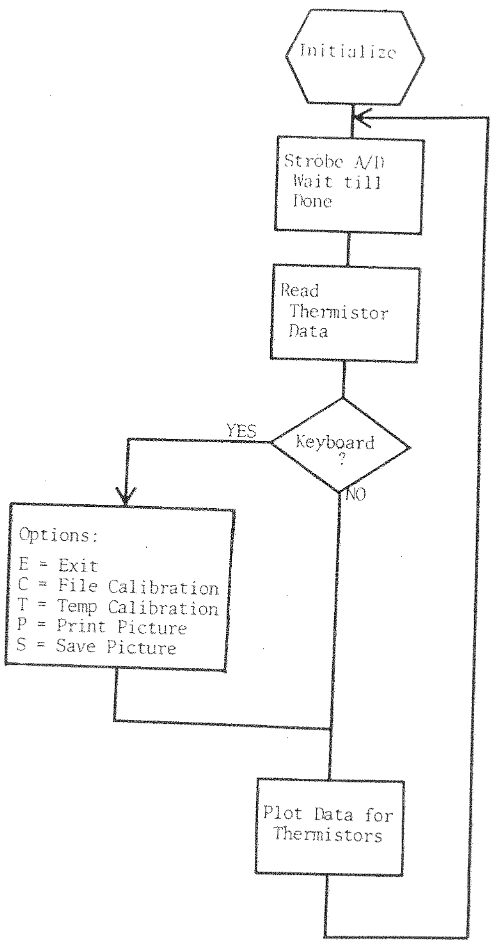

Figure 1. This flowchart gives the general pattern of control needed to scan the thermistor array.

The A/D converter is designed to be very versatile in its ability to convert various voltage ranges into binary numbers. We have set the controls on our A/D to convert signals in the range of 0–10 volts. Other options could be used with different designs.

Control of the A/D conversion process (as well as the selection of each thermistor) is done by the computer using the sequence of steps flow-charted in Figure 1. The hardware that implements these steps is composed primarily of electronic switches (CD4051). Each switch is controlled by signals sent from the parallel port of the Apple computer and acts by selectively switching each thermistor into the measurement circuitry. Once a thermistor is switched into the measurement circuitry, the voltage across it is detected and amplified. At the same time, an offset voltage is added to the signal. The electrical schematic for the full interface circuitry is given in Figure 2. Switching time is less than 40 nanoseconds. This device is powered by three regulated DC voltages (−12, +5, +12) that can be taken from the Apple power supply through the backplane connector.

The sensor system is the most critical component of the measurement process, and as such, must meet certain requirements. First, the sensors should have a linear response to temperature changes over the usable range. Also, they must be able to maintain good mechanical contact with the skin surface. Further, they should be somewhat rigid so they can be accurately positioned over specific landmarks on the skin surface. Finally, they should be electrically stable and mechanically sturdy so they can be used over long periods of time without exhibiting sensitivity changes or mechanical breakdowns. Part of this latter requirement has been met by the design of the array cable for holding down the sensors.

One design of the sensor system that we have found to offer these features uses matched thermistors. These units cost about $3.00 each (UUT-45J, Fenwall Electronics, 63 Fountain Street, Framington, Massachusetts, 01701) and can be accurate to 0.1 degree. Each thermistor is mechanically mounted and electrically connected to a flexible strip of ribbon cable (30 conductor, UL style 2713 FR-1, Newark Electronics, Industrial Drive, Norcross, Georgia 30329). This cable provides a firm support for the thermistors yet is lightweight, flexible, and capable of maintaining excellent mechanical reliability.

The connections of the thermistors to the cable and the cable to the Apple is given in Figure 3. Each thermistor has one end connected to positive 5 volts, (brought to it along one line of the ribbon cable), while the other end is connected to individual wires of the ribbon cable. The entire cable assembly is connected to the interface box through a pair of 16 pin header connectors which fit into IC sockets that are wired to the interface board.

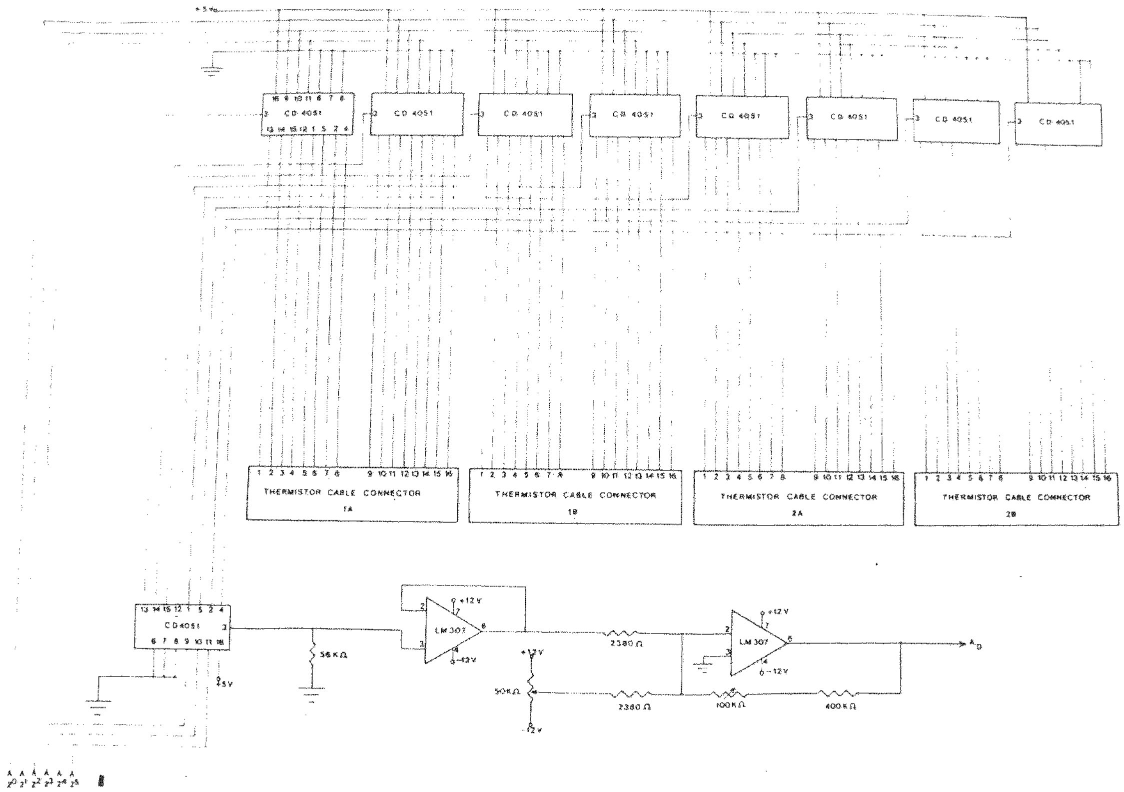

Figure 2. The schematic for the interface details the electronic circuitry necessary for the Apple to scan the thermistor array.

This arrangement allows the user to easily connect and disconnect cables of differing configurations as might be required for different applications such as upper cervical or whole spine scanning.

Software

Operation of the temperature scanning apparatus is under the control of a BASIC computer program. While this program accomplishes all of the necessary control and display steps, it operates too slowly for our needs. This is because BASIC is an interpretive language.

Fortunately, there exists a procedure for converting the original BASIC program into a faster, machine language program. This is done by using a commercially purchased compiler program (Hayden Applesoft Compiler, 50 Essex Street, Rochele Park, N.J. 07662). The compiled version of the BASIC program operates ten times faster and is capable of scanning the entire thermistor array and displaying the results in under one second.

The display portion of the program works by drawing lines on a calibrated background (Figure 4). The line length on each side increases with increasing temperature. The "dot" represents the differential temperature between the two sides. The background display was developed using a general purpose plotting program (Scientific Plotter, Interactive Microware, Inc. P.O. Box 771, State College, Pa. 16801) and is stored as a picture file on the storage disk. It is loaded into the high resolution graphics area just before the compiled program is run. The compiled program, oblivious to the presence of the background display, simply draws the lines on the screen. Generation of hard copy output is accomplished by using a software program (Enhanced Paper Tiger Graphics, Computer Station Inc.) which transfers a copy of the picture to the printer.

It is important to note that being programable, this instrument has a great deal of flexibility. Many functions can be envisioned in actual use, such as the changing of displays, the performance of on-line calibration, the comparison of several records, the plotting of differences, and so on. Each function can be developed as a separate program module; in use the modules can be linked together by means of an executive program which continually samples the keyboard and, upon recognizing a certain keypress, will activate the appropriate program.

Testing and Calibration

Testing and calibration of the instrument entails defining both its accuracy and precision. The accuracy indicates how close the reported temperatures are to the

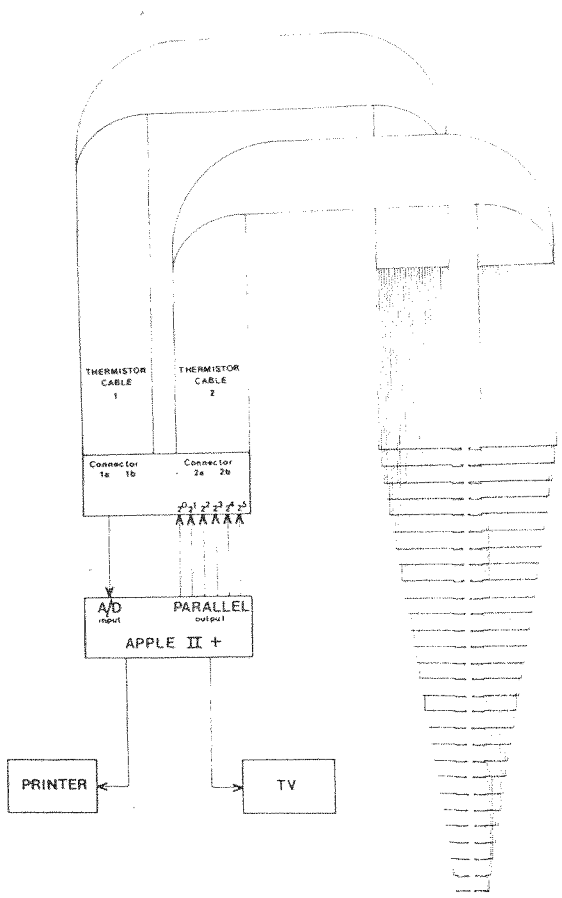

Figure 3. The thermal sensors, mounted on the ribbon cable, are connected to the Apple via the interface box. The interface box receives controlling signals ($2^0 - 2^5$) from the Apple and returns thermal signals (appropriately conditioned) on the A/D line.

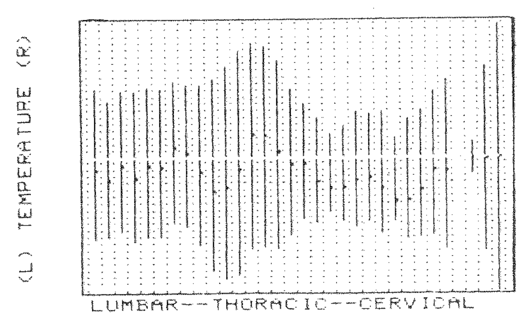

Figure 4. The display graph shows the absolute temperature values for all of the thermistors. The right-most three lines are calibrated to read 33, 34 and 35° Centegrade.

correct temperature. The precision measures reproducibility of any readings. In problems where relative changes are the significant feature, high precision is most important. Problems where absolute temperature values are required need high accuracy.

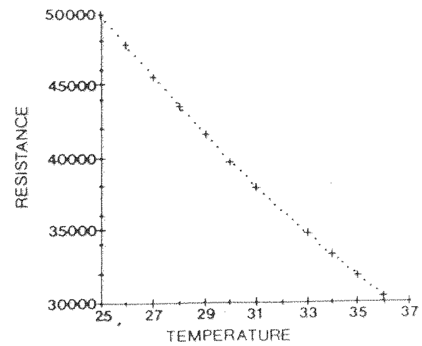

Figure 5. The linearity of the thermistors within small temperature ranges makes them ideal for use in this project. Resistance units are ohms; temperature is in Centegrade.

The linearity of the thermistors resistance to its temperature is one of the most critical aspects of its operation. Linearity implies that a given change in temperature will result in a predictable change in thermistor resistance. Since only the resistance can be measured, linearity allows one to relate the resistance measurements to the temperature. A plot of the resistance of the thermistors versus its temperature is given in Figure 5. While a slight overall curvature is seen, the linearity is quite acceptable over the 30–37 degree range our later studies will be using.

Even though each thermistor is closely matched, there exist minor differences in each that must be corrected. This was done by holding the sensor array in an insulated box so that all thermistors are kept at the same temperature. Variations in their output signals can be measured and stored as offset correction data. This data corrects for the minor variations between thermistors.

While the reported accuracy of each thermistor is only 0.2 degrees C., signal averaging and offset calibration allows the accuracy to exceed 0.1 degrees. This is matched by its precision.

In order to simplify interpretation of the results, six data channels have been wired with fixed resistors. These resistors are chosen to mimic the response of thermistors at 33, 34 and 35 degrees C. and they occupy positions 30–32 on the right hand side of the display.

DISCUSSION AND CONCLUSIONS

IR systems, capable of providing simultaneous temperature information at many points on the back cost more than five times as much as the present system. That these systems provide overall temperature as opposed to temperature at selected points does not justify the cost difference. The present system has been repeatedly calibrated and tested on volunteers, before, during and after adjustments. It has maintained its accuracy and precision and has proven capable of providing information about relatively rapid changes in the temperature profile. Preliminary results have been consistent in terms of showing temperature changes with adjustments for both the whole spine and exclusively cervical thermistor arrays.

Thus, the low-cost temperature scanning instrument we present is capable of meeting the needs implicit in chiropractic research questions dealing with the effect of manipulation and posture on skin surface temperatures. Such needs include accuracy, reliability, flexibility and ease of display of spinal temperature profiles in real-time. Preliminary studies using volunteers are underway to determine any limitations in the design or experimental protocol.

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Computer-Aided Pattern Analysis of Temperature Differentials

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ABSTRACT

Chiropractic analysis often incorporates the evaluation of heat distribution patterns observed in skin temperature profiles. Historically, temperature recordings of the spine have been made with a heat detection instrument using a thermocouple design. The advent of refinements in infrared technology, however, have greatly enhanced temperature detection in terms of accuracy and reliability. The present research reflects the development of computer software designed to express the data obtained with a dual channel heat sensing instrument. Two phases are involved: a) digital information, received from the sensing instrument, is standardized, stored for future analysis, and retrieved for comparisons with other graphs; b) stored data is graphically displayed, statistically analyzed, and otherwise compared. The data is displayed for visual observation as a) temperature data received from either channel of the sensing instrument or b) relative temperature differences between data from both channels of the sending instrument. For statistical evaluation, corresponding readings (comparisons between graphs) are plotted against one another and analyzed by a moving Pearson Product Moment correlation and moving *t*-test. This evaluation is graphically represented with a numeric display of pertinent statistical values. Current work indicates that a 10 point moving correlation and *t*-test will yield accurate comparisons between graphs. (J Manipulative Physiol Ther 1989; 12:345–352).

Key Indexing Terms: Pattern Recognition, Skin Temperature, Research, Chiropractic.

INTRODUCTION

Skin temperature readings are of interest to chiropractors as a means of indicating changes in mechanical and physiological events such as metabolic muscle activity or subcutaneous vascularization. The application of heat detection instruments for the purpose of recording temperature covers a spectrum of interests ranging from use as a diagnostic tool (1–4), to use as an analytical instrument related to the detection of spinal subluxation (5).

This level of interest has resulted in attempts to develop instruments that record the temperature of conducted or radiated heat with a high degree of accuracy and reliability. Early units, still in use, are hand held galvanometers employing single or double thermocouple sensors. Later technology resulted in the development of instruments employing thermistors with greater sensitivity to heat, but still relying on skin surface contact for detection. These instruments, however, are least desirable for temperature measurements for the following reasons: a) surface contact instruments irritate the skin and hence alter the accuracy and repeatability of measurements; b) although thermistors are more sensitive than thermocouples, both are considered slow in response to change in temperature. Due to this last property, these instruments, when used at glide rates approximating 1 cm/sec or more do not equilibrate to the temperature of a given area of skin before they are advanced. This results in temperature readings that are inaccurate. Reliability is also in question, since the glide rate can vary within readings and between readings.

Recent advances have generated the appearance of uni-, bi-, and multipolar infrared detectors. These instruments have improved the accuracy of heat detection

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Paper submitted March 2, 1988.

due to the fact that they are several orders of magnitude more sensitive to temperature change than thermocouples. Since these detectors respond rapidly to temperature change, equilibration problems inherent in thermocouple and thermistor devices are not present. In addition, infrared instruments detect radiant heat and therefore do not need to make contact with the skin. This eliminates the problem of contact-induced changes in skin temperature.

Although infrared detection offers the above-mentioned advantage, certain problems must be addressed in order to enhance instrument accuracy. Since infrared detectors are extremely sensitive to environmental heat, they must be placed in a thermally-stable casing. Also, the skin area being examined has to be constant and independent of the detector's distance from the skin. This problem may be dealt with by employing a lens system to focus the area of detection to a constant width. In addition, the heat insulating and reflective properties of human hair present a problem to accurate detection of heat radiated from above the hairline when recording the cervical region. This concern can be partially resolved by the detection of a constant width area of heat, focused by a lens system as mentioned above. The user should be aware of the necessity of moving hair (when possible) from the path of the detectors.

Reliable temperature detection, as described above, is one of the primary obstacles to overcome with heat detection instruments. In addition, anatomical placement and glide rate of the instruments must be closely controlled in order to generate valid data. While the necessity to refine such instruments, in terms of their detection characteristics, is of a high priority, the analysis of temperature data is often overlooked. The present study, therefore, has been conducted to establish a model for analysis of data that provides consistent and objective results. While interpretation of data will remain a parameter for continuing research, it is apparent that a standard for analysis of temperature data must be initially established to support such endeavors.

MATERIALS AND METHODS

The algorithms designed in this study were tested on arbitrarily conceived data, as an actual temperature detection instrument was not employed. However, the data pool consisted of a range of values that closely paralleled actual graphs. This data was not intended to cover the entire range of graphic configurations. Actual data therefore could result in graphic depictions not included in this study. The analysis algorithms are applicable to any temperature sensing device able to interface with a computer. Programs were written under MS/DOS in Pascal language using a 384K RAM Tandy 1000 computer with a 20 megabyte hard-disk. These programs were designed to assume that the data originated from a bilateral temperature sensing instrument. It was also assumed that any instrument employing these algorithms would have an inherent standardized output to distance ratio (number of readings/unit distance) and accurate anatomical placement in order to generate valid data for comparison. Instruments not operating under this criterion could not be used with this paradigm. The standardized output/distance ratio could be achieved by direct means, such as attaching a wheel to the rear of the instrument. This wheel, in contact with the skin, would indicate when a fixed distance had been traveled, signalling the instrument to respond with a temperature reading. This ratio could also be achieved by indirect means, such as using a pacing device that moves the instrument at a constant speed, responding with temperature readings at fixed time intervals.

The selected data was read into the computer as a series of values ranging from −128 to +127. These values covered the range of an eight-digit binary number (one byte). The range of values was divided in half to represent data from the left temperature sensor (−128 to −1) and from the right temperature sensor (0 to 127). It was assumed that temperature values would be received by the computer from the instrument at unit distances along the patient's spine. Data, up to 300 readings from each sensor, could be stored in RAM.

Graphic Display

In the implementation of computerized storage and display, it was realized that graphs of different lengths could be generated. This would arise in at least two situations. In the first instance, full spine graphs would generate more data, and thus occupy more space than cervical graphs. Secondly, if different instruments employing different output/distance ratios were used to detect temperature change in the same area of the spine (cervical region, for example), the output graphs would be of varying lengths. In order to achieve efficient use of the computer display and storage devices, as well as generate graphs of equal length for comparative purposes, a standardization procedure was devised. The quantity of data was normalized to 100 data points. This procedure was accomplished by interpolating the digital input at intervals represented by the following formula: $(n - 1)/(L - 1)$; where n represents the number of individual data points obtained and L represents the number of data points used for each normalized series (100 points). The value obtained from this formula designates the intervals between the first and last data points which would be used for a given temperature sensing series. If less than 100 data points are initially obtained, the computer will generate enough points, at the interval specified, to total 100. If more than 100 data points are initially obtained, the computer will record only 100 data points at the interval specified. This formula permits all graphs, regardless of the number of data points obtained, to be displayed with the same length for purposes of comparative analysis.

This method was employed for graphic displays of left and right probe temperature readings, as well as the numerical difference between the two, which results in a graphic display of bilateral temperature change. Program routines were developed to visually display up to twenty-one right, left, or bilateral temperature change graphs.

Graph Analysis

Graph analysis, in this study, employed the rationale that temperature data would be collected from the same individual over a specified period for the purpose of comparing and establishing patterns or changes in patterns. In order to evaluate the graphs (temperature profiles) in sufficient statistical detail, each graph was sectioned into 91 overlapping regions of 10 data points each.

Two comparisons involving a Pearson Product Moment correlation analysis, and a third involving a modified *t*-test, were made. The first comparison, or Index of Similarity, was designed to ascertain the best correlation between two of three graphs obtained from the same anatomical region. Correlation coefficients (rAB, rAC, rBC) for graphs A vs. B, A vs. C, and B vs. C, respectively, were gathered at each of the 91 regions and compared. The coefficients were used to generate an Index of Similarity for each graph. The index for each graph represented a percentage based on the average of all regional correlations for that graph vs. each of the other two graphs being compared. Therefore, the graph with the highest index would be most similar to the other two, and conversely, the graph with the lowest index would be least similar. The index for Graph A, for example, was determined by the following expression:

$$\text{Sum } (rAB + rAC) \times 100/(2 \times 91)$$

where A, B, and C represent different graphs. The index was then calculated for graphs B and C. This served to establish, as a base pattern, the two most similar graphs for comparison to any subsequent temperature readings of the same anatomical region.

The second analysis, a two-way comparison, involved a more detailed analysis of the two most similar graphs. Considering the total number of positively correlated regions between the two graphs, the number and location of those regions exceeding $p > 0.05$ were determined. This information provided a measure of the percent of the two graphs that were positively correlated at a given level of statistical significance. Graphic displays were also highlighted in these regions. This provided a visual comparison of locations where significant correlations existed.

Since the magnitude (horizontal amplitude) of positively correlated graph regions would reflect changes in the intensity of heat at those locations, this parameter was also analyzed. This third comparison was developed as an option which could be performed on each region of the two most similar graphs (A and B for example) that were positively correlated at $p > 0.05$. Regions of graphs that were analyzed were subjected to a Student's *t*-test as modified by Spiegel (6).

Where:

$$t = \frac{\bar{A} - \bar{B}}{\sqrt{S_A^2 + S_B^2}} \qquad \sqrt{N - 1}$$

Since two samples were compared, degrees of freedom were 2N-2, where N was the region size of 10 data points. Positively correlated regions were considered different in terms of magnitude only when t values exceeded $p > 0.05$. When a fourth graph or temperature profile was considered, the first comparison (Index of Similarity) was performed on the two best correlated graphs from the initial set of three and the fourth graph. From this new set of three graphs, a new pair of best correlated graphs could emerge, or the initial set could remain as the best correlated pair. If the new pair emerged, this set was subjected to the second or two-way comparison and compared to the initial pair. This was done to monitor statistical and visual changes occurring in graphic patterns with the emergence of new data.

RESULTS

Figure 1 demonstrates a visual display of left, right, and numerical difference (right minus left) graphs. Any of these graphic profiles could be compared with subsequent readings of the same counterpart; i.e., right vs. right, left vs. left, right-left vs. right-left. In order to test the strength of the standardization procedure, three graphs were constructed from a common pool of 257 data points (Figure 2). Graphs were normalized from 257 to 100 data points (A), 9 to 100 points (B), and 65 to 100 points (C). Graphs B and C were derived from every 32nd and 4th of the original 257 data points, respectively. The graphs were analyzed for differences in deviation by a two-way Pearson correlation. The percentage of correlated regions (out of 91) at $p > 0.05$ was also determined. It can be seen in Figure 2 that

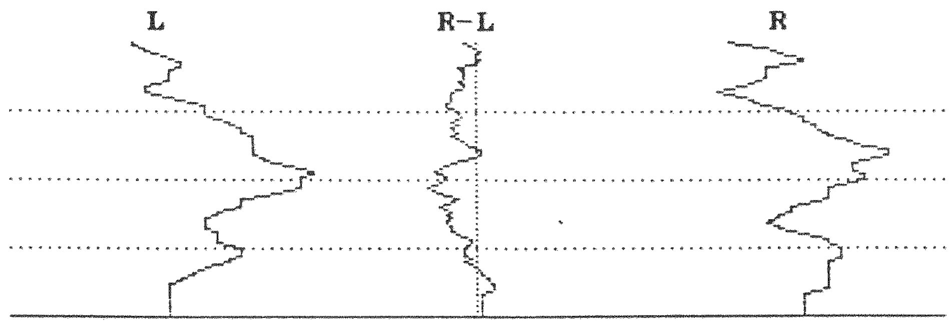

Figure 1. Left, right, and right-left temperature graphs. The data from which the graphs were constructed was arbitrarily chosen and designated as hypothetical temperature readings. Any of these graphic profiles could be compared with subsequent readings of the same counterpart, i.e., R vs. R, L vs. L, L-R vs. L-R.

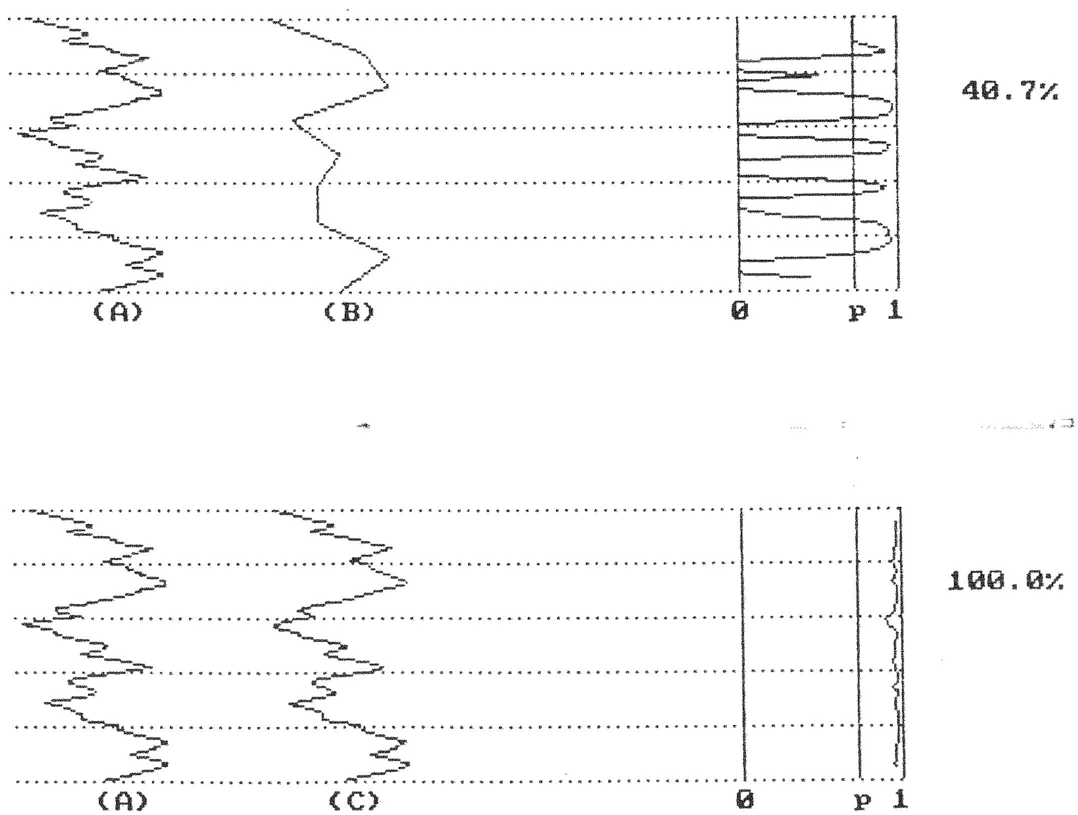

Figure 2. Effects of number of data points on the correlation of standardized graphs. Graphs A, B, and C are standardized to 100 data points from 257, 65, and 9 data points, respectively. Graph B was derived from every 32nd data point in the original pool of 257. Graph C was derived from every 4th data point of the original 257. The analysis block reflects segments of the graphs that exhibited zero correlation (left) to perfect positive correlation (right). Values to the right of the dividing line (p) represent regions of the graphs that are positively correlated at $p > 0.05$. The closer to the right side of the block, the more positively correlated are the segments. Negative correlations were not considered since similar patterns of the graphs would be represented by changes in the same, not opposite directions. The percentage represents the number of positively correlated segments (out of 91) that were significant at $p > 0.05$.

with as few as 9 data points, two graphs from the same data pool still exhibited an overall average positive correlation of 40.7% at $p > 0.05$. An overall average correlation of 85.7% was demonstrated when interpolation was made from as few as 33 data points (not shown). One hundred percent of the regions were positively correlated at $p > 0.05$ with 65 data points (every 4th data point of the pool of 257).

Figure 3 demonstrates a selection of three temperature graphs for comparative analysis of differences in vertical deviation (Index of Similarity). A, B, and C correspond to the graphs from left to right (graphs 1, 2, and 3). Indices for A, B, and C reflect how well each graph is correlated to the other two graphs. Values were determined by taking the average of the correlation coefficient (r) for each graph vs. the other two graphs, as described in Methods and Materials. It can be seen from the information in Figure 3 that graphs 1 and 3 show the greatest number of positive correlations, as values for A and C are respectively higher than the value for B. The percentage of regions that were positively correlated between the three graphs was calculated to be 52.7.

Figure 4 demonstrates further evaluation of the graphs which were most closely correlated (two-way comparison). Following the same analytical procedure, the percent of the total 91 data regions that were positively correlated at $p > 0.05$ was determined. In this instance, 73.6% of the 91 vertical regions showed a positive correlation at $p > 0.05$. These areas have been shaded on the graphs, and depicted graphically in the analysis block.

In order to demonstrate analysis of a subsequent temperature series in relation to the previous two most positively correlated graphs, a fourth temperature graph was constructed. The analysis as described in Figure 3 was repeated between graphs 1, 3, and 4 (Figure 5). In this comparison, graph 4 demonstrated a greater positive correlation to graph 1. This is evidenced by the average r values for A and C, which were greater than

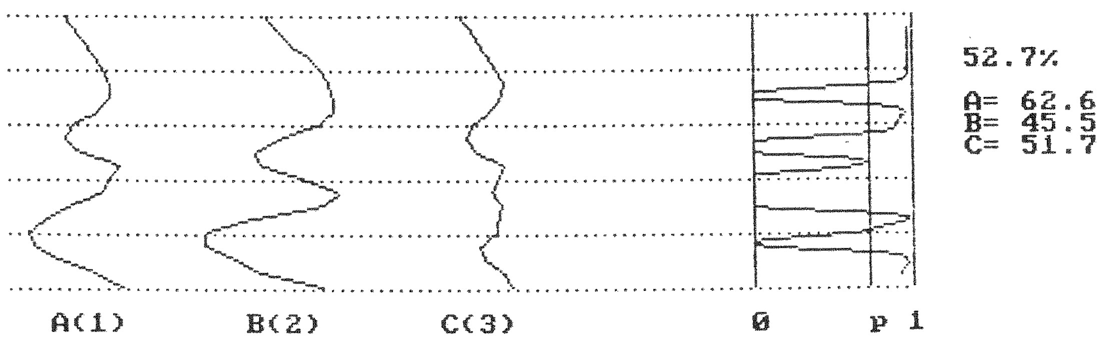

Figure 3. Correlation analysis of selected temperature graphs. The graphs depicted could be representative of either three left, right, or left-right temperature series. A, B, and C are indices of the extent of positive correlation of each graph, with each of the other two, expressed as a percent of the 91 vertical segments of each graph. The expressions below are described in the Materials and Methods section: A = Sum(rAB+rAC) × 100/(91 × 2) B= Sum(rAB+rBC) × 100/(91 × 2) C= Sum(rAC+rBC) × 100/(91 × 2). The percentage (52.7) of significantly correlated segments ($p > 0.05$) is derived from the following expression where rAB, rAC, and rBC are sequential correlations for each of the 91 vertical segments: Sum(rAB+rAC+rBC) × 100/(91 × 3).

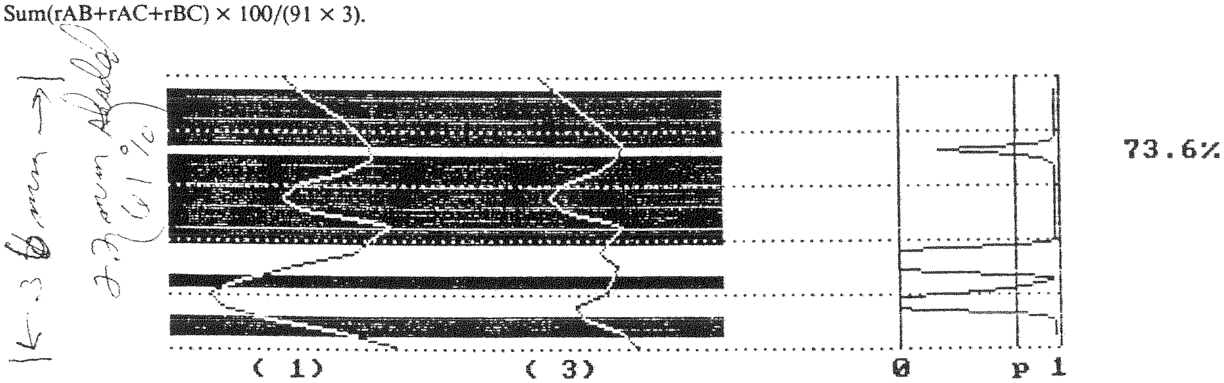

Figure 4. Extent of correlation between selected graphs. Graphs represent the two most highly correlated (1, 3) from a pool of three (Figure 3). The percentage represents the number of areas of positive correlation which exceed $p < 0.05$ over the total of 91 vertical segments. The left and right lines of the analysis block represent a range of zero to positive 1 correlation, respectively. The line between zero (0) and positive (+1) represents a $p > 0.05$. Areas to the right of this line are significant at the 95% confidence level. Areas falling into this category are also shaded on the graphs for visual clarification.

the value for B (as described for Figure 3). In this instance the two most positively correlated graphs changed from 1 and 3, to 1 and 4. This is substantiated by the percentage of correlation between the three graphs (65.9), which exceeded the percent of positive correlation exhibited between the initial three graphs (Figure 3). This factor alone indicates that graphs 1, 3, and 4 are, as a group, more similar than graphs 1, 2, and 3. Both sets of graphs are compared in Figure 6. In order to evaluate the extent to which graph 4 is more closely correlated to graph 1 than the previous relationship between graphs 1 and 3, areas of positive correlation at $p > 0.05$ were shaded on the graphs and the information expressed as a percentage. It can be seen that 86.8% of the 91 vertical segments of graphs 1 and 4 are positively correlated at $p > 0.05$ as compared to 74.7% of graphs 1 and 3. Shaded areas permit visualization of the locations where the correlated areas vary between the pairs of graphs.

In addition to graphs deviating vertically, graphs may vary in magnitude (horizontal amplitude) also. The analysis of two graphs for magnitudal differences is seen in Figure 7. Regions that were positive in correlation at $p > 0.05$ were considered to vary in magnitude (horizontal amplitude) when t-values exceeded $p > 0.05$. It can be seen from Figure 7 that the unshaded area of the lower quadrant of the two graphs represented a significant ($p > 0.05$) variation in magnitude (horizontal displacement). Subsequent analysis demonstrated that 64.8% of the positively correlated vertical regions did not differ significantly in magnitude. The remaining 33.0% of the correlated regions accounted for the portion of the graph differing in horizontal amplitude.

DISCUSSION

The intent of the present study, in the absence of any temperature detecting instrument, has been to propose a model for a reliable method of analysis of temperature data. While the quality of the data gathered is a function of the accuracy of the instrument and the reliability of the user's technique, the algorithms presented in this study do not differentiate data quality. Statistically based analyses, as employed in this study, provide the same consistency of analysis, regardless of whether the data is theoretical or real. Other types of analysis do not function in this manner. In this regard, Schram and Hosek (7) have addressed the impact of real data vs.

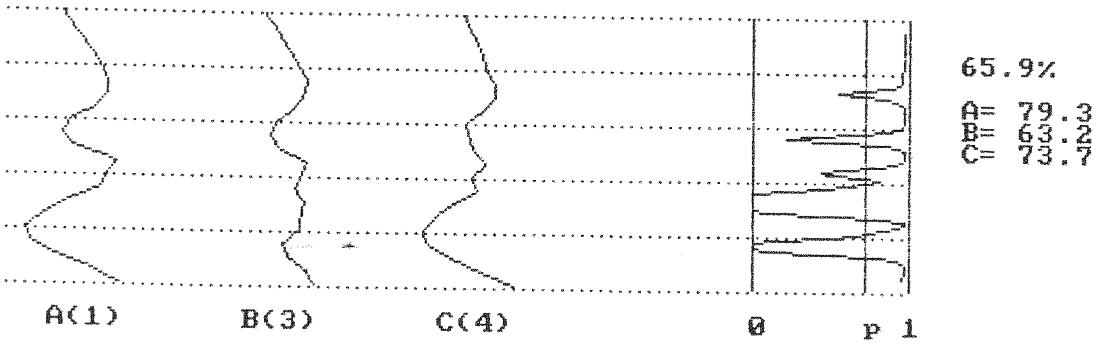

Figure 5. Comparison of a temperature series to an existing positively correlatred pair of temperature graphs. Graph 4 represents a temperature series to be compared against the two most positively correlated graphs from an initial pool of three graphs (Figure 3). Values for A, B, and C are derived as described in the Materials and Methods section. The percentage (65.9) represents the percent of positive correlation between the three graphs.

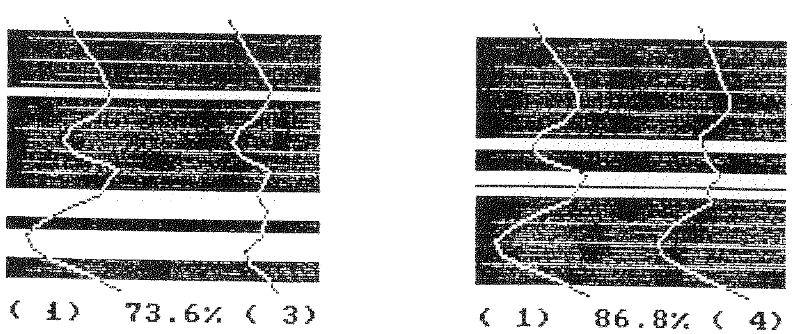

Figure 6. Comparison of pairs of graphs with respect to the percent of significant correlation among vertical regions. The two pairs of graphs, (1 vs. 3) and (1 vs. 4), respectively, represent the initial, most closely matched graphs compared to a subsequent, more positively correlated pair.

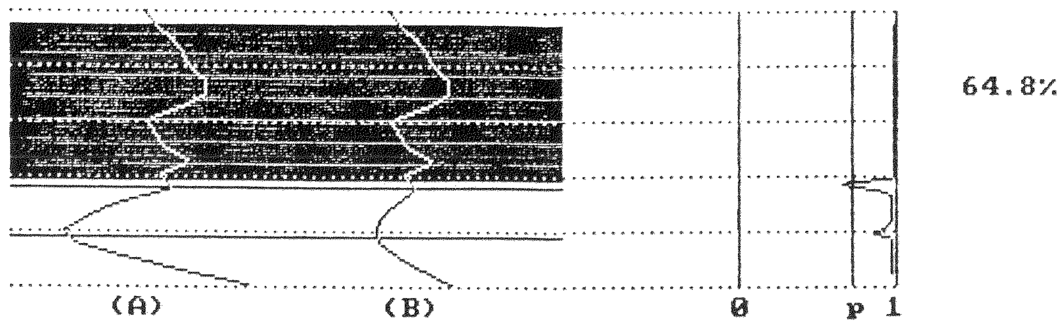

Figure 7. Comparison of graphs by vertical regions and magnitude (horizontal amplitude). The graphs depicted could be representative of either two left, right or left-right temperature series. The graphs depicted represented a 98% positive correlation over all 91 vertical segments. The unshaded areas of the graphs represent the vertical segments (areas) that differed by the *t*-distribution at $p > 0.05$. This was interpreted as a significant difference in magnitude between that area of the two graphs. The percentage of positively correlated vertical regions that did not differ in magnitude was calculated as 64.8.

theoretical data on a model system involving X-ray analysis. These authors clearly demonstrated that errors introduced into analysis by the experimenter and equipment are not compatible with a mathematically rigid analysis. The work of these authors serves to emphasize the importance of employing analysis systems based on mathematical assumptions that account for the variability of real data.

In this present study, for purposes of simulating instrument output, certain assumptions which are believed to be currently feasible were made: a) the instrument would possess a standard output to distance ratio; b) all data was assumed to have been processed by an analog to digital converter and appropriate computer interface to give a response in the −128 to +127 range (as stated in Methods and Materials). It was further assumed that data collected would be from the same anatomical locations.

The algorithms designed in the present study are therefore applicable to virtually any instrument meeting requirement (a). The reliability and extent of comparison of segmental analyses of data collected from the same region of the spine would be dependent upon the degree of human error introduced (consistent anatomical placement, for example).

The intent of this study, however, has been to evaluate the credibility of the algorithms per se. In that regard, information relative to the standardization procedure employed in this study suggests that the response time of any given temperature detection instrument is not critical with regard to graph quality. This is evidenced by the fact that graphs constructed from 257 to as few as 65 data points from the same pool of information exhibited 100% correlation. Since different types of instruments are likely to have different response times, the fact that diverse ranges of data input can be standardized without compromising graph accuracy is reassuring. However, temperature profiles generated from real data using actual instruments will be required for substantiation.

The methods of correlating graphs described herein has allowed for a precise analysis of the extent and location of similarities. In this regard, special attention was given to partitioning graph profiles into regions that overlapped by 9 data points per 10 data point interval. This permitted a detailed comparison of graph regions traversing vertically. In order to compare these regions, the Pearson correlation was used specifically for analysis of vertical deviations. This test was selected because it detects common trends without dependence on magnitude or absolute values. This serves to reduce error that could be introduced due to poor technique or instrument inaccuracy.

In regions of graphs that were significantly correlated, the parameter of horizontal amplitude was analyzed by a modified *t*-test. Since the regions were positively correlated, the *t*-test differentiated absolute values by magnitude.

No attempts were made in this study to develop an interpretation of the clinical significance of correlated graphs. However, an explanation of the ramifications of correlation, as used in this study, is in order. In the initial comparison of three graphs (Index of Similarity), the index generated reflects those graphs which are most closely correlated. In addition, the overall correlation between the three graphs is expressed as a percentage. This information indicates that in reality, three graphs that expressed a very low overall percent correlation could be compared for closest similarity. The evaluator, if desiring to compare only graphs of high overall similarity, must establish a limit below which graphs would not be considered. In actual practice, however, graphs obtained from real data may be considerably less than perfectly correlated, but still clinically significant in relation to temperature changes in specific graph regions. The second comparison of data (two-way comparison) takes this concept into consideration. Graphs that were found to be most similar were subsequently analyzed by regions. The resulting graphs were visually highlighted to show specific areas of correlation where $p > 0.05$. Thus, two graphs, highly correlated in one area only, could be viewed as clinically significant although a low percent of overall correlation could be expressed if other areas were dissimilar. The selection of the lower limit of acceptability, in addition to the situation described, could depend on such factors as the accuracy of the instrument or anatomical locations from which the data is acquired. In any event, the selection of limits of acceptability should remain the choice of the evaluator.

CONCLUSION

Changes in pattern, both vertically and horizontally (magnitude), have been considered. From the methods described, graphs can be compared over time for changes in temperature deviations at any given location. Those changes can further be analyzed to determine if significant changes in magnitude have occurred. This creates a two-dimensional analysis between any two graphs. Changing patterns may also be recognized by continuously comparing the most recent graph against the two previously most closely matched graphs.

The method of comparing graphs by computer-aided statistical analysis and subsequent visual display has served the principle intent of this study. Future investigations will involve implementation of the methods employed into the clinical setting with state of the art temperature detection instruments.

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weaknesses, several areas of importance warrant discussion, those being: anticipated outcomes, data management and recycling, and reporting and the use of assessment results. The first step in assuring that results are used to stimulate changes toward curricular improvement is to share them with department faculty members. A written report is prepared and distributed to the faculty. The results of assessment activities are used to generate discussion among the faculty and changes for improvement within the curriculum. When developing any assessment tool, it is critical that the objectives of the activity being assessed are linked to the institutional exit objectives that are in turn linked directly to the college mission statement and goals. This offers a substantial linkage of objectives that are essential for effective assessment procedures regarding students' academic achievement. Follow-up regarding curricular changes made for improvement must be tracked and documented by a group of faculty dedicated to that specific task.

CONCLUSION

As faculty continues to search for ways to improve assessment methods for student academic achievement, it is important to share what we have done, the lessons learned from the trials, and the improvement to be made. The PTS promises potential as a useful grading tool as well as a method to investigate curricular strengths and weaknesses. The reporting instrument that we have devised has been useful in documenting and reporting performance examination results at our institution and could be used by individuals, departments, and trimesters for documenting, reporting, and disseminating a variety of assessment results.

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Thermographic Pattern Analysis Using Objective Numeric Methods

Edward F. Owens, Jr., M.S., D.C., Sherman College of Straight Chiropractic

Analysis of paraspinal skin temperature patterns has been used in several chiropractic techniques as a method for detecting imbalances in the sympathetic nervous system that may be indicative of vertebral subluxation. The paraspinal skin temperature is often recorded with single- or dual-probe infrared, or thermocouple devices that provide a graph of temperature with respect to position along the spine. Interpretation of the temperature graphs varies with different techniques, but generally involves inspection of the graph by the doctor, looking for similarities in the pattern when compared to previous graphs, or deviations in symmetry of graphs. Patients are generally judged by the practitioner as being "in" or "out" of pattern based on this visual inspection. As this determination can sometimes be difficult, attempts are being made to develop a numeric method for comparison of skin temperature patterns. Such an objective comparison of skin temperature patterns will be critical in future studies of the stability of the measure, or changes that occur with chiropractic spinal adjustment.

METHODS

The TyTron C-3000 Paraspinal Thermal Imaging System (Titronics Research & Development Co., Oxford, IA) was used to collect thermographic patterns on 27 patients during the course of a blinded randomized clinical trial of the effects of chiropractic adjustment on athletic performance. The TyTron is a hand-held dual-probe noncontact infrared thermometer interfaced to a Windows-based PC computer. The TyTron is equipped with an encoded roller and photocell pickup that provides continuous information on distance along the spine as thermal scans are recorded digitally. The temperature patterns on the left and right sides of the spine can be displayed on the computer screen, along with a plot of side-to-side temperature differences. This difference graph is used most frequently in pattern analysis in the HIO or specific upper cervical toggle technique.

In a preliminary study of thermographic pattern stability, two experienced doctors of chiropractic were asked to judge the similarity of graphs recorded at successive visits. In a blinded fashion, the doctors indicated whether each scan represented a very similar, moderately similar, or dissimilar pattern.

RESULTS

A total of 76 temperature graphs were judged of sufficient quality for the comparison. The results for each doctor were tallied using a 3 × 3 agreement table. The percent agreement found was 38%, with a kappa calculated as .0008.

DISCUSSION

The results of this informal preliminary study underscore the importance of the development of an objective measure of thermographic pattern similarity. These results also complicate the matter, in that there may be no reliable clinical measure against which to validate the numeric method. Putting this complication aside for the time being, a search is underway for the best numerical method to apply in the assessment of thermographs. Current investigations center around choosing the best computational method, based on ease of use and comparability with pattern analysis as performed by practitioners. Since blinded evaluation of pattern congruence has been shown not to be highly reliable, a consensus determination can be used to create a comparison scale for the numeric method.

CONCLUSION

The need exists for an objective numerical method to compare paraspinal thermographic scans for similarity and stability over time. Such methods should offer increased objectivity in the determination of pattern congruence and will be critical in future studies of reliability and stability of clinical measures of skin temperature. Investigations are underway to identify the most applicable and least complicated computational method.

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The Effectiveness of the Application of Auxiliary Therapies in a Clinical Setting
An Evaluation of the Teaching of Modalities

Richard P. Ruegg, B.Sc., Ph.D., D.C., Canadian Memorial Chiropractic College

Chiropractors generally employ auxiliary therapies such as interferential current, electrical muscle stimulation, and ultrasound to control pain, enhance healing, and reduce inflammation. Most regulatory jurisdictions require training in the physical therapies which is currently provided by most chiropractic colleges. The Council on Chiropractic Education (CCE) currently requires a minimum of 96 modality treatments during the clinical internship. The purpose of the study was to evaluate the use of modality, through the review of patient files and the observation of modality treatments, as a means of assessing the effectiveness of undergraduate instruction and clinical supervision in the application of the auxiliary therapies.

METHODS

Random observations of electrotherapy, laser, and ultrasound were performed unannounced, at which time the patient's diagnosis and plan of management were reviewed. The plan of management was checked for clinician approval of the designated modality and the treatment itself observed for proper setup and application. Patient identity was not recorded, thereby ensuing patient confidentiality. Nor was the treating intern or the supervising clinician identified. Results were recorded as Yes/No responses.

RESULTS

Patient files consistently provided approved diagnoses and plans of management. Virtually all contraindications were observed. However, several results raised considerable concerns. Frequently the plan of management did not include the modality employed for treatment. Often the selected intensity was not appropriate nor was the modality applied in the recommended fashion.

DISCUSSION

The results raised concerns regarding both the instruction of auxiliary therapy in the preclinical program as well as the supervision of treatment in the clinical internship. It appears as though intern modality treatments are less than effective based on the observations made. Instruction in the

Standards of Care

Council on Chiropractic Practice

Clinical Practice Guideline

Number 1

Vertebral Subluxation in Chiropractic Practice

1998

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Vertebral Subluxation in Chiropractic Practice

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2 Instrumentation

RECOMMENDATION

Instrumentation is indicated for the qualitative and/or quantitative assessment of the biomechanical and physiological components of vertebral subluxation. When using instrumentation, baseline values should be determined prior to the initiation of care.

Rating: Established
Evidence: E, L

Commentary

The chiropractor uses a variety of procedures to assess the vertebral subluxation. These methods may include history taking, physical examination, imaging procedures and instrumentation. Through information gained from research and personal experience, the chiropractor generally assigns a personal value to each procedure in a particular clinical circumstance. The intent of this chapter is to describe clinical applications for the various instruments that may be used by chiropractors in examining their patients for evidence of vertebral subluxation.

Definition of instrumentation: The use of any tool or device used to obtain objective data, which can be recorded in a reproducible manner, about the condition of the patient relative to vertebral subluxation. Such instrumentation as that described below may provide information concerning the biomechanical and/or neurological aspects of vertebral subluxation.

POSTURAL ANALYSIS

Sub-Recommendation

Postural analysis using plumb line devices, computerized and non-computerized instruments may be used to evaluate changes in posture associated with vertebral subluxation.

Rating: Established
Evidence: E, L

Posture analysis is recommended for determining postural aberrations associated with vertebral subluxation. The findings of such examinations should be recorded in the patient record. In order to encourage standardization of reporting, it is suggested that findings be recorded in a form consistent with manufacturers' recommendations.

Posture analysis may include the use of such devices as the plumb line, scoliometer and posturometer.[1-8] Posture is often analyzed by x-ray methods[9-13] simply by visualizing the patient and making determinations based on that visualization. The procedure is often enhanced by a plumb line and other vertical and horizontal lines.

Rating: Established
Evidence: E, L

Standard EEG and computerized EEG techniques, including spectral analysis and brain mapping, have been shown to change following chiropractic adjustments or manipulation.[72, 161, 204] Such procedures may be useful in evaluating possible effects of chiropractic care on brain function.

SOMATOSENSORY EVOKED POTENTIALS (SSEP)

Sub-Recommendation

Somatosensory evoked potentials may be used for localizing neurological dysfunction associated with vertebral subluxations.
Rating: Established
Evidence: E, L

Somatosensory and dermatomal evoked potentials are used for localizing neurological abnormalities in the peripheral and central conducting pathways. These findings are useful as objective indicators of the level or levels of involvement.[73-86, 154] One study reported that improved nerve root function was observed in subjects who received a high-velocity chiropractic thrust; similar changes were not observed in controls.[73]

SKIN TEMPERATURE INSTRUMENTATION

Sub-Recommendation

Temperature reading devices employing thermocouples, infrared thermometry, or thermography (liquid crystal, telethermography, multiple IR detector, etc.) may be used to detect temperature changes in spinal and paraspinal tissues related to vertebral subluxation.
Rating: Established
Evidence: E, L

The measurement of paraspinal cutaneous thermal asymmetries and other measurements of anomalies have been shown to be a mode of sympathetic nervous system assessment, [88, 90, 91, 93-95, 97-103, 160] which may be used as one indicator of vertebral subluxation. Demonstrable changes in thermal patterns have been observed following chiropractic adjustment.[19, 92] Thermocouple instruments have been shown to demonstrate an acceptable level of reliability and clinical utility applicable to the assessment of vertebral subluxation related temperature changes.[87, 89, 96, 104] Normative data have been collected concerning the degree of thermal asymmetry in the human body in healthy subjects.[105] These values may serve as one standard in the assessment of sympathetic nerve function and the degree of asymmetry as a quantifiable indicator of possible dysfunction.[106]

Council on Chiropractic Practice

Clinical Practice Guideline

Number 1

Vertebral Subluxation in Chiropractic Practice

2003

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2 Instrumentation

RECOMMENDATION – Unchanged

Commentary – Unchanged

POSTURAL ANALYSIS

Sub-Recommendation – Unchanged

Commentary – Addition:

It is recommended that posture also be assessed dynamically since vertebral subluxation has been implicated in altering postural dynamics.[1] High speed photography, electrogoniometry, accelerometry, electromagnetic, and videobased systems have all been used to measure the segmental positions and orientation of the moving body.[2]

BILATERAL AND FOUR-QUADRANT WEIGHT SCALES

Sub-Recommendation – Unchanged

Commentary - Unchanged

MOIRE CONTOUROGRAPHY

Sub-Recommendation – Unchanged

Commentary - Unchanged

INCLINOMETRY

<u>Sub-Recommendation</u> - Unchanged

Commentary - Unchanged

GONIOMETRY

<u>Sub-Recommendation</u> – Unchanged

Commentary - Unchanged

ALGOMETRY

<u>Sub-Recommendation</u> – Unchanged

Commentary - Unchanged

CURRENT PERCEPTION THRESHOLD (CPT) TESTING

<u>Sub-Recommendation</u> – Unchanged

Commentary - Unchanged

ELECTROENCEPHALOGRAPHY (EEG)

<u>Sub-Recommendation</u> – Unchanged

Commentary - Unchanged

SOMATOSENSORY EVOKED POTENTIALS (SSEP)

Sub-Recommendation – Unchanged

Commentary - Unchanged

SKIN TEMPERATURE INSTRUMENTATION

Sub-Recommendation – Unchanged

Commentary - Unchanged

SURFACE ELECTROMYOGRAPHY

Sub-Recommendation – Unchanged

Commentary - Unchanged

MUSCLE STRENGTH TESTING

Sub-Recommendation - Addition:

Muscle strength and endurance testing may be used to ascertain and track muscle force generation and neuromuscular status. Clinically, it may be useful to quantify differences in strength between limbs or bodily segments. The evaluation of strength may be characterized by the experienced examiner based on various technologies. Manual, mechanized and computerized muscle testing may be used to determine changes in the strength and other characteristics of muscles. These changes may be a result or a cause of alterations of function at various levels of the neuromuscular system and/or any other system related to the patient. Such changes may be associated with vertebral subluxation.

Rating: Established
Evidence: E, L

Policy Statement of the International Chiropractors Association

POLICY STATEMENTS

The ICA stands ready to cooperate in a broad-based, nationwide campaign on the part of the chiropractic profession to establish insurance review procedures that are ethically sound, economically fair, and which will ensure that the insurance industry and the chiropractic profession can collectively meet the health care needs of the insured patient.

LOW-FORCE ADJUSTIVE TECHNIQUES

The International Chiropractors Association recognizes chiropractic techniques that utilize low force adjustments and soft tissue contacts to achieve correction of the varied components of the subluxation complex. Such techniques, when utilized in attempts to reduce and stabilize biomechanical lesions through alteration of the biodynamics of the musculoskeletal system, are recognized as part of chiropractic practice.

SPINAL SPRAIN AND STRAIN INJURIES

Inherent in most spinal sprain and strain injuries, there exists a biomechanical, neurological component of articular malposition referred to chiropractically as subluxation. Such subluxation, if not addressed and merely treated with soft tissue therapeutics and/or joint immobilization forms of care, may lead to joint fixation and/or instability and loss of motor unit integrity.

It is the opinion of the International Chiropractors Association that in such injuries evidence of the chiropractic vertebral subluxation complex should be analyzed and, if present, be corrected by specific chiropractic articular adjustment before immobilization procedures are applied. Lack of such correction of articular misalignment (subluxation) may result in permanent impairment, for waiting more than an hour, much less days, may lead to joint fixation, motion impairment, neurological insult and/or hypermobility of the intervertebral motor unit. Adjustive reduction of the articular subluxation must be accomplished with due regard to soft tissue injury, attempt to enhance recovery and contribute to the prevention of future joint motion impairment, neurological impairment and deteriorative pathological consequences.

THERMOGRAPHY

The International Chiropractors Association holds that thermography or thermal diagnostic analysis has been an integral part of chiropractic since the 1920's. It is valid diagnostic modality in the practice of chiropractic.

The International Chiropractors Association further recognizes the value of thermographic examination and protocol procedures, having been established in refereed, peer-reviewed scientific journals, as well as being taught and used under the auspices of CCE-accredited chiropractic colleges.

It is the position of the International Chiropractors Association that thermography studies are a reasonable and customary method of chiropractic examination to evaluate the autonomic components of the vertebral subluxation complex, when clinical need for the study has been established by the attending doctor of chiropractic.

TEXAS
GUIDELINES FOR
CHIROPRACTIC QUALITY ASSURANCE AND
PRACTICE PARAMETERS

A UNITED EFFORT BY THE CHIROPRACTIC PROFESSION IN TEXAS TO ESTABLISH ITS OWN PRACTICE GUIDELINES USING ACCEPTED CONSENSUS METHODS.

COMMISSIONED BY THE TEXAS CHIROPRACTIC ASSOCIATION AND BASED UPON THE GUIDELINES FOR CHIROPRACTIC QUALITY ASSURANCE AND PRACTICE PARAMETERS OF THE MERCY CENTER CONSENSUS CONFERENCE.

A T.C.A. PUBLICATION
1994

3

Instrumentation

Chapter Outline

rough approximation of capability (15,64,167,207) and its use is limited. Accuracy in manual assessment requires differences in strength of 35% or more.(166) Hand-held dynamometers, while not eliminating all the problems of manual testing, provide greater degrees of accuracy and reliability.(19,26,177)

2. Instrumented strength measurement testing

Diagnostic assessment naturally falls into three categories: 1) preventive evaluation (as in employee job-matching); 2) post-injury evaluation; and 3) outcome monitoring following treatment. (5,16,81,127,149,152,166,172,195) Significant clinical information can be obtained toward these objectives, but careless interpretation of test data can result in inappropriate clinical decisions. Acute disorders are a contraindication to strength test protocols. The average discrepancy between symmetrical muscle groups for healthy populations has been reported as much as 12% (17,123,135,166,217) When evaluating an individual's performance, differences of 20% or more may be needed to discriminate abnormalities.

a. Isometric testing

There are several technical concerns in the performance of isometric tests: 1) the inertial effects at the onset of the test; 2) patient fatigue; 3) patient posture; and 4) patient motivation. The objective of the test is to identify and record the maximum voluntary contraction force that can be sustained.(30) At this time,the tasks that can be adequately represented with isometric tests are sagittally symmetrical. Up to 70% of work postures can be approximated symmetrically. Normative data for occupational classifications of lifting activities (29,214) as well as for reciprocal trunk strength ratios (113,131,195) are available. Normative data is used to evaluate extremity strength for post-injury assessment or seasonal sports fitness.(166) Bilateral differences greater than 15-20% indicate abnormality.

b. Isokinetic testing

The primary measurement obtained is the torque generated which is only valid during the controlled part of the motion. The maximum voluntary effort will coincide with the greatest mechanical advantage of the joint for the motion that is being attempted.(10) There are two technical concerns with isokinetic measurements. They are: 1) gravitational effects; and 2) torque overshoot. Both may be corrected through computerized correction routines and damper settings. Standard isokinetic measurements are commonly taken at increments of 30 degrees per second using 2-6 repetitions with the maximum single torque value used as the measure of performance. As with isometric evaluation, the normal extensor/flexor trunk ratio falls when impairment is present.(16,124,128,130,188,195) Kannus, (109) Nunn and Mayhew(144) feel the side-to-side comparison of extremity testing has some importance.

c. Isoinertial testing

While no testing method devised allows an assessment of free dynamic motion such as would occur at a work site or in sports, isoinertial equipment may come closer than others. Several authors have examined the ability to predict performance by controlling torque during movement.(99,104,105,120,121,149,185) Isoinertial systems can be made capable of monitoring position, velocity and torque simultaneously. Measures of regional coupled motions appear to hold promise in discriminating fatigue effects from healthy movement.(149) Likewise, velocity measurements appear to be sensitive to lumbar spine disorders. Normative data is available for a number of occupational subgroups including sedentary workers.(74)

Physiologic Measurements

A. Thermographic Recordings

Body heat loss to the environment takes place passively by convection, conduction, radiation, and evaporation. Regional body temperature is governed by the interaction of central autonomic control mechanisms(165) and multi-segmental spinal vasomotor reflexes.(67) Regional variations of sympathetic thermoregulation produce a complex pattern of temperature distribution including cephalocaudal, diurnal and circadian patterns.(78) Accurate measure requires accommodation of the skin to an ambient room temperature of 20.0 to 25.0C. For reproducible measures, the patient needs to establish constant patterns of work and rest and follow-up testing should be performed at the same time of day.(159) Measurements of skin temperature and the amount of heat radiated from anatomically symmetrical regions yields useful information about the relative circulatory volume to each part. Areas of increased cutaneous temperature have been ascribed to vasodilation, inflammation,(1,52,95,114,115,116,146) and muscle spasm,(40,51,110) to name a few. Decreased cutaneous temperature may reflect vasoconstriction, vascular obstruction, or fibrous and fatty replacement.(106) An abundance of literature is available documenting employment of thermography as a screening tool; e.g., detection of deep vein thrombosis, identification of allergic reaction,(9) qualification of vascular phenomena, and the identification of pain.(151,175) The clinical value of the data, however, remains uncertain.

1. Thermocouple devices

Several thermocouple devices have been marketed to be used for the manual determination of local paraspinal temperature variations.(43,155,197) While sometimes still used, these types of paraspinal measures have not been shown to have good discriminability, and both their validity and reliability of measurement is highly doubtful.(31,197)

2. Telethermography

Measurement of skin temperature differences across the torso, head an extremities is a highly controversial procedure that has been proposed as a means of evaluating functional changes from somatic lesions. Various forms of "gold standard" comparison have been used including surgical confirmation of disc herniation and percentage agreement or statistical correlation with other more widely accepted diagnostic procedures. Normative date are available; for example, see Chang et al., 1985, (31) Feldman and Nickolff (55) 1984, Goodman et al., 1986 (75) and Uematsu et al., 1988. (198) A number of efforts to evaluate diagnostic truth from telethermographic measures have been made. (77, 94,198,199) Unfortunately, a high proportion of the writings on the topic reflect opinion or fail to account for sample population factors such as prevalence, bias or experimental blinding procedures.

The results of comparative studies of thermography and other diagnostic procedures for nerve root entrapments are quite varied. (52,68,158) Where some studies claim that thermography has little diagnostic and uncertain prognostic value in the evaluation of low back pain and radiculopathy, (134,183) others praise its sensitivity and positive predictive value. (28,198) Thermographic images have been used in the diagnosis of myofascial pain syndromes and their respective pain referral zones. Perhaps the strongest evidence for use of telethermography is for cases of suspected neurodystrophy. (150,20) There has been a high correlation between the thermographically defined referral zones and those as described in the literature. Additional zones, not previously identified, have also been recognized. (47) Meta-analysis attempting to resolve the question of clinical utility for thermography has concluded that the procedure cannot be recommended as routine since its role remains unclear. (88)

Hubbard (94b) has written an interesting commentary on various criticisms of the thermography literature for lumbar radiculopathy concluding with the need for more studies published in the "mainstream" literature with attention to the political climate and valid criticism.

3. Liquid Crystal Thermography

Liquid crystal thermography is a diagnostic tool that uses an elastomeric sheet impregnated with cholesteric crystals which is placed in contact with the patient's body. Body temperature differences can be displayed, studied and stored as a permanent record.

B. Galvanic Skin Response (GSR)

Devices to detect differences in paraspinal regional electrical skin resistance have been employed by the chiropractic profession for many decades. Loci of lowered skin resistance were thought to be related to areas of cutaneous hyper or hyposympathetic activity which, themselves, would be due to a putative vertebral subluxation. Other devices have been employed to detect punctate areas to lowered skin resistance putatively corresponding to acupuncture points (i.e.,"point finders"). A final category consists of an apparatus designed to measure digital (hand) GSR, thought to reflect global levels of sympathetic nervous system activity, and, by influence, general levels of arousal.

These devices are subject to a high degree of intra- and inter-subject variability calling into question their reliability. Older Class II studies are seriously in need of update and replication with modern instrumentation and more rigorous research methodology. Recent Class II studies have cast serious doubt on the reliability and validity of GSR in assessment of spinal dysfunction. (70,140)

C. Electrophysiologic Recordings

Several variables affect all electrophysiologic recordings: 1)the size and location of the recording electrode; 2)the configuration of the electrode position relative to the structure being recorded; 3)characteristic resistance of the tissues; 4)the pathophysiology of the patient's problem and 5)artifacts.

1. Electrodiagnosis

Several specialized procedures are available to evaluate select neuromuscular functions. These include measures of myoelectric activity during muscular loading, fatigue studies, conduction velocity tests, H-wave and F-wave responses, and evoked potentials. Generally these studies can be simply grouped as either 1)stimulation studies; or 2)electromyography (EMG). (37) The clinical procedures are sometimes divided according to whether needle or surface electrodes are used.

Surface electrode studies may be used in many cases, but are traditionally applied to the examination of nerve conduction velocities, reflex studies and kinesiological evaluations. (23,126) In kinesiologic applications, up to 16% of the surface recordings from the upper leg muscles, for example, is from co-contraction activity. (49) Surface electrodes may be used with repetitive stimulation to examine suspected myoneural junction disorders. Somatosensory evoked potentials (SSEP) are performed with surface electrodes. SSEP serve to discern between peripheral and cord (dorsal column) lesion sites.(79) Needle electrode studies are classically termed electromyography. This technique may be used in all varieties of electrodiagnostic studies, but it is required to detect denervation, myoneural junction disorders, cerebellar and brainstem tremors, anterior cord disease and motor unit potentials. To obtain accurate information about single motor units, needle electrodes are necessary.

a. Nerve stimulation studies

Nerve stimulation studies can be performed using either surface or needle electrodes. Basic information may be gained about the neuromuscular peripheral sensory and motor components using conduction velocity and reflex responses of the nerve (i.e., H-reflex and F-waves). Practically, this information may be used to evaluate the nerve trunk integrity as well as significant compression, or temporal dispersion from entrapment or metabolic neuropathy. Both sensory and motor studies permit analysis of wave form, amplitude and duration of the impulse. (98) Nerve compression from lumbar root lesions can be quantified. (44,53,79,211) While nerve conduction velocity is a poor index for radicular syndromes, F-waves and H-reflexes are more useful. Similar use can be made for study of complaints from the upper extremity. (79,193) Sensitivity and specificity for each of the following electrodiagnostic procedures are well studied. Se-

THE DOCUMENTARY BASIS FOR DIAGNOSTIC IMAGING PROCEDURES IN THE SUBLUXATION-BASED CHIROPRACTIC PRACTICE

BY

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CHAPTER 8

Thermography

Abstract

The practicing chiropractor is frequently faced with the challenge of providing objective documentation of soft tissue lesions. Thermography has been used to detect and characterize neuromuscular dysfunction, and is a useful tool in evaluating vasomotor changes following sensory nerve irritation. (1,2)

Introduction

Soft tissue lesions due to injury or degenerative changes in the spine are frequently encountered in chiropractic practice. Traditional examination procedures often involve subjective interpretation by the examiner, or reports of pain and reduplication of symptoms by the patient. Equivocal clinical findings, the need for medico-legal evidence, or unsatisfactory response to a course of treatment are indications for additional examination procedures such as thermography, EMG, videofluoroscopy, CT, and MR imaging.

Plain radiography, videofluoroscopy, CT, and MR imaging provide anatomical and biomechanical information. In contrast, thermography provides physiological data. Correlation of history, physical findings, imaging studies, and physiological studies enable the clinician to more effectively evaluate the components of the vertebral subluxation complex, and better characterize the soft tissue lesion.

Thermography

Since the introduction of the neurocalometer by Evins in 1924, skin temperature measurements have played a significant role in the clinical practice of chiropractic. (3) In the 1960's, thermographic imaging was being used by investigators to evaluate spinal lesions. (4,5) Sensory nerve irritation is believed to produce reflex vasoconstriction of the arterioles of the skin, altering thermographic patterns. Urrichio described thermography as a physiological test that aids primarily in the diagnosis of sensory nerve irritation. He stated that when a sensory nerve is irritated, the sympathetic nerve fibre associated with it causes vasoconstriction of the capillaries under the skin. (6)

Early thermographic research in neuromusculoskeletal disorders resulted in equivocal findings. Karpmen et al noted that "Traumatic back injuries were readily evaluated thermographically," and reported that "No patient...had a normal thermogram in association with an abnormal x-ray film." (7)

Edeiken et al conducted early investigations where thermographic studies were compared with myelographic findings in patients with herniated discs. They concluded that "The thermographic and myelographic findings were similar." (8) Edeiken later recanted the results of his early studies. He stated that neuromuscular thermography was an investigational and research tool, but not useful in the diagnosis and management of musculoskeletal disease. (6) Goldberg et al reported that "...thermography of the back was negative in cases of herniated intervertebral discs." (4)

Much of the controversy surrounding early thermographic studies in neuromuscular disorders appears due to a failure to clearly define a "normal" thermographic pattern. In addition, failure to use standardized protocols could also have contributed to these conflicting reports. (9)

Standardized protocols and computer assisted analysis have dramatically improved the diagnostic sensitivity of thermography in neuromuscular disorders. Uematsu et al developed a computer calculated method of collecting thermographic data. They compiled normative data on 90 asymptomatic patients. Readings were obtained from 40 matched regions of the body surface. They then examined thermal asymmetries in 144 patients with low back pain. When asymmetries exceeded more than one standard deviation from the mean temperature of homologous regions in control subjects, the positive predictive value in detecting nerve root impingement was 94.7%. The specificity, or proportion of persons without the condition who had a negative test result, was 87.5%. (10,11)

Chafetz et al compared thermographic examination with CT of the lumbar spine. Fifteen asymptomatic subjects and 19 patients with CT scans demonstrating thecal sac contour distortion or nerve root displacement were examined. All 19 patients with positive CT scans had abnormal thermograms, a sensitivity of 100%. The specificity, however, was 60%. (12)

Several other investigators have compared thermographic findings with those of other diagnostic modalities. Weinstein and

Weinstein compared cervical thermography with EMG, CT, myelography, and surgical exploration. Five hundred patients with neck or upper extremity complaints were studied. One hundred ninety-seven (39.4%) were found to be positive for root pathology. Of these, 190 (96.4%) were ultimately confirmed by EMG, CT, myelography, and/or surgery. (13)

Hubbard conducted a study of 805 thermographic examinations. A high correlation was reported (94%) between pain distribution patterns and cervical and lumbar thermograms. The thermographic results were well correlated with EMG, myelography, and CT studies. Fifty-two control thermographic studies were performed on young asymptomatic patients, and 90% were reported as "normal." (14)

Despite the value of thermography as a diagnostic tool in the evaluation of soft tissue lesions, there are potential shortcomings which must be addressed:

1. Electronic thermographic equipment is expensive.
2. Strict protocols must be followed to minimize artifacts.
3. Interpretation requires a high level of training and experience.
4. The examination is relatively time consuming.
5. The use of thermographic imaging to evaluate motor nerve involvement is not supported in the literature.

The principal application for thermography in the evaluation of soft tissue lesions appears to be in demonstrating and characterizing sensory nerve involvement.

Legal Considerations

To the chiropractor involved in personal injury cases, admissibility of a diagnostic test is an important consideration. Another concern is whether a given procedure is reimbursed by third party insurers. The Florida case of *Palma v. State Farm Fire and Casualty Company* addressed the issue of whether thermography was a necessary medical expense under a no-fault statute. The trial court held that thermography was of "unproven and dubious value in the diagnosis of musculoskeletal disease and nerve root impingement." The Fourth District Court of Appeals reversed the decision of the trial court.

The appeals court found that the trial court erred in ignoring the Second District Court of Appeal in the case of *Fay v. Mincey*. The court held that thermography when "used by qualified health-care professionals...is a sufficiently reliable and acceptable 'scientific medical' diagnostic procedure, and, therefore, testimony and evidence relating to a particular thermographic study is admissible under appropriate circumstances." (6,15)

In *Palma*, the appeals court by implication required payment for thermographic studies found necessary and ordered by the treating chiropractic physician. In the New Jersey case of *Thermographic Diagnostics v. Allstate*, the court held that "...thermography has a firm scientific basis...It is beyond the period of initial research and has medical value..." (16, 6)

Conclusion

Thermography may be used to characterize thermal changes associated with neuromuscular dysfunction associated with the vertebral subluxation complex.

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DOCUMENTARY EVIDENCE

The Chiropractic Care of Myofascial Patients

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sitivity is normal or abnormally high or low. He writes, "**Normal PTo in the deltoid and shin bone in a patient with chronic pain syndrome involving the lower back, the neck, or other parts of the body proves that the painful condition developed as a result of injury or pathology and is not related primarily to the patient's hypersensitivity to pain. This conclusion has important clinical, medical, and legal implications. Patients who are accused of malingering after having suffered trivial injuries that then resulted in chronic pain can be exonerated by proving to have abnormally high or normal pain tolerance. A lower-than-normal pain tolerance may explain the complaints in other cases.**"[5,p.407]

Physically active patients, particularly athletes, may exhibit increased PTo.[6] On the other hand, patients who are generally poorly conditioned have a lower pain threshold. [8,p.297-298]

GAUGING TREATMENT TO PATIENT NEEDS

Decreased PTo over both bone and muscle indicates that the patient has a low pain threshold. Physical and manual therapies may exacerbate this patient's symptoms. The intensity of therapy should be tempered properly until the patient's PTo increases, as indicated by successive algometer measurements.[5,p.408]

GENERALIZED MUSCLE TENDERNESS

Pressure algometry is also of value in determining whether a patient has diffuse generalized muscle tenderness. Decreased PTo over the deltoid (or muscles in general) in relation to the tibia suggests myopathy or an endocrine or metabolic disorder that affects the myofascia. Such conditions include hypothyroidism and estrogen deficiency,[7] as well as hypoglycemia and partial peripheral resistance to one's endogenous thyroid hormones. [9][10]

Thermography

Hot spots (HSs) on thermograms are small areas that are warmer than surrounding skin or the corresponding skin on the normal contralateral side of the body. They are often discoid in shape. HSs are usually less than 5 to 10 cm in diameter, and they are 1 to 2° C warmer than normal skin areas. HSs are thought to result from the deep-to-superficial flow of blood caused by irritative foci such as myofascial trigger points. Fischer and Chang emphasize that the point of maximum tenderness in a HS is usually located eccentrically and not in the middle of the HS. Their explanation for this eccentric location is that the veins carrying the blood from deep to superficial layers of tissue run diagonally and not perpendicularly. These authors measured with an algometer the point of maximum tenderness in HSs of 14 patients. The PTs (pressure/pain thresholds) of the points of maximum tenderness were statistically significantly lower than over the contralateral normal tissues.[11]

Fischer conducted a study of 50 subjects in which he used algometry to compare the pressure sensitivity of HSs with normal tissues on thermograms. Algometric measurements of the HSs showed that the increased heat emission corresponded to a point that was abnormally pressure-sensitive. When the tender point in a HS was 2 kg/cm^2 more sensitive to pressure than the corresponding tissue on the opposite side of the body, 87% of HSs contained such tender points. When the tender point in the HS was 1.5 kg/cm^2 more sensitive than the opposite side, 97.8% of HSs contained tender points. Fischer wrote, "The results indicate the high sensitivity of PTH (PT) in detection of tender spots manifested as HSs, and show that a 1.5% side-to-side difference is preferable as a criterion."[12,p.148] He found that the difference in PT between HSs and the opposite normal sides was statistically highly significant ($P < 0.0001$).

Fischer points out that a hypersensitive point whose sensitivity has been quantified by PT measurement may be either a myofascial TrP or a fibromyalgic TnP; differential diagnosis may be necessary.[12,p.148] **My thinking on the question is that a TnP is on a continuum with a TrP. The difference being that with a TnP, the threshold of the local nerve endings in a palpable taut band hasn't decreased sufficiently to give rise to the phenomena of referred sensation or autonomic phenomena. One reason I say this**

is that it has been conceded by authorities of fibromyalgia that when subjected to compression, some foci diagnosed as TnPs do refer like TrPs.[25] The difference between TnPs and TrPs, then, is probably one of degree of irritability.

24-Hour Electromyography (EMG)

Patients with myofascial pain syndromes may have palpable spasms in the area of pain complaint that persist even while the patient is asleep. Fischer and Chang[13] conducted a study with 9 experimental subjects and 12 control subjects. Most experimental subjects had spasms on one side of the back, which corresponded to the side of complaint. Spasms were detected by palpation with the fingertips of one clinician, and were confirmed by two other independent clinicians. EMG recordings from surface pasted-on electrodes were obtained with a portable, battery-operated tape recorder that patients wore for 24 hours. The researchers found that on the spasmodic sides of the patients' backs, the average microvoltage was 11.67, whereas the average microvoltage on the non-spasmodic sides was 1.11. The microvoltages from both sides of the backs of control subjects were an average of .2227. These differences are highly statistically significant.

The correlation between painful muscle spasms and elevated EMG activity has been demonstrated.[20][21] Normal muscles produce no electrical activity when they're at rest,[14][15][16][17] as during sleep.[14,p.83][18][19] Fischer and Chang's study confirmed that people without palpable paraspinal spasms generate no significant electrical activity during sleep. It also demonstrated, however, that **palpably spastic paraspinal muscles do generate significant electrical activity during sleep. This is significant because the muscle's electrical activity was unrelated to any conscious, voluntary efforts of the patients.**

Fischer and Chang found that 24-hour EMG records showed that **the patient's use of spastic muscles during his waking hours gave rise to a higher EMG output from those muscles. They pointed out that this finding is relevant to patient management in that spasms may be aggravated by use of the muscles.[13,p.153]** Rest, with time off from work if necessary, is judicious when spasms are present.

The authors point out that use of 24-hour EMG recording equipment may not at this time be feasible for clinicians. They recommend as alternatives use of a tissue compliance meter (which shows abnormal resistance to penetration associated with spastic muscle contractions),[22] and thermography (which records heat from localized hyperthermia associated with spastic muscles).[11]

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be available in the courtroom. A better alternative is the use of a positive print of the X-ray. Use of a positive print also maximizes the likelihood that the trial judge will allow the X-ray to go with the jury into the deliberation room. This is clearly preferable to simply displaying it during the physician's testimony.[3]

[1] Lane's Goldstein Tr Tech §12.80 (3rd Ed); Annot, Preliminary Proof, Verification, or Authentication of X-rays Requisite to Their Introduction in Evidence in Civil Cases, 5 ALR3d 303.

[2] Annot, Admissibility Under Uniform Business Records as Evidence Act or Similar Statute of Medical Report Made by Consulting Physician to Treating Physician, 69 ALR3d 104, §5; Annot, Admissibility of X-ray Report Made by Physician Taking or Interpreting X-ray Pictures, 6 ALR2d 406.

[3] Annot, Propriety of Permitting Jury to Take X-ray Picture, Introduced in Evidence, With Them into Jury Room, 10 ALR2d 918.

§7:09. Thermograms.

Thermography is a diagnostic method to determine the existence or degree of soft tissue injuries to nerves or muscles.[1] There are presently two types of thermography, liquid crystal and electronic. The liquid crystal technique involves the placement of a flexible rubber sheet of heat sensitive crystals about the area of the body to be investigated. The sheet conforms to the body and is warmed by skin temperature. Changes in the color of the crystals are proportional to the temperature of the skin with which they have made contact.[2] Electronic thermography is based upon the principle that the wavelength of infrared energy is proportional to temperature. Sensors measure the infrared energy emitted by the skin of the subject and convert that energy into electronic impulses. A computer interprets the electronic impulses and projects the result on a television screen, in color, with variations in the color of the display representing variations in skin temperature.[3] A thermogram is the graphic representation of the heat emitted from the affected area of the patient's body. In the case of electronic thermography, it is a color photograph of the computer screen.[4]

While the principles involved in thermography have been known since the time of Hippocrates,[5] the technology to make diagnostic use of these principles has evolved only relatively recently. As a new and somewhat controversial technique,

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thermography has met with considerable resistance offered as evidence in the courts.[6] Three areas of difficulty emerged: acceptance of thermography as a valid scientific the expertise of the sponsoring witness[8] and the pı administration of the test itself.[9]

The landmark case concerning the admissibility of a scientific test is Frye v. United States.[10] Frye held that, foı results of a test to be admissible in evidence, the scien principles from which the test's deductions are made mus sufficiently established as to have general acceptance in relevant scientific community as being reliable and accur Despite the fact that there are several thousand articles c cerning thermography[11] and a number of books devoted to subject,[12] this has been a problem in many of the early case Until thermography gains general acceptance with the cou counsel should have the sponsoring witness make spec reference to the wealth of favorable literature on the subject a counsel should be prepared to introduce in evidence represen tive publications from reputable journals which speak favoral of thermography as a diagnostic tool in soft tissue injury cas In the past, the American Medical Association characteriz thermography as a diagnostic technique still under investig tion.[14] The author has now been advised that the Associatior committee on the subject has withdrawn that opinion and ma soon release a position paper accepting thermography as a val diagnostic tool.[15] This recognition by the leading medic association in the United States should greatly assist i satisfying the requirement set out in Frye.

The second problem area with the admissibility of thermo grams in trial has been the lack of expertise of the sponsorin expert witness. In part, this has been attributable to the relativ novelty of thermography. Because the clinical use of thermogra phy is fairly new, most witnesses involved in the reported case admittedly had little training or familiarity with it. However thermography is now sufficiently recognized and board certifi- cation in this subspecialty is offered by two different groups: the American Academy of Thermographers, composed entirely of medical doctors, and the American board of Clinical Thermology, an interdisciplinary group including chiropractors.

A chiropractor has been held to be a properly qualified expert to administer and testify concerning thermography.[16]

The final area of concern in presenting thermography testimony has been the proper administration of the test. Specialty groups in the field have established definite protocols which must be strictly followed for the test to be considered valid. This is ripe ground for cross-examination and could easily lead to exclusion of the test results. Requirements include certain preparatory conduct or abstention on the part of the injured party with regard to cigarette smoking, pain medication and even bathing. Requirements also exist for the test site, such as a strictly temperature-controlled room, proper allowance for the patient to adjust to the ambient temperature while unclothed, and so on. Constant observation of the patient is required as are multiple administrations of the test over a period of time to preclude any possible feigned result by action on the part of the test subject.[17]

A thermogram can vividly illustrate a plaintiff's soft tissue injury for the jury. If an injured party has been complaining to the treating physician or chiropractor for a long period of time, of pain in the area of the left shoulder blade, for example, a clearly asymmetrical thermogram showing an area of hot temperature in that vicinity may convince the jury that the plaintiff's complaints have been genuine, despite any lack of objective findings on the part of the defense medical examiner. For such reasons, thermography is a technique with which every personal injury attorney should become intimately familiar.

---

[1] Rein, The Primer on Thermography (1983); Note, Thermography, Objective Evidence of Nerve and Soft-Tissue Injury, 21 Idaho L Rev 117 (1985).

See generally Wexler, An Overview of Liquid Crystal and Electronic Lumbar, Thoracic and Cervical Thermography (1978); Wexler, Atlas of Thermographic Lumbar Patterns (1978); Rein, Thermography: The Medical and Legal Implications, 20 Trial 46 (Fall 1984); Zinn, Thermograms: Persuasive Tools in Soft Tissue Injury Cases, 19 Trial 68 (February 1983).

[2] Procida v. McLaughlin, 195 NJ Super 396, 479 A2d 447 (1984).

[3] Procida v. McLaughlin, 195 NJ Super 396, 479 A2d 447 (1984).

[4] Procida v. McLaughlin, 195 NJ Super 396, 479 A2d 447 (1984).

[5] Hippocrates noted that mud placed upon an inflamed area of a patient's body dried more rapidly than mud on surrounding areas. The basic principle of

thermography is that injured soft tissues become inflamed and have greater blood flow resulting in warmer skin temperature near the affected area. Ordinarily, skin temperature should be extremely close to identical on the right and left sides of the body. Asymmetry in heat distribution is indicative of inflammation and therefore of some abnormality. Rein, The Primer on Thermography (1983).

[6] Admitting thermograms in evidence: Fay v. Mincey, 454 So 2d 587 (Fla 1984); Blanchard v. A-1 Bit & Tool Co., 406 So 2d 773 (La App 1981); Argenta v. Shahan, 135 Mich App 477, 354 NW2d 796 (1984), revd on other grounds 424 Mich 83, 378 NW2d 470 (1985) (thermographic evidence not opposed); Procida v. McLaughlin, 195 NJ Super 296, 479 A2d 447 (1984).

Contra McAdoo v. United States, 607 F Supp 788 (ED Mich 1984); Burkett v. Northern, 43 Wash App 143, 715 P2d 1159, review den 106 Wash 2d 1008 (1986).

See Annot, Thermographic Tests: Admissibility of Test Results in Personal Injury Suits, 56 ALR4th 1105; 46 Am Jur 2d, Proof of Facts, §275 (excellent list of questions and answers to establish proper foundation for test and sponsoring witness).

[7] See, e.g., McAdoo v. United States, 607 F Supp 788 (ED Mich 1984).

[8] See, e.g., Burkett v. Northern, 43 Wash App 143, 715 P2d 1159, review den 106 Wash 2d 1008 (1986).

[9] Ferlise v. Eiler, 202 NJ Super 330, 495 A2d 129 (1985).

[10] Frye v. United States, 293 F 1013 (CA DC 1923).

[11] Procida v. McLaughlin, 195 NJ Super 396, 479 A2d 447 (1984).

[12] Procida v. McLaughlin, 195 NJ Super 396, 479 A2d 447 (1984).

[13] See, e.g., McAdoo v. United States, 607 F Supp 788 (ED Mich 1984).

[14] Burkett v. Northern, 43 Wash App 143, 715 P2d 1159, review den 106 Wash 2d 1008 (1986).

[15] In December of 1987, the American Medical Association's Council on Scientific Affairs issued an "informational report" favorable to the diagnostic use of thermograms. The report has not yet formally been accepted or approved by the House of Delegates. American Medical Association, Council on Scientific Affairs, Informational Report of the Council on Scientific Affairs: Thermography in Neurological and Musculoskeletal Conditions (Dec., 1987).

[16] Faye v. Mincey, 454 So 2d 587 (Fla 1984).

[17] Procida v. McLaughlin, 195 NJ Super 396, 479 A2d 447 (1984).

§7:10. Photographs.

The introduction of well-chosen photographs into evidence allows the trial lawyer to visually transport the jury to the scene of an accident, to transform testimony about distances into meaningful spatial relationships and to display for the jury the actual injuries about which the plaintiff has testified. Photo-

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to be sensitive to lumbar spine disorders. Normative data is available for a number of occupational subgroups, including sedentary workers.

THERMOGRAPHY

Since the introduction of the neurocalometer by Zvins in 1924, skin temperature measurements have played a significant role in the clinical practice of chiropractic. In the 1960s, thermographic imaging was being used by investigators to evaluate spinal lesions. Sensory nerve irritation is believed to produce reflex vasoconstriction of the arterioles, of the skin, altering thermographic patterns. Urrichio described thermography as a physiological test that aids primarily in the diagnosis of sensory nerve irritation. He stated that when a sensory nerve is irritated, the sympathetic nerve associated with it causes vasoconstriction of the capillaries under the skin.

Early thermographic research in spinal disorders resulted in equivocal findings. Karpmen et al noted that "Traumatic back injuries were readily evaluated thermographically," and reported that "No patient ... had a normal thermogram in association with an abnormal x-ray film."

Standardized protocols and computer assisted analysis have dramatically improved the diagnostic sensitivity of thermography in neuromuscular disorders. Uematsu et al developed a computer-calculated method of collecting thermographic data. They compiled normative data on 90 asymptomatic patients. Readings were obtained from 40 matched regions of the body surface. They then examined thermal asymmetries in 144 patients with low back pain. When asymmetries exceeded more than one standard deviation from the mean temperature of homologous regions in control subjects, the positive predictive value in detecting nerve root impingement was 94.7%. The specificity, or proportion of persons without the condition who have a negative test result, was 87.5%. Chafetz et al compared thermographic examination with CT of the lumbar spine. Fifteen asymptomatic subjects and 19 patients with CT scans demonstrating thecal sac contour distortion or nerve root displacement were examined. All 19 patients with positive CT scans had abnormal thermograms, a sensitivity of 100%. The specificity, however, was 60%.

Several other investigators have compared thermographic finding with those of other diagnostic modalities. Weinstein and Weinstein compared cervical thermography with EMG, CT, myelography, and surgical exploration. 500 patients with neck or upper extremity complaints were studied. 197 (39.4%) were found to be positive for root pathology. Of these, 190 (96.4%) were ultimately confirmed by EMO, CT, myelography, and/or surgery.

Hubbard conducted a study of 85 thermographic examinations. A high correlation was reported (94%) between pain distribution patterns and cervical and lumbar thermograms. The thermographic results were well correlated with EMO, myelography and CT studies. 52 control thermographic studies were performed on young asymptomatic patients, and 90% were reported as "normal."

At least two state Appellate Court decisions have found that evidence relating to liquid crystal thermography results are admissible as evidence to demonstrate injury resulting from automobile accidents. See Fay v. Mincey, 454 So.2d 587 (Fla. 2nd DCA 1984); Crawford v.

Shivashankar, 474 So.2d 873 (Fla. 1st DCA 1985).

Despite the value of thermography as a diagnostic tool in the evaluation of soft tissue lesions, there are potential shortcomings which must be addressed:

1. Electronic thermographic equipment is expensive.

2. Strict protocols must be followed to minimize artifacts.

3. Interpretation requires a high level of training and experience.

4. The examination is relatively time consuming.

5. The use of thermographic imaging to evaluate motor nerve involvement is not supported in the literature.

The principal application for thermography in the evaluation of soft tissue lesions appears to be in demonstrating and characterizing sensory nerve involvement.

Body heat loss to the environment takes place passively by convection, conduction and radiation. Regional body temperature is governed by the interaction of central autonomic control mechanisms and multi-segmental spinal vasomotor reflexes. Regional variations of sympathetic thermoregulation produce a complex pattern of temperature distribution including cephalocaudal, diurnal and circadian patterns. Accurate measure requires accommodation of the skin to room temperature, which should be kept at between 33.5 to 34 C. For reproducible measures, the patient needs to establish constant patterns of work and rest and follow-up testing should be performed at the same time of day. Measurements of skin temperature and the amount of heat radiated from anatomically symmetrical regions yields useful information about the relative circulatory volume to each part. Areas of increased cutaneous temperature have been ascribed to vasodilation occurring during a migraine headache, inflammation or muscle spasm. Decreased cutaneous temperature may reflect vasoconstriction, vascular obstruction, fibrous and fatty replacement. An abundance of literature is available documenting employment of thermography as a screening tool; e.g., detection of deep vein thrombosis, identification of allergic reaction, qualification of vascular phenomena, and the identification of pain.

1. Thermocouple devices

   Several thermocouple devices have been marketed to be used for the determination of local paraspinal temperature variations. Patterns of heat along the spinal column and their changes following spinal adjustments, provide useful data in some chiropractic techniques.

2. Telethermography

   Measurement of skin temperature differences across the torso, head and extremities as a means of evaluating functional changes from somatic lesions.

14.4.4. **Rating**: Established
Strength of recommendation: Type B
Consensus Level: 1

B. Muscle strength testing

Many chiropractic techniques utilize manual muscle testing for evaluation of vertebral subluxation. These techniques typically use manual muscle testing for the purpose of vertebral subluxation and other malpositioned articulations and structures analysis and are typically limited to gross bilateral differences in patient resistance or a virtually total lack of resistance that is easily detectable by the experienced practitioner. Manual and mechanized muscle testing may also be used to demonstrate subtle changes in muscle strength as a result of nerve function.

1. Manual - Manual evaluation of muscle strength gives only an approximation of capability. One reference indicates that a difference of 35% in muscle strength must exist to be detected by manual testing.

14.5.1. **Rating**: Estabished
Evidence: E, L
Consensus Level: 1

2. Hand-held (Dynamometer) - The dynamometer is a hand-held device which produces greater reliability and accuracy than manual testing.

14.5.2. **Rating**: Estabished
Evidence: E, L
Consensus Level: 1

3. Modular - Isometric (e.g., Dynatron 2000, myo-logic), Isokinetic, Isoinertial.

14.5.3. **Rating**: Established
Evidence: E, L
Consensus Level: 1

Physiologic and Electrophysiologic Measurements

A Temperature reading devices

Highly significant temperature changes have been noted in spinal and paraspinal tissues following a chiropractic adjustment. Hand-held thermographic devices "have been evaluated and shown to have moderate to excellent inter-examiner reliability over short time durations."

Early chiropractic investigators recognized three basic physiological concepts that underlie the value of cutaneous thermography:

- ☐ the body is segmented into "dermatomes";
- ☐ side-to-side skin temperatures are generally symmetrical unless dysfunction exists; and
- ☐ any anomalous deviation from a gradually increasing paraspinal skin temperature from S-2 to C-1 may be indicative of the vertebral subluxation and other malpositioned articulations and structures or other dysfunction.

1. Thermocouple

   a. Single-channel (e.g., chirometer)

   b. Dual-channel (e.g., Neurocalograph (NCGH), Thermoscribe, Analograph)

   The dual probe devices give a bilateral comparative temperature reading of the paraspinal tissues. However, the instrument requires skin contact. Plaugher suggests that the evaluation of the cervicothoracic junction is not suitable, and that inter- and intra-examiner reliability ranges from fair to excellent.

14.6.1.	**Rating**:	Established
	Evidence:	E, L
	Consensus Level:	**1**

2. Infrared Thermography

   Infrared instruments, because they record changes in temperature rapidly and require no skin contact, have been considered superior over thermocouple devices.

   1. Single-channel (dermathermagraph) double-channel (e.g., Accolade, Tytron C-2000, VT 2000)

14.6.2.	**Rating**:	Established
	Evidence:	E, L
	Consensus Level:	**1**

B. Multi(channel (e.g., Visitherm II)

14.7.1	**Rating**:	Established
	Evidence:	E, L
	Consensus Level:	**1**

C. Cryogenic-cooled detector thermal imaging cameras (Inframetrics, Agema, Mikron)

"A thermogram provides a graphic representation of neural fiber irritation by demonstrating a change in the thermal regions, innervated by that particular nerve."

14.8.1 **Rating**: Established
Evidence: E, L
Consensus Level: 1

D. Current Perception Threshold Devices (e.g., neurometer)

The current perception threshold device is a variable constant current sine wave stimulator proposed as a simple non-invasive and quantitative measure of peripheral nerve function. The neurometer has been shown to be appropriate for rapid screening for neural dysfunction.

14.9.1 **Rating**: Established
Evidence: E, L
Consensus Level: 1

E. Electroencephalography (EEG)

Standard EEG and computerized EEG, also known as brain mapping, have been shown to be useful in chiropractic patient management.

14.10.1. **Rating**: Established
Evidence: E, L
Consensus Level: 1

F. Tissue compliance measurements

The tissue compliance instruments measure soft tissue consistency or compliance. Caution should be used in interpreting pre- and post-adjustment readings based on information which has shown that 26% of readings taken ten minutes following initial testing were significantly different without any intervention. A bilateral difference of greater than 2mm at 2 kg is significant and suggests pathological asymmetry.

14.11.1. **Rating**: Established
Evidence: E, L
Consensus Level: 1

2. Surface electromyography (EMG) is the technique of collecting and recording the electrical activity of the muscles.

Clinical Studies

CRJ

A NEW APPROACH TO THE UPPER CERVICAL SPECIFIC, KNEE-CHEST ADJUSTING PROCEDURE: PART I

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Dessislava V. Boneva, DC

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ABSTRACT

Objective: The purpose of this paper is to outline an upper cervical knee chest adjustment procedure for correcting the atlas subluxation.

Clinical Features: The first patient was a 30-year-old man who had indigestion, low back pain, and a spondylolisthesis L5/S1. His examination indicated a C1 subluxation. The second patient was a 27-year-old man with chronic sinusitis, headaches, nervousness, and insomnia. His examination revealed an atlas subluxation. The third patient, a 39-year-old woman, complained of joint pain, depression, nearsightedness, headaches, difficulty breathing, and allergies. Her examination displayed findings consistent with a C1 subluxation.

Intervention and Outcome: All three patients received the upper cervical knee-chest procedure described in this paper. These patients demonstrated correction of their upper cervical subluxation via pre and post Blair protracto x-ray views, spinal thermography, and pelvic balance leg length equality examinations.

Conclusion: The findings of these case studies indicate the upper cervical knee-chest procedure is a successful method for correcting the upper cervical subluxation.

Key Words: Upper Cervical Spine, Atlas Subluxation, Blair Protracto Views, Spinal Thermography, Upper Cervical Knee-Chest Adjustment.

INTRODUCTION

This is part one of a two-part series. This paper will outline an upper cervical knee-chest adjustment procedure for correcting the C1 subluxation. Three patients, each with atlas subluxation, have been chronicled to demonstrate short-term, mid-term, and long-term responses to upper cervical care on the knee-chest table. Part two will reference cases that have presented with C2 subluxation. Part two will outline an upper cervical knee-chest adjustment procedure for correcting the C2 subluxation. The adjusting protocol described in this paper is original and has been developed by the authors.

These three patients received the following protocol for upper cervical analysis. The spinographic examination consisted of an A-P open mouth, neutral lateral, base posterior, left and right 55° diagonals, and left and right Blair protracto views. We performed spinal thermography in the cervical spine and pelvic balance leg check examinations two times, or more, before the first upper cervical adjustment to establish each patient's individual pattern. Immediately following the first upper cervical adjustment and any adjustment following, the patient rested in a supine position with cervical support for one hour. A post leg check was performed along with a post spinal thermography in the cervical spine to detect the short-term effect of each upper cervical correction. We performed spinal thermography and pelvic balance leg checks on each patient during each subsequent office visit, and we used these criteria to determine the progress of the upper cervical correction, as well to ascertain the necessity of an additional upper cervical adjustment.

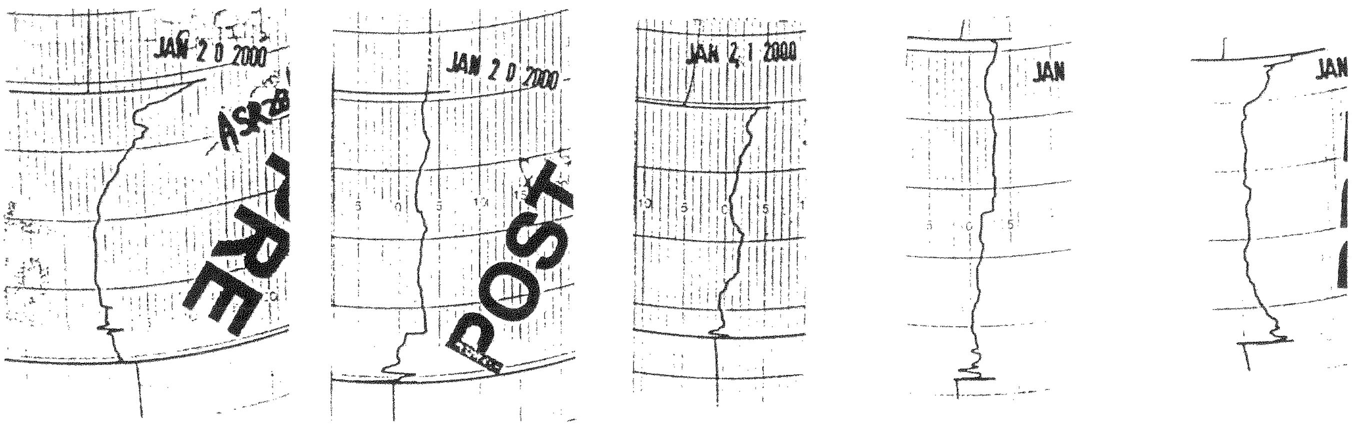
CASE STUDY

The first patient was a 30-year-old man who complained of long standing lower back pain and indigestion. Upon examination it was determined that this patient had a grade 1 spondylolisthesis L5/S1. He frequently had taken over-the-counter antacids for indigestion and was not taking any prescription medications or under any other care program or treatment plan.

Upper cervical chiropractic analysis indicated aberrant neurophysiological function in the cervical spine via spinal thermography and a leg length inequality (LLI)(8 mm short leg right side). His spinal listing was analyzed to be an atlas ASR7/33.5. Additionally, a series of lumbar x-rays consisting of an A-P, lateral, and left and right oblique revealed a stress fracture in the L5 pars.

Over the course of four weeks of care, this patient had ten

There had been no detectable LLI since the upper cervical adjustment. Cervical spine thermography did not improve significantly for two weeks following the upper cervical correction (Fig. 3).



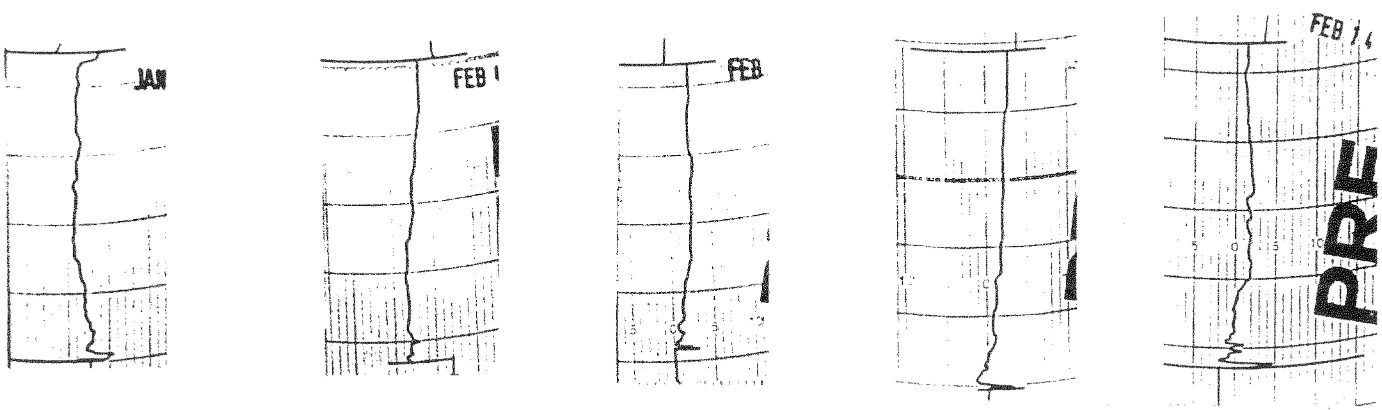
PRE- Jan 20, 2000
Patient's established pattern, LLI-8mm right, "Indigestion, lower back pain"

POST- Jan 20, 2000
Pattern slightly reduced. Reading performed following one hour rest, supine position. LLI absent

PRE- Jan 21, 2000
Pattern persist, LLI-absent, "lower back pain"

POST- Jan 21, 2000
Pattern reduced LLI-absent, "lower back pain is improving"

PRE- Jan 28, 2000
Significantly similar to established pattern, LLI-absent. No adjustment is performed on this day due to balanced leg length, "feeling better"



PRE- Jan 31, 2000
Pattern reduced, LLI-absent "no lower back pain, however has developed a pulling sensation in upper back and down right arm"

PRE- Feb 4, 2000
Reading much improved, LLI-absent, "same as last visit"

PRE- Feb 7, 2000
Clear reading, LLI-absent, "feeling good"

PRE- Feb 11, 2000
Clear reading with no evidence of neuropathophysiology in the cervical spine, LLI-absent, "feeling good"

PRE- Feb 14, 2000
Slightly rough reading with no indication of return to the established pattern, LLI-absent, "feeling good"

FIGURE 3. *Patient 1 daily office visit cervical spine thermography chronicled with LLI examination and subjective findings.*

office visits and received one upper cervical adjustment. The first set of Blair protracto views were taken one day before the first upper cervical adjustment. The post-adjustment right Blair protracto view was taken two weeks following the first upper cervical adjustment. A considerable reduction in the misalignment of the first cervical vertebra can be observed between the pre- and post-adjustment right Blair protracto views (Fig. 1A and B). The pre- and post-adjustment leg check examination from the upper cervical adjustment demonstrates improvement in the LLI (Fig. 2A and B).

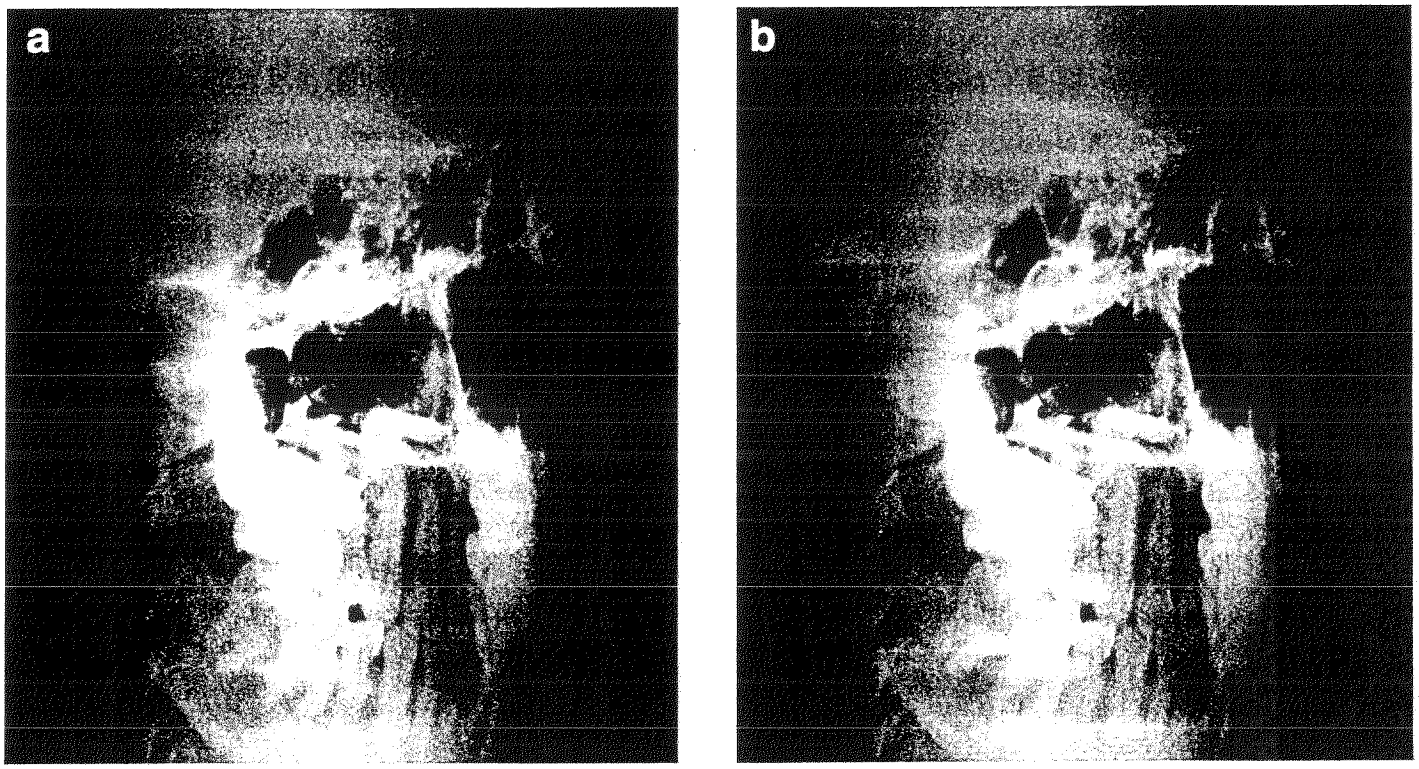


Figure 1 A and B. *A) Patient 1 pre-adjustment Blair protracto x-ray performed prior to the first upper cervical adjustment. B) Patient 1 post-adjustment Blair protracto view performed 2 weeks following the first upper cervical adjustment. The C0-C1 articulation is circled on both films. The lateral margins of this articulation should line up perpendicular to the joint surface angle (slope angle).*

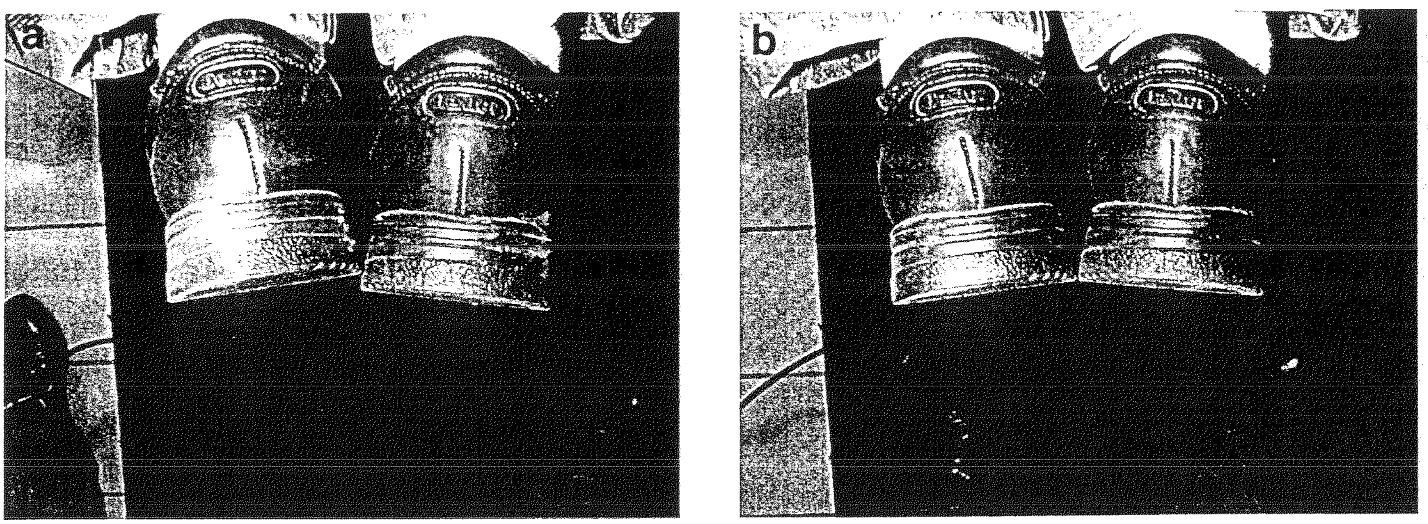


Figure 2 A and B. *A) Patient 1 pre-adjustment leg length inequality (LLI) examination, performed prior to the first upper cervical adjustment, B) Patient 1 post-adjustment LLI examination, performed following the first upper cervical adjustment and one-hour rest.*

LUMBAR RANGE OF MOTION

	Left and Right Lateral Bending			Flexion/Extension		
	Rep 1	Rep 2	Rep 3	Rep1	Rep 2	Rep 3
prior to 1st upper cervical adjustment	59	62	69	92	102	105
following 1 month upper cervical care	67	69	68	108	109	112

TABLE 1. *Illustration of the pre- and post-adjustment lumbar range of motion examination of the patient described in Case 1. The entire motion has been recorded between left and right lateral bending and flexion/extension.*

However, since that time, subsequent thermographic analyses have remained perfect. A lumbar range of motion study (executed using computerized dual inclinometry by J Tech Medical in Heber City, Utah) was performed minutes before the first upper cervical adjustment, repeated after the upper cervical adjustment, again after one hour recuperation, and again on the fourth week of care. No significant improvements were noted between the same day pre- and post-adjustment examination. However, the four-week post-adjustment examination revealed significant improvements in the flexion/extension motion (Table 1).

Lumbar range of motion was performed in the flexion/extension plane, left and right bending plane, and with left and right rotation. For flexion/extension, the patient stood with normal posture, feet shoulder width apart. A skin marking pencil was used to mark T12 spinous process and the sacral base. The dual inclinometer has two sensors, a master and a slave. The master records angles relative to the slave sensor position. These measurements are recorded through a computer program. The master sensor was placed vertically with its midsection coinciding with the sacral base level. The slave sensor was placed with its midsection corresponding to the mark at T12. The patient was asked to bend forward as far as possible and his degree of flexion was recorded by the computer program. Then, the patient was asked to lean back as far as possible, while arching his lower back. At his maximum extension position, his degree of extension was recorded. This procedure was repeated three times. The range of motion study was considered valid if, for three consecutive trials, variation was within 5° or 10%, whichever is greatest. For left and right bending, the master sensor was placed with its superior margin corresponding to the sacral base mark and the slave sensor's inferior margin coinciding with the mark at T12. The patient started in the same neutral position and was asked to bend to the left as far as possible, then to the right as far as possible. Recordings were repeated as described for flexion/extension. For left and right rotation, the patient was asked to put his hands on the top of his shoulders – right hand on left shoulder and left hand on right shoulder. Then, the patient was asked to bend down to approximately 45°. The master sensor was placed on the horizontal plane with its midsection coinciding with the sacral base mark. The slave sensor was placed on the horizontal plane with its midsection corresponding to the mark at T12. The patient was asked to elevate his left shoulder to the maximum position and a recording was made. The patient was then asked to raise his right shoulder to the maximum position and a measurement was recorded. Each plane of motion was examined with three repetitions to comply with the standards set forth for validity as previously discussed.

This patient has reported no subsequent episodes of indigestion or lower back pain. Between the 10th day following the first upper cervical adjustment and the 16th day, this patient experienced a pulling sensation in his upper thoracic region and both shoulders. At the time of this writing, this patient is continuing care and is into his fifth week.

The second patient, a 27-year-old man, began upper cervical chiropractic care after complaining of chronic sinusitis, headaches, nervousness, and insomnia. He denied taking any prescription medication during the course of care and was not involved in any other form of care or treatment. Upper cervical chiropractic analysis indicated aberrant neurophysiological function in the cervical spine via spinal thermography and a 9 mm short leg, left side, LLI. This patient's spinal listing was analyzed to be atlas ASR8/29.

Over the course of nine weeks, this patient had nine office visits and two upper cervical adjustments. His response to the upper cervical care was excellent; he no longer reported headaches or nervousness, and he resumed normal sleeping patterns. His chronic sinusitis had moved from an 8, on a scale of 1 to 10, with 10 being the worst, to a 3. The last upper cervical adjustment was performed seven weeks before the post Blair protracto view. We observed considerable correction of the atlas misalignment between the pre-adjustment Blair protracto view taken before the first upper cervical adjustment and the post-adjustment Blair protracto view performed nine weeks later (Fig. 4A and B). There had been no detectable LLI since the second upper cervical adjustment (Fig. 5A and B). The cervical spine thermography is chronicled in Figure 6.

A lumbar range of motion study (following the established protocol) was performed prior to the first upper cervical

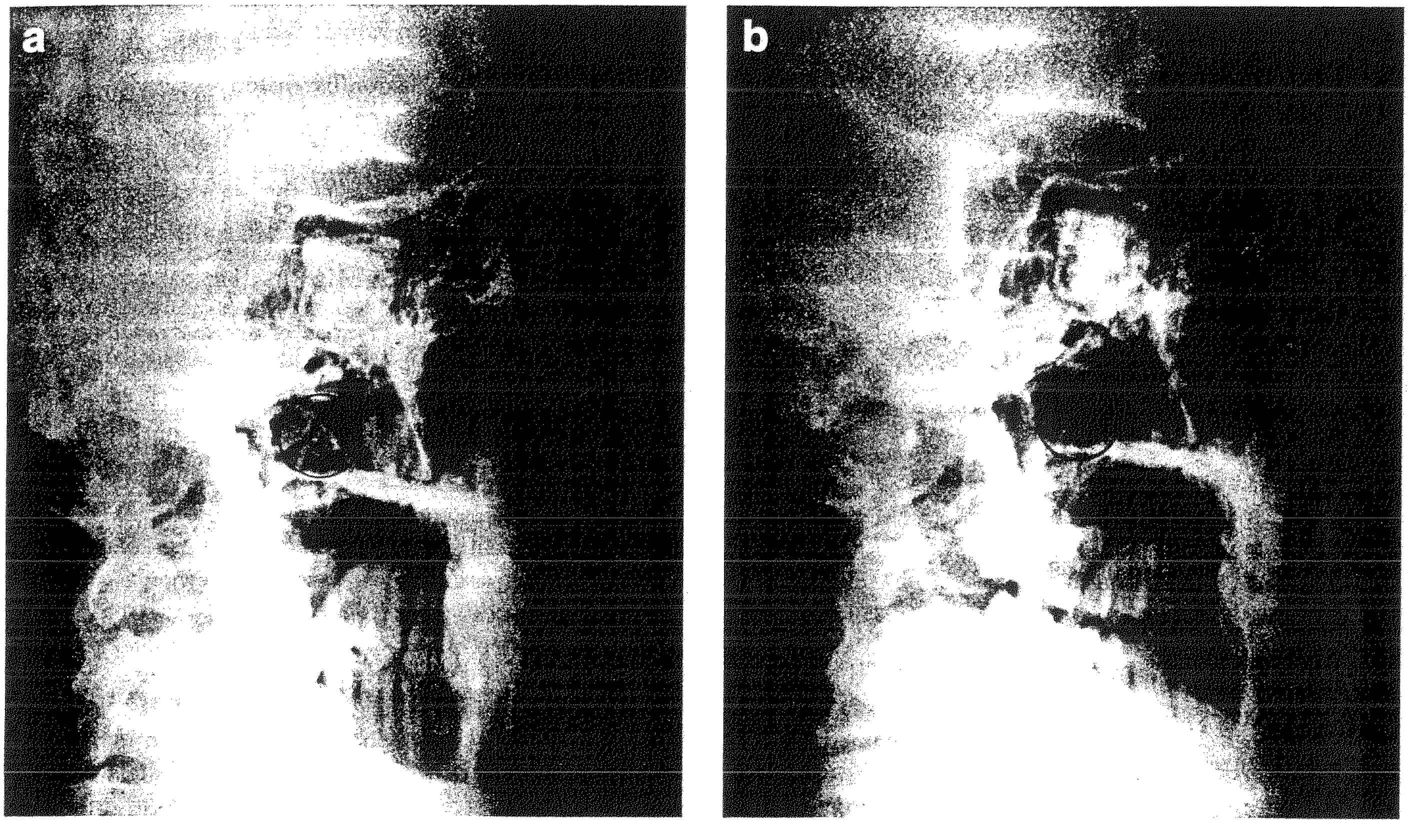


FIGURE 4 A and B. *A) Patient 2 pre-adjustment Blair protracto x-ray performed prior to the first upper cervical adjustment. B) Patient 2 post-adjustment Blair protracto view performed 9 weeks following the first upper cervical adjustment.*

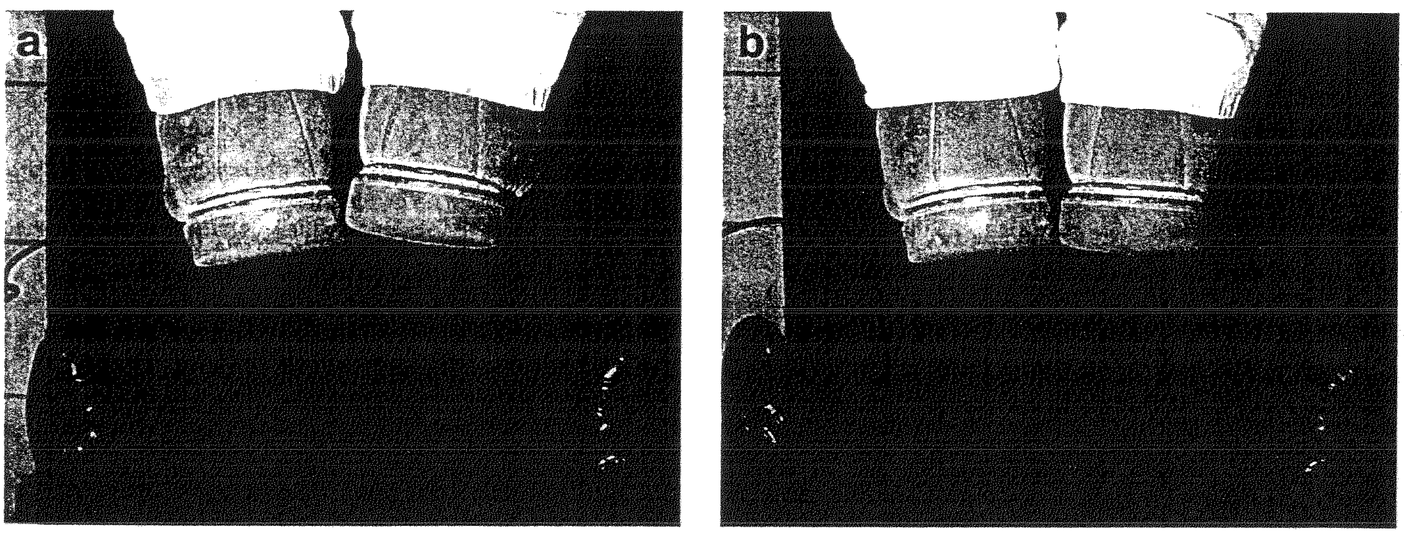
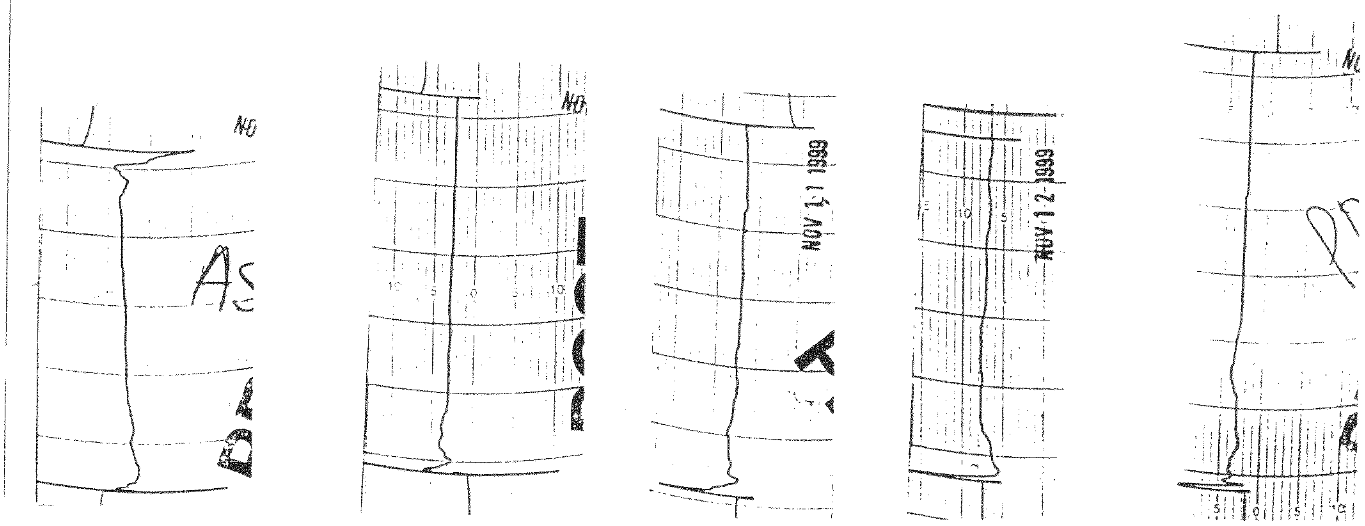


FIGURE 5 A and B. *A) Patient 2 pre-adjustment LLI examination, performed prior to the first upper cervical adjustment, B) Patient 2 post-adjustment LLI examination, performed following the first upper cervical adjustment and one-hour rest.*



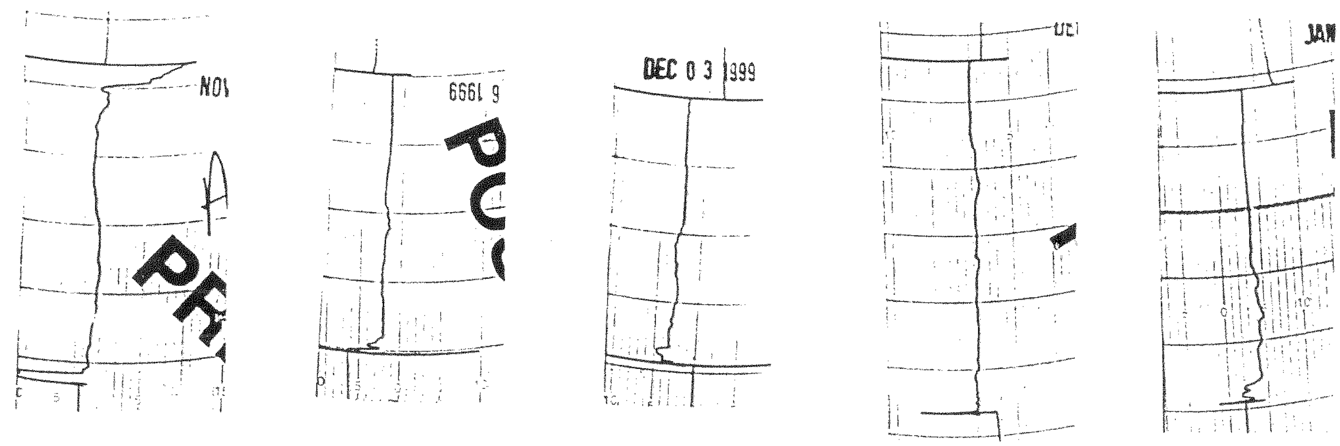
PRE- Nov 8, 1999
Patient's established pattern, adjustment of atlas ASR30/22 LLI-9mm left. Chronic sinusitis headaches, nervousness and insomnia

POST- Nov 8, 1999
Post reading following one hour rest. Reading indicates initial success from 1st upper cervical adjustment. LLI-absent

PRE- Nov 11, 1999
Clear reading with no evidence of aberrant neurophysiological function in the cervical spine. LLI-3mm left

PRE-Nov 12, 1999
Clear reading LLI-3mm left "headaches persist"

PRE- Nov 16, 1999
Clear reading, LLI-9mm left "some headaches, sleeping better"



PRE- Nov 26, 1999
Return of patients pattern. LLI-9mm left, adjustment C1 ASR30/22, "headaches continue"

POST- Nov 26, 1999
Clear reading, LLI-absent "rested better following this adjustment"

PRE- Dec 3, 1999
Clear reading LLI-absent "feeling much better, no headaches"

PRE- Dec 17, 1999
Clear reading, LLI-absent "feeling great, sleeping very good"

PRE- Jan 14, 2000
Clear reading, LLI-absent "doing a lot better"

FIGURE 6. *Patient 2 daily office visit cervical spine thermography chronicles with LLI examination and subjective findings.*

adjustment, again after the one-hour recuperation time following the first upper cervical adjustment, and again on the ninth week of care. Improvements in lumbar range of motion are documented in Figure 7.

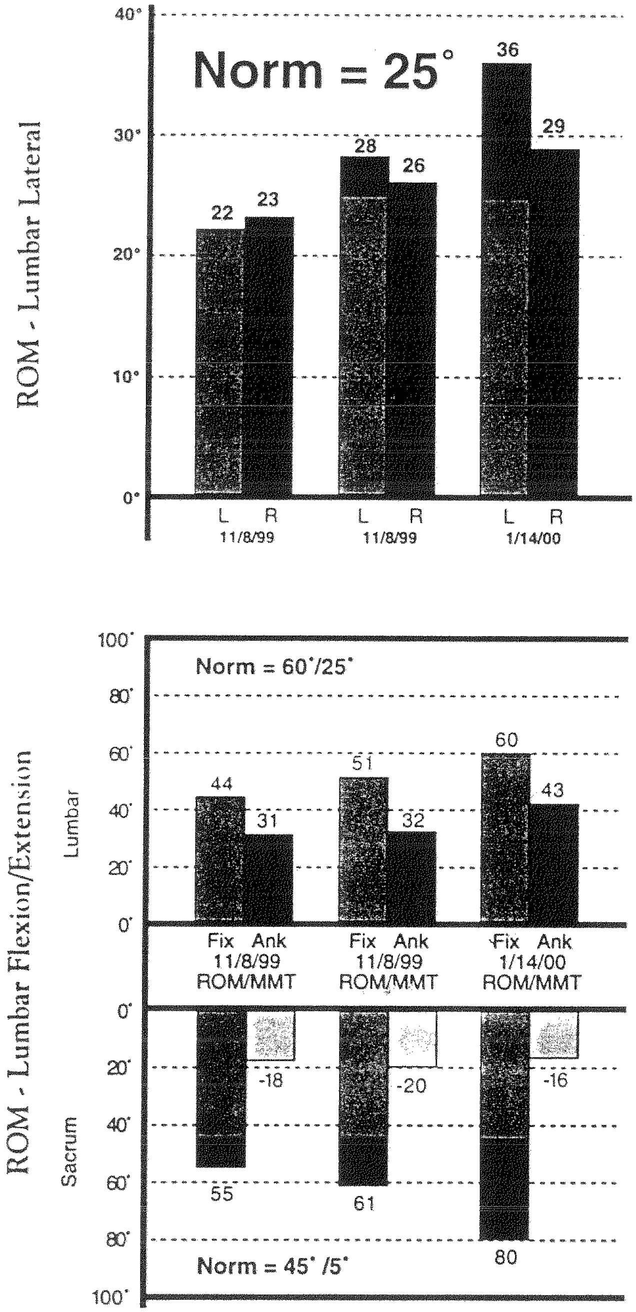


FIGURE 7. *Illustration of the pre- and post-adjustment lumbar range of motion examination of the patient described in Case 2. The first column represents the findings before the first upper cervical adjustment. The second column represents the findings of the examination performed following the first upper cervical adjustment and one hour of rest. The third column illustrates the examination performed 9 weeks following the initiation of upper cervical care.*

The third patient was a 39-year-old woman, who began upper cervical care complaining of joint pain, depression, near sightedness, headaches, difficulty breathing, and allergies. This patient was not taking prescription drugs or being treated with any type of medical care or treatment plan, and she did not engage in an exercise program or begin taking vitamins, minerals, or herbs following the initiation of upper cervical care.

Upper cervical chiropractic analysis indicated aberrant neurophysiological function in the upper cervical spine via spinal thermography and a 12 mm short leg, right side, LLI. This patient's spinal listing was analyzed to be atlas ASR10/33.

Over nine months, 54 office visits, and five upper cervical adjustments, this patient has responded excellently judging by both subjective and objective measures. She no longer complains of joint pain, depression, nearsightedness, headaches, difficulty breathing, or allergies. This patient also reported that, the day

TABLE 2

Category	before first upper cervical adjustment
General Health	35
Health Change	50
Physical Condition	45
Limitations due to Physical Health	50
Limitations due to Emotional Health	0
Social Functioning	37
Pain	45
Energy/Fatigue	15
Emotional Well-Being	40

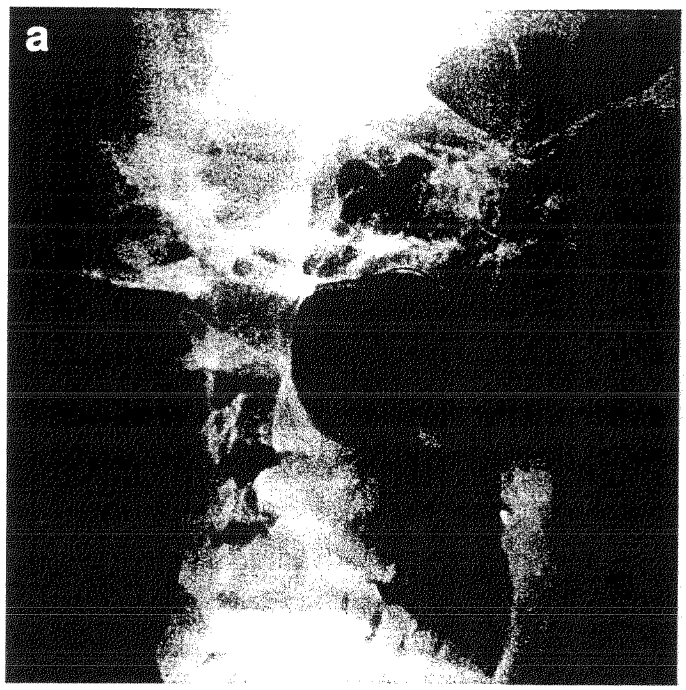


FIGURE 8A. *Patient 3 pre-adjustment Blair protracto x-ray performed before the first upper cervical adjustment.*

after the first upper cervical adjustment, she experienced a marked change in her visual acuity. She was able to watch TV and perform other tasks without her glasses. Her last upper cervical adjustment had been performed 3-1/2 months before taking the post-adjustment Blair protracto view (Figure 8B). A complete reduction of the atlas misalignment can be seen by comparing Figures 8A and B.

A pre- and post-adjustment bone mineral density examination demonstrated a marked change from an abnormal bone mineral density before the first upper cervical adjustment to a normal bone mineral density 6 weeks following the first upper cervical adjustment (Fig. 9A and B). This patient completed three short-form Rand-36 Health Surveys (1) (Table 2). This patient has since been on maintenance upper cervical care and has not required another upper cervical correction.

5 weeks following upper cervical care	6 months post upper cervical care
45	55
75	75
65	72
75	75
0	100
37	62
77	77
30	45
48	68

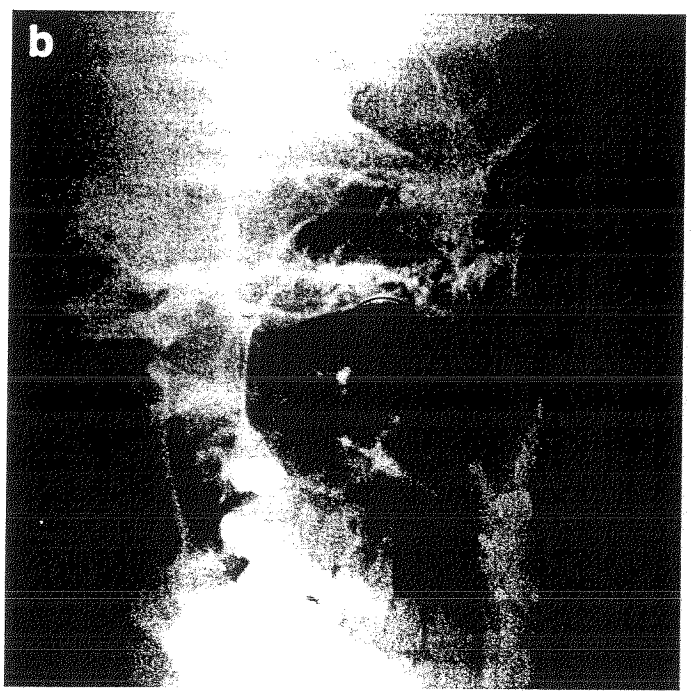


FIGURE 8B. *Patient 3 post-adjustment Blair protracto view performed 8 months following the first upper cervical adjustment.*

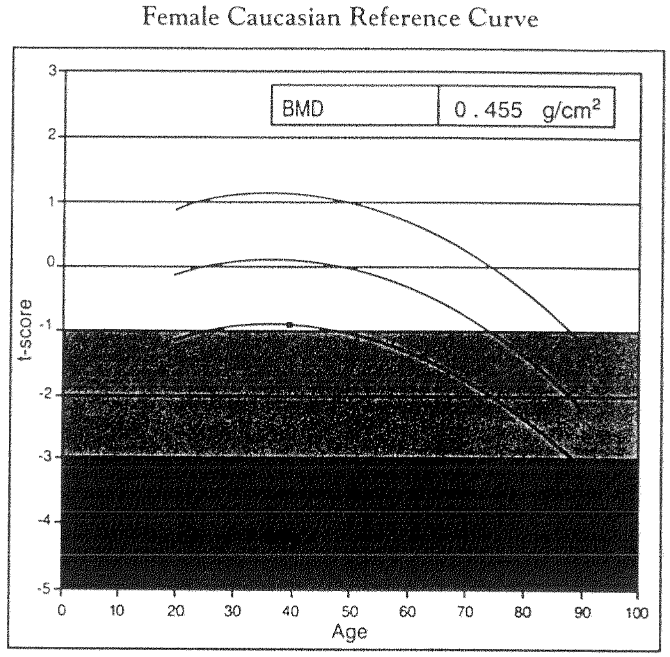


FIGURE 9A. *Bone mineral density examination performed before the initiation of upper cervical care. A normal study will fall within the three lines, age related. Patient 3's first BMD is slightly below normal with a BMD of 0.455 g/cm².*

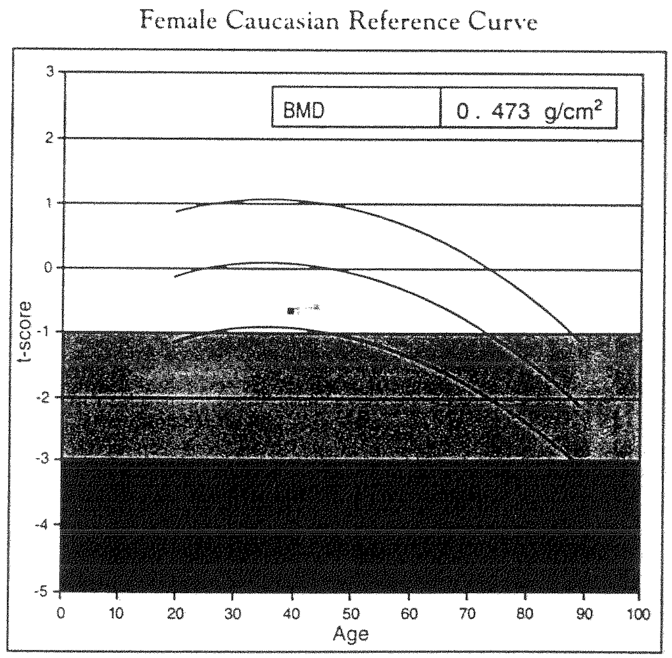


FIGURE 9B. *The second BMD was performed following 5 weeks of upper cervical care. This study demonstrates a marked change to normal BMD at 0.473 g/cm².*

The upper cervical knee-chest adjustment procedure was the only form of care administered to these three patients. Each of these patients has given permission to publish his or her findings.

KNEE-CHEST TABLE

The evolvement of the knee-chest table began as B.J. Palmer developed the Palmer Recoil Toggle Adjustment in the early 1900s (2). The table used for the Palmer Recoil was a two-piece table in which the front section for the chest and head resemble the shape of the chest-headpiece for the knee chest table currently used. Dr. Palmer discarded the back section of the two-piece table in the early 1930s and placed patients in the knee-chest posture. The knee-chest table became more prominent as Dr. Palmer developed the HIO adjustment, later named the specific adjustment (3,4). The knee chest table was employed in the B.J. Palmer Research Clinic, beginning in 1935 (5). Resurgence in knee-chest adjusting began in the late 1980s and early 1990s through the work of Michael Kale (6).

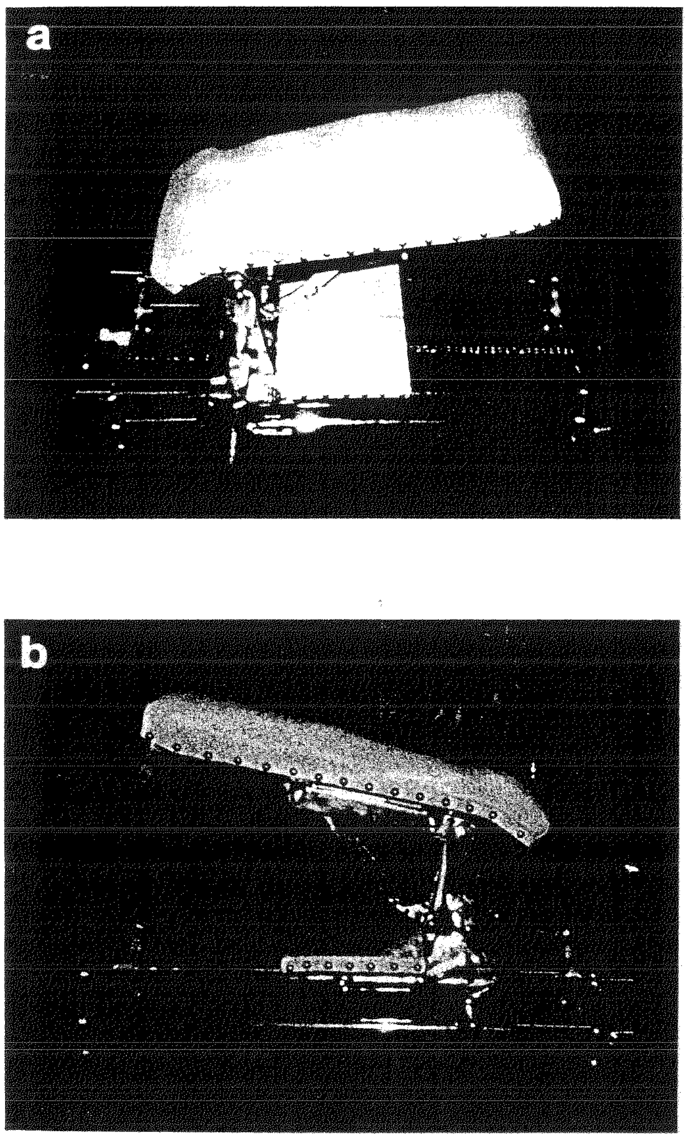


FIGURE 10. *Two views of the knee-chest table*

The upper cervical knee-chest adjustment is performed on a knee-chest table with solid chest-headpiece (Fig. 10).

The chest-headpiece has a built-up, rounded-off segment on the front end for placement of the patient's midsternal notch. Toward the back of the chest-headpiece, immediately following this built-up, rounded-off segment, a slight dip in the chest-headpiece surface provides a "cradle" for the atlas/axis movement during the adjusting procedure. Further back on the chest-headpiece, following the slight dip the chest-headpiece, a flat surface extends to the end of the chest-headpiece. The the chest-headpiece is 12 inches wide and 24 inches long (from front to back), and the highest section of the front end of the chest-headpiece is 22 inches from the floor. For the knee-chest procedure described in this paper, the table is set at 14° relative to the floor.

CHIROPRACTIC EXAMINATION OVERVIEW (SPINAL THERMOGRAPHY AND LEG CHECK)

We perform two procedures to determine, on any given office visit, the need for an upper cervical adjustment and to monitor the status of the previous correction. Full-spine spinal thermography is performed on the initial visit, then at two weeks and four weeks following the first upper cervical adjustment, and then periodically as necessary. Spinal thermography of the cervical spine, performed on each daily office visit, is evaluated according to the established rules for pattern analysis (7,8). We used cervical spine thermography to evaluate the neurophysiological function of the spine (9-15). We determined prone leg length inequality (LLI) on each office visit (16-20) by using digital photographs (Fig 2 and 6) and by chiroslide (21). The clinician determines whether a specific upper cervical adjustment is required from all the clinical findings, including thermography and LLI exam. The doctor may postpone the adjustment, however, to observe the patient's progress before performing the required adjustment during a subsequent visit.

POST-ADJUSTMENT REST

Following the initial upper cervical adjustment, each patient must rest in the supine position for at least one hour. The patient will be required to rest for at least 45 minutes following each subsequent upper cervical adjustment. Some patients may be required to rest for longer periods depending on their specific situation (such as traveling for two or more hours for the office visit). The value of rest has been established both by the early pioneers of specific chiropractic (22) and by more recent practitioners (7).

X-RAY OVERVIEW

We used Blair protracto views specifically to determine atlas misalignment. The Blair x-ray analysis (23-25) is a nonorthogonally based analysis that emphasizes the relative positions of the articular surfaces in the upper cervical spine. We considered the condyle slope angles, convexity, and convergence angles observed through the x-ray views described previously when adjusting the atlas.

We were unable to locate in the literature an established time period for performing post-adjustment Blair protracto x-rays. Our experience is that positive changes are observed in most patients between four to six weeks following the adjustments when the patient's upper cervical spine remains free of subluxation. In some cases, however, changes are observed more rapidly, and in others, changes are not evident for 12 weeks or more. For practitioners using this upper cervical specific knee-chest procedure, we recommend a four- to six-week period of time for post-adjustment protracto views. Immediate changes are not often observed when studying C0-C1 articular surfaces compared with changes observed in gross orthogonal appearance.

Correction is a dynamic process. Extensive research performed at the B.J. Palmer Research Clinic (26) demonstrated that the "manual adjustment position" was invariably different, sometimes remarkably so, from what they described as the "Innate adjustment norm position." Through this work, correction of the upper cervical subluxation appears to be an ongoing process, where the upper cervical spine is continually migrating to a more stable position as long as it is free from subluxation.

ATLAS ADJUSTMENT

There are eight atlas listings: ASL, ASR, PIL, PIR, double AS, ASR/PIR, ASL/PIL, and double PI. The misalignment component of the atlas subluxation occurs between the occiput and atlas. The articular alignment between C1 and C2 is not considered an important factor relating to the upper cervical subluxation. The C1-C2 articulation is highly moveable and is void of any anatomical feature that would precipitate misalignment in three planes simultaneously. Upon rotation, the C1-C2 articulation has been found to produce 69% to 77% of the total amount of rotation for the entire cervical spine (27). The C0-C1 articulation averages 4° of paradoxical movement upon cervical rotation. The lateral mass of the atlas shifts in the opposite direction from its matching condyle. Movement of C1 in the opposite direction to its matching condyle opens the C0-C1 articulation, thereby facilitating cleavage around the condyle's convex sloping angle through the knee-chest procedure.

The condyles possess three distinct, individually unique anatomical properties: convergence angle, slope angle, and convexity. These anatomical properties can produce misalignment in three planes simultaneously (23-25,28). The convergence angle is the degree that the condyle deviates from the central A-P line toward the medial to lateral plane, from the "z" axis toward the "x" axis. This measurement is obtained from the base posterior x-ray spinograph (Fig. 11).

The slope angle delineates how much the lateral margin of the condyle deviates medially from its superior to inferior border.

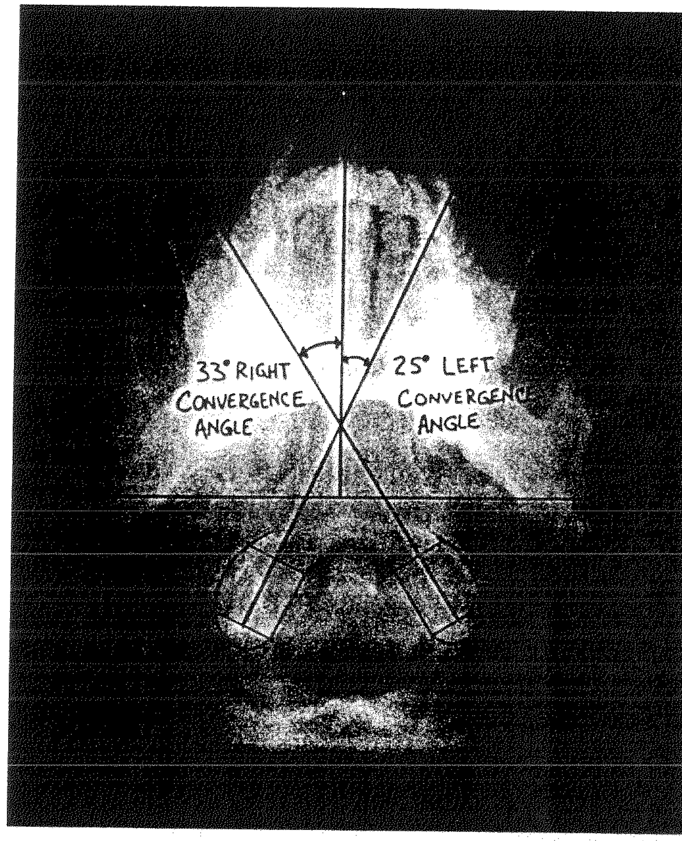


FIGURE 11. *Base posterior x-ray demonstrating measurement of the convergence angle.*

The slope angle is determined by the Blair protracto view (Fig. 12). The atlas lateral mass wraps around the convexity of the condylar slope angle, through its articulation, causing C1 to deviate from a straight path along the convergence angle.

The atlas, in subluxation, will track along the longitudinal axis of one condyle (Fig. 13) with its corresponding atlas lateral mass (labeled "tracking side" condyle and/or lateral mass). The C1 lateral mass on the opposing side will slide off of its articular surface with its corresponding condyle, on the transverse axis (Fig. 13). The lateral mass shifts on the transverse axis at the same angle as the convergence angle on the "tracking side." The lateral mass that slides off of its condyle on the transverse plane is referred to as the "slide side" lateral mass. Both of the C0-C1 lateral mass/condyle articular surfaces misalign in subluxation. Movement between C0-C1 takes place in four basic ways (23-25) (Fig. 13A, B, C, D).

ASL, ASR, double AS, ASL/PIL, ASR/PIR Listings

Atlas listings represent the direction of atlas misalignment relative to the condyles. An ASL listing depicts the atlas moving Anterior, Superior and Left of its juxtaposition relative to the occipital condyles (Fig.14A). An ASR atlas listing characterizes the atlas misalignment to be Anterior, Superior, and Right (Fig. 14B).

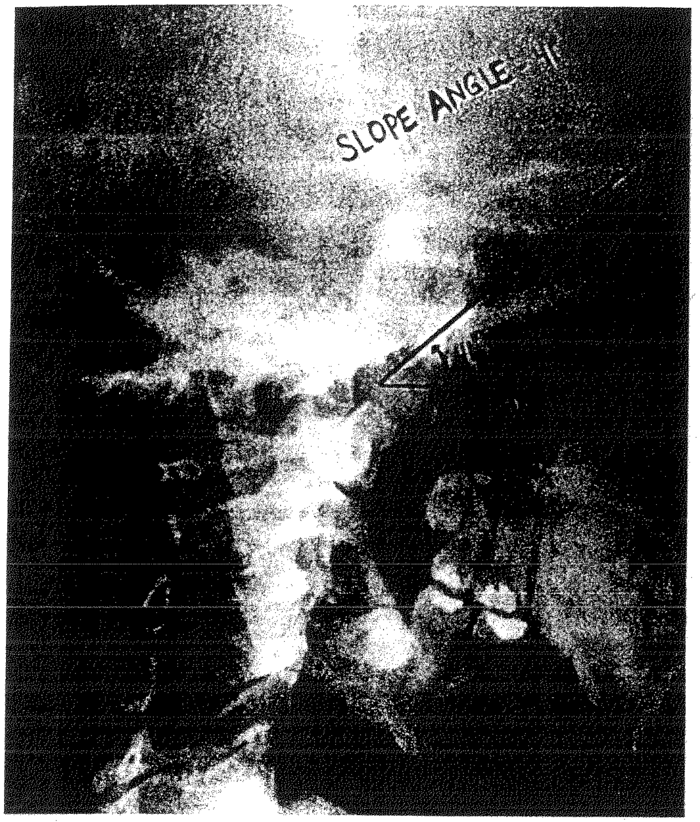


FIGURE 12. *Blair protracto x-ray depicting the slope angle. A line is constructed directly perpendicular to the lateral edge of the Blair Protracto x-ray (line AA). Another line is constructed which follows along the trajectory of the C0-C1 articulation and is continued in the superior direction (line BB). An angle is formed where line (AA) intersects with line (BB) and is considered the slope angle.*

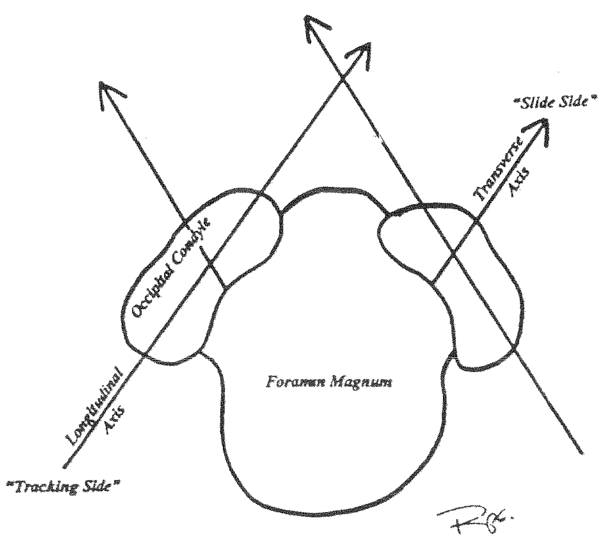


FIGURE 13. *Illustration of the "tracking side" and "slide side" of atlas misalignment. In subluxation, one atlas lateral mass tracks anterior and lateral on the longitudinal axis, while the other C1 lateral mass slides away from the condyle on the transverse axis.*

The double AS listing occurs when the atlas misaligns anterior and superior on both sides. With a double AS listing, one side will appear more dominant or misaligned to a greater degree than the other. A double AS misalignment, when the right articulation appears misaligned to a greater degree than the left articulation, is adjusted and recorded with the same procedure followed for an ASR listing. A double AS with the dominant misalignment on the left side is adjusted and recorded as an ASL atlas listing.

The ASL/PIL develops when the left atlas lateral mass "slides" superior and anterior relative to the left condyle. At the same time, the right lateral mass of atlas "slides" inferior and posterior relative to the right condyle. ASL/PIL is adjusted and recorded following the same procedure detailed for an ASL listing. The ASR/PIR listing is opposite of ASL/PIL: the right lateral mass tracks anterolateral and superior relative to the right condyle and the left lateral mass of atlas slides inferior and posterior relative to the left condyle. The ASR/PIR is adjusted and recorded the same as an ASR listing.

Total Misalignment observed between the occiput and atlas occurs simultaneiously in three separate planes. For the ASL and ASR atlas listings, there are lateral, anterior, and superior components to the atlas misalignment. The varying degrees of each of these components is determined by the "tracking side" convergence angle and "slide side" slope angle. The unique design of the condyles from one person to the next, along with the commonality of asymmetry (23-25,29-32) within each individual patient, brings about different presentations of atlas misalignment with differing amounts of the anterior, superior, and lateral components. The convergence angles and slope angles are measured to guide the doctor in designing the specific adjustment that will address these unique differences found within each patient.

Superior Component: The anterior tubercle of the atlas is the landmark used to determine whether the atlas has moved superior or inferior. Superior movement is denoted by displacement of the atlas anterior tubercle on the "+y" axis. The superior component is created by the condylar slope angles and is always accompanied by misalignment in the anterior direction.

Lateral Component: Laterality refers to the movement as the atlas vertebra shifts from the mid-sagittal line on the "+x" axis. The atlas misalignment will move with either left or right laterality in this plane. The side (right or left) of laterality, with the ASR, ASL, double AS, ASR/PIR, ASL/PIL atlas listings is toward the "slide side." An ASL atlas listing depicts an atlas with left laterality, and an ASR atlas listing describes an atlas with right laterality. It is useful to visualize how tracking of the right lateral mass precipitates lateral movement toward the left (Fig 13A).

Anterior Component: Anteriority of the atlas refers to anterior movement on the "+z" axis of the entire C1 vertebra (Fig. 14A and B). The overall direction of the anterior movement depends solely on the "tracking side" convergence angle. However, the total distance that C1 travels in the anterior direction is inhibited by the "slide side" slope angle.

Convergence Angle: With the ASL and ASR atlas listings, the atlas shifts in the anterolateral direction along the longitudinal axis of the "tracking side" convergence angle (Fig. 13 and 14A and B). The anterolateral direction is approximated by marking points on a base posterior x-ray corresponding to the "belly," or middle, of the C0-C1 articulation. The midsection of the atlas lateral mass and its corresponding condyle is the most accurate place to observe misalignment of C1 (23-25). There is slight rotation introduced in C1's anterolateral direction of misalignment as the convexity of the "tracking side" convergence angle does not allow the atlas to move in a straight line at the angle of the "tracking side" convergence. The amount of rotation on the anterolateral plane depends upon the convexity of the "tracking side" convergence angle.

Slope Angle: Without the slope angle, the atlas would move only anterolateral or posterolateral. A two-directional misalignment would tend to correct itself without a specific adjustment (28). As the atlas tracks and slides in the anterior and lateral direction, the slope angle on the "slide side" diverts C1's pathway toward the superior direction. The "slide side" slope angle does not change the direction of the anterior and lateral displacement but inhibits the total distance of displacement in the anterolateral direction. The percentage of anteriority and laterality in the misalignment depends on the amount of diversion present in the superior direction.

Percentage of Misalignment: The percentage of superiority is the constant that determines the amount of misalignment occurring in any of the three planes. Superiority will affect the amount of movement in the anterior and lateral direction. The percentage of superiority is not affected, however, by the percentage of the anterior and lateral movement.

To calculate the percentage of superiority representing the total misalignment, the "slide side" slope angle is divided by 90 and then multiplied by 100. Ninety is a constant, as the possible ranges for the slope angle would be 0° to 90° (average slope angles will be from 30° to 48°). A "slide side" slope angle of 42° would be calculated by dividing 42 by 90 then multiplied by 100; i.e., 42 divided by 90 equals 0.466, multiplied by 100 gives 46.6%. The percentage of superiority for this misalignment is 46.6%.

The percentage of superiority is subtracted from 100 to arrive at the sum of movement in the anterior and lateral direction. The "tracking side" convergence angle determines how this sum is appropriated between the lateral and anterior directions. The lateral component is calculated by dividing the "tracking side" convergence angle by 90, then multiplying by the sum left over for the anterior and lateral direction; 90 is a constant derived from the total range of degrees possible for a convergence angle, 0° to 90°. Following the original example, with a "tracking side"convergence angle of 25° the calculation would be 25 divided

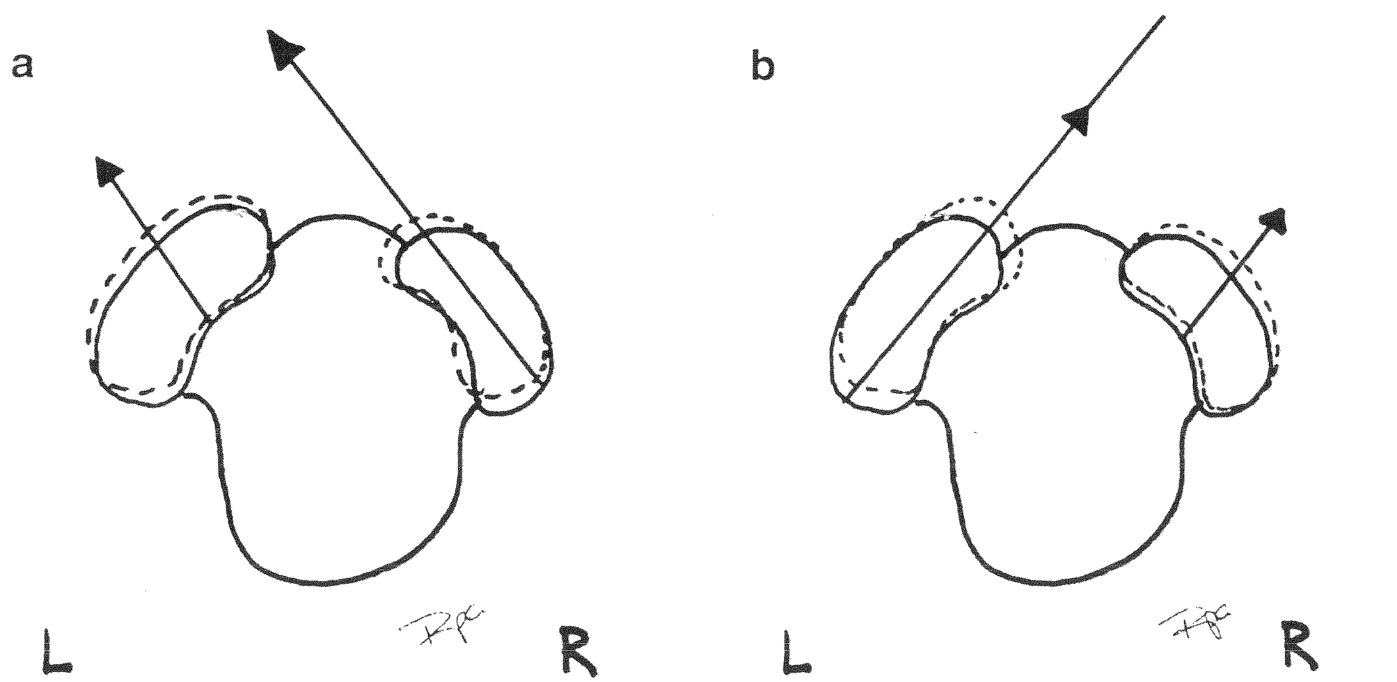


FIGURE 14 A. and B. *These two illustrations outline the two possible ways an atlas can misalign along the convergence angles. The letter listing for each of these misalignments are; A) ASL, B)ASR.*

by 90, which equals 0.277; 0.277 is multiplied by 53.4% (100 minus the 46.6% calculated previously) and yields 14.8%. The lateral component, in this example, accounts for 14.8% of the total misalignment.

The anterior component is determined by subtracting both the superior and lateral percentages by 100. In the example provided, 46.6% plus 14.8% equals 61.4%; 100 minus 61.4% yields 38.6% of anteriority making up the total misalignment.

Line of Drive: The line of drive, in concert with torque, is paramount to the specific adjustment. The angle formed between the doctor's sternal notch and the contact point on the patient determines the line of drive administered. The doctor changes the line of drive by altering his stance to put his sternal notch at the proper angle over the patient's contact point.

There are three planes ("x," "y," and "z" axis) to consider when administering the specific adjustment to a ASL or ASR atlas subluxation: the superior to inferior ("x" axis), the anterior to posterior ("y"), and the lateral to medial ("z" axis). The atlas does not misalign purely in one direction, but, rather, in varying degrees toward each of these three planes. For adjusting, a practitioner addresses all three planes by concentrating on two lines of drive: the inferior line of drive addressing the superior aspect of the misalignment, and the posterior and medial lines of drive addressing the anterior and lateral aspect of the misalignment, respectively.

The inferior line of drive angle is the specific angle that the doctor thrusts in the inferior directions (all directions cited in this section are relative to the patient's C1 vertebra). The inferior line of drive angle addresses the superior component of the total misalignment and is determined by the "slide side" slope angle and table setting. The inferior line of drive angle is figured by multiplying the "slide side" slope angle by the constant 0.5, then subtracting this sum by the 14° table angle. An inferior line of drive directed precisely down the slope angle would negate the torqueing from the adjustment. If there were only one direction of misalignment (inferior to superior), the best way of correction would be directly down the "slide side" slope angle. However, with three directions of misalignment, the amount of torque necessary to correct of all three directions must be factored into each line of drive. The 0.5 constant puts the doctor's inferior line of drive at an angle that allows for correction of the superior aspect of misalignment, through torque, without negating the doctor's ability to confront the anterior and lateral aspects of the misalignment. A "slide side" slope angle of 44° with a 14° angle table setting would yield an 8° inferior line of drive angle (i.e., 44° multiplied by 0.5 equals 22°; 22° minus 14° (table angle) yields an 8° inferior line of drive angle). An 8° inferior line of drive refers to the doctor's midsternal notch being 8° from the straight lateral to medial direction toward the superior to inferior direction. This angle may also be described to be 8° from the "x" axis toward the "+y" axis. When the "slide side" slope angle is less than 24°, this calculation will yield a negative inferior line of drive angle. A "slide side" slope angle of 24° would be recorded as -2 (i.e., 24° multiplied by 0.5 equals 12, 12 subtracted by the 14° table angle is -2°).

The posterior and medial line of drive angle - the specific angle that the doctor thrusts between the posterior and medial directions - will be expressed in degrees from the lateral to medial plane towards the anterior to posterior plane, "x" axis to the "z" axis. The posterior and medial line of drive mechanically addresses the anterior and lateral components of the total misalignment and is ascertained by the "tracking side" convergence angle. The "tracking side" convergence angle is subtracted from 90, then multiplied by 0.5, to obtain the proper adjusting angle. The constant 90 is obtained from the range of possible "tracking side" convergence angles, 0° to 90°. The torqueing aspect of the adjustment needs to be factored in when determining the posterior and medial line of drive. A posterior and medial line of drive opposite of the anterolateral direction of misalignment is not suitable when considering the effect the torque has on the correction. The misalignment is not only in three planes simultaneously but the "tracking side" convexity produces a slight rotation that also needs to be accounted for through the torque applied by the doctor. A "tracking side" convergence angle of 27° would yield 63° of anterior movement. The posterior and medial line of drive would be 31.5° (90° - 27° = 63°, 63° x 0.5 = 31.5°) from the medial to lateral plane, "x" axis, toward the anterior to posterior plane, "+z" axis. For this example, the doctor's midsternal notch is placed 31.5° from the straight lateral to medial direction toward the anterior to posterior direction.

A line-of-drive angler, which is set on the side of the table opposite the doctor, is used to aid the doctor in positioning himself at the proper line of drive. Its two arms are constructed with one arm corresponding to the inferior line of drive angle and the other arm indicating the posterior and medial line of drive angle. A compass on the bottom sets each arm at the precise angle.

Torque: The torque encompasses all three aspects of the misalignment: laterality, superiority, and anteriority. Simultaneous misalignment in three separate planes "locks" the atlas out of juxtaposition. A torqueing action performed by the doctor, consistent with the specific misalignment, is essential for consistent correction of the misalignment. The torqueing mechanism is accomplished through the shoulders of the doctor. The doctor's elbow and wrist joints should not flex or extend through the adjusting procedure. The doctor's entire shoulder girdle rotates. For an ASL, the shoulder girdle is rotated counterclockwise. The ASR listing necessitates a clockwise rotation in the shoulder girdle.

Within the shoulder girdle rotation, the torque is further refined corresponding to the "slide side" slope angle and "tracking side" convergence angle. The percentage of superiority within the misalignment determines the amount of superior to inferior torque that will be necessary. The doctor's shoulder on the contact side (left for ASL, right for ASR) moves in the inferior direction for the superior to inferior portion of the torque. The opposing shoulder will follow.

The percentage of anteriority determines the amount of anterior to posterior torque required. The doctor's shoulder on the contact side moves posteriorly in the direction of the anterior to posterior portion of the torque. With varying degrees of superiority versus anteriority in the total misalign-ment of ASL and ASR atlas listings, the torque will be applied with a combination of the superior to inferior and anterior to posterior directions.

Laterality does not affect the direction of torque, only the amplitude. When laterality increases, the doctor's midsternal notch will move toward being centered over the patient's contact point, and less torque is needed for correction. As laterality becomes less significant in the total misalignment, the doctor's stance shifts away from the patient and the midsternal notch to contact point angle increases.

Doctor's Stance: The doctor's position and stance are designed to create a balanced posture so the doctor may navigate the line of drive with the proper torque. The doctor stands in a position to angle his midsternal notch to correspond with the necessary line of drive. The doctor's front foot (left for ASL or right for ASR) placement ranges from being under the patient's shoulder girdle, on the listing side (Fig 15A), to above the patient's head with the toes pointed at a 45° angle, superior and medial. The doctor's back foot is on the same plane as the front foot and may range from being behind the patient's knees up to the patient's shoulder girdle. The back foot is pointed at the same angle as the front and both feet are a shoulder's width apart. The specific foot positions will change according to the inferior line of drive and the posterior and medial line of drive.

The doctor's front foot is positioned to achieve the proper angle to address the three planes of misalignment. As the inferior line of drive increases (greater "slide side" slope angle), the doctor's front foot will migrate towards the patient's head (Fig. 15B). As the posterior and medial line of drive increases (lesser "tracking side" convergence angle), the doctor's front foot shifts anterior, relative to the patient's C1 vertebra, moving away from the patient (Fig. 15C).

The percentage of superiority and anteriority determines the position of the doctor's back foot. Placing the doctor's feet parallel to the superior and inferior plane of the patient is most conducive to an anterior to posterior torque (Fig. 15D). The doctor's foot position will move toward being parallel to the patient as misalignment in the anterior plane becomes greater than the misalignment in the superior plane.

To increase the doctor's ability to effect a torque in the superior to inferior direction, the back foot is shifted lateral and superior, relative to the patient's position. As the superior component of the misalignment increases (increased "slide side" slope angle), the doctor's back foot shifts lateral and superior in a balanced position to allow the doctor to administer the proper torque (Fig. 15C).

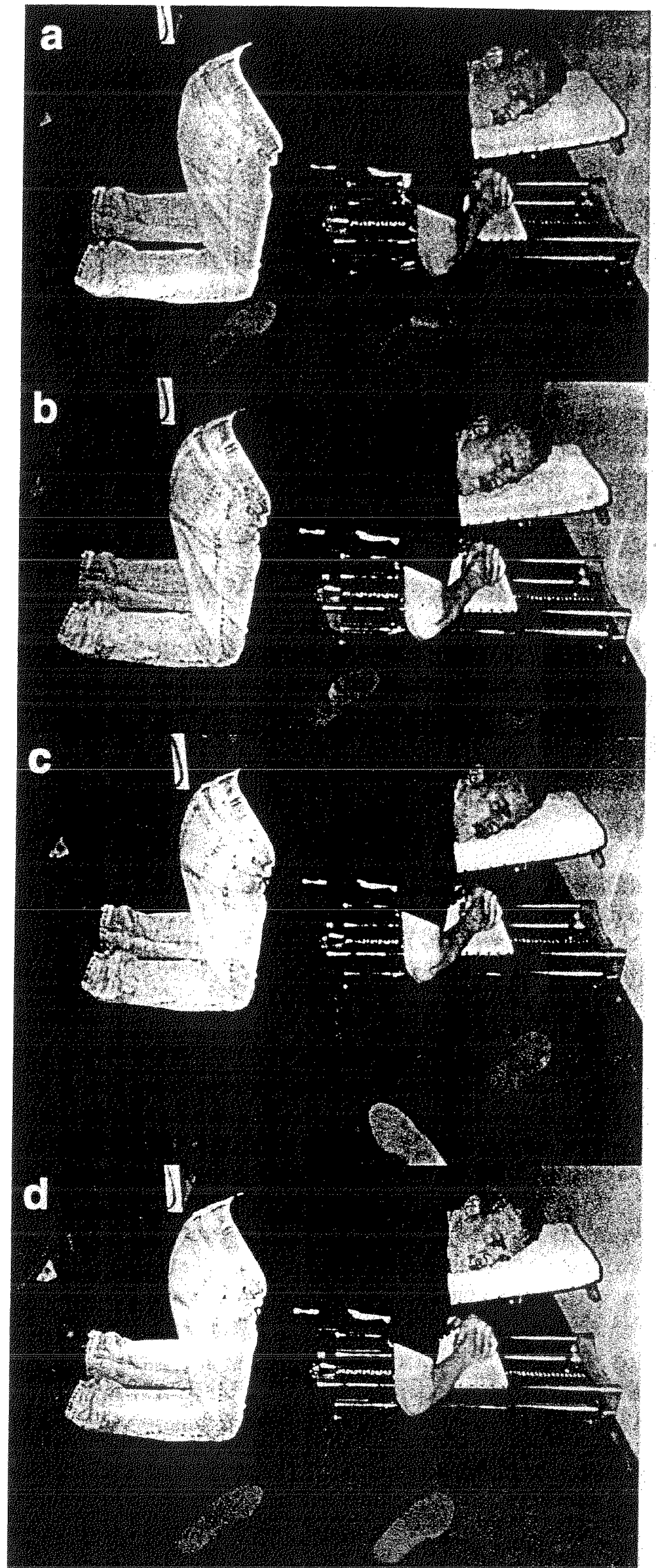
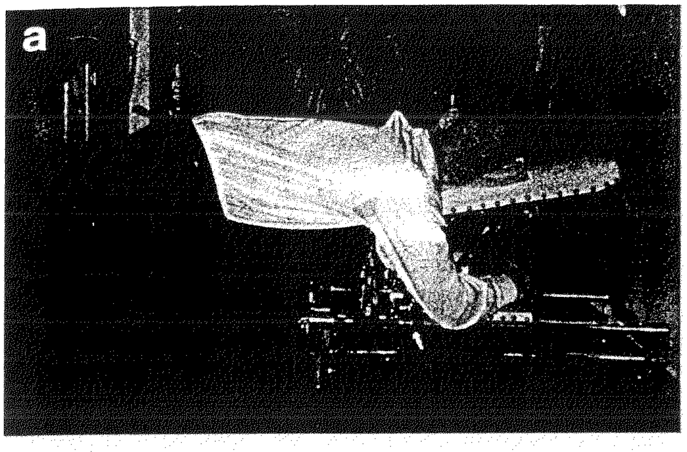


FIGURE 15 A, B, C, D. *Various doctor stance positions for the ASR atlas listing. The stance will be altered depending on the "tracking side" convergence angle and "slide side" slope angle. For ASL listings, the doctor's stances will be the same, only on the opposite side.*



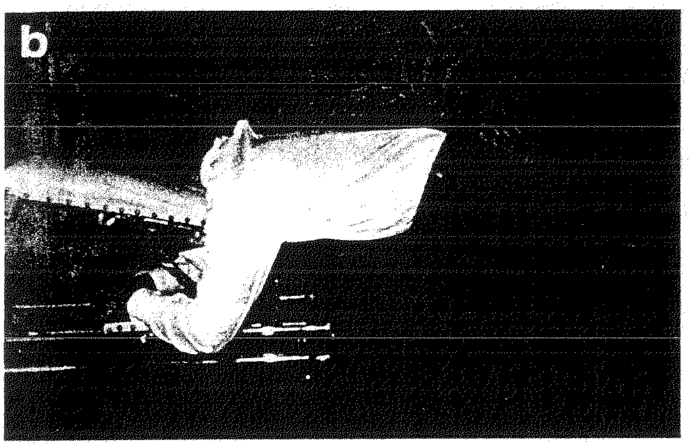


FIGURE 16. *Illustration of proper patient positioning on the knee-chest table. Note the patient's head and neck are placed firmly against the table in photo B.*

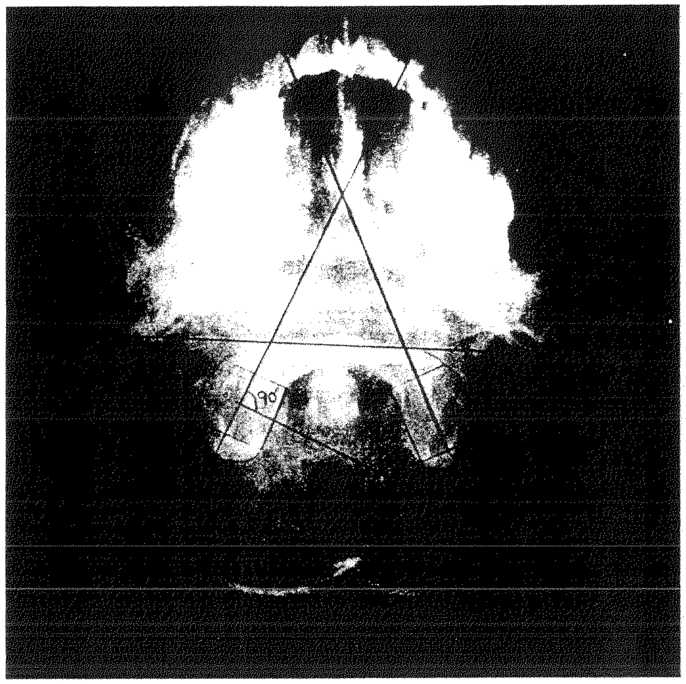


FIGURE 17. *Base posterior x-ray demonstrating the measurement of the ASL and ASR contact point.*

Adjustment Procedure: Six-Step Approach

1. *Patient Position:* The patient's knees are placed on the floor in front of the knee-chest table with the thighs perpendicular to the floor. The patient's midsternal notch is placed on the front end of the chest-headpiece. The patient's head is turned toward the right for an ASR listing and toward the left for an ASL listing. The patient's neck and ear on the side opposite to the listing are placed in solid contact with the chest-headpiece (Fig. 16).

2. *Contact:* The specific contact point is the anatomical place on the patient that the doctor will contact in order to perform the specific upper cervical adjustment. By using the ASL and ASR atlas listings, the doctor determines this point by plotting a perpendicular line through the midsection of the "tracking side" lateral mass that intersects the posterior arch on the other side. The contact by the doctor's pisiform is on the patient's posterior arch, anterior to this intersection (Fig. 17) (left for ASL, right for ASR).

3. *Tissue Pull:* Preceding the posterior arch contact, the doctor performs a tissue pull to take the slack out of the soft tissue covering that contact point. The tissue pull is accomplished with the middle digit of the appropriate hand (right hand for ASL and left hand for ASR) beginning at the posterior most portion of the posterior arch of the atlas (contact side) and pulling the tissue, gently, in a semicircular sweep with a low arc, toward the contact point. For ASL, the half circle will be in the counterclockwise direction; and for ASR, clockwise. As with all tissue pull procedures, the tissue pull is held until the pisiform roll-in.

4. *Roll-in:* The doctor's contact hand (left for ASL, right for ASR) is arched in the classic toggle position (33) with the elbow on that side at approximately 150°. Beginning at the point arrived at through the previous tissue pull, the doctor's contact hand is rolled in (clockwise for ASL, counterclockwise for ASR) to firm up the connection between the doctor and the patient. The doctor's wrist or elbow joints do not move. The lateral aspect of the elbow on the contact hand of doctor will remain at a 150° angle, with the entire elbow joint moving superior and medial, relative to the patient, as the roll-in is accomplished.

5. *Set Down:* The doctor's hand (opposite the contact hand side) is placed in a criss-cross fashion over and around the contact hand. The elbow (opposite the contact hand side) should be at the same angle as the contact hand side, approximately

150°. The set down is a slight movement made by the contact hand, after the opposing hand is in adjusting position, to locate the "pocket." The "pocket" is where the doctor's hands and patient's contact point perfectly harmonize and is the most comfortable position.

6. *Body Drop:* The body drop describes the doctor's action to generate the proper speed for the setting the atlas misalignment into its correct position and for directing the force through the segment being adjusted. The doctor must perform the adjustment to "throw" the force through the segment being adjusted, instead of allowing the force to rebound back to the doctor, by using the proper body drop and torqueing action previously described.

It is speed, not force, with this knee-chest procedure that overcomes the body's resistance to correction of the misalignment. The body drop begins with the doctor's weight on the balls of his feet and his lumbosacral region slightly arched. The adjuster shifts his body weight instantly from the back foot to the front foot while bending the knees with the transfer of force. The lumbosacral region of the doctor will "drop" down with the bending of the knees. Speed is generated through the weight transfer and L5 "drop" as opposed to through movement of the elbows and hands. Improperly performed adjustments performed will often be painful to the patient and will not correct the subluxation.

This adjustment produces an audible, which can be felt and often heard by the doctor, and typically the adjustment is not painful. Approximately 40 to 60 lbs of force are generated for the correction. As few as 5 lbs of force are necessary in some cases, such as for infants, whereas a force greater than 60 lbs may be necessary in others. For adolescent and adult patients, 40 to 60 lbs of force are used initially. The amount of force may be altered on subsequent adjustments as necessary. The doctor develops a "feel" for proper force in each individual case, that is, sufficient force to overcome the internal resistance of the upper cervical spine of the patient in order to create a summation of forces that will "unlock" the torqued misalignment. However, for the best results, the doctor should use the least amount of force possible that will overcome that point of resistance.

Record Listing: Recording the ASL and ASR atlas listings is a three-step process. First the letter listing ASL, ASR, ASL/PIL, etc, then the inferior line of drive angle followed by the posterior and medial line of drive angle. These three features will allow the doctor to quickly know listing, torque, line of drive, and doctor stance, and to visualize the misalignment. An ASR listing with a 44° "slide side" slope angle and a 22° "tracking side" convergence angle would be recorded as an ASR8/34; 44° multiplied by 0.5 yields 22°. The table angle of 14° is subtracted from 22° to arrive at the inferior line of drive angle of 8°. The "tracking side" convergence angle of 22° is subtracted from 90°, which yields 68°; 68° is multiplied by the constant 0.5 which produces a 34° posterior and medial line of drive. Therefore, ASR8/34 would be the recorded listing.

B.J. Palmer wrote in The Subluxation Specific-The Adjustment Specific:

> Pursuant to this idea, I wish I could find out, or know, or use some method which would express in quantity that which exists only in an abstract sense and, while with quantity, is always without that quantity factor being within our reach. Let a student study 1,000 PRI axis torqued subluxations, he will come to the conclusion that no two are of the same quantity of misalignment in same directions. To list the adjustment as 'PRI' is to make it appear that all 1,000 should receive a common hand-me-down adjustment. One may be more lateral than another, how are we to indicate to him how much of each direction to give in his adjustment to properly tailor-make his adjustment for this particular torqued subluxation which is not like any other? Let me suggest the following for torque adjustments: If the basis were 100% and each were divided into equal quantities, then 'P' would be 33 1/3%; 'R' would be 33 1/3%, and 'I' would be the same. Thus should I indicate that adjustment as 'PRI' it would mean that, in my opinion, it should be adjusted as much 'P' as it would be to 'R' and 'I'.
> Should I list the adjustment: Px
> Rxx
> Ixxx, it would say that it should be adjusted 'P', but the adjustment should be TWICE AS MUCH from the 'R' as from the 'P' and three times as much from 'I'.

Atlas Listings: PIL depicts an atlas misaligned Posterior, Inferior, and Left; PIR depicts an atlas misaligned Posterior, Inferior, and Right. The posteriority occurs as one of the atlas lateral masses tracks posteriorly on one condyle while the other one slides underneath the other (Fig. 14C, 14D). This is the origin of the posterior movement of the entire atlas vertebra. Due to the slope and convexity of the condyles, as the atlas shifts posteriorly, in relation to the condyles, the anterior tubercle of atlas moves inferiorly. Therefore, posterior misalignment of the atlas is always accompanied with inferior movement just as anterior misalignment of the atlas is accompanied by superior movement. The laterality occurs on the "tracking side."

Total Misalignment: The PIL and PIR atlas listings are three-directional torque misalignments with lateral, posterior, and inferior components of each individual misalignment. All three planes of misalignment are mechanically addressed through the line of drive, torque, and doctor's stance.

Line of Drive: The line of drive for PIL and PIR atlas listings is in the anterior and medial direction relative to the patient's C1, and the angle of the line of drive is determined by the "tracking side" convergence angle. However, the paradoxical movement of C1 onto C0 in cervical rotation (27) should also be considered when determining the proper anterior and medial line of drive angle. The position of the doctor's midsternal notch will determine the specific line of drive administered and should correspond to the "tracking side" convergence angle plus 4°. As the patient's head is rotated to the right for a PIR atlas listing, a 30° convergence angle on the "tracking side" will coincide with a 34° line of drive angle. The doctor's midsternal notch will form an angle (34° in this example) from the A to P plane moving posteriorly toward the medial to lateral plane, or "-z" axis toward the "x" axis. The paradoxical movement at the C0-C1 articulation upon cervical rotation cannot be readily ascertained in the current office setting. The line of drive is an estimate that puts the doctor in proximity of the "tracking side" convergence angle. With the knee-chest procedure described in this paper, proximity will render the desired result.

Torque: For the PIR listing, the patient's head is turned toward the right on the chest-headpiece, and a counterclockwise torque through the doctor's shoulders is performed. For a PIL atlas listing, the patient's head is turned toward the left, and a clockwise torque, through the doctor's shoulders, is administered. The convexity of the "tracking side" convergence angle presents an obstacle in the same manner described for ASL and ASR, but the rotation precipitated by the convexivity is in the opposite direction. The torque should be in the opposite direction to address this convexivity.

Doctor's Stance: The doctor's stance coincides with the line of drive. For the PIL and PIR atlas listings, the doctor's stance depends upon the "tracking side" convergence angle. The two positions are labeled position 1 and position 2.

For position 1, the doctor's front foot (left for PIL and right for PIR) is placed under the patient's shoulder girdle on the side that the patient's head is turned (Fig. 15A). The front and back feet are parallel to each other, and the toes point at a 45° angle superior and medial to the patient. Position 1 is used when the "tracking side" convergence angle is 29° or higher.

Position 2 is the same as position 1 except that the doctor is on the opposite side of the table (Fig. 18). The doctor's front foot (right for PIL and left for PIR) is placed under the patient's shoulder girdle on the side opposite the direction that the patient's head is turned. The doctor's front and back feet are parallel to each other and the toes point at a 45° angle superior and medial to the patient. Position 2 is used when the "tracking side" convergence angle is less than 29°.

Adjustment Procedure: Six-Step Approach

1. *Patient Position:* Same as that described for ASR and ASL listings. With a PIL atlas listing, the patient's head is turned toward the left. For a PIR atlas listing, the patient's head is turned toward the right.

2. *Contact:* The contact point is determined by extending the line drawn through the convergence angle of "tracking side" until this line intersects with the lateral margin of the posterior arch of atlas on the "tracking side." Contact is made on the posterior arch of the atlas, at the constructed intersection, with the pisiform of the right or left hand; left hand for PIL listing and right hand for PIR listing.

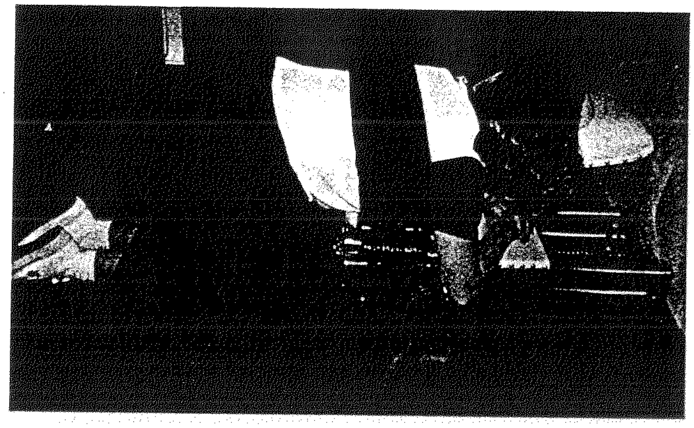


FIGURE 18. *Depicts doctor stance position for a PIL atlas listing. For the PIR listing, the doctor stance is the same on the opposite side of the table.*

3. *Tissue Pull:* The tissue pull is conducted in the same manner as for the ASL and ASR atlas listing except that the tissue pull is conducted in the opposite direction. For example, for the ASR atlas listing, the tissue pull is clockwise. The PIR atlas listing tissue pull is counter-clockwise.

4. *Roll-in:* The roll-in is performed in the same manner as described for ASL and ASR atlas listings except for the elbow joint movement. With the PIL and PIR atlas listings, the elbow joint on the contact side of doctor stays fixed during the roll-in process and does not move medial and superior. The left arched hand is the contact hand for PIL, and the right arched hand is the contact hand for the PIR listing.

5. *Set Down:* The set down is performed in the same manner described for ASL and ASR atlas listings.

6. *Body Drop:* The body drop is performed in the same manner described for ASL and ASR atlas listings.

Record Listing: The PIL and PIR atlas listings will be recorded in three steps. First, the listing (PIL or PIR), then 1 or 2 reflecting the doctor's position, followed by the "tracking side" convergence angle plus 4°. For example, a PIL listing adjusted in position 1 that has a 32° "tracking side" angle is recorded as PIL 1/36.

DISCUSSION AND CONCLUSION

This upper cervical specific, knee-chest procedure is designed to analyze the upper cervical misalignment according to the articular surfaces, use spinal thermography and postural studies to monitor the upper cervical subluxation and its correction, and to deliver an adjustment that will successfully address each of the three planes of misalignment, unique to the C0-C1 articulation, to correct the atlas subluxation.

We have presented three cases that have responded well to this upper cervical knee-chest procedure. The criteria set forth to evaluate the success of care for correcting the upper cervical subluxation was spinal thermography, x-ray analysis, and LLI examinations. Ancillary examinations, such as bone mineral density, lumbar range of motion studies, and the Rand 36 health questionnaire indicate overall improvement in a patient's function, but are not necessarily used to determine correction of the upper cervical subluxation.

Part II of this report will detail the analysis and correction of the C2 subluxation via the upper cervical specific, knee-chest adjustment.

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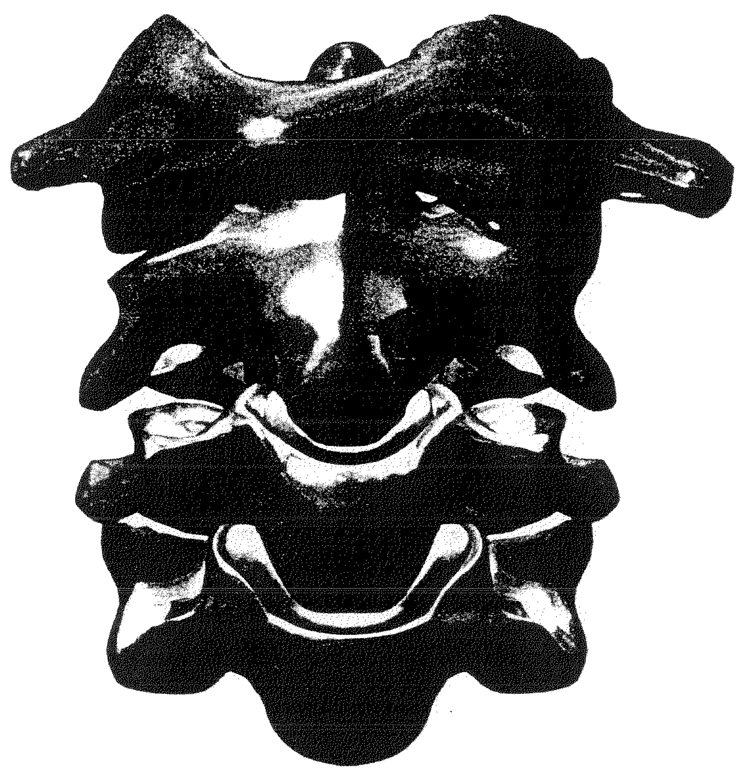

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Vertigo, Tinnitus, and Hearing Loss in the Geriatric Patient

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ABSTRACT

Objective: To document clinical changes after a course of chiropractic care in a geriatric patient with vertigo, tinnitus, and hearing loss.

Clinical Features: A 75-year-old woman with a longstanding history of vertigo, tinnitus, and hearing loss experienced an intensified progression of these symptoms 5 weeks before seeking chiropractic care. Radiographs revealed a C3 retrolisthesis with moderate degenerative changes C4-C7. Significant decreases in audiologic function were evident, and the RAND 36 Health Survey revealed subjective distress.

Intervention and Outcome: The patient received upper cervical-specific chiropractic care. Paraspinal bilateral skin temperature differential analysis was used to determine when an upper cervical adjustment was to be administered. Radiographic analysis was used to determine the specific characteristics of the misalignment in the upper cervical spine. Through the course of care, the patient's symptoms were alleviated, structural and functional improvements were evident through radiographic examination, and audiologic function improved.

Conclusion: The clinical progress documented in this report suggests that upper cervical manipulation may benefit patients who have tinnitus and hearing loss. (J Manipulative Physiol Ther 2000;23:352-62)

Key Indexing Terms: Vertigo; Tinnitus; Vestibular System; Cervical Spine; Chiropractic

INTRODUCTION

Vertigo, tinnitus, and hearing loss symptoms are usually attributed to the vestibular system. However, these symptoms may be the most obvious signs of a more complex presentation, especially in geriatric patients. Vertigo may be described as dizziness, faintness, lightheadedness, disorientation, or disequilibrium. Subjective vertigo is an illusion of movement of oneself, whereas objective vertigo is an illusion of movement of objects around oneself. Tinnitus is the perception of sound in the absence of an acoustic stimulus and may have a buzzing, roaring, whistling, or hissing quality or may involve more complex sounds that vary over time. Tinnitus is usually accompanied by hearing loss.[1]

The clinician can evaluate the cause of vertigo in 3 basic categories: peripheral, central, and systemic.[2-5] Vestibular functions belong to the peripheral category with the exception of the central nerve system and vascular supply, which compose the central category. Vestibular dysfunctions found in the systemic category may be important in the geriatric patient because they occur as a result of side effects from medications (eg, anticonvulsants, hypnotics, antihypertensives, alcohol, analgesics, tranquilizers) or an underlying systemic pathologic condition (diabetes, hypothyroidism).

A correlation between cervical spine disorders and vestibulocochlear symptoms have been reported.[6-12] The proprioceptive cervical afferent nerve fibers assist in the coordination of eye, head, body, and spatial orientation and the control of posture.[13] Dizziness and subjective balance disturbances are common symptoms in cervical pain syndromes. Hyperactivity of the spinovestibular afferents in the cervical spine brings on cervicogenic vertigo.[8] Cervical spondylosis with instability has been reported to produce Barré-Lieou syndrome, which may present as a triad of vertigo, tinnitus, and hearing loss.[14] Rzewnicki[9] reported that degenerative changes in the cervical spine often cause pain, vertigo, and pathologic results of otoneurologic test.

Bjorne et al[6] found a much higher occurrence of signs and symptoms of cervical spine disorders in patients diagnosed with Meniere's disease, a condition that includes acute attacks of vertigo with tinnitus and hearing loss, when comparing subjects in the general population. Most of these patients had problems in the upper cervical region. Hulse[15] reported that functional deficits in the upper cervical spine can lead to tinnitus, vertiginous episodes, a feeling of ear pressure, otalgia, and deafness and recommended chiropractic management of the upper cervical spine based on the results of his study involving 62 patients with vertebrogenic hearing loss.

Chiropractic care to the cervical spine has been reported to improve and ameliorate symptoms of vertigo, tinnitus, and hearing loss.[16-19] It is reasonable to conclude that successful chiropractic intervention in these cases occurred because of improved cervical spine function, with its neurologic and vascular components.

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postulated to jeopardize some functions of the medulla.[55-57] Rosenberg et al[58] reported a case of cervical cord impingement without a demonstrable misalignment observed with magnetic resonance imaging, bringing on signs and symptoms of medulla compression. Hack et al[59] found a well-organized connective tissue bridge from the rectus capitus posterior minor muscle through the atlanto-occipital junction inserting onto the dura by way of the posterior atlanto-occipital membrane. The posterior atlanto-occipital membrane was securely fixed to the dura by several fine connective tissue fibers. These two structures appear to function as a single entity. Hinson and Zeng[60] have observed through dissection that fibrous connective tissue serves to bridge the posterior longitudinal ligament and the dura from the top of the odontoid process to the lower body of C2. The posterior longitudinal ligament was found to be firmly attached to the periosteum of the anterior canal at this level. In addition, posterior connective tissue bridging to the posterior arch of C1 and to the lamina of C2 was evident. These findings suggest that the cord at the cranio-vertebral junction may be influenced by biomechanic aberrations in the upper cervical spine, which are evident through protractor cervical radiograph views.[40,41,61,62] Interruption of the neural pathways at this level could result in the symptoms reported in this case.

One theory has proposed that irritation of sympathetic nerves can elicit spasms within the vertebral artery, leading to a decrease in blood flow to the brain stem and brain. Terret[63] reported that misaligned vertebrae that guide arteries to the brain, presumably in the upper cervical spine, could create sufficient stress on the arteries to constrict the lumen. A decrease in blood circulation to vital auditory and vestibular centers could result in the presenting signs and symptoms in this case.

Compromise of the first 4 cervical spinal nerves, first 5 thoracic spinal nerves, or the superior cervical sympathetic ganglion through atlas subluxation could have been a factor in the pathogenesis of this case. These structures may be affected by an aberrant C1 position directly and indirectly. The first 2 cervical spinal nerves and superior cervical ganglion can be directly affected by atlas misalignment, thus altering their function. The third and fourth cervical spinal nerves and upper 5 thoracic spinal nerves may be jeopardized because of biomechanic changes, with structural compressions occurring as a result of atlas subluxation.[17]

Any mechanisms proposed appear plausible for this case. One mechanism by itself is less likely than a combination of some or all of the suggestions.

Thermography

The STDA performed on this patient was the sole criteria used to determine the presence or absence of aberrant neurophysiology in the cervical spine. Thus the timing of an adjustment in the upper cervical spine, as described, was determined by reading the STDA.

Thermoregulation is thought to be centered in the hypothalamus and refined through spinal neuronal function at

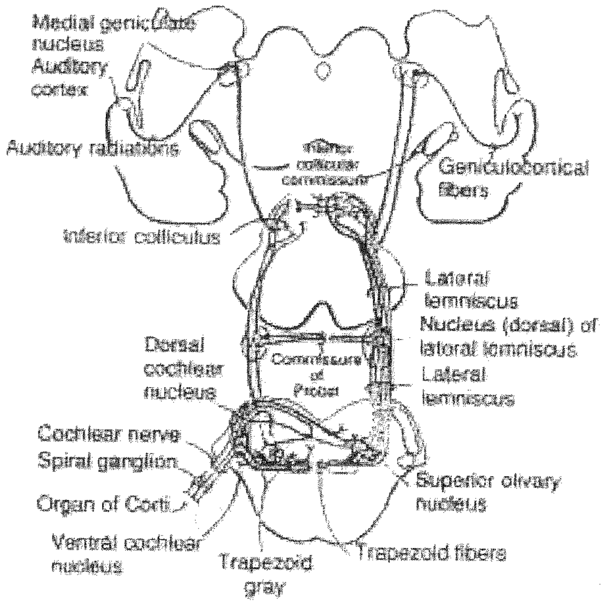


Fig 6. *Neurologic pathway for the cochlear portion of the vestibular apparatus. Reprinted with permission from Guyton AC, Hall JE, editors. Textbook of medical physiology. 9th ed. Philadelphia (PA): WB Saunders; 1996.*

each spinal cord segment. Logically, this occurs for the purpose of segmental adaptation from environmental stresses. The hypothalamic set point, the core temperature of the body as determined by the hypothalamus, is filtered at each spinal segment by way of thermoregulative C-sympathetic nerve cell bodies. Temperatures have been documented to vary 5° C at individual spinal segments. Wallace et al[34] illustrated

> This set point, however, is refined at each spinal segment by thermoregulative "C" sympathetic nerve cell bodies. Local, segmental thermoregulation by spinal cell bodies was shown to function even in the absence of hypothalamic input in decerebrate rabbits. Spinal nerve-cell bodies respond to thermoceptive, nociceptive and mechanoceptive afferents within their respective (and sometimes adjacent) dermatomes.
>
> At each dermatomal segment, efferent axons connect thermoregulatory spinal "C" cell bodies to the paraspinal ganglions. At the ganglion, these neurons synapse with postganglionic thermoregulative efferents, some of which terminate cutaneously. Cutaneous sympathetic thermoregulatory neuronal function regulates vasomotor activity within the dermal arterioles and capillaries. Vasodilation tends to increase skin temperature, resulting in a greater heat transfer rate to the surrounding environment. Conversely, vasoconstriction causes the skin to approach ambient temperature, tending to conserve core heat.

(Fig 7) Bilateral skin temperature differential studies allow the clinician to observe paraspinal temperature at a location proximal to each spinal segment. The pattern system is a system developed to analyze bilateral skin temperature differential data gathered through neurocalograph readings. Skin temperatures are constantly changing as a function of the adaptive process throughout the entire human system by

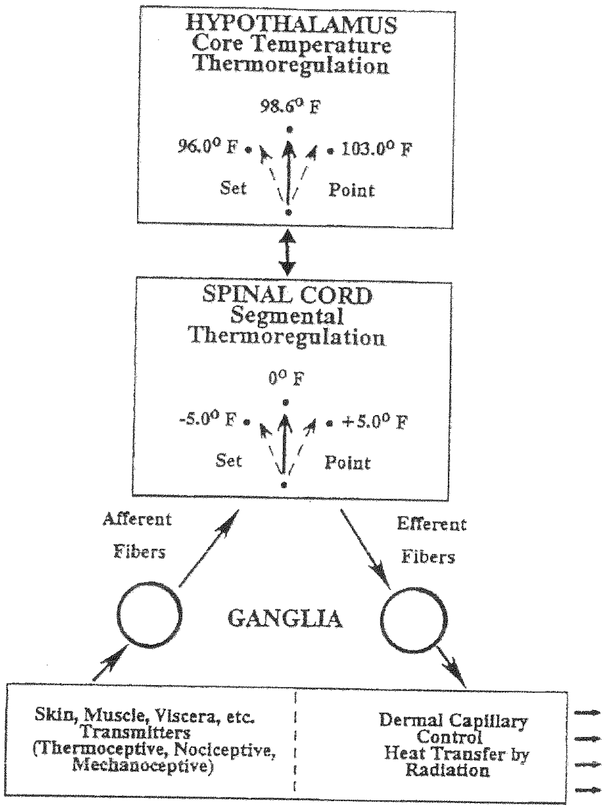


Fig 7. *Simplified representation of thermoregulation. Reprinted by permission of the Chiropractic Research Journal from Wallace et al.*[34]

methods previously described.[36] Differences in temperature found from one side of the spine to the other that are static and persistent over time (days, weeks, or months) indicate a lack of thermal adaptation and are thought to be the result of aberrant neurophysiology.

An STDA graph reading that is static and persistent over time is considered to be the patient's pattern. Palmer[16] believed that a vertebral subluxation does not change in its general nature or fluctuate in vertebral positioning from day to day but becomes fixed, causing the same or similar neurologic insult over time. The upper cervical vertebrae are structurally unique and asymmetrical.[40,41,58,59] The supporting soft tissues in the upper cervical spine have their inherent strengths and weaknesses. These 2 factors give upper cervical vertebrae a propensity toward returning to their original misaligned position in subluxation. Therefore we would expect that neuronal dysfunction as caused by a vertebral subluxation would consistently disturb neurologic function. Hence, bilateral skin temperature differentials are not balanced and do not change over time in the presence of vertebral subluxation.

Clinically, the STDA graph reading should be evaluated on each case, looking at its reproducibility and chronicity. There are characteristic deviations within each patient's pattern. When these deviations are constant, they compose the patient's individual subluxation pattern. The clinician arrives at identifying the patient's pattern by comparing the current STDA graph with previous readings to determine duplicating characteristic deviations. Each patient's pattern may have 2, 3, or even more of these specific break points, which are unique and must all be present to be considered a pattern.

It is thought that the spine, surrounding soft tissues, and injured neuronal tissue go through cycles of repair as part of the healing process.[30] Structural changes occurring as a result may present STDA graph readings with characteristics similar to the original pattern. However, these STDA graph readings are normal and transient. If the clinician will allow a short period of time, these readings will usually disappear. Therefore it is prudent to consider the administration of an upper cervical adjustment after seeing the original pattern on 1, 2, or even more office visits to distinguish between a true and false pattern. This is a clinical judgement made on each individual case. An adjustment in the upper cervical spine administered at the wrong time can be detrimental to the patient's outcome.

Duff[29] found after recording over 35,000 comparative full spine STDA scans that no constant, static deflection or bilateral asymmetry in skin temperature can be found below the C2 level of the spine when the upper cervical region is in its proper juxtaposition and not subluxated. His paraspinal readings were performed by thermocouple instrumentation with a constant glide neurotempometer to ensure accuracy in gliding speed. The readings were made on each patient in a copper-grounded and copper-shielded booth to eliminate variable external energies, such as radio waves, television waves, Hertzian waves, and electromagnetic waves, thus preventing their influence on the graph reading. Duff[29] concurred with Palmer's original thought[31]: that asymmetrical skin temperature differentials were the result of heat resistance build-up from a blockage of nerve energy or nerve interference. With the assumption that human electricity flowing through nerves operates on the same principle as electricity flowing through wires, interference to electrical force will cause a local elevation of temperature dispersing at 90-degree angles from the point of impediment. Some heat is lost from absorption before it reaches the skin as it travels through soft tissue. However, it is thought that a significant amount of this increased temperature is reflected in the skin and alters the symmetry of bilateral skin temperature paraspinally.

CONCLUSION

This case details changes before and after treatment with long-term follow-up care in a clinical setting. Daily notes, bilateral skin temperature readings, and clinical impressions were included to illustrate the day-to-day clinical thinking process in this case.

A case study is limited in its ability to provide conclusions; one single case should not be taken out of context. It is possible that the patient described here recovered through spontaneous remission or because she believed her problem had been discovered and improved, creating a placebo

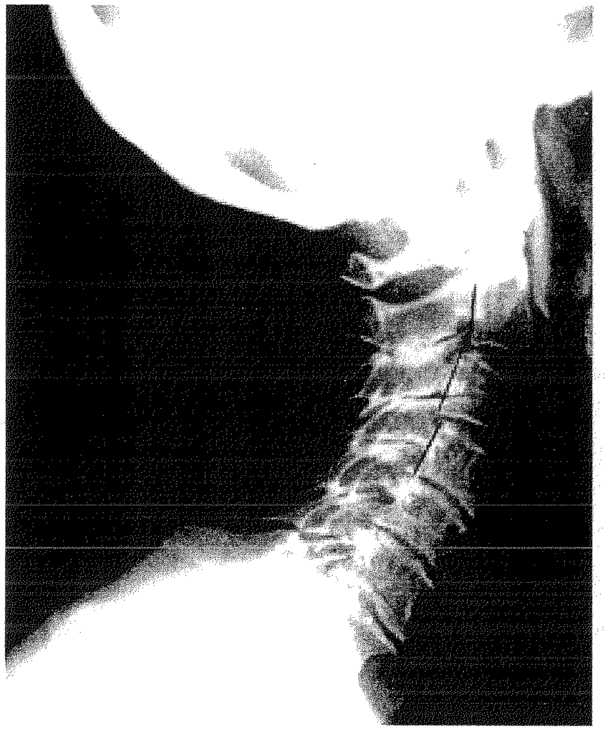


Fig 1. *Initial neutral lateral cervical radiograph depicting C3 retrolisthesis.*

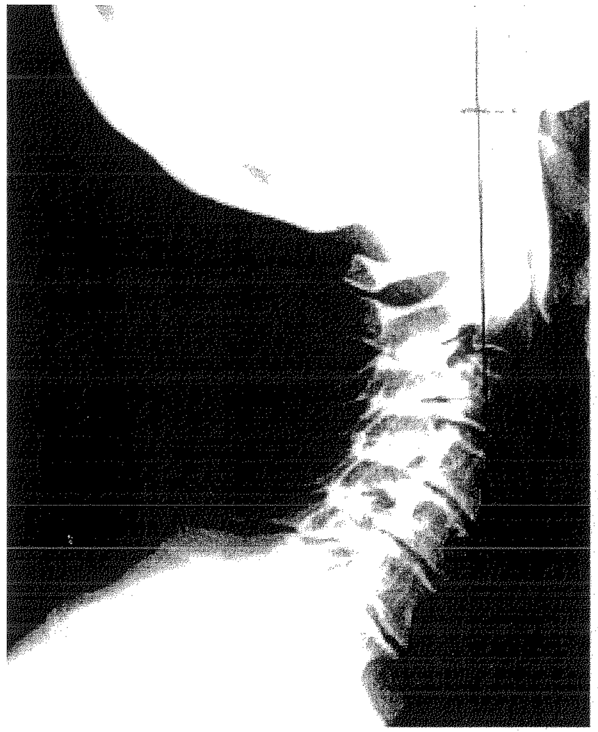


Fig 2. *Initial neutral lateral cervical radiograph with anterior-posterior gravity line. A* perpendicular line *is constructed from the top of the film intersecting through the apex of the odontoid process of C2. The study is considered normal when the line passes through the C7 vertebral body.*

CASE REPORT

A 75-year-old woman with episodic dizziness, pain and pressure in the left ear, hearing loss in both ears that had progressively worsened, anxiety attacks, and an overall nervousness presented to our chiropractic practice. The patient stated that she had anxiety around a crowd of people and requested that her appointments be scheduled when there was less patient traffic. Although she had these symptoms for the past several years, 5 weeks before her visit the vertigo and tinnitus had increased in frequency and severity. For 27 years, she had been taking nerve medication for anxiety, nervousness, and insomnia on a palliative schedule. The patient did not have a family history of vertigo, tinnitus, and hearing loss.

On examination, neck extension produced dizziness. Weber's test was negative, and Rinne's test was positive, with both air and bone conduction reduced bilaterally, indicating a sensorineural hearing loss.

The initial neutral lateral cervical radiograph depicted a retrolisthesis of the 3rd cervical vertebra (Fig 1). The 3rd cervical vertebral body appears to be 2 mm posterior to the C2 vertebral body and 2 mm posterior to the C4 vertebral body. There was moderate degeneration noted throughout from C4 to C7.

The cervical gravity line measured by a neutral lateral cervical radiograph is constructed to determine weight-bearing in the cervical region.[20,21] A line is drawn perpendicular to the top of the film, from the apex of the odontoid process, and should pass through the C7 vertebral body. A significant anterior weight-bearing is noted on the initial neutral lateral cervical film (Fig 2).

Active flexion/extension cervical radiographs were performed to determine the specific degree of intersegmental motion in the cervical spine. The patient was instructed to look up as far as possible, tilting her chin up for the extension view. She was asked to tuck her chin to her chest and look down as far as possible for the flexion view. The initial set of radiographs were taken 20 minutes before the first upper cervical adjustment. The flexion/extension cervical films were analyzed according to the Penning method.[22,23]

The Penning analysis is accomplished with the flexion and extension lateral cervical radiographs. In this case, the flexion film was superimposed on the extension film. A 14 × 17 in transparent film was anchored between the superimposed films to record. With C7 matched between the flexion and extension radiographs, a line was drawn on the transparent film across the top of the flexion radiograph. This same procedure was repeated for C6 and each vertebrae in the cervical spine, including C1. An angle was measured at the intersection of the lines formed from the superimposing of C7 and C6. This procedure was duplicated for each motor segment in the cervical spine. Care was taken to restrict any movement of the extension radiograph or the transparent film. The extension radiograph was taped to the view box, and the transparent film was fastened to the view box.

Table 1. *Penning method of radiographic determination of loss of range of motion in case #6882, a woman aged 75 years*

	Our patient	Established normal value	% of normal
Examination # 1		Date of radiograph 5/01/98	
C1-C2	11	None	NA
C2-C3	5	12.5	40
C3-C4	15	18	83
C4-C5	10	20	50
C5-C6	2.5	21.5	11.6
C6-C7	0	15.5	0
Examination # 2		Date of radiograph 6/12/98	
C1-C2	13	None	NA
C2-C3	8	12.5	64
C3-C4	15.5	18	86
C4-C5	10	20	50
C5-C6	6	21.5	28
C6-C7	2	15.5	13
Examination # 3		Date of radiograph 2/11/99	
C1-C2	14	None	NA
C2-C3	7.5	12.5	60
C3-C4	15.5	18	86
C4-C5	8.5	20	42.5
C5-C6	7	21.5	32.5
C6-C7	5	15.5	32

Dvorak et al[24] have found clinical value in the evaluation of functional flexion/extension radiographs measured with the Penning analysis. They found statistically significant differences between people with cervical-related disorders and a healthy population.

The Penning analysis[22,23] indicated a substantial loss of motion at the C2/C3, C4/C5, C5/C6, and C6/C7 motion segments. The C3/C4 segment appeared to be within normal ranges in the gross sense. However on closer observation, it was determined that on extension of the cervical spine, C3 moves 2 mm posterior to the C4 vertebral body and on flexion C3 moves 2 mm anterior to the C4 vertebral body. This motion segment appears to have exaggerated movement. Three millimeters or more of sagittal translation on flexion and extension is considered unstable.[25] However, the margin of error with pencil marking of plane view radiographs should be considered when determining instability. The degeneration present in the cervical spine appears to be a stabilizing factor.

A second flexion/extension cervical radiograph examination was performed 6 weeks after the original study, and a third flexion/extension cervical radiograph examination was performed 9½ months after the original study (Table 1). Improvements were noted at 6 weeks at the C2/C3, C5/C6, and C6/C7 motion segments. The third study revealed little change from the second study, with the exception of continued improvement with C6/C7 motion.

The next day after the initial examination, an audiologic examination was performed with a RAND 36 Health Survey. All the initial examinations were performed before the administration of the first specific chiropractic adjustment.

A Beltone series 109 audiometer with ear cups (Beltone, Chicago, Ill) was used to perform the audiologic function examination. A total of 11 different frequencies were tested: 125, 250, 500, 750, 1000, 1500, 2000, 3000, 4000, 6000, and 8000 Hz. At each frequency, the instrument was calibrated so that 0 dB, the volume at which a normal hearing person can barely perceive sound at a given frequency, was considered normal. When the volume of the tone must be increased to 40 dB above the normal for detection, for example, that patient is said to have a hearing loss of 40 dB at the frequency tested.[26]

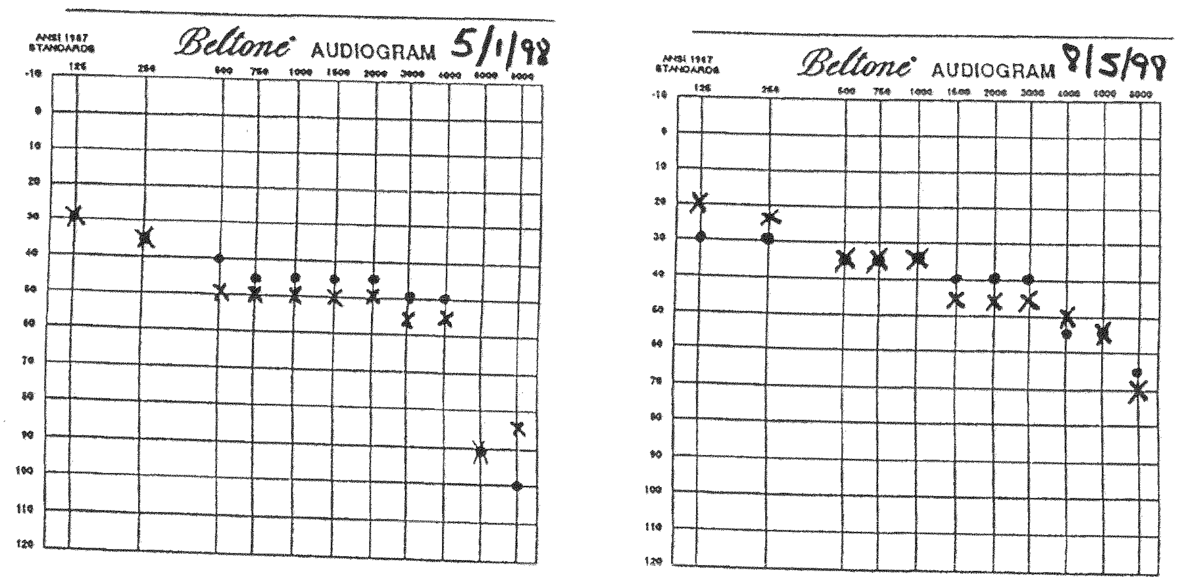
A set of ear cups were placed over the patient's ears. The patient was seated with her back to the examiner and was holding a hand-held device with a button. She was instructed to push the button when she detected sound. The button is attached to the Beltone instrument (Beltone, Chicago, Ill) by wire and is designed to illuminate a light on the front panel of the instrument, indicating that a sound has been detected. When the light came on, the examiner recorded the decibel level at the appropriate frequency level. After a sound was positively identified, the examiner switched to a new frequency. The decibel level was turned down to –10 at the new frequency, then increased at 5-dB intervals. The time between changing the decibel level was altered at random periods of between 5 and 10 seconds. Each finding was confirmed by repeating the procedure.

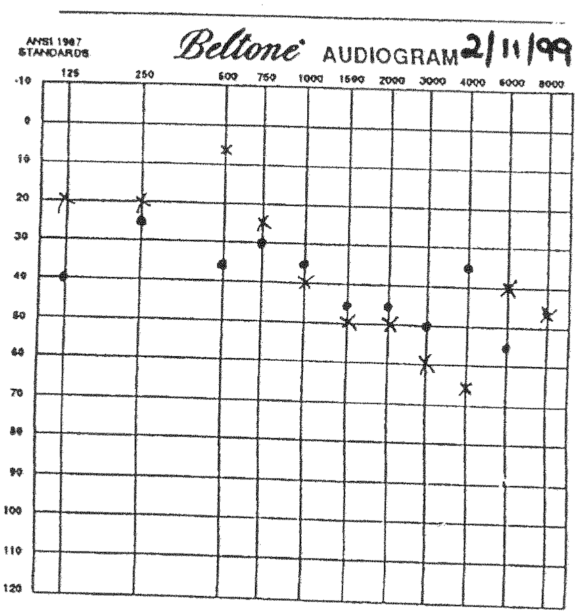
Audiologic losses of function were evident at all frequencies; however, the 6000 and 8000 Hz frequency range were the farthest away from the normal range.[26] The patient first detected sound in her left ear with the frequency of 6000 Hz at 90 dB and 8000 Hz at 85 dB. In her right ear, sound was detected at 90 dB with the frequency of 6000 Hz and 100 dB at the 8000-Hz frequency. Significant losses were recorded in the mid-frequency ranges as well. From the frequencies between 500 and 4000 Hz, the patient detected sound between 40 to 50 dB in the right ear and 50 to 55 dB in the left ear. Her hearing loss was most profound at higher frequencies.

Three audiometric examinations were performed: the first before the initiation of care, the second 3 months after the initiation of care, and the third examination was administered 9½ months after initiation of care (Fig 3).

The RAND 36 Health Survey[27] was devised to quantitatively analyze a patient's health status in outcome studies. The survey was designed for use in clinical practice and research, health policy evaluations, and general population surveys. There are 9 scored categories: general health, health change, physical functioning, limitations caused by physical health, limitations caused by emotional problems, social functioning, pain, energy/fatigue, and emotional well-being.

The RAND 36 Health Survey was completed by the patient at the initiation of care, 6 weeks after the initiation of care, and then 6 months after the last regular office visit (9½ months after initiation of care). Because of specific questions within the survey itself, at least 4 weeks is the necessary passage of time before another survey can be completed. The second survey and the second set of flexion/extension cervical radiographs were performed 6 weeks after the first adjustment to compare subjective progress with cervical spine changes.





TEST	Right Ear (Red)	Left Ear (Blue)
AIR	O—O	X—X

Fig 3. *Audiometric examinations.*

The survey[27] indicated that the patient had limitations caused by physical health and emotional problems, including social functioning and emotional well-being. She had a raw score of 0, 0, 50, and 48 in these categories, respectively, indicating problems. The RAND 36 Health Survey assesses health on a subjective scale in 9 health concepts and is scored from 0 to 100, where 100 indicates the best subjective health.

The patient received an upper cervical-specific chiropractic analysis consisting of a paraspinal bilateral skin temperature differential analysis (STDA) with a set of cervical radiographs to assess the misalignment in cervical spinal listing. On each office visit, she was requested to record any symptomatic changes on a daily case record form.

On each office visit, a paraspinal bilateral STDA was performed in the cervical spine by a neurocalograph. The STDA was used to determine the presence or absence of neurophysiologic dysfunction, interpreted as a vertebral subluxation.[28-39] The neurocalometer, developed by Dossa Evins and B.J. Palmer, was the first instrument developed to measure temperature differentials to ascertain neuronal dysfunction.[28-33] The neurocalometer is a dural-probed instrument that assesses bilateral paraspinal skin temperature differentials. Bilateral skin temperature differential affords the opportunity to investigate physiologic function of the nervous system.

Through analysis of the cervical radiographs, the atlas spinal listing was concluded to be anterior, superior, and right. This represents the misaligned position of the atlas in relation to the occipital condyles.[40,41] The atlas had misaligned anterior to the occipital condyles on both articulations. The left lateral mass of atlas was tracking along the convergence angle in relation to the right occipital condyle. As a result, the right lateral mass of atlas also moved anterior in relation to the right occipital condyle and was forced to slide off the right condyle-lateral mass track with right laterality. Superiority or inferiority of the atlas is derived from the relative position of the anterior tubercle of the atlas. When the atlas moves anterior in relation to the occipital condyles, the anterior tubercle shifts to the superior position. Therefore there are three directions (anterior, superior, and right) of atlas misalignment in relation to the occipital condyles.

A specific adjustment to the atlas was accomplished through knee-chest posture with a solid head piece.[16,18,42] With the spinal listing of anterior, superior, and right with each adjustment, the patient was instructed to place her midsternal notch on the front of the knee-chest table and turn her head to the right with the left side of her head also on the table. She was instructed to relax, laying her shoulders and neck on the table. For the adjustic thrust, a contact was made with the pisiform of the right hand onto the soft tissue covering the posterior arch of atlas. A tissue pull and roll in was performed with the right hand in an arched position to create tension and release slack of the surrounding soft tissues. The tissue pull was accomplished with the tip of the middle digit on the left hand beginning at the posterior-most portion of the atlas posterior arch and pulling the tissue in a half circle with clockwise direction toward the anterior portion of the atlas posterior arch. This procedure was performed to remove the slack from the soft tissue covering the contact point, to promote a better set, and to allow a smoother adjustment for the patient. The roll in, a slight movement performed to keep the previously pulled tissue taut to secure the contact point, was accomplished by arching the right hand in the adjustic position and rolling the pisiform contact in the counterclockwise direction onto the posterior arch, where the tissue had just previously been firmed up with the described tissue pull. After the roll-in by the right hand, the left hand was placed over and around the right hand in a criss-cross fashion to produce a torquing toggle action at the moment of the thrust. A high-velocity, low-amplitude torque and toggle thrust was administered. A torque and toggle action is necessary to address the 3 directions of atlas misalignment. The adjustment does produce an audible sound that is heard by the patient but should not be painful when applied correctly.

Immediately after each specific adjustment, the patient was required to rest supine with cervical support for 1 hour.[18] Rest is necessary for the soft tissue supporting the upper cervical region to adapt to the new atlas position.[29,30] The soft-tissue support and vertebra, itself, have a tendency to move back into the subluxated position. The rest period allows these tissues time to increase in strength at the new location and ultimately promotes a longer term atlas correction. An STDA was performed after the 1-hour rest period on office visits during which a specific atlas adjustment was administered. The patient was instructed to learn to sleep on her back or side without lying with her spine in a kinked position; she was also instructed not to sweep, vacuum, wash dishes, or perform work above her shoulders for 1 week after an adjustment. In addition, she could not take medication 12 hours before an STDA, and she could not consume caffeine 4 hours before an STDA.

Over the course of 3½ months and 29 office visits, 3 specific atlas adjustments were performed. The patient improved subjectively, as evidenced by the RAND 36 Health Survey and the detailed daily office visit remarks (Fig 3). She did not experience episodes of vertigo after the first few weeks of care. She reported that her hearing had noticeably improved. The patient had stopped taking medication for her nervousness, anxiety, and insomnia on her own volition because these symptoms were alleviated. Six months after the last office visit, the patient consented to undergo retesting. A RAND 36 Health Survey, cervical flexion/extension and neutral lateral radiographs, audiometric study, daily case record update, and STDA were performed. At that time, she had continued hearing improvement and did not have dizzy spells, pressure in her ears, or insomnia; her nervous condition was not present.

The second and third neutral lateral cervical radiograph performed 14 weeks and 9½ months after the initiation of chiropractic care demonstrated improvement in the cervical weight-bearing (Fig 4, *Left* and *Right*). Although the last study is not within the normal range, significant gains are evident. Care was not administered between the second and third neutral lateral film, although continued improvements are apparent.

Cervical flexion and extension radiographs performed 6 weeks after the first upper cervical adjustment demonstrate improvements in all cervical intersegmental motion segments with the exception of C4/C5, which remained without change. A total of 9½ months after the initial set of flexion/extension films, the final set was taken and demonstrated improvements in the lower cervical spine, whereas minor changes occurred in the mid- to upper cervical regions. Less degeneration is noted on the flexion, extension, and neutral lateral cervical radiographs taken 9½ months after the initiation of care than on the original set.

Audiometric study performed after 13 weeks of care demonstrated improvement in all frequencies. However, the most striking changes occurred at the highest frequencies tested, at 6000 and 8000 Hz. Both the left and right ears went from 90 dB required for a response at a frequency of 6000 Hz to 55 dB for a response at the same frequency. The left ear went from the initial recording of 100 dB required for a response at a frequency of 8000 Hz to 65 dB necessary, and the right ear went from an initial 85 dB requirement to 70 dB at the 8000 Hz frequency. The third audiometric study was performed 9½ months after the initiation of care. It showed notable improvement at some frequencies, especially the highest ones, and regression at other frequency levels (Fig 3).

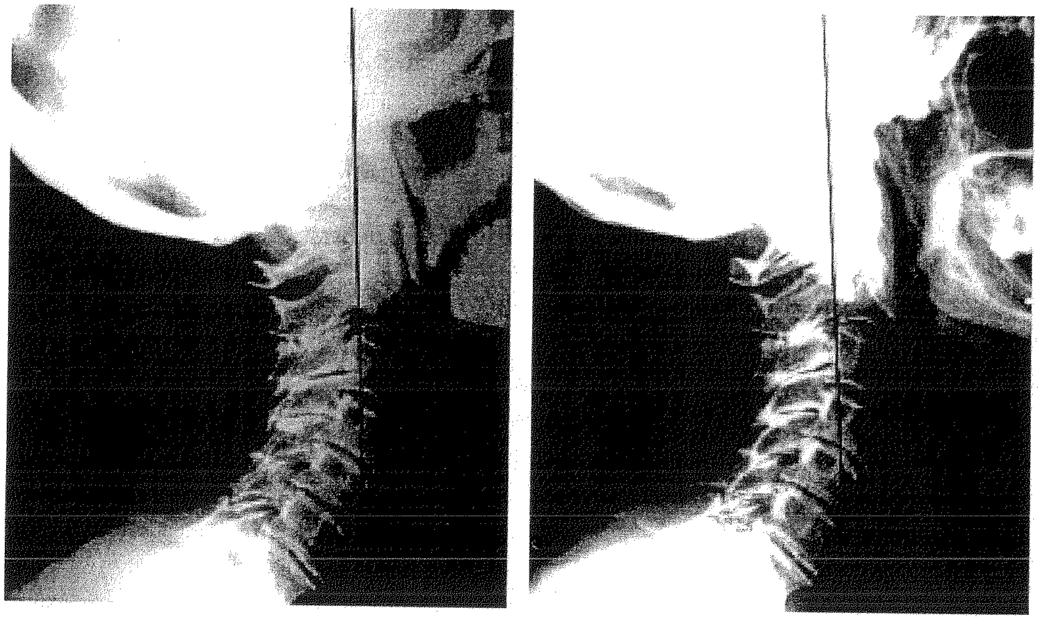


Fig 4. Left, *Neutral cervical radiographs taken 6 weeks after the initiation of chiropractic care.* Right, *Neutral lateral cervical radiographs taken 9½ months after the initiation of chiropractic care.*

The RAND 36 Health Survey was used to ascertain subjective process in a quantitative manner. The original survey was taken before the first specific adjustment, and the second survey was taken 6 weeks after the initiation of specific care. The largest gains were observed in the health change, limitations caused by physical health, limitations caused by emotional problems, social functioning, and emotional well-being categories. The RAND 36 Health Survey details continued improvements of subjective status 9½ months after treatment. After a few office visits, the patient was less reluctant to having her appointments with other people. She may have established a friendly rapport with patients because of having consistent appointment times. Possibly her tolerance had increased, as documented by the RAND 36 Health Survey, demonstrating sizeable changes in her emotional and social well-being scores. Patients with vestibular dysfunction often have symptoms typical of panic disorders and/or hyperventilation,[43] which is consistent with this case. The anxiety and nervousness associated with this patient may well have been related to the vestibular dysfunction because these symptoms disappeared with the vertigo, tinnitus, and improvement in hearing.

DISCUSSION

Pathophysiology

The patient's symptoms were consistent with Meniere's disease. Meniere's disease is characterized by recurrent prostrating vertigo, sensorineural hearing loss, and tinnitus. Many believe Meniere's disease results from abnormality in fluids of the inner ear, specifically the presence of endolymphatic hydrops in the vestibular apparatus. Although endolymphatic hydrops do exist, there has not been a significant correlation evident between Meniere's disease and endolymphatic hydrops.[44] Endolymphatic hydrops is a pathologic finding, whereas Meniere's disease is a clinical entity.[6] There is no single test to confirm the presence of Meniere's disease,[45] and many conditions may present with same or similar symptoms.

The patient's radiographs revealed signs of cervical instability at the C3/C4 motion segment with considerable cervical degeneration between C4-C7. Dechler[46] reported that degenerative changes in the cervical spine from C4-C7 are common with morbus Meniere's disease. This patient's audiometric studies revealed hearing deficits at higher frequencies, which is opposite of the expected symptom with Meniere's disease. The onset of Meniere's disease is usually seen in a younger patient; many geriatric patients may present with signs and symptoms that appear like Meniere's disease.

The clinical outcome in this case directs our attention to the cranio-vertebral junction as a possible source of pathophysiology.

Both the vestibular and cochlear nerves join at the internal auditory meatus to form the 8th cranial nerve, which enters the brain stem at the cerebellopontine angle (Fig 5).[47] The vestibular nerve projects to the vestibular nuclei in the medulla oblongata and into the inferior cerebellar peduncle. The cochlear nerve projects to the cochlear nuclei. Therefore the 8th cranial nerve consists of 2 functional divisions, equilibrium and hearing, which have a close relation to their respective nuclei in the medulla.[48]

The vestibular nuclei are located approximately at the junction of the medulla and pons and receive signals from the vestibular apparatus. The vestibular nuclei are richly interconnected with components of the brainstem reticular formation.[49] After receiving positional information, the vestibular nucleus sends motor responses to coordinate

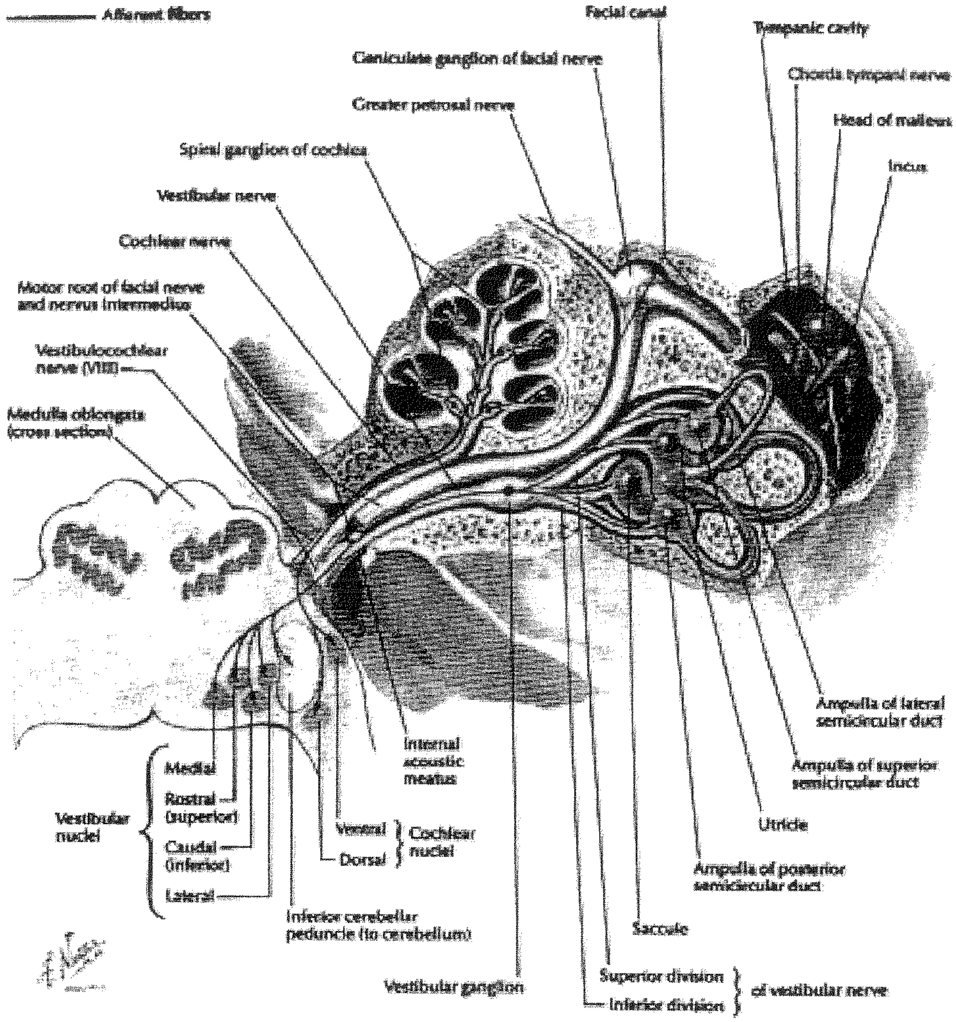


Fig 5. *Neurologic pathway of the vestibulocochlear nerve (Cranial Nerve VIII). Copyright 1989. Novartis. Reprinted with permission from the Atlas of Human Anatomy, illustrated by Frank H. Netter, M.D. All rights reserved.*

appropriate eye movement, neck movements, and body postural changes for maintaining balance.[26]

Auditory function begins in the cochlear portion of the vestibular apparatus. Auditory nerve signals are transmitted mainly by the inner hair cells in the organ of Corti. Nerve fibers from the spiral ganglion of Corti go to the dorsal and ventral cochlear nuclei, which are located in the upper portion of the medulla. All fibers synapse and many pass to the opposite side of the brain stem and terminate in the superior olivary nucleus. Some of these fibers also pass ipsilaterally to the superior olivary nucleus on the same side. From the superior olivary nucleus, the auditory pathway passes upward through the lateral lemniscus, with some of the fibers terminating in the lateral lemniscus nucleus. Many fibers bypass there and nearly all terminate in the inferior colliculus. The pathway then passes to the medial geniculate nucleus, where all fibers again synapse. The pathway then proceeds to the auditory cortex in the superior gyrus of the temporal lobe through the auditory radiation (Fig 6).[26] Interference in any portion of these neural pathways can bring about nerve-related hearing impairment.

Wilkins[51] reported that as part of the aging process, arteries elongate and the brain "sags." As a consequence, redundant arterial loops and bridging of intrinsic hindbrain veins may cause cross-compression of cranial nerve root entry zones in the cerebellopontine angle. This pulsatile compression can be seen to produce hyperactive dysfunction of the cranial nerve. The 8th cranial nerve may be affected, bringing on symptoms of tinnitus and vertigo.

Cervical afferents have been postulated as the cause of cervicogenic vertigo[52,53] and hearing loss. With abnormal function occurring in the joint receptors of the cervical spine, aberrant nerve signals are sent to the brain stem through ascending tracts; inappropriate adaptive responses follow because of incorrect environmental monitoring of positional change.

A 3-directional misalignment of the atlas may compromise the size of the neutral canal space[18,54] and has been effect. The spinal structural changes recorded in this case along with neurophysiologic recuperation weigh against the placebo affect. The time span in which the patient had the original symptoms before the instigation of chiropractic care makes spontaneous remission less likely.

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CASE REPORTS

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Thermal Asymmetry of the Upper Extremity in Scalenus Anticus Syndrome, Leg-Length Inequality and Response to Chiropractic Adjustment

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ABSTRACT

Objective: To describe a case of a vasomotor, vascular form of thoracic outlet syndrome that causes upper extremity thermal asymmetry, and to discuss a single subject case study (N-of-1) comparing the correlation of a subjective test for putative atlas vertebral subluxation complex (supine leg-length inequality) with a single blinded objective measurement [temperature differential (delta°T)] on the dorsum of the hands.

Clinical Features: A 71-yr-old woman with a cold, painful right hand and chronic neck pain sought chiropractic evaluation. There was a left head tilt and muscular hypertonicity with fibrous bands in the opposite scalenes and sternocleidomastoid. Thermographic examination revealed a large temperature differential (12° F) between the dorsum of the right and left hands, with the superficial veins on the dorsum of the cold hand collapsed. Thoracic outlet provocation tests were negative. A left-side leg-length inequality potentially indicative of putative upper cervical subluxation was also noted. A diagnosis of presumptive thoracic outlet syndrome with vasomotor vascular complications subsequent to altered cervical biomechanics was made.

Intervention and Outcome: Treatment was limited to chiropractic, upper cervical, vectored, linear adjustment of the atlas vertebra. Temperature differential between the hands improved significantly after individual atlas adjustment(s) and in the long term.

Conclusion: Scalenus anticus syndrome and upper extremity thermal asymmetry may result from altered cervical biomechanics caused by atlas vertebral subluxation complex. Furthermore, the supine leg check may be of value in determining the necessity of atlas adjustment. (J Manipulative Physiol Ther 1997; 20:476–81).

Key Indexing Terms: Thoracic Outlet Syndrome; Chiropractic; Leg-Length Inequality

INTRODUCTION

Scalenus anticus syndrome (SAS) is a form of thoracic outlet syndrome (TOS), a condition recognized as early as 1628 (1). It is a condition whose difficulty in diagnosis makes it controversial. SAS is typically caused by compression of the upper thoracic neurovascular bundle. In most cases, the cause is uncertain, but it is often related to trauma (1–3). Known causes of TOS include anatomical abnormalities, such as cervical ribs, callus formation after clavicular fracture, hypertrophy of the scalenus anticus (SAS) and functional disturbances, such as shortening or spasm of the scalenus anticus, medius and pectoralis minor, weak shoulder girdle with drooping shoulder posture and high thoracic lordosis presenting round shoulders and head forward posture (1–3).

Vascular complaints related to TOS are divided into venous, arterial, and vasomotor types; these make up 3–10% of total cases (1). Differential diagnosis may be difficult (Table 1), because all vascular forms can cause a cold, painful hand. Other conditions involving an upper extremity vasomotor or abnormal sympathetic discharge are shown in Table 2.

The use of thermography as a diagnostic tool for vascular problems, including those in TOS, has established thermal symmetry to be the normal condition of the body; thus, asymmetric temperature patterns are indicative of pathology (3–7). In checking for skin temperature thermal patterns, Plaugher found that liquid crystal thermography was inexpensive, provided a distinct color contrast, was simple and showed good intra-examiner reliability (7).

Conservative treatment for TOS/SAS has included resting the extremity, ice, heat, shoulder strengthening exercises, postural correction, myofascial release and manipulation (1–3, 8), including specific upper cervical chiropractic adjustment (9). One of the tests used to determine putative chiropractic subluxation and the need for adjustment is the so-called "quick" or visual leg check, as used in both prone and supine positions. Some studies have shown good interexaminer reliability for determining the short leg in the prone position (10, 11); however, those findings have been challenged (12). A Consensus Panel on the prone leg check recommended that practitioners should not rely solely on the results of leg checks to determine the course of treatment (13).

The supine leg check has been proposed as an indicator of putative upper cervical vertebral subluxation complex (VSC)

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Table 1. *Vascular types of TOS*

- Venous: edema, cyanosis, venous collateralization, symptoms increased on exertion, positive provocation tests
- Arterial: paresthesia (tingling), numbness, weakness, symptoms increased on exertion, positive provocation tests and Bakody's sign
- Vasomotor: negative or indefinite provocation tests and Bakody's sign, unilateral collapse of superficial veins, symptoms initiated by exertion, equivalent bilateral pulse pressure

(many of these signs, symptoms and tests are equivocal)

Table 2. *Sympathetic mediated, vasomotor syndromes of the upper extremity*

- Raynaud's disease: intense sympathetic discharge precipitated by exposure to cold or emotional stress; usually bilateral, blanching of the digits with sweating giving way to cyanosis then hyperemia and rubor, usually painless with some parasthesias (numbness, tingling, burning)
- Acrocyanosis: skin of both hands is persistently cyanotic, cold and sweating, pain is absent
- Reflex sympathetic dystrophy: unilateral severe burning pain, cold, sweating, allodynia, hyperalgesia, hyperesthesia

(14, 15); however, in a recent (1992) extensive review of leg-length inequality (LLI) by Mannello, no test of the upper cervical style supine leg check was discussed or referenced (16). Attempts to objectify this clinically noted phenomenon have been undertaken (17, 18), but no definitive confirmation of the reliability of the supine leg check test has been presented.

This case provided a unique opportunity to conduct a single (N- of-1) case study of the supine leg check for putative atlas VSC. In this study, the subjective finding of LLI—and with that finding, the decision of whether or not to adjust the patient—is correlated with an objective measurement, temperature differential (delta°T) on the dorsum of the hands.

CASE REPORT

A 71-yr-old female suffered from a cold, mildly painful right hand. Her symptoms began after a fall some 3 wk before, were constant and had no exacerbations or remissions. The patient's history included a severe auto accident 3 decades before (whiplash-type, cervical acceleration/deceleration injury), chronic neck pain and stiffness with an occasional acute exacerbation. The patient suffered from chronic obstructive pulmonary disease, cardiomegaly, angina, and wore a transdermal nitroglycerin patch.

The right hand demonstrated pallor and was cold to touch, with the superficial veins on the dorsum of the hand collapsed. There was no weakness, numbness, paresthesia, edema, cyanosis or sweating of the affected hand. The radial pulse was strong and even bilaterally. Provocation tests (Adson's, Wright, Roos) were negative and did not affect the temperature differential between hands. Bakody's sign (placing the forearm of the affected side on top of the head to induce scalene relaxation, decompress the subclavian artery and allow blood to flow, thus warming the limb) was negative. Horner's syndrome was ruled out as there was no ptosis, pupillary constriction or abnormal sweating patterns.

There was limited cervical range of motion, active or passive, which was not painful. The patient's head was tilted to the left and her right shoulder was elevated and had increased muscle tension. Fibrous muscular bands, painful to moderate pressure, were noted on palpation in the right trapezius, sternocleidomastoid and scalenes. A functional left LLI on supine check was recorded.

X-ray examination showed cervical kyphosis and significant arthrosis. Anteroposterior cervical (nasium) showed the tilting of the head, measuring 8° to the left, with lateral cervical scoliosis to the right; it was negative for cervical ribs. After specific upper cervical X-ray procedures and analysis (19), a listing was derived to allow for vectored adjustment of the atlas.

Based on the vascular symptoms and myopathological signs, and despite the lack of exacerbation on provocation tests [which can be unreliable (1–3, 8)], a preliminary clinical diagnosis was made of a vascular-type TOS/SAS, subsequent to altered cervical biomechanics. Later literature review uncovered the possibility of a vasomotor mechanism that closely matched the noted signs and symptoms; thus the diagnosis was specified.

During interviews after the completion of the study, the patient stated that her hand would warm rapidly after adjustment and stay warm for extended periods of time. When the hand again became cold, it would happen relatively quickly (within minutes), most commonly during periods of exertion. These findings are more consistent with a vasomotor mechanism than with a compressive, vascular mechanism.

The patient also stated that she was in the habit of falling asleep in a recliner; if her head ended up extended and flexed laterally left, she would wake up with the cold hand. Presumably, this position stretches the scalenes for a long period of time, which suggests that extending the length of time the provocation tests were performed might have given a positive finding.

The patient was released pain free with a small residual hand temperature differential of 2° F. Checked 6 months after release, she was asymptomatic, the leg length checked even and the temperature differential had remained at 2° F. Since then, the patient fell and suffered with the same symptoms—LLI and cold right hand, which responded quickly to care.

N-of-1 Case Study

The protocol for the study was set up so that at the beginning of each visit an assistant recorded the skin temperature on the dorsum of the patient's hands using liquid crystal indicator strips (Cole-Parmer, Chicago, IL). The strip, with an accuracy of ± 1.8° F., indicates temperature as green, blue (cooler temperatures) or brown (warmer temperatures).

Gloves were then placed on her hands and she was instructed not to give any information to me as to how she was feeling. Blinded to the patient's condition, I used a supine leg check as a go/no-go test for atlas adjustment.

In the supine leg check, the patient (with closed heel shoes) stands at the foot of the adjusting table, sits down, evenly slides back and lies down. The examiner grasps the heel of each foot, lifts the legs just slightly to take the play out of the knees and squares the heels parallel to the end of the adjusting table. The relative leg length difference is then viewed at the shoe/sole interface. A LLI of greater than 1/8 inch was taken as an indication of atlas VSC and the necessity for adjustment.

For the purposes of this study, vectored, linear adjusting of the atlas [Grostic (19), NUCCA (20), etc.] was the only treatment used. If LLI was found, atlas adjustment was given; if not, the patient was instructed to return as necessary, or in a maximum of 7–10 days.

The patient and assistant were instructed that if there were no improvement in the first 3 wk, the study would be discontinued and the patient would be re-evaluated. Once past this point, the study was to continue until the patient was subjectively asymptomatic and/or not showing signs of upper cervical VSC via LLI for a month. The patient was given the option of discontinuing participation at any time. Informed consent, including the potential value of a more comprehensive treatment regimen, was obtained before the beginning of this study.

The results shown in Figure 1 demonstrate significant hand warming after atlas adjustment several times and an even subjective leg check coinciding with decreased hand temperature differential. The two initial visits were used to establish the hand temperature differential and familiarize the patient with the supine leg check.

The patient wore a nitroglycerin patch in the left superior pectoral area and was directed to switch to the opposite side at a time of her choosing, record the date, then switch back after 4–6 wk. There was no significant change in the pattern of temperature differential and LLI during the time the nitroglycerin patch was switched (days 32–64).

A statistical analysis of the data was done using the *t* test. In this case, the delta°T with LLI is compared with the delta°T without LLI. The *t* test is generally accepted as a valid statistical test for intersubject studies, but can be considered controversial here because the data comes from just one subject (21).

In this single case study, the independent variable is the finding of the subjective supine leg check for LLI: even or uneven. The dependent variable is the objective temperature differential between the hands: the delta°T.

The hypothetical relationship between the variables is as follows: the independent variable, the leg check, indicates whether or not it is necessary to adjust the patient's atlas. Adjustment is thought to normalize cervical biomechanics. Normalized cervical biomechanics might then reduce the tension of the scalenus anticus muscle, which is thought to be irritating the sympathetic plexus of the brachial artery. Decrease in sympathetic irritation results in vasodilation and warming of the cold hand, which would then be measured by the liquid crystal strips, quantifying the dependent variable as the temperature differential between the hands (the delta°T).

The data (Table 3, day 178) shows that in 36 visits over 6 months, the hand delta°T when LLI was present averaged 10.3°F. When there was no LLI, the delta°T averaged [illegible]°F; this was a significant difference [t (34) = 12.6; $p < .001$].

DISCUSSION

This is an unusual case in many respects, and the evidence for the mechanisms by which a TOS/SAS would cause the set of symptoms noted, and how atlas VSC could result in abnormal tension of the scalenes, is tenuous at best. Still, I believe a rational argument can be made to explain the symptoms and results of treatment.

Mechanism Vascular Considerations

Although the mechanical compression of the subclavian artery has been seen in cases of TOS, it is uncommon compared with neurological involvement (1). In addition, blood flow volume in arteries is not significantly reduced until 75% of the lumen is compromised (4), suggesting a slow onset and recovery of vascular symptoms. In an arterial type of compression, the patient is most likely to complain of numbness and tingling and a diminished radial pulse during orthopedic examination (22). It is difficult to account for the observations in this case—no palpable decreased pulse pressure, even with provocation; rapid temperature changes; superficial venous collapse; no swelling—based on a subclavian artery/vein occlusive mechanism.

A segmental facilitation reflex from upper cervical VSC has the theoretical potential to cause cooling in the skin. When tested, chiropractic adjustment of the atlas did cause skin warming in a fingertip, but it is not known if this was a bilateral or unilateral warming, the warming was very small (0.31°F), and was perhaps transient (23). Based on the very small skin warming in the study noted above, it hardly seems possible that a segmental vasoconstriction facilitation mechanism could have produced the large temperature changes seen in this case. An alternative explanation for vascular involvement is outlined in a case study by Palmer, who hypothesized that compression of the subclavian artery by a hypertrophic or spasmed scalenus anticus muscle may irritate the sympathetic plexus accompanying the artery, resulting in ipsilateral upper extremity vasoconstriction and cooling (4).

Vernon found evidence of brachial artery compression in a case of costoclavicular syndrome, a variant of TOS, using photoelectric plethysmography (8). He noted that in palpatory monitoring of the radial pulse during provocation tests for TOS, subtle changes in pulse pressure, which indicate brachial artery compression, may be missed. Such changes were not evident in this case or Palmer's case, yet artery compression is hypothesized and was demonstrated by angiogram after extensive provocation in Palmer's case.

Vernon also noted that one of the symptoms associated with the costoclavicular variant of TOS includes temperature changes, again like those seen in this and Palmer's case, but he did not speculate about the mechanism that might produce the temperature changes. Palmer's hypothesis of subclavian artery sympathetic irritation and subsequent vasoconstriction in the

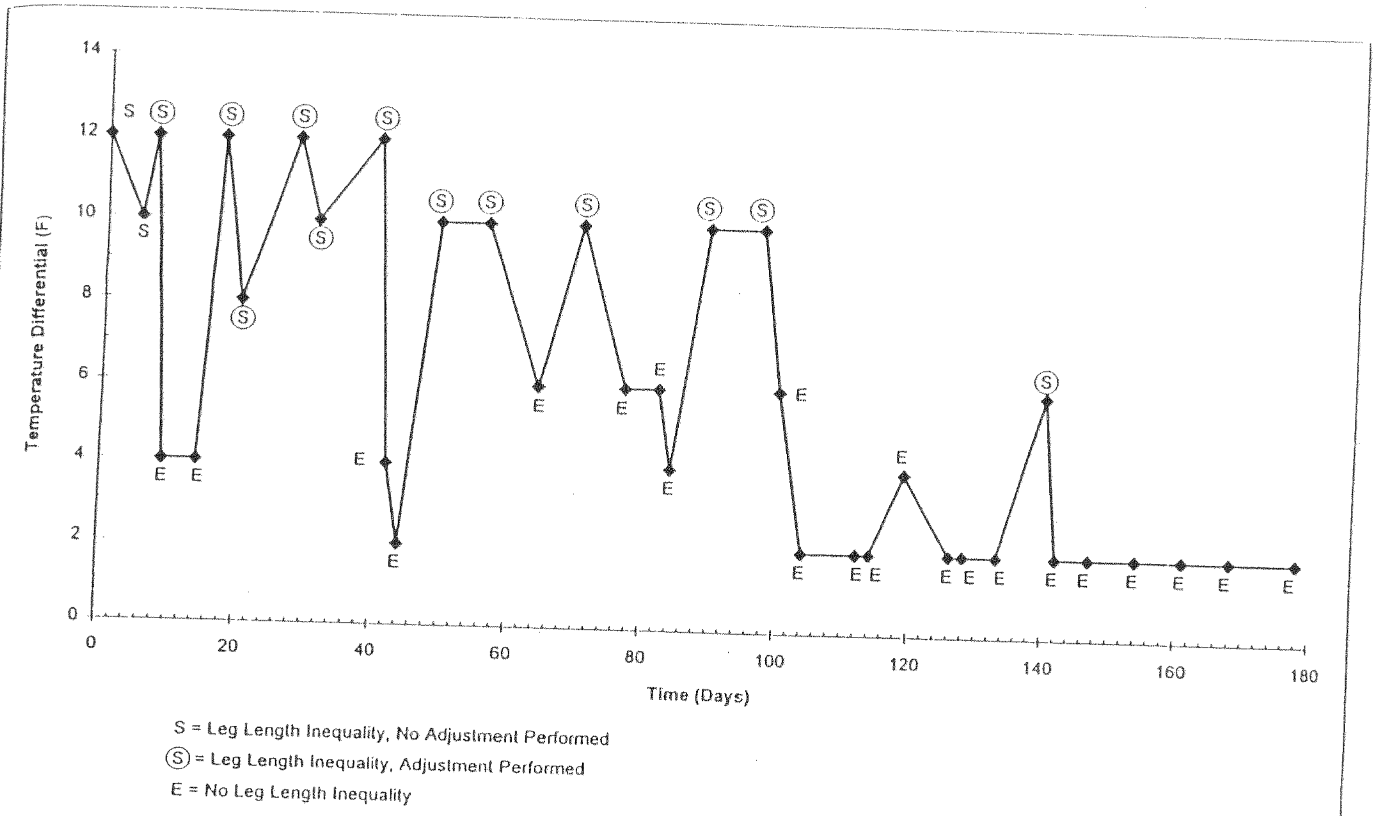

Fig. 1 *Visits, time between visits, temperature differential, leg check results and whether adjustment was performed.*

skin would explain the cold hand. The limited capillary skin blood flow would reduce the flow into the superficial veins, causing those veins to collapse. The radial artery would not be affected by superficial vasomotor capillary constriction and there would be no decrease in radial pulse pressure.

In Palmer's study and case report, the sympathetic irritation hypothesis was tested using a stellate ganglion block on the affected side, which resulted in a complete but temporary elimination of the symptoms of cold and pain in the hand and arm.

Biomechanics

It has been noted in medical (24, 25) and chiropractic (26) literature that some cases of atlas malposition cause a deviation of the skull from vertical. Such deviation can create a response of the body to contract the anterior cervical muscles on the opposite side (24, 26), causing lower cervical scoliosis (25, 27). The muscles involved in laterally flexing the cervical spine to compensate for the deviation of the skull are the anterior cervical muscles—the sternocleidomastoid and the scalenes (28).

If adjustment of the atlas can return the skull to a vertical orientation [a treatment goal in upper cervical analysis (29) and demonstrated in other case studies (26)], the opposing anterior cervical muscles may then cease contraction in the attempt to orient the head vertically, releasing pressure on the subclavian artery.

In this case, an anteroposterior cervical nasium X-ray revealed a head tilt of 8° to the left, an atlas plane line of 11° (high on right) and a scoliosis of the lower cervical spine to the right. An anteroposterior cervical (nasium) after the study showed the head tilt was 3° and the atlas plane line at 6°. Although the mensuration of the cervical scoliosis decreased as the degree of the atlas plane line did, the cervical scoliosis appeared unchanged. Post-treatment examination revealed a palpatory decrease in the tension and sensitivity of the anterior cervical muscles and a diminution of fibrous muscular bands.

It is possible that, given the age of the patient and the degree of degenerative arthritis, the biomechanical ability of the cervical spine to compensate for atlas misalignment and head tilt was limited. Given cervical hypomobility, perhaps the muscles that provide more global movement, in this case the scalenes

Table 3. *Leg-length and hand-temperature differential*

	Day 178		Day 145		Day 104	
	LLI	No LLI	LLI	No LLI	LLI	No LLI
Mean delta T (°F)	10.3	3.2	10.3	3.4	10.6	4.4
SD (°F)	1.7	1.6	1.7	1.6	1.3	2.0
n	14	22	14	18	13	10
	t(34) = 12.6		t(30) = 12.7		t(21) = 10	
	$p < .001$		$p < .001$		$p < .001$	

and sternocleidomastoid, become more involved in trying to attain a vertical orientation of the head. Such involvement might lead to significantly abnormal tension of the scalenus anticus, encroachment of the brachial artery and sympathetic stimulation. Such a confluence of factors may help explain the unusual symptoms seen in this case.

N-of-1 Study

Despite the positive patient outcome noted in the case report, there are several problems with the case study that may cast some doubt upon the results.

1. The criteria for the termination of the study (asymptomatic and/or no LLI for 1 month) may have biased the results for several visits in which the patient's LLI was checked as even. Although I did not know what the temperature differential was (the temperature differential could have been high although the LLI checked even), the low temperature differential for these last visits may have biased the statistical results toward significance.

To check for the effect of termination criteria, the data was analyzed at day 145, before the month of checking with no LLI. The results continue to show a significant concordance (Table 3). The finding of a short leg at day 140 may have been an error; there were no other times when a temperature differential of less than 8° coincided with a finding of LLI. As such, the data was reanalyzed at day 104, after the last episode of significant temperature differential. The results also showed significant concordance (Table 3).

Despite the elimination of the data in what amounts to a period of monitoring the patient to insure stability, days 104–178, the statistical concordance between the subjective LLI test and the objective temperature differential reading remains quite high.

2. The person doing the examination for LLI also did the treatment and, although the leg check was, by design, the sole criteria as to whether or not an adjustment was performed, visual clues could theoretically have influenced the decision. If so, any such clues were not consciously taken into consideration and, given the high concordance with the blinded temperature differential, any such clues would presumably have been obvious.

I was aware initially that the patient must have improved, since the study was not aborted in the first 3 wk. However, the figure shows that after day 15, LLI was indicated for 5 visits in a row; such findings would not be conducive to a bias by the examining/treating doctor that the patient was getting better or a suspicion that LLI and putative atlas subluxation was correlated with symptomatic improvement.

3. The patient was aware (not blinded) to the LLI examination and may have attempted to simulate an LLI based on how she felt subjectively and whether or not she felt she needed an adjustment. However, the patient was initially naive that a leg check was correlated with her cold hand and the atlas adjustment. The first two visits were leg checks with no adjustment despite the high temperature differential and subjective symptoms. The next visit, under the same conditions, an adjustment was given; during the next two visits, however, no adjustment was given. A pattern here would have been hard to discern.

Eventually, the patient may have learned to associate an improvement in symptoms with the adjustment, and may thus have altered her positioning while being examined for LLI so as to receive an adjustment when she was subjectively symptomatic. This scenario seems unlikely and is flatly denied by the patient. Even if this is what happened, it only invalidates the concordance of the temperature differential with LLI but bolsters the likelihood that the atlas adjustment affected the patient's symptoms to the degree that she would alter her posture to receive an adjustment.

4. The results could have been caused by spontaneous remission over time. Again, however, it is difficult to explain by coincidence the sudden, dramatic decrease in temperature differential (days 9 and 42) after adjustment and the patient's report of rapid warming after adjustment. In addition, it would be difficult to argue that the patient altered her positioning to receive an adjustment (see 3, above) because the treatment was working, yet consider this a spontaneous remission.

Although this single case study has potential problems in that the subject and examining/treating doctor were not completely blinded, the concordance between LLI and the hand temperature differential is high and the results, although not strong or conclusive, provide some evidence that the phenomenon of LLI may be a genuine reflection of upper cervical VSC and that the supine leg check has objective validity.

CONCLUSION

The potential for pressure on the subclavian artery by a hypertonic, fibrotic scalenus anticus muscle causing sympathetic irritation and inducing abnormal vasomotor activity should be considered in cases of unilateral temperature differential, pain and pallor of the upper extremity. Vectored upper cervical atlas adjustment to improve cervical biomechanics should be considered as part of a treatment regimen in cases of vasomotor vascular TOS.

In this single-case study, there was a significant statistical concordance between a test for putative upper cervical VSC—supine LLI, treatment by atlas adjustment and the outcome measure of recorded temperature differential on the dorsum of the hands.

Although this single case study suggests the efficacy of using upper cervical style supine leg check as an indicator for atlas adjustment, it also points to the necessity for conducting a large scale inter- and intraexaminer reliability study of this often-used test.

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L5 and S1 nerve fiber irritation demonstrated by liquid crystal thermography – a case report

T. Kobrossi DC, DABCT*

A case report is presented of a 28 year old male who incurred an acceleration type injury to the low back. Investigation utilizing the Flexi-Therm Mark II ®L.C.T. liquid crystal thermography revealed a right sided L5 and a left sided S1 nerve fiber irritation subsequently confirmed by CT scanning. Thermography apparently has a 93% rate of accuracy when compared to EMG, and is a relatively objective examination test procedure. Brief discussion of the method is given and the routine views for a lumbar study are described.

KEY WORDS: thermography, chiropractic, manipulation

Un rapport de cas a été présenté à propos d'un homme de 28 ans qui a contracté une blessure à accélération au bas du dos. L'examen réalisé au moyen de la thermographie au crystal liquide Flexi-Therm Mark II ®L.C.T., a révélé une irritation de la fibre nerveuse du côté droit L5 et du côté gauche S1, qui a été confirmée par la suite grâce à l'analyse CT. Apparemment, la thermographie a une taux d'exactitude de 93% lorsqu'on la compare à l'EMG, et est une procédure relativement objective d'examain. Une brève discussion de la méthode est donnée, et des avis de routine pour une étude lombaire y sont décrits.

MOTS CLÉS: thermographie, chiropraxie, manipulation

Introduction

Lumbar thermography has been variously reported as 71 to 90% accurate when compared to the myelogram, in screening for nerve root irritation. This depends on whether the lumbar pattern alone was studied, or if it was done in combination with a study of the pattern of the lower extremities.[1,2,3] Lumbar, thoracic and cervical thermography have been found to be 93% accurate when compared to the E.M.G., which was 82% accurate.[1,4]

Some of the most practical and useful applications of thermography have involved diagnostic screening for nerve root irritation, peripheral nerve injuries, reflex sympathetic dystrophy or causalgia, and musculo-skeletal soft tissue injuries.[5] It is also no surprise that it has become probably the best and most informative objective test to corroborate or rule out a patient's subjective complaints. It is the only test giving practical objective information about sensory nerve fiber irritation.

Method Theory

The normal human body emits a heat pattern from its surface topography in a symmetrical fashion. Any irritation of a nerve root or peripheral nerve fiber can produce changes (thought to be mediated on the basis of sympathetic nerve over-activity) leading to vasoconstriction and hence decreased heat emission along the course of the nerve affected.[6] However, the low back thermographic patterns (usually hot) are caused by a different mechanism. They are muscle irritation patterns at the site of the local irritation and are seen specifically as such in the low back area. They are not specifically seen in conjunction with nerve fiber irritation at other levels in the spine. This most likely has to do with the anatomic distribution of the musculature of the low back area.[4,10] As might be expected, sensory nerve fibers appear to be more delicate and subject to various kinds of alteration in functions. Subtle changes in the heat emission pattern can be detected in them even when there are no motor changes determined by E.M.G. A simple bulging disc with or without nerve root compression can cause sensory changes and spasm of the innervated adjacent interdigitating erector spinal muscles accounting for the characteristic lumbar nerve irritation patterns.

Currently, this themographic pattern of the body's heat emission can be recorded by two different methods, liquid crystal contact thermography and electronic thermography. The former was used in the following case.

Technique

The Flexi-Therm† Mark II ®L.C.T. system unit possesses liquid crystals embedded in elastometric rubberized sheets mounted on a transparent plexiglass box. The liquid crystal "air pillows" can be closely contoured to various body surfaces. With body contact, an image appears on the box which represents the heat pattern in that area. High resolution instant color photography records the image generated.[7,8,9]

Eight thermographic boxes progressively numbered 24, 26, 28, 29, 30, 31, 32, and 33 (corresponding with the median celsius temperature ranges of their incorporated liquid crystal Flexi-Therm sheets) served to record the thermographic finding in the patient.

The views routinely done for a lumbar study include lumbar spine, buttocks, right and left lateral buttocks, right and left lateral thighs, posterior thighs, anterior thighs, posterior legs, anterior legs, dorsal and plantar feet (see figure 1).

Case Report

R.D. is a 28-year-old male that was involved in an acceleration type of accident one year ago. He complained of constant low back and left lower extremity pain. Orthopeadic examination was equivocal. X-rays of the lumbar spine were unremarkable. His physician advised him to return to work after one month and could not understand why the patient was still claiming disability.

A thermographic study using the Flexi-Therm Mark II ®L.C.T. revealed left sided L5 and S1 nerve fiber irritation plus an

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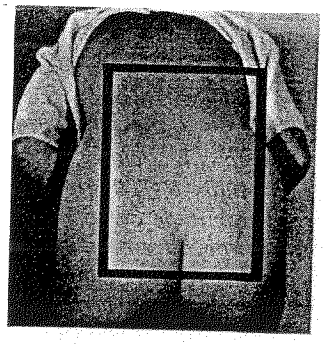
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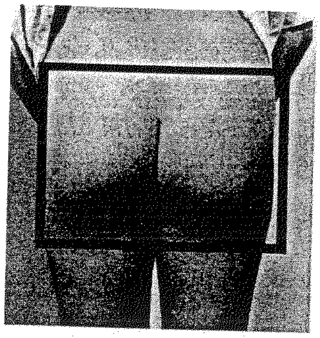
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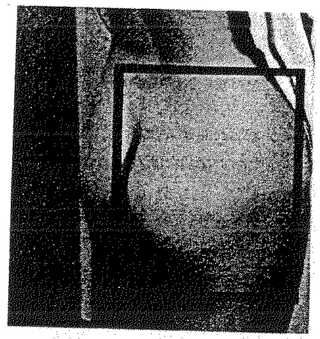
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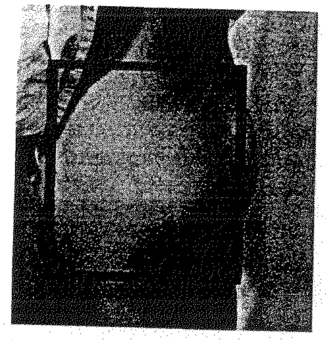
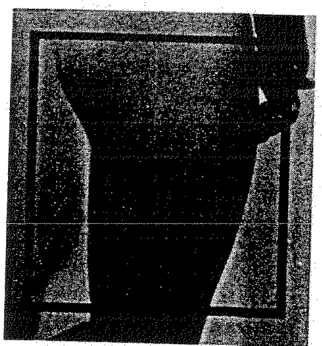

lateral buttock (l)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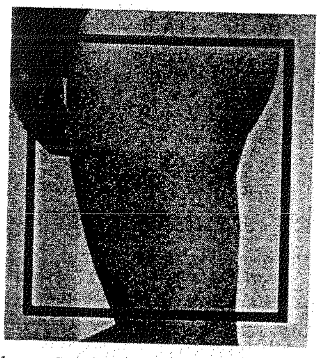
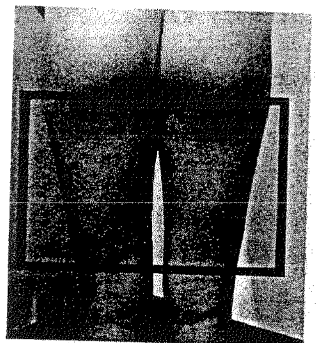
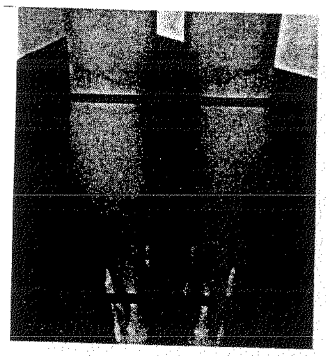
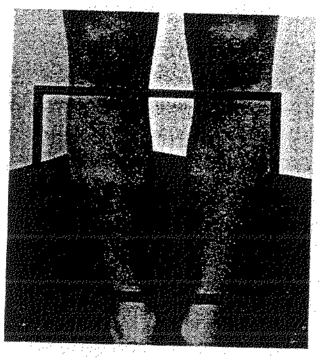

lateral thigh (l)


posterior thighs


posterior legs


anterior thighs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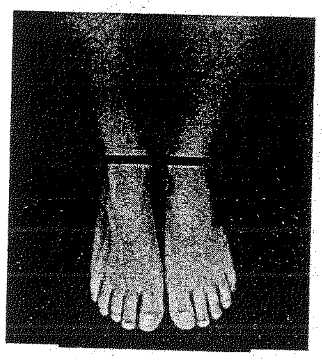
dorsal surface feet

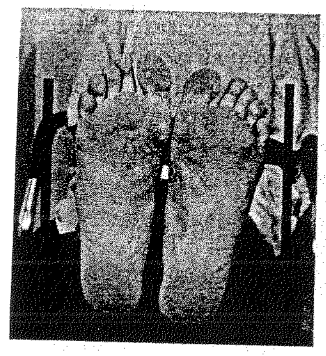
plantar surface feet

Figure 1: Positioning for liquid crystal thermography.

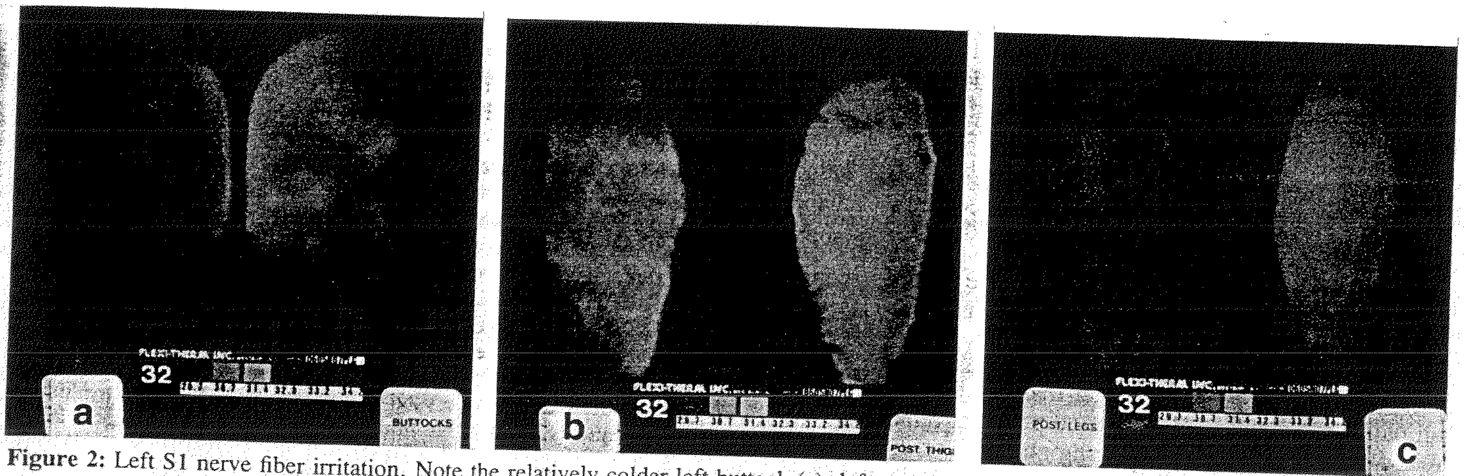

Figure 2: Left S1 nerve fiber irritation. Note the relatively colder left buttock (a), left posterior thigh (b) and left posterior leg (c) as compared to the right. Please also note that these are black and white photographs of coloured thermograms.

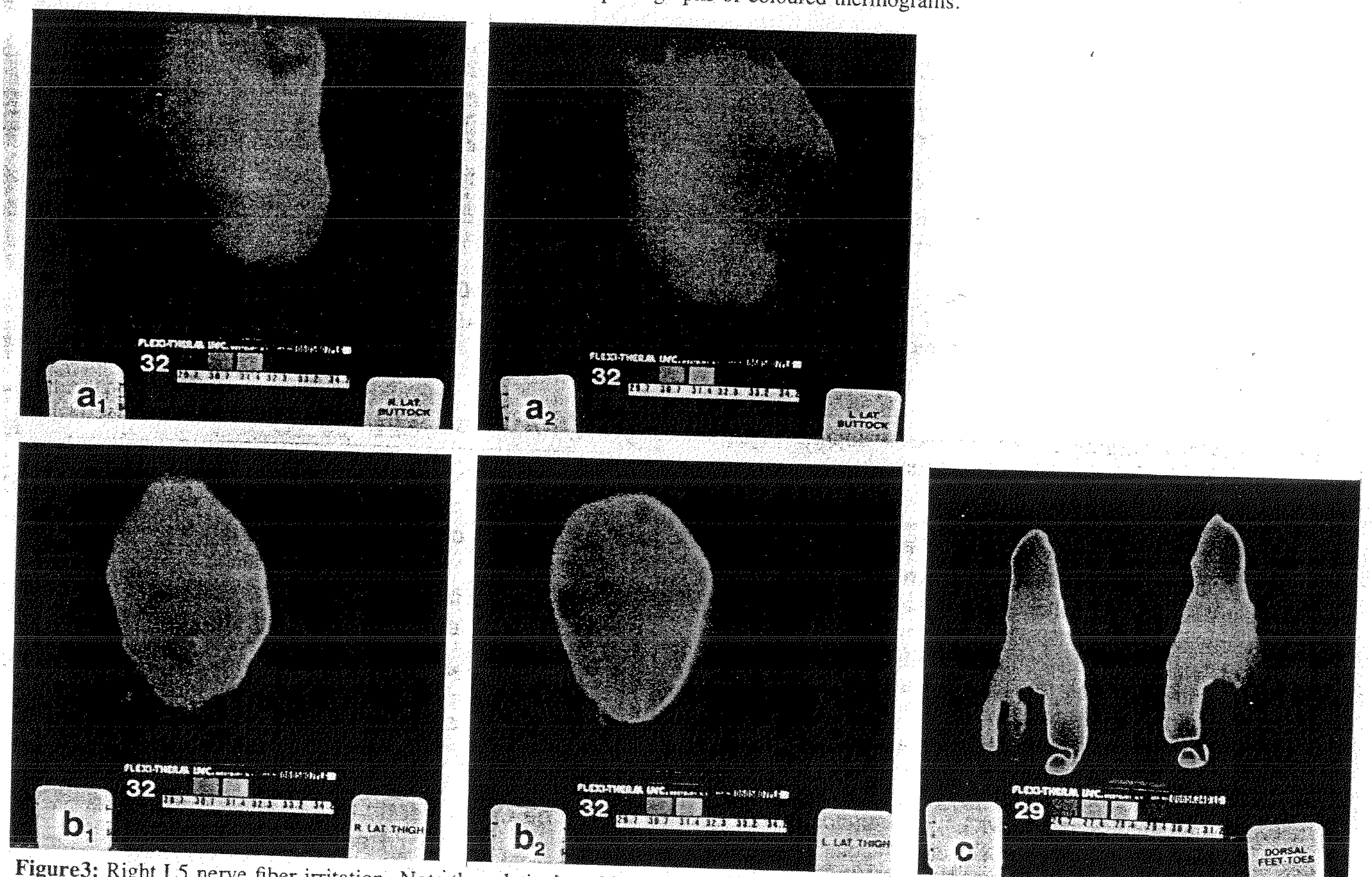

Figure3: Right L5 nerve fiber irritation. Note the relatively colder right lateral buttock (a_1/a_2), right lateral thigh (b_1/b_2) and right dorsal foot (c) as compared to the left.

abnormality of the right L5-S1 facet joint. There was a relative decrease in the vascular heat emission pattern of the left posterior buttock, left posterior thigh and left posterior leg, as compared to the right, describing the left SI dermatome. (fig 2) There was also a relative decrease in the vascular heat emission pattern of the right lateral buttock, right lateral thigh and right dorsal foot as compared to the left, delineating the right L5 dermatome. (fig 3)

From the weight of the above evidence, a C.T. scan was done that confirmed disc bulges at L4-5 and L5-S1.

Discussion

Thermography is a harmless test that can be administered to all patients, including children and pregnant females, without fear of the side effects of ionizing radiation or drugs.

The presence or absence of nerve root irritation can rapidly be quantitated to either corroborate or disprove a patient's complaints of pain and dysfunction.

Documentation of persistence of injury or improvement can be easily substantiated in follow-up serial thermography. It would certainly seem reasonable to perform a thermographic study prior to myelography since a negative former would only be confirmed by the latter. However, one must keep in mind that while the thermogram is helpful in determining which nerve fiber is involved, it does not replace the myelogram as a diagnostic tool since it cannot demonstrate exactly where the nerve fiber is being irritated, nor what is causing that irritation.

Before accepting thermographic results, one should know and trust the thermographer. Only a well trained and Board certified thermographer should be consulted in order to guarantee a reliable study.

Summary

Thermography is emerging as a most useful adjunct in the diagnosis of musculo-skeletal injuries. It is the only test that can provide an objective, graphic indication of a patient's sympathetic nervous system. Contrary to impressions suggested by the lay press, it does not show a picture of pain. It is a demonstration of physiology, and can show sensory nerve changes which might reasonably explain a patient's pain. Conversely, absence of any such demonstrable involvement can also make a strong statement if there is continued pain behaviour.[1,5,6,9,11] In the above case, lumbar thermography was invaluable in validating the patient's complaint.

The relationship between the thermogram and other tests was best summarized by Wexler[(4,11)]:

What .... (physiology)	– thermogram:	sensory nerve
	EMG:	motor nerve
	Bone scan:	bone pathology
Where and why (anatomy)	– plain x-ray	
	myelogram	
	epidural venogram	
	CT scan	
	discogram	
When	– History & comparison studies.	

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Moire Contourography and Infrared Thermography: Changes Resulting from Chiropractic Adjustments*

NANCY E. BRAND, D.C. AND CHRISTINE M. GIZONI, D.C.

ABSTRACT

Reliable standardized methods utilizing infrared thermography and moire contourography were employed as dependent variables to measure the effects of a single chiropractic adjustment. Data was gathered from 18 male and female patients prior to and after the adjustment. Results of the infrared thermography indicated significant changes after the adjustment ($p < .0005$). The limited duration of the study and selection criteria allowed no significant changes to be discerned from the moire contourography data. (J Manipulative Physiol Ther 1982; 5:113–116)

Key indexing terms: moire contourography, infrared thermography, chiropractic adjustments.

INTRODUCTION

An important issue within the chiropractic profession is the development of accurate and reliable methods to determine the effects of chiropractic adjustments. Such determinations can be invaluable to the chiropractic physician to aid in impartially documenting patient progress via non-invasive means. These may also serve as guides for the most effective mode of treatment. The research to be described represents a preliminary study of the integration of two simple and inexpensive measurement systems: infrared thermography and moire contourography.

Thermography has been an area of interest within the chiropractic profession since the introduction of the neurocalometer by Evins in 1924.[1] The mechanism of heat loss and infrared radiation from the body has been discussed by Hardy,[2] Hardy and Soderstrom,[3] DuBois,[4] and Hardy and Muschenheim,[5] since the late 1930's. Jenness[6] has recently cited the role of thermography with regard to its uses in structural diagnosis. Thermographic changes have been studied with regard to musculoligamentous injuries of the spine (Karpman, Knebel, Semel, and Cooper).[7] Changes noted in thermography in post-trauma patients have been evaluated by Connell, Morgan, and Rousselot.[8]

There have been conflicting opinions of the diagnostic role of thermography in clinical practice. In part, this is due to the lack of reliable, standardized procedures.

In an effort to insure reliability and to improve patient monitoring, standardized methodologies for thermography and moire contourography[9-12] have been developed and applied by researchers at the New York Chiropractic College.

The concept of moire contourography claims its origins from many disciplines. Soil deformation analysis by contourographic methods was performed by Kim and Stanley.[13] Smith utilized it to determine corneal topography.[14] Other researchers have previously applied moire contourography to do body surface studies.[15-20] Moire topography yields itself to these various areas by giving three dimensional information of surfaces using ordinary light. It is a completely safe method of analysis suitable for human subjects.

Since the body surface is determined by both osseous and soft tissue components, departures from bilateral symmetry may be indicative of musculoskeletal disorders. It must be emphasized that these procedures of themselves cannot be confirmatory for differential diagnosis, although they have been shown in some cases to have high correlation in selected disorders.

MATERIALS AND METHODS

The rationale of this project is based upon the assumption that a single chiropractic adjustment may result in significant dorsal topographical and thermal changes. These changes may be correlated with clinical examinations and patient perceptions prior to and following a chiropractic adjustment.

This study was performed with 18 patients who agreed to participate. As part of their initial orientation, the

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Paper submitted March 8, 1982.

subjects were briefed in the objectives of the research and were shown photographs and materials indicative of the procedures to which they would be subjected. Those who agreed to participate were required to sign an "Informed Consent Form." Each of the subjects acted as his own control in a pre-post test design.

Each of the subjects was tested prior to and after chiropractic therapy in accordance with methodologies developed in our laboratories and presented in the detailed procedures below. All procedures developed in our laboratories have reliability coefficients exceeding .9 ($p < .01$). Details of the procedures are as follows:

1. Each subject is given a brief orientation to the procedures; an "Informed Consent" is required.
2. The subject is requested to wear a gown which opens in the back. Underclothing is removed.
3. The subject is assisted to a prone position on an examining table.
4. With the subject's gown opened in the back, a minimum of three minutes elapses to allow temperature stabilization of the entire cervical, thoracic, and lumbar regions. Laboratory temperature is maintained constant (72°F ± 1°F).
5. The spinous processes are palpated and marked with a non-toxic watercolor pen at T1, T7-8 and L6 regions.
6. At each of the vertebral levels, T1, T7-8, L5 a watercolor mark is made one inch bilaterally from the spinous processes.
7. The infrared thermography procedures begin with the operator starting at the L5 level, positioning the collimating tube of the infrared gun one inch laterally to the right of the spinous process. A spacing guide (½″) maintains the proper distance between the dorsal surface of the subject and the infrared receiving end of the collimating tube. The spacing guide trails the collimating tube and, hence, does not create measurement artifacts due to pressure (See Figure 1). The event marker button is pressed, which places an event mark on the temperature recording chart. This procedure permits subsequent correlation of temperature and vertebral level.
8. The procedure described in Step 7 is repeated for the left side of L5, and again for each of the other areas described.
9. The subject is assisted to a standing position and is brought over to the moire apparatus.
10. The subject is asked to disrobe. Maximal standards of privacy compatible with research are maintained throughout the procedure.
11. The standardized moire exercises performed by the subject in response to the instructions of the operator are summarized:
    a. The subject takes a half set forward.
    b. The subject is asked to raise his right leg and then his left leg.
    c. Step 11b is repeated.
    d. The subject then slides his heels into the inner heel guide of the foot plate and is told to point his feet at a normal natural position and to look straight ahead.
    e. The subject is asked to raise his shoulders, and then let his arms and hands fall naturally at his side.
    f. Repeat Step 11e above.
    g. The subject is directed to look straight ahead, not to bend his knees, and to distribute his weight evenly.
12. A Polaroid picture is taken (See Figure 2).
13. The subject then puts the gown on and an osseous adjustment is given by a chiropractic physician who is familiar with the subject's medical history.
14. The procedures described in steps 3 through 12 are repeated after the chiropractic adjustment is given.

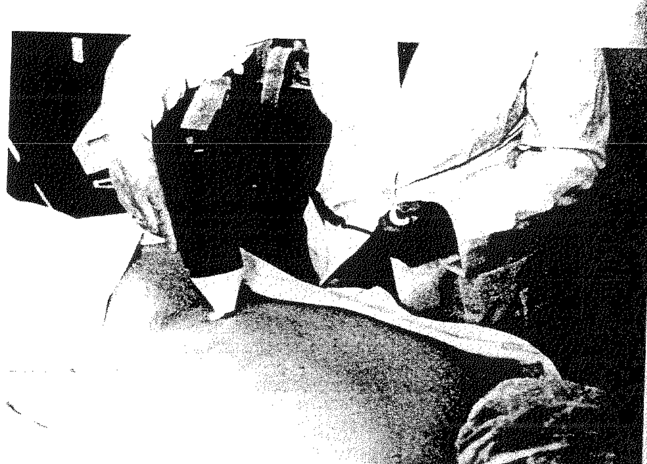

Figure 1. Infrared gun

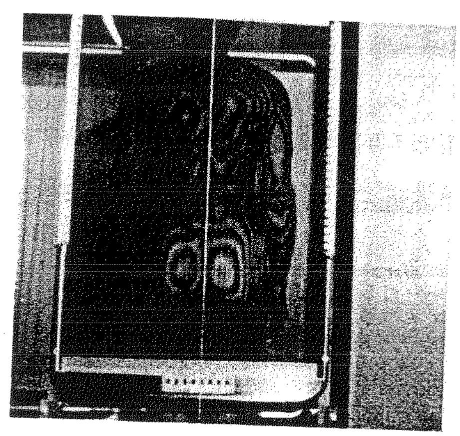

Figure 2. Moire contourography

RESULTS

In order to compare the pre-adjustment and post-adjustment measurements for each dependent variable, nine *t*-tests for correlated groups[21] were performed. Since the nine dependent variables were assumed to be related, a significance level of .05/9 = .0056 was used for each analysis in order to maintain the .95 confidence level. One-tailed *t*-tests were performed since the alternate hypotheses predicted specific directions of change.

Analysis of the pre- and post-adjustment moire measurements revealed no significant differences for all three regions. Table 1 lists the means, standard deviations, *t*-ratios, and degrees of freedom for the pre- and post-adjustment moire measurements for each region.

Table 2 lists the means, standard deviations, *t*-ratios, and degrees of freedom for the six sets of pre- and post-adjustment infrared thermography measurements. Significant differences ($p < .0005$) were found for the T1 measurements on both the right ($t = 4.0$, df = 17) and left ($t = 4.5$, df = 17) sides and for the T7-8 measurements on the right side ($t = 4.2$, df = 15). For all of these regions the mean thermographic measurement was lower after the adjustment.

DISCUSSION

The infrared thermography study disclosed highly significant temperature changes following chiropractic adjustment. These temperature changes were found in the T1 and T7-8 regions after a single chiropractic adjustment.

The precise nature of the phenomenon is not known. It is likely that the mechanism is extremely complex. However, we may suggest several hypotheses as possible explanations based on the subluxation complex. These postulations may include neurotoxic, mytonic, cardiovascular and/or localized inflammatory reactions. In the light of the significance of these temperature changes ($p < .0005$) it is our belief that clinical intensive studies are warranted to determine their clinical value as a monitoring methodology, as well as the mechanisms of the thermographic changes and their implications.

The data collected in this study regarding the moire contourography did not appear to be significant. There may be many reasons for this. One consideration is the lack of selective criteria of the patients sampled. A number of the patients may have had a long standing structural condition (e.g., structural scoliosis) that does not lend itself to a significant topographical change resulting from the single chiropractic adjustment.

It is our recommendation that a more comprehensive study should be designed; patients should be selected on the basis of having functional conditions which are amenable to topographical improvement under a short treatment schedule. Past studies have shown moire to be a useful screening technique and a 0.85 correlation with structural scoliosis has been attained.[15] False negatives and false positives due to neuromuscular and vascular conditions limit its usefulness as a screening device. Moire contourography alone is not a technique that is useful as a confirming differential diagnostic methodology. It is evident in this study that substantial changes in thermography were attained even when moire contourography studies did not demonstrate significant differences.

The utilization of a non-invasive multiphasic system which integrates information derived from a variety of methodologies warrants the comprehensive study recommended above. Such a system may provide an ideal means for broad-based screening of vast population and offers no risk to the individual.

TABLE 1. Statistical Values for Pre- and Post-adjustment Moire Contourography Measurements for Each Region.

	Pre-Adjustment	Post-Adjustment	t-Ratio	Degrees Freedom
Region One	$\bar{x} = -4.8$ s = 7.4	$\bar{x} = -4.8$ s = 5.4	−0.0	21
Region Two	$\bar{x} = 3.1$ s = 8.2	$\bar{x} = 2.9$ s = 9.1	0.1	21
Region Three	$\bar{x} = -0.5$ s = 6.0	$\bar{x} = -1.4$ s = 4.5	0.6	21

$\bar{x}$ = Mean; s = Standard Deviation

TABLE 2. Statistical Values for Six Sets of Pre- and Post-adjustment Infrared Thermography Measurements.

		Pre-Adjustment	Post-Adjustment	*t*-Ratio	Degrees Freedom
T1	Left	$\bar{x} = 95.7$ s = 2.0	$\bar{x} = 94.4$ s = 1.8	4.5	17
	Right	$\bar{x} = 95.4$ s = 2.1	$\bar{x} = 94.2$ s = 2.0	4.0	17
T7-8	Left	$\bar{x} = 95.0$ s = 2.0	$\bar{x} = 93.8$ s = 1.6	4.0	17
	Right	$\bar{x} = 95.3$ s = 1.9	$\bar{x} = 94.0$ s = 1.7	4.2	15
L5	Left	$\bar{x} = 94.7$ s = 2.4	$\bar{x} = 93.3$ s = 2.0	4.0	16
	Right	$\bar{x} = 95.0$ s = 2.2	$\bar{x} = 93.2$ s = 2.3	3.9	16

$\bar{x}$ = Mean; s = Standard Deviation

ACKNOWLEDGEMENTS

The authors wish to acknowledge the Foundation for Chiropractic Education and Research, the Polaroid Corporation, and the Nate B. and Frances Spingold Foundation for making this research possible. In addition, gratitude is extended to Dr. Bertram Spector and Fujie Fukuda for their continued support and encouragement. Special appreciation is given to Lori Baliunas for her expert skills in compiling the data and preparing this manuscript. We would like to express our appreciation to John J. Kukor of St. John's University, Jamaica, NY, for statistical evaluation. Finally, we acknowledge, with gratitude, the significant contributions of Dr. William Rice, Dr. Steven Finando, and Dr. Scott Wilson, and the staff of the Wholistic Health Center, Manhasset, NY.

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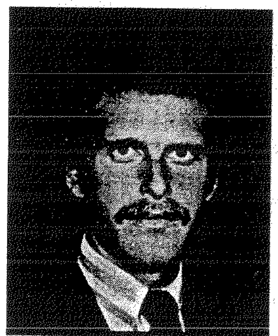
Thermography, moiré topography and full spinal radiographs: a preliminary report



Dr Auerbach

Gary A. Auerbach, DC
Eustace L. Dereniak, PhD
Arvind S. Marathay, PhD
Tucson, Arizona

This program will evaluate the efficacy of two non-invasive forms of diagnostic equipment for use as structural evaluators in a correlative study to the currently used ionizing radiation form of x-ray. Designed as a technical and clinical study, it will encompass the use of x-radiation of full spine postural x-rays — moire topography and thermography. Thermography has rarely been utilized to determine areas of spinal lesions known to the chiropractic profession as subluxation patterns, although thermal response has been a principal tool of many of their diagnostic instruments. Both absolute as well as relative thermal distribution will be analyzed and standard deviations under various sub-group populations will be explored. Moire topography will enable the viewer to determine on a three-dimensional plane the type of A-P as well as lateral deviation of the overall human spinal superstructure. This study will compare the full spinal x-ray to determine the correlative percentile for scoliosis diagnosis. This new system would be a highly effective alternative to ionizing radiation since it is non-invasive.

Within the chiropractic community, the accuracy f the instrumentation used to discriminate structural ıformation of whatever source needs to have a high egree of reliability and correlation to other modes of ıstrumentation. Structural evaluation has been the ea of expertise of the chiropractic physician for the ıst four generations. A precise repeatable means of valuation needs to be established throughout the ıiropractic community. X-radiation, infrared, and pographical pictorials are three possible modes of ıstrumentation which can accurately lead to a precise structural analysis.

Examining the relationships between these three ethods of study are Dr Gary Auerbach, a Tucson ıiropractic physician, Dr Eustace Dereniak and Dr rvind Marathay, both of the Optical Sciences Center of the University of Arizona. Under investigation are two types of non-invasive forms of diagnostic equipment. They are optical moire topography and thermography and are being compared to full spinal x-rays to see what, if any, correlation exists.

Thermography, a pictorial representation of temperature distribution,[1] has been studied by the chiropractic profession on a limited basis but not utilizing independent evaluators to determine to what degree it relates to both structural and vascular phenomena, although the thermal response quotient has been used as a principal tool of many of the instrumentations used today.

Using a full spinal x-ray, the chiropractor is given a vast amount of information regarding postural integrity. Full spinal thermography, along with x-rays, allows for more complete information regarding both overall superficial vascularity as well as localized areas of involvement known as the subluxation complex.

Recently, the medical profession has been using thermographic techniques to determine various types of disc diseases,[2] bone density changes,[3] soft tissue inflammatory changes, usually the result of traumatic insults which include strain and sprain injuries,[4] and systemic involvements as with diabetes.[5]

Additional studies by Dr Dereniak have developed a differential color temperature thermograph. This work, combined with but not directly related to this program, is supported by a three-year National Cancer Institute Grant.[6,7]

The second non-invasive diagnostic tool being correlated is optical moire topography. A moire topographical picture enables the viewer to extract three-dimensional information of the overall human superstructure of posterior to anterior as well as lateral deviation. The moire fringes are produced as a result of interference between two spatially superposed periodic gratings. The frequency of the moire fringes corresponds to the differential frequency, called beats, of the two gratings. The phenomenon

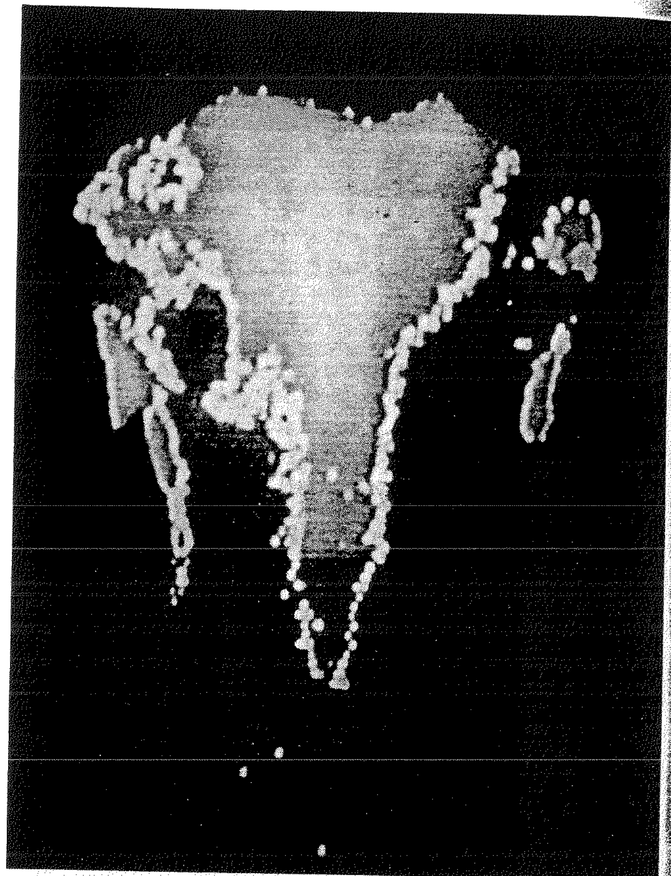


Figure 1a

Figure 1b

Dr Gary Alan Auerbach received a BS degree in accounting from the University of Arizona in 1971, and his DC degree from Palmer College of Chiropractic in 1975. He did his postgraduate studies at the University of Arizona in 1977-78. He is a member of the Health Systems Agency Preventative Care Task Force, and a member of the HSA Certificate of Need and Rate Review Committee. The current president of the Chiropractic Association of Arizona, Dr Auerbach is also a member of the ACA and ICA. He is in private practice at 6145 E. 5th Street, Tucson, Arizona 85711.

Dr Eustace L. Dereniak received his BS degree in 1963 from Michigan Technological University, his MS degree from the University of Michigan in 1965, and his PhD from the University of Arizona in 1976. Dr Dereniak's fields of major current interest are applied research in the far infrared spectrum, and cryogenically cooled detector/electronics technology. His professional affiliations, activities and honors include: the Optical Society of America, Tau Beta Pi, Phi Kappa Phi, and Eta Kappa Nu. Dr Dereniak has had several manuscripts published and he is currently an assistant professor at the Optical Sciences Center of the University of Arizona in Tucson.

Dr Arvind S. Marathay has a BSc in physics and mathematics from Bombay University, an MSc in technical optics from London University, a PhD from Boston University and he did postdoctoral work at the University of Pennsylvania. He has been a teacher and lecturer at several universities. His fields of major current interest include: physical optics, optical processing, coherence theory, quantum coherence theory, and electro-optic light modulators and scanners. Dr Marathay has had numerous papers published. He is currently an associate professor in the Optical Sciences Center of the University of Arizona in Tucson.

can also be observed when two gratings of the same frequency are displaced relative to each other. Dr Marathay, who holds a doctorate in technical optics with special emphasis in interference and diffraction patterns, feels that this technique has the capability of being instrumental in the determination of postural deviation and scoliosis detection. He is familiar with the developments of postural contour mapping as done by Takasaki[8,9] and Free.[10]

Dr Fletcher H. McDowell, Professor of Neurology, Cornell University College of Medicine, stated the problem at a workshop on the research status of spinal manipulative therapy sponsored by the National Institutes of Health, February 2-4, 1975. Dr McDowell said:

> "In the area of diagnostic techniques at the clinical level, careful scrutiny of the accuracy and reliability of chiropractic diagnostic methods is needed. As Dr Remington mentioned, the accuracy of these methods affects every clinical study. It is clear to any of you who have studied the reliability of clinical diagnostic techniques, that there is enormous variability between individual observers.
>
> "Chiropractic physical diagnostic techniques at the bedside need to be carefully correlated with what is seen on x-rays, and what is found with techniques like thermography, and so forth, on a blinded basis."

In working with these three modes of diagnostic equipment, certain methods to correlate relative spatial quadrants have been established. Inherent in the use of thermography because of the variation of the image form is a difficulty in locating certain reference points. The authors have now developed a way to correlate all three types of pictorial transmissions. The identification marks are not used in these test shots because they are just examples of the types of images the authors are utilizing. In the next update, this unique marking system will be demonstrated.

Figure 1a is an example of an AGA thermographic image from the posterior, studying an area from the coccyx to the seventh cervical region. General muscular vascular layers can be seen to have a symmetrical basis, but a closer examination reveals a breakup in the left shoulder and mid-dorsal region. A compression fracture of the second lumbar vertebra six months previous was being evaluated to see if a thermal response was demonstrable. Isotherm lines indicate areas of equal temperature.

Figure 1b illustrates a vascular abnormality in the right femur head region as caused by an advanced case of hypertrophic degenerative osteoarthritis in the acetabular joint.

Figure 2 is a moire topographical comparison of

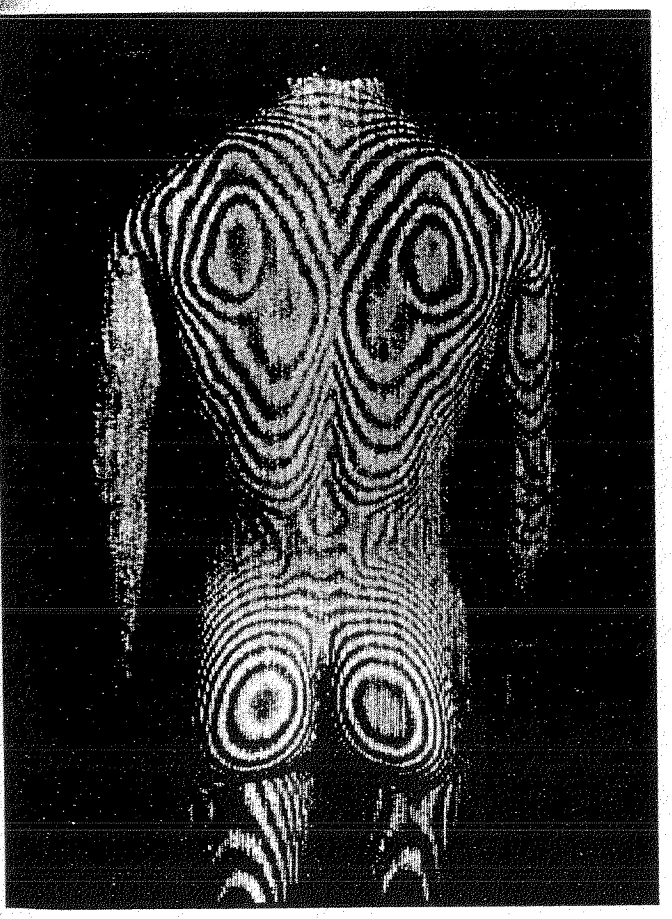


Figure 2a

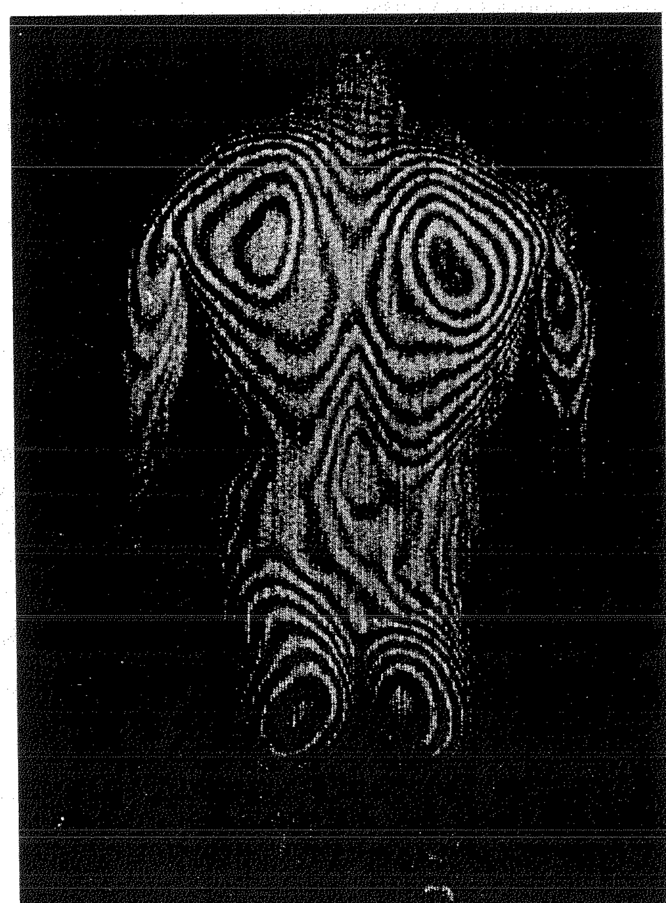


Figure 2b

two individuals, 2a with good bilateral symmetry and 2b being an individual with a severe rotatory scoliosis with rotation in the pelvis. Each wave configuration demonstrates a 6mm change in elevation.

Figure 3a is a full spinal x-ray using a gradient image intensifier of a normal individual and Figure 3b demonstrates a rotatory scoliosis through the lumbar-dorsal region.

A continuing study now underway will investigate a large population of both symptomatic and asymptomatic individuals under closer clinical and technological controls to see what information would be gained from these two forms of non-invasive analysis. If a high correlation is found to exist for the detection of postural and physiological deviations from normal, large scale use with both private industrial and public school screening can be implemented. □

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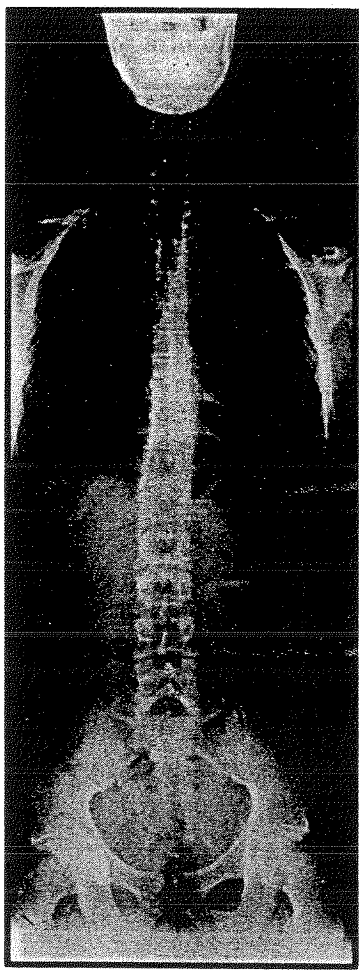

Figure 3a

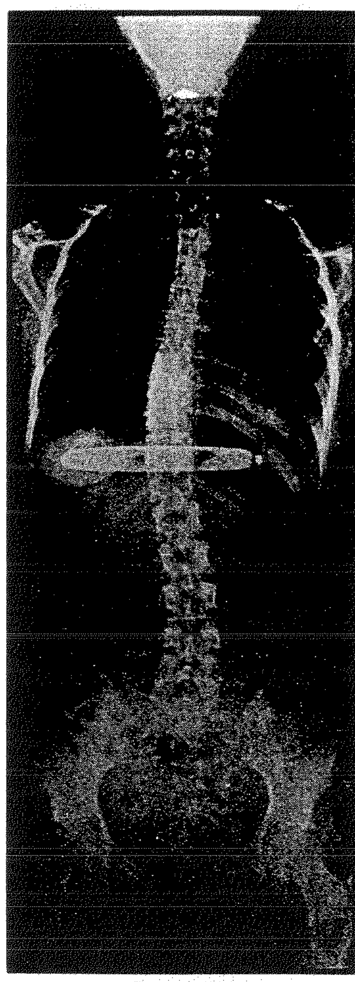

Figure 3b

CASE STUDY

Upper Cervical Chiropractic Care for a Patient with Chronic Migraine Headaches with an Appendix Summarizing an Additional 100 Headache Cases

Erin L. Elster, D.C.

ABSTRACT

Objective: To review the effectiveness of chiropractic care using an upper cervical technique in the case of a 35-year-old female who presented with chronic daily tension and migraine headaches, and to summarize, in an Appendix, the examination findings and results for 100 additional chronic headache cases.
Clinical Features: At age 23, the patient, a professional ice skater, sustained a concussion by hitting her head against the ice. Prior to the concussion, no health problems were reported. Following the concussion, tension and migraine headaches ensued. Symptoms persisted over the next twelve years, during which time the patient utilized daily pain medications.
Intervention: During the patient's initial chiropractic examination, evidence of a subluxation stemming from the upper cervical spine was found through thermographic and radiographic diagnostics. Chiropractic care using an upper cervical technique was administered to correct and stabilize the patient's upper neck injury. Diagnostics and care were performed in accordance with the guidelines of the International Upper Cervical Chiropractic Association.
Outcome: Evaluation of the patient's condition occurred by doctor's observation, patient's subjective description of symptoms, and thermographic scans. All headaches were absent following three months of care. At the conclusion of her case at one year, all symptoms remained absent.
Conclusion: The onset of the symptoms following the patient's fall on her head; the immediate reduction in symptoms correlating with the initiation of care; and the complete absence of all symptoms within three months of care; suggest a link between the patient's concussion, the upper cervical subluxation, and her headaches. Further investigation into upper cervical trauma as a contributing factor to headaches should be pursued.

Key Indexing Terms: *upper cervical spine, chiropractic, migraine, cluster, tension, sinus, headache, trauma, thermography*

INTRODUCTION

The following case report describes a 35-year-old professional ice skater's fall on her head at age 23; the onset of headaches following the blow to the head; the intervention of chiropractic care utilizing an upper cervical technique; and her symptomatic response. An appendix details the examination findings and results utilizing the same upper cervical chiropractic procedure in 100 additional chronic headache cases.

Reports documenting successful treatment of patients with headaches using chiropractic care are limited primarily to Palmer's research conducted seventy years ago (using a similar upper cervical technique), which was never published in a peer-reviewed, indexed fashion.[1-2] Palmer's chiropractic care included paraspinal thermal scanning using a neurocalometer (NCM), a cervical radiographic series to analyze upper cervical misalignment, and a specific upper cervical adjustment performed by hand. Positive results (symptoms were dramatically improved and/or eliminated) were achieved in approximately 1000 headache cases (from 5000 Palmer Research Clinic cases) whose upper cervical subluxations were corrected.

The rationale for the use of chiropractic care in this case was to correct the patient's upper cervical subluxation that was discovered during her initial evaluation. Patients with other neurological conditions such as Parkinson's disease and Multiple Sclerosis, who presented with similar upper cervical subluxations, also responded favorably to chiropractic intervention.[3-4] It should be noted that, in such cases, patients reported a substantial blow to the head or whiplash injury prior to the onset of symptoms and diagnoses. This case suggests a correlation between a blow to the head, upper cervical subluxation, and neurological disease, and serves to establish a foundation for future research.

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CASE REPORT

This 35-year-old female attended a chiropractic evaluation and recalled her health history following a concussion twelve years prior. Medical records obtained from the patient's neurologist confirmed her history, diagnoses, and treatment.

At age 23, the patient, a professional ice skater, fell and hit her head against the ice. She was temporarily rendered unconscious and diagnosed with a concussion.

Figure 1: A patient being scanned with the Tytron C-3000 system

In the ensuing months, she noticed the onset of headaches. The headaches worsened in frequency and severity over time. She thought the heavy headdresses she wore as costumes in ice skating performances aggravated the headaches. She stated that migraine headaches occurred every month during her menstrual period and usually two to three times throughout the other three weeks of a month. Lesser headaches occurred every day in between the migraines. At approximately age 29, she thought the headaches increased in severity and frequency. She reported that she awakened everyday with a headache and rarely went to sleep without one. In describing the headache location, she stated that the pain started in her neck or base of her skull and then spread to her forehead, temple, or side of her head. Although she never experienced aura preceding migraine onset, she often suffered with nausea and vomiting. She reported she took Tylenol with codeine almost every night in order to sleep through the pain, Ibuprofen several times per week, and Maxalt with every migraine. Her physician recommended she incorporate stress reduction, good sleep, hydration, nutrition, exercise, and eliminate "food triggers", but her headaches continued. Her sister, a massage therapist who frequently massaged the patient, said her right trapezius muscle was chronically hypertonic.

After the patient's medical history was recorded, her evaluation was performed in accordance with the guidelines of the International Upper Cervical Chiropractic Association (IUCCA) through their Applied Upper Cervical Biomechanics (AUCB) program.[5] It should be noted that there are numerous chiropractic techniques that focus upon the upper cervical spine; however, only the technique used in this case will be discussed in this report.

A paraspinal thermal analysis was performed with the Tytron C-3000 (Figure 1- Titronics Research and Development) from the level of C7 to the occiput according to thermographic protocol.[6-8] (Figure 2) Paraspinal digital infrared imaging, which measures cutaneous infrared heat emission, is a form of thermography, a neurophysiological diagnostic imaging pro-

Figure 2
Tytron C-3000 Thermographic Protocols

Environmental Controls —

- The temperature of your office should be held around 70 degrees Fahrenheit.
- No direct cooling or heating vent drafts should bear on the scanner.
- The scanner should not be placed in direct sunlight.
- Place the scanner holder away from the computer monitor and CPU.

Patient Preparation —

- 15 minutes of office acclimation time must occur before scanning the patient.
- The patient's spine must be disrobed or loosely gowned during acclimation.
- The patient must remain free from direct heating or cooling drafts.
- No direct sunlight should bear on the patient while in the office.
- No EMS, TENS, US, hot or cold packs, or acupuncture before scanning.
- The patient must be free from sunburn.

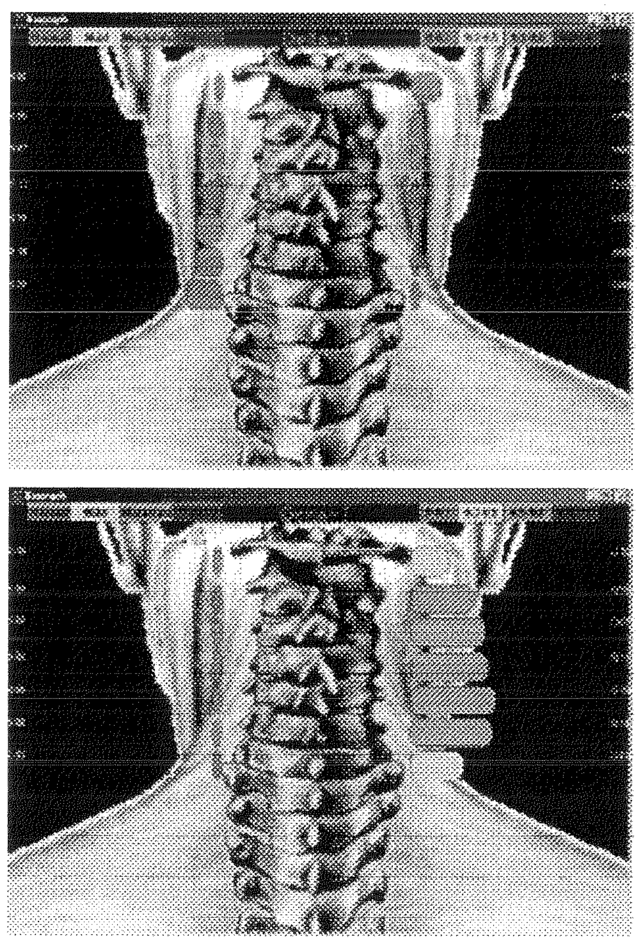
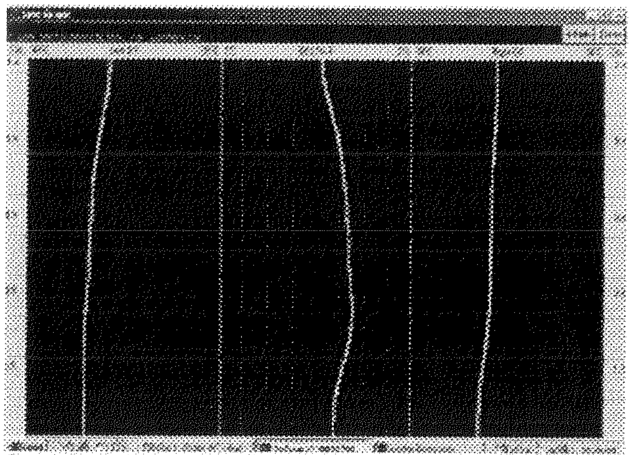
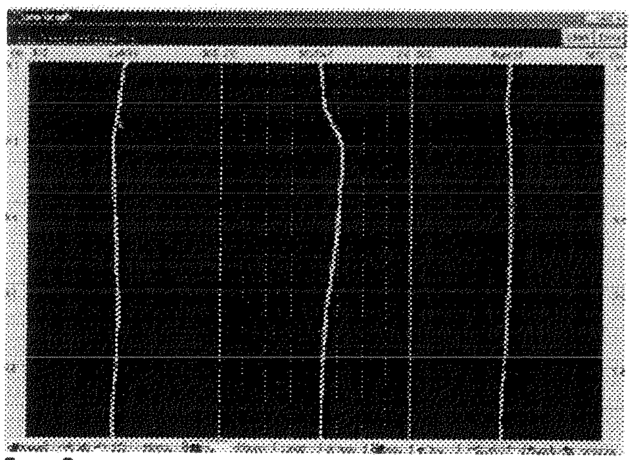


Figure 3: Example of cervical side to side thermal comparison. Normal scan (top), Thermal Asymmetries at multiple levels (bottom).

Figure 4: Establishment of static pattern.



Scan 1



Scan 2

cedure. Thermography has been established in chiropractic as a practical and sensitive test for spinal nerve root irritation, articular facet syndromes, peripheral nerve injuries, sympathetic pain syndromes, and the vertebral subluxation complex.[9-11] Since the amount of blood passing through the skin is directly controlled by the sympathetic nervous system (through control of dilation or constriction of blood vessels), the temperature of any one area of the skin reflects the neurological control of that area. Normal or abnormal skin temperature then becomes an indicator of normal or abnormal neurological function. In blind studies comparing thermographic results to that of CAT scan, MRI, EMG, myelography, and surgery, thermography was shown to have a high degree of sensitivity (99.2%), specificity (up to 98%), predictive value, and reliability.[12-14] Thermography has been effective as a diagnostic tool for breast cancer, repetitive strain injuries, headaches, spinal problems, TMJ conditions, pain syndromes, arthritis, and vascular disorders, to name a few.[15-24] A limited number of articles have been published demonstrating the use of paraspinal thermal imaging as an integral part of upper cervical protocol, including reports of patients with Parkinson's disease and Multiple Sclerosis.[3-4]

Compared to established normal values for the cervical spine, the subject's paraspinal scans contained thermal asymmetries of 0.6°C. (Figure 3) According to cervical thermographic guidelines, thermal asymmetries of 0.5°C or higher indicate abnormal autonomic regulation or neuropathophysiology.[25-28]

In addition to revealing thermal asymmetries, the subject's scans displayed static thermal differences (Figure 4), thus, a thermal "pattern" was established. "Pattern analysis" of paraspinal temperatures, first developed by Palmer, has received increased attention in chiropractic research.[3-4,29-39]

Because upper cervical misalignments were suspected in this patient, a precision upper cervical radiographic series was performed.[40] The x-ray equipment included a laser-aligned frame (American X-ray Corporation) to eliminate image distortion. To maintain postural integrity, this subject was placed in a positioning chair using head clamps. In addition, the patient was aligned to the central ray using a laser (Titronics Research and Development) mounted on the x-ray tube. The four views (lateral, anterior-posterior, anterior-posterior open mouth, and base posterior) enabled examination of the upper cervical spine in three dimensions: sagittal, coronal, and transverse. Analysis of the four views was directed towards the osseous structures (foramen magnum, occipital condyles, atlas, and axis) that are intimately associated with the neural axis.[40] (Figure 5) Left laterality and left anteriority of atlas was found (Figure 6).

In accordance with AUCB upper cervical protocol, the two criteria used to determine subluxation in this case were thermal asymmetry (measured by paraspinal thermal imaging) and vertebral misalignment (measured by cervical radiographs). Because both criteria (0.6°C thermal asymmetry and left laterality and anteriority of atlas) were met, a care plan was discussed with the patient. In addition, it was recommended that the subject continue her medical treatment and medications unless otherwise advised by her physician.

Following the patient's consent, chiropractic care began with an adjustment to correct the left laterality and anteriority of at-

Figure 5, Drawing Lines of Mensuration
(See Figure 6, page 4)

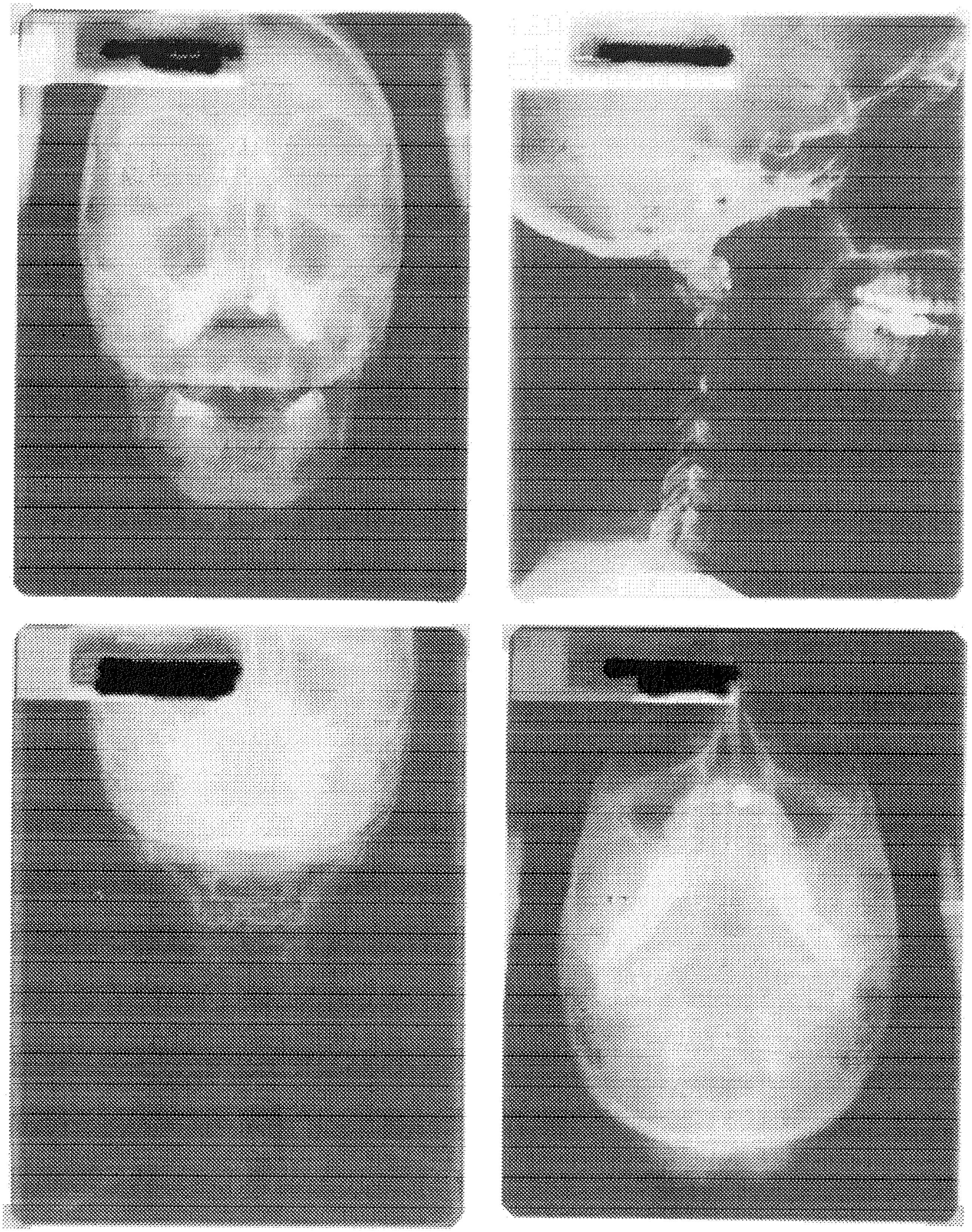
To determine laterality from the anterior-posterior open mouth film, a horizontal line was drawn across the upper one-third of the foramen magnum's arch from cortex to cortex. The foramen magnum line was bisected with a vertical median line from the film's top to bottom.

Using a compass's point on the vertical line, arcs were drawn through each lateral mass of atlas. Using the left lateral mass as the constant, if the right lateral mass stayed within the right arc, the atlas was listed as "left". If the right lateral mass extended beyond the right arc, the atlas was listed as "right".

Axis laterality was determined by locating the position of the odontoid and spinous processes according to the vertical median line. To determine atlas rotation from the base-posterior film, an atlas plane line was drawn through the transverse foramen of atlas. The next line was drawn horizontally across the cortical borders of the clivus (ossification center of the skull) from cortex to cortex. This skull line was bisected.

Atlas rotation was determined by using a protractor to measure the difference between the bisected skull line and the atlas plane line. An angle less than 90 degrees represented "anteriority". An angle more than 90 degrees represented "posteriority".

Figure 6: Patient XRays with Lines of Mensuration



See Figure 5, page 3 for explaination of how lines of mensuration were drawn.

las. To administer the adjustment, the patient was placed on a knee-chest table with her head turned to the left (Figure 7). The knee-chest posture was chosen because of the accessibility of the anatomy to be corrected. Using the left posterior arch of atlas as the contact point, an adjusting force was introduced by hand.[41] The adjustment's force (force = mass X acceleration) was generated using body drop (mass) and a toggle thrust (acceleration).

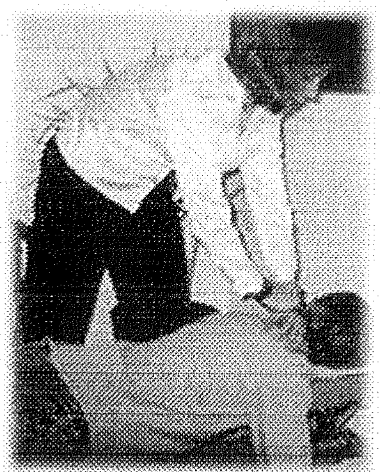


Figure 7: Example of patient positioning for knee-chest adjustment.

Next, the patient was placed in a post-adjustment recuperation suite for fifteen minutes as per thermographic protocol.[6-8] (Figure 2) After the recuperation period, a post-adjustment thermal scan was performed. The post-adjustment scan revealed a thermal difference of only 0.1 °C, which was considered normal according to established cervical thermographic guidelines (compared to the pre-adjustment differential of 0.6 °C). Therefore, resolution of the patient's presenting thermal asymmetry (elimination of the thermal "pattern") was achieved. (Figures 8 & 9).

All subsequent office visits began with a thermal scan. An adjustment was administered only when the patient's presenting thermal asymmetry ("pattern") returned. If an adjustment was given, a second scan was performed after a fifteen-minute recuperation period to determine whether restoration of normal thermal symmetry had occurred. This subject's office visits occurred two times per week for the first two weeks of care, one time per week for the following four weeks, two times per month for the following month, and one time per month thereafter.

After the first adjustment, during the first two weeks of care, thermal asymmetry was present at two office visits so two adjustments were performed. The patient reported experiencing two severe headaches during the first two weeks of care. She still awakened daily with a headache, but she claimed the pain was milder and that it resolved by the afternoon. She also stated her neck was feeling looser and better and that she required less pain medication.

During weeks three through five, thermal scans were normal so no adjustments were administered. The patient could not recall experiencing any headaches and did not use any pain medication during these three weeks.

Between weeks six and eight, two adjustments were performed and two mild headaches were reported.

During the third month of care, no adjustments were necessary, no headaches were reported, and no medication was used.

At the end of the third month of care, the subject was involved in an auto accident in which another car unexpectedly turned in front of her. During her office visit the following day, she claimed she was traveling at approximately 30 miles per hour when she hit the other car. Her symptoms included neck pain and headaches since the accident. She also reported experiencing soreness in her left foot and leg from braking at the time of impact. Her thermal scan indicated a return in thermal asymmetry. Cervical radiographs were retaken to ensure no fractures or dislocations had taken place as well as to determine whether her original x-ray findings had been altered. The films were taken and analyzed as previously illustrated. No change in x-ray listing was found. Accordingly, she was adjusted as previously described. Within a week after this adjustment, all neck soreness and headaches had dissipated and no further adjustments were required.

During the nine months following the accident, the subject was examined once per month. Thermal symmetry was present at each visit, so no adjustments were administered. The patient had not experienced a single headache during that time and had not required any pain medication. During the year of care, no other intervention was reported that could have provided an alternative explanation for the dramatic improvement of the patient's condition.

Figure 8

These graphs demonstrate when the patient was not "in pattern" and no adjustment was given on those days.

DISCUSSION

Consider the case chronology. A healthy, 23-year-old female sustained a concussion by falling on her head. During the subsequent months, tension and migraine headaches ensued. Advice and treatment was sought but the headaches persisted for twelve years. During a chiropractic evaluation utilizing an upper cervical technique, an upper cervical subluxation was found. After the initial adjustment to the patient's upper neck was administered, the patient's symptoms began to subside and continued to improve until absent during the care period.

As the patient was healthy prior to the fall on her head and developed symptoms following the concussion, it follows that the impact had a causal effect on her health problems. Hundreds of medical references substantiate this deduction by naming head and neck trauma as a cause of headaches.[42-62]

Medical references also name the brainstem as a primary site for headache origin.[63-65] According to researchers, migraine headaches have been attributed to malfunctions of the brainstem trigeminal nucleus and brainstem serotonergic pathways that affect nerves and blood vessels in the head. It is thought that abnormal activation of sympathetic nerves triggers vasoconstriction within the brain stem. Consequently, the blood supply to the brain is reduced, causing the dilation of arteries within the brain to meet the brain's oxygen supply. This vasodilation is the source of headache pain.

The relationship between the upper cervical spine and the brainstem is an area requiring further research. Since chiropractic care appeared to stimulate the patient's symptomatic improvements, then it follows that the care may have generated improvement in her brainstem function. The theory discussed below is proposed to explain the relationship between upper cervical subluxation and neurological dysfunction.

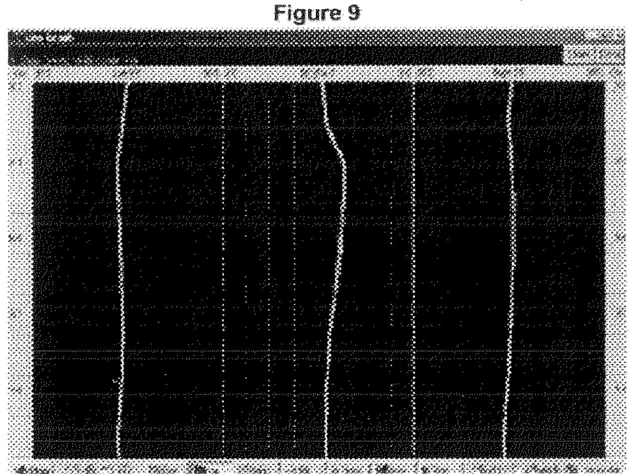
After a spinal trauma, central nervous system facilitation can occur from an increase in afferent signals to the spinal cord and/or brain coming from articular mechanoreceptors.[66-70] The upper cervical spine is uniquely at risk for this problem because it possesses inherently poor biomechanical stability (lacks intervertebral discs and vertical zygapophyseal joints) along with the greatest concentration of spinal mechanoreceptors. Due to central nervous system facilitation from the upper cervical mechanoreceptors, hyperafferent activation of the sympathetic vasomotor center in the brainstem and/or the superior cervical ganglion may occur and may ultimately lead to headaches. Therefore, reversal of the upper cervical injury could alleviate activation of the sympathetic nervous system, thereby eliminating headaches.

In summary, the following hypothesis for the cause and correction of the patient's condition is submitted. The patient's fall on her head caused the spraining of spinal ligaments in her upper neck, allowing for an upper cervical subluxation. Due to the upper cervical subluxation, a variety of complex, detrimental neurological changes developed (probably originating in the brainstem), which ultimately allowed for the manifestation of the patient's headaches. The patient's symptoms remained until the upper cervical subluxation was discovered and reduced. Once the patient's upper cervical alignment was corrected and stabilized, irritation to the central nervous system was eliminated and the patient's normal neurophysiology was restored.

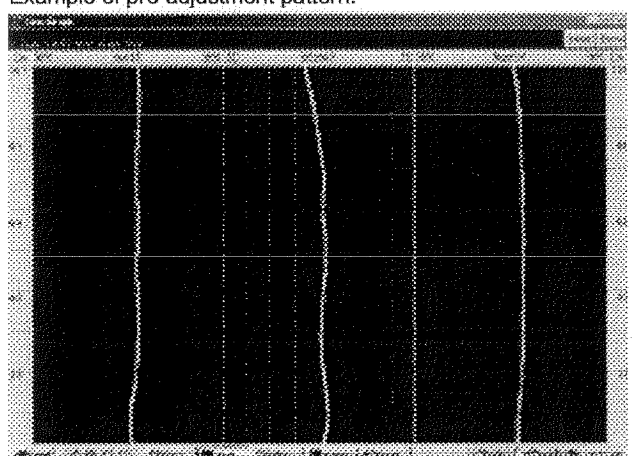
CONCLUSION

This case report details the medical history and symptoms of a 35-year-old female suffering from headaches for twelve years after a fall on her head; the twelve-month intervention of chiropractic care utilizing an upper cervical technique; and the patient's symptomatic response. Evidence of an upper cervical subluxation was found using thermographic and radiographic diagnostics. It was corrected by performing a specific adjust-

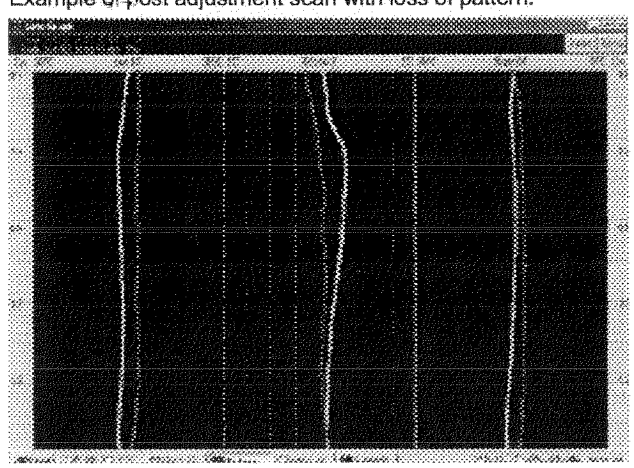
Figure 9



Example of pre-adjustment pattern.



Example of post adjustment scan with loss of pattern.



Example of pre and post scans together.

ment by hand to the first cervical vertebra according to radiographic findings. The upper neck subluxation could have been caused by an ice skating fall in which the patient sustained a concussion. The patient's headaches were absent by the third month of care and remained absent at the conclusion of the patient's case at twelve months.

An additional 100 chronic headache cases, detailed in the Appendix, were examined and cared for using the same upper cervical procedure. Similar favorable results were produced in the majority of patients. To confirm this positive outcome, it is recommended that a more extensive study using control subjects be performed. In addition, further investigation into upper cervical injury and resulting neuropathophysiology as a possible etiology or contributing factor to headaches should be pursued.

APPENDIX: SUMMARY OF 101 CHRONIC HEADACHE CASES

The appendix summarizes 101 cases (the case study plus 100 additional cases) examined and cared for in the author's private practice over a five-year period in a non-study environment without control subjects and does not purport to be a controlled research study. Rather, this appendix serves to provide a foundation for future research due to the common examination findings in all subjects and the positive results achieved with this upper cervical chiropractic procedure.

All headache patients were examined and cared for with the previously described upper cervical chiropractic procedure, according to the protocol of the International Upper Cervical Chiropractic Association. The four chronic headache categories suffered by the subjects included migraine, cluster, tension, and sinus. From 101 headache patients, 37 migraine cases, 57 tension cases, 1 cluster case, and 6 sinus cases were examined. Patients ranged in age from 5 to 77 years. Frequency of headaches ranged from one headache per month to daily headaches. Patients had experienced headaches between 1 and 57 years. All patients had been diagnosed by their physicians and most had suffered for years in pain and "had tried everything" to find relief including but not limited to pain medications (prescriptions, over the counter, injections, etc.), massage, rolfing, acupuncture, herbs, cervical manipulation, Chinese medicine, biofeedback, hormone pills, etc.

Statistics of each case (age, gender, headache type, years duration, number of headaches per month before and after care, etc.) are located in Table 1. Upon examination with paraspinal digital infrared imaging, all patients showed static thermal asymmetry of at least .5°C, or thermal "pattern". In addition, all patients' laser-aligned cervical radiographs showed upper cervical deviation from the neural axis. Since all patients showed evidence of upper cervical subluxations upon examination and all patients consented to care, upper cervical care was administered to all 101 patients. Before beginning care, patients were cautioned to continue medical treatments unless otherwise advised by their physicians. It should be noted that twenty additional headache patients were examined and accepted for care during the same time period but chose to discontinue care during the early treatment weeks due to personal, financial, or other reasons. Therefore, those additional patients' data were omitted from this report.

All 101 cases are found in Table 1. The migraine case discussed in the case report, Case 24, will be used to illustrate the table. Column 2 of the table lists the patient's headache diagnosis: migraine (M), tension (T), cluster (C), or sinus (S). Since Case 24 suffered both daily tension and migraine headaches, "T & M" is noted. Columns 3 and 4 list the patient's age (35) and gender (F). Column 5 lists the number of years headaches were present before the patient sought help from upper cervical care (12 years for Case 24). Column 6 lists the number of months of care required to achieve the substantial reduction or elimination of headaches. Since Case 24 was headache-free by the third month of care, "3" is listed. Column 7 lists the degree of thermal deviation in each patient's paraspinal thermal scan (.6°C for Case 24). Column 8 lists each patient's upper cervical x-ray listing (ALA for Case 24). Atlas listings are depicted with laterality of left (L) or right (R) and rotation of anterior (A) or posterior (P). The lateral movement of axis is listed to the left (ESL) or right (ESR). Finally, Column 9 lists whether a patient recalled a trauma to his/her head and/or neck that could have caused the upper cervical subluxation found during examination. Since Case 24 recalled multiple falls on the ice as a professional ice skater including one concussion, "yes" was noted. Columns 10 and 11 list the number of headaches suffered per month prior to and subsequent to upper cervical care. Since Case 24 suffered daily headaches prior to upper cervical care and no headaches after care, "30" and "0" are listed.

From a total of 101 cases, 85 patients' headaches were completely resolved within 1 to 8 months of upper cervical care. Twelve of the remaining cases were improved in that their headaches were greatly reduced but some residual headaches occurred. All patients under the age of 18 had their headaches resolved within two months of care. Most adult cases were resolved within four months. Some subjects required six months or more to achieve maximum benefit, but these were patients who had suffered with headaches for many decades. Four cases showed little to no improvement.

When questioned, 87 of 101 patients recalled at least one specific traumatic event (fall, accident, whiplash, concussion) that preceded their headache onset and could have caused their upper cervical subluxation. The most common traumas included whiplash and/or concussion as a result of auto accidents and traumas during sports including skiing, cycling, horse back riding, ice skating, football, gymnastics, snow boarding, skate boarding, etc. Frequently, parents of children with headaches reported that their child had a difficult birth requiring forceps or suction and concluded that perhaps birth trauma had been the source of their child's upper cervical injury.

ACKNOWLEDGMENTS

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Table 1. Data For 101 Chronic Headache Cases

Case No.	HA Type	Age	Gender	Years of HA	# Months of Care	Thermal Deviation	X-Ray Listing	History of Trauma	# HA per Month Before Care	# HA per Month After Care
1	C	44	M	20	2	0.7	ARP	YES	30	0
2	M	44	F	10	5	0.7	ESL	YES	10	3
3	M	48	M	4	1	0.5	ARA	YES	1	0
4	M	52	F	13	8	1.0	AL	YES	4	0
5	M	40	F	10	1	0.7	ALA	NO	2	0
6	M	49	F	4	5	0.5	AL	YES	10	2
7	M	23	F	14	1	1.6	AL	YES	1	0
8	M	25	F	18	3	0.5	ESL	YES	4	0
9	M	47	F	10	1	0.5	ALA	YES	4	0
10	M	47	F	26	2	0.5	ALP	YES	1	0
11	M	28	F	18	6	0.5	ESR	NO	20	4
12	M	59	M	30	2	0.7	ALP	YES	2	0
13	M	23	M	6	6	0.5	ESR	YES	30	0
14	M	53	F	30	3	0.6	ARP	YES	4	0
15	M	48	F	28	6	0.7	ESL	NO	21	2
16	M	46	F	6	2	0.5	ESR	YES	4	0
17	M	46	F	35	8	0.5	AR	NO	16	4
18	M	48	F	35	6	0.5	AL	YES	2	0
19	M	53	F	40	10	0.5	AR	NO	30	25
20	M	24	F	5	1	0.5	ALP	YES	2	0
21	M	25	F	20	3	0.5	ARA	YES	30	0
22	M	27	F	2	3	0.6	ESL	YES	2	0
23	M	42	F	25	2	0.5	ARA	YES	1	0
24	M & T	35	F	12	3	0.6	ALA	YES	30	0
25	M & T	19	F	2	1	1.0	ALA	YES	5	0
26	M & T	49	F	40	2	0.5	ESR	NO	30	0
27	M & T	48	F	35	1	0.7	ARA	YES	5	0
28	M & T	28	F	4	2	1.0	ESL	YES	20	0
29	M & T	67	F	57	6	0.5	AR	YES	4	1
30	M & T	12	F	1	3	0.5	AR	NO	12	0
31	M & T	44	F	36	4	1.0	ALA	YES	30	2
32	M & T	15	F	2	3	1.1	ESL	YES	30	2
33	M & T	9	M	3	1	0.5	AL	YES	10	0
34	M & T	34	F	22	6	0.5	ESL	NO	30	1
35	M & T	43	F	30	4	0.6	AR	YES	10	0
36	M & T	45	F	3	6	0.5	ARP	YES	8	0
37	M & T	45	F	25	7	0.6	AL	YES	30	15
38	M & T	41	F	6	3	0.5	ESL	YES	8	0
39	S	47	M	20	1	0.5	ALP	YES	8	0
40	S	43	F	20	2	0.6	ALA	YES	2	0
41	S	52	F	8	2	0.5	AR	YES	4	0
42	S	16	F	3	2	0.7	ARP	NO	1	0
43	S	36	F	12	6	0.5	AR	YES	30	20
44	S	16	F	9	2	0.5	AR	YES	4	0
45	T	48	F	20	3	0.5	ESR	NO	4	0
46	T	17	F	7	2	0.5	ALA	YES	8	0
47	T	56	F	14	1	0.8	ARP	YES	8	0
48	T	30	M	4	2	0.5	ESL	YES	30	0
49	T	50	F	5	3	0.5	ESL	YES	30	0
50	T	61	F	2	1	0.5	AR	YES	4	0
51	T	26	F	6	3	0.5	ESL	YES	8	0
52	T	46	F	23	3	0.6	ARA	YES	8	0
53	T	36	F	6	1	0.5	ALA	YES	30	0
54	T	11	M	5	1	0.5	ESL	YES	8	0
55	T	62	F	2	5	0.6	ESL	YES	5	0
56	T	41	M	1	3	0.9	AR	YES	10	0
57	T	52	F	2	1	0.9	AR	YES	30	0
58	T	37	F	15	4	0.5	ARA	YES	30	0
59	T	41	F	10	4	1.0	ESR	YES	30	0

Table 1. Data For 101 Chronic Headache Cases (Cont.)

Case No.	HA Type	Age	Gender	Years of HA	# Months of Care	Thermal Deviation	X-Ray Listing	History of Trauma	# HA per Month Before Care	# HA per Month After Care
60	T	60	F	50	6	0.5	ESR	YES	10	2
61	T	28	F	11	2	1.2	ESR	YES	2	0
62	T	28	F	2	4	0.5	AR	YES	30	0
63	T	48	F	40	4	0.5	ESL	YES	30	0
64	T	17	M	10	2	0.5	ARP	YES	5	0
65	T	50	F	1	1	1.5	ARA	YES	5	0
66	T	36	F	17	1	0.6	ALA	YES	5	0
67	T	55	F	2	1	0.5	ESR	YES	5	0
68	T	40	F	20	6	0.5	AL	YES	5	1
69	T	54	F	20	6	0.6	ESR	YES	30	2
70	T	54	M	15	1	0.5	AR	YES	2	0
71	T	48	F	3	4	0.5	ESL	YES	20	0
72	T	52	M	5	2	0.5	AL	YES	5	0
73	T	26	F	1	1	0.5	ARP	YES	8	0
74	T	33	F	10	2	1.0	ARA	NO	4	0
75	T	40	F	7	3	0.5	ESR	YES	30	0
76	T	58	F	1	1	0.7	ARP	YES	2	0
77	T	52	F	2	3	0.9	ESL	YES	30	0
78	T	43	F	12	2	0.5	ARA	YES	4	0
79	T	39	F	1	1	0.6	ALP	NO	30	0
80	T	48	F	1	2	0.5	ESL	YES	2	0
81	T	77	F	2	1	0.5	AL	NO	30	0
82	T	8	F	1	1	0.5	ARA	YES	4	0
83	T	61	F	30	6	0.5	AR	YES	30	0
84	T	25	F	1	2	0.5	ALA	NO	20	0
85	T	21	F	10	1	0.5	ARP	YES	4	0
86	T	35	F	1	1	0.5	ALA	YES	30	0
87	T	50	M	13	5	0.7	AL	YES	30	0
88	T	25	M	1	1	1.3	AR	YES	2	0
89	T	9	M	5	1	0.6	ARA	YES	30	0
90	T	22	M	4	1	0.5	AR	YES	1	0
91	T	40	F	1	1	0.6	AL	YES	4	0
92	T	50	M	1	2	0.5	ARP	NO	12	0
93	T	36	M	29	2	0.6	ALA	YES	15	0
94	T	8	F	2	2	0.8	ARP	YES	30	0
95	T	5	F	1	1	0.7	AL	YES	5	0
96	T	64	F	40	1	0.6	AL	YES	30	0
97	T	15	F	1	2	1.2	ALP	YES	30	0
98	T	44	F	5	6	0.5	ESR	YES	30	15
99	T	32	F	2	4	0.6	ALP	YES	20	0
100	T	40	F	1	1	0.5	ALA	YES	2	0
101	T	16	F	1	2	0.5	ALP	YES	2	0

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CASE STUDY

Female Infertility and Chiropractic Wellness Care: A Case Study on the Autonomic Nervous System Response while Under Subluxation Based Chiropractic Care and Subsequent Fertility

Tammy M. Kaminski, DC

ABSTRACT

Objective: This case study describes a woman, previously diagnosed with a lazy (reproductive) system, who became pregnant after commencing subluxation-based chiropractic care.
Clinical Features: A 31 year old woman presented to have her nervous system evaluated after her husband's encouragement. They were under medical treatment for infertility as they had been attempting to become pregnant for over 12 months, and the woman had been taking Clomiphine Citrate (clomid) for 3 months. Her previous child, three years old, had been conceived naturally.
Chiropractic Care and Outcome: The initial chiropractic examination revealed increased aberrant autonomic and motor nervous system function detected on the thermography scans and sEMG scans, respectively. For the first three months (21 visits) of care the practice member received Diversified chiropractic adjustments followed by four months (12 visits) of Torque Release adjustments. At each visit prior to structural diversified adjustments, motion and static palpation, visual observation, Deerfield leg check and cervical syndrome test were performed to detected vertebral subluxations. The Torque Release Technique (TRT) utilizes the Intergrator™, a torque and recoil release adjusting instrument and three phases comprised the evaluation. After one month of care the practice member chose to stop taking the clomid. By the third month of care she reported having normal menses for two months and drug-free ovulation by month four. Nine months after chiropractic wellness care, the practice member conceived and proceeded to experience a successful full term pregnancy.
Conclusion: After receiving wellness chiropractic care for the detection and correction of vertebral subluxations, the practice member showed marked improvement in autonomic and motor system function as demonstrated on her sEMG and thermography scans. In additon, after having great difficulty conceiving, she became pregnant nine months after commencing chiropractic care. Further studies are needed to document the relationship between infertility, autonomic nervous system function, and the response to wellness chiropractic care, including subsequent fertility.

Key words: *infertility, chiropractic, wellness, subluxation, practice member, Torque Release Technique, Diversified Chiropractic Technique, EMG, thermography.*

INTRODUCTION

The purpose of this article is to describe chiropractic wellness care, the autonomic nervous system response, and subsequent fertility in a 31 year old female struggling with infertility.

Infertility is described as failure to achieve conception by those who have not used contraception for at least one year.[1] About 15% of couples in the United States experience infertility.[2,3] It is an emotional[4,5] and often times a very costly endeavor for those seeking answers and cures. Generally, a variety of tests and drug therapies with many side effects are involved. It is important for the public to know there are natural, more cost-efficient ways to identify interference to fertility.

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Infertility can be caused by many factors. Problems with ovulation and hormonal balance, fallopian tube damage often caused by pelvic inflammatory disease (PID), endometriosis and low sperm count are the most frequently diagnosed conditions in the medical field. In general, infertility caused by problems in the woman's reproduction system is more often treated than infertility caused by problems with the man's reproductive system[6].

Today extensive medical tests are available for couples seeking allopathic intervention for their infertility. Laparoscopy is one such procedure. It is a surgical procedure used to examine the abdominal organs and the female pelvic organs to diagnose problems such as cysts, adhesions, fibroids and infections.[7] Tissue samples can also be collected for biopsies.

Medication is commonly used as medical response to infertility. Clomiphine Citrate (clomid) to induce ovulation, Crinone Progesterone Vaginal gel, Lupron to prevent egg release from the ovaries and Fertinex, a purified subcutaneous injected follicle stimulating hormone (FSH) are a few prescribed drugs.[8] The practice member is this case was prescribed Clomiphine Citrate (clomid), often referred to as the "fertility pill." [9] When the ovaries do not produce and release eggs due to hormonal imbalances, clomid works by helping the pituitary gland stimulate this function.

Surgery is often the medical mode of treatment for endometriosis and repairing damaged fallopian tubes. Assisted reproduction technology such as in vitro fertilization (IVF) and intrauterine insemination (IUI) are used for a variety of infertility problems. IVF is performed when fallopian tube blockage (often after unsuccessful surgery), cervical narrowing, and low sperm counts are the cause of the infertility. IUI is most commonly used for infertility associated with endometriosis, unexplained infertility, anovulatory infertility, very mild degrees of male factor infertility and for some couples with immunological abnormalities.[10] Additional infertility drugs are administrated with these procedures. IVF involves follicle suppression, follicle stimulation, maturing follicles, egg retrieval, fertilization of retrieved egg and sperm specimen. If the eggs are successfully fertilized an embryo transfer will take place. For the IUI procedure the egg is not retrieved but fertilized by placing highly motile sperm in the cervix or high in the uterine cavity (intrauterine).

Studies have shown the relationship of vertebral subluxations and autonomic nervous system dysfunction.[11,12,13,14] Improved gynecological function has been reported while receiving chiropractic care, including with these conditions: dysmenorrhea, amenorrhea, PMS and sexual dysfunction. Women under regular chiropractic care note a more balanced system during their life cycle change of menopause. Chiropractic does not treat symptoms or conditions but allows the nervous system to function more efficiently. This is accomplished through specific chiropractic adjustments that reduce and eliminate spinal cord tension and interference. The body and mind can function in harmony promoting health, wellness, and the ability to handle the physical, emotional, and chemical stresses that challenge a couple experiencing infertility.

Case Report

Personal History: A 31 year old female presented for care after her husband's encouragement; they were having difficulty conceiving and it was causing increased emotional stress. She stated her medical doctor had diagnosed her with a "lazy system" and irregular ovulation. The drug clomid was prescribed to increase ovulation. At the initial examination the practice member had been on clomid for three months. Her diet and exercise routines were subjectively rated as poor while sleep patterns and general health were rated as good (scale: poor, good, excellent). She experienced seasonal sinus headaches and allergies with increased symptoms to mold occasionally taking OTC sudafed for this condition. Other health concerns were irregular menstrual cycles and migraines. Three years prior, she had conceived naturally and has a daughter. As a child the practice member had received allergy shots and used an intermittent inhaler. She had usual childhood illnesses and was vaccinated.

Examination and Re-Examination Findings: The initial examination revealed a visually healthy female. All deep tendon reflexes were normal and ROMs were performed effortlessly within normal range. As she was trying to conceive no radiographs were taken. Thermographs and sEMG scans were performed on the initial visit and subsequent re-examinations.

The Thermography scan is a paraspinal skin temperature study, with standardized protocols and established normative data utilized for computer analysis and comparision, which is used to assess sympathetic nerve function.The Static EMG scan is a paraspinal study, also with standardized protocols and established normative data (25-500Hz)utilized for computer analysis and comparison, which is used to assess location and extent of abnormal paraspinal muscle function (motor system).[15]

The following are the thermal results:

1) March 24, 2000 Initial Exam - Temperature differences one or two standard deviations greater than the mean (mild asymmetry) were observed at T1, T2, T6, T9, L2, L4. Temperature differences two or three standard deviations greater than the mean (moderate asymmetry) were observed at L3. Temperature differences three or four standard deviations greater than the mean (severe asymmetry) were observed at T3, T5, T11. Temperature differences four or more standard deviations greater than the mean (very severe asymmetry) were observed at T12, L1. (See Table 1a, page 3).
2) May 10, 2000 First Re-exam - Temperature differences one or two standard deviations greater than the mean (mild asymmetry) were observed at C5,T9. Temperature differences two or three standard deviations greater than the mean (moderate asymmetry) were observed at C6,T1. A temperature difference three or four standard deviations greater than the mean (severe asymmetry) was observed at C7. A temperature difference four or more standard deviations greater than the mean (very severe asymmetry) was observed at L5. (See Table 2a, page 4).
3) October13, 2000 Second Re-exam - Temperature differences one or two standard deviations greater than the mean (mild asymmetry) were observed at C1, C3, C5, T8, L1, L2, S1. Temperature differences two or three standard deviations greater than the mean (moderate asymmetry) were observed at C4, T11. (See Ttable 3a, page 5).
4) March 9, 2001 Third Re-exam - Temperature differences one or two standard deviations greater than the mean (mild asymmetry) were observed at C3,S1. Temperature difference two or three standard deviations greater than the mean (moderate asymmetry) was observed at T2. (See Table 4a, page6).

The following are the Static EMG results:

1) March 24, 2000 Initial Exam - Elevations one or two standard deviations above the mean were observed at C1(R), C5(L), C7(L&R), T4(L), S1(L&R). This is indicative of a mild elevation. An elevation two or three standard deviations above the mean was observed at C1(L). This is indicative of a moderate elevation. An area of significant asymmetry was noted at the following site: C5. (See table 1b, page 7).

(Continued on Page 7)

TABLE 1A

THERMAL: Fri Mar 24, 2000 at 12:29PM [Chart]

Asymmetry Table, degrees FAHRENHEIT

DIF	PSD	NSD	NORM	TEMP	SITE	TEMP	NORM	NSD	PSD	DIF
xxx				98.4	C1	98.9	0.41	0.29		0.50
xxx				98.8	C2	97.3	0.41	0.29		0.50
xxx				98.2	C3	98.9	0.41	0.29		0.69
xxx				96.9	C4	97.2	0.41	0.29		0.33
xxx				95.9	C5	96.2	0.41	0.29		0.31
xxx				94.1	C6	94.3	0.41	0.29		0.24
xxx				92.7	C7	93.0	0.41	0.29		0.26
xxx				91.6	T1	92.3	0.36	0.31	*	0.73
0.76	*	0.31	0.36	92.1	T2	91.3				xxx
xxx				93.2	T3	91.8	0.36	0.31	***	1.41
xxx				91.5	T4	92.0	0.36	0.31		0.43
xxx				90.8	T5	92.1	0.36	0.31	***	1.29
xxx				90.8	T6	91.6	0.36	0.31	*	0.79
xxx				91.2	T7	91.8	0.36	0.31		0.60
xxx				91.5	T8	92.1	0.36	0.31		0.61
0.86	*	0.31	0.36	91.1	T9	90.2				xxx
xxx				90.0	T10	90.6	0.36	0.31		0.63
xxx				89.8	T11	91.3	0.36	0.31	***	1.51
xxx				90.3	T12	92.1	0.36	0.31	****	1.76
xxx				89.4	L1	91.3	0.40	0.34	****	1.92
xxx				88.0	L2	88.7	0.40	0.34	*	0.75
xxx				87.4	L3	88.6	0.40	0.34	**	1.19
xxx				86.9	L4	87.7	0.40	0.34	*	0.84
0.18		0.34	0.40	86.8	L5	86.7				xxx
xxx				86.5	S1	86.7	0.40	0.34		0.25

[illegible]

THERMAL: Fri Mar 24, 2000 at 12:29PM [NCM]

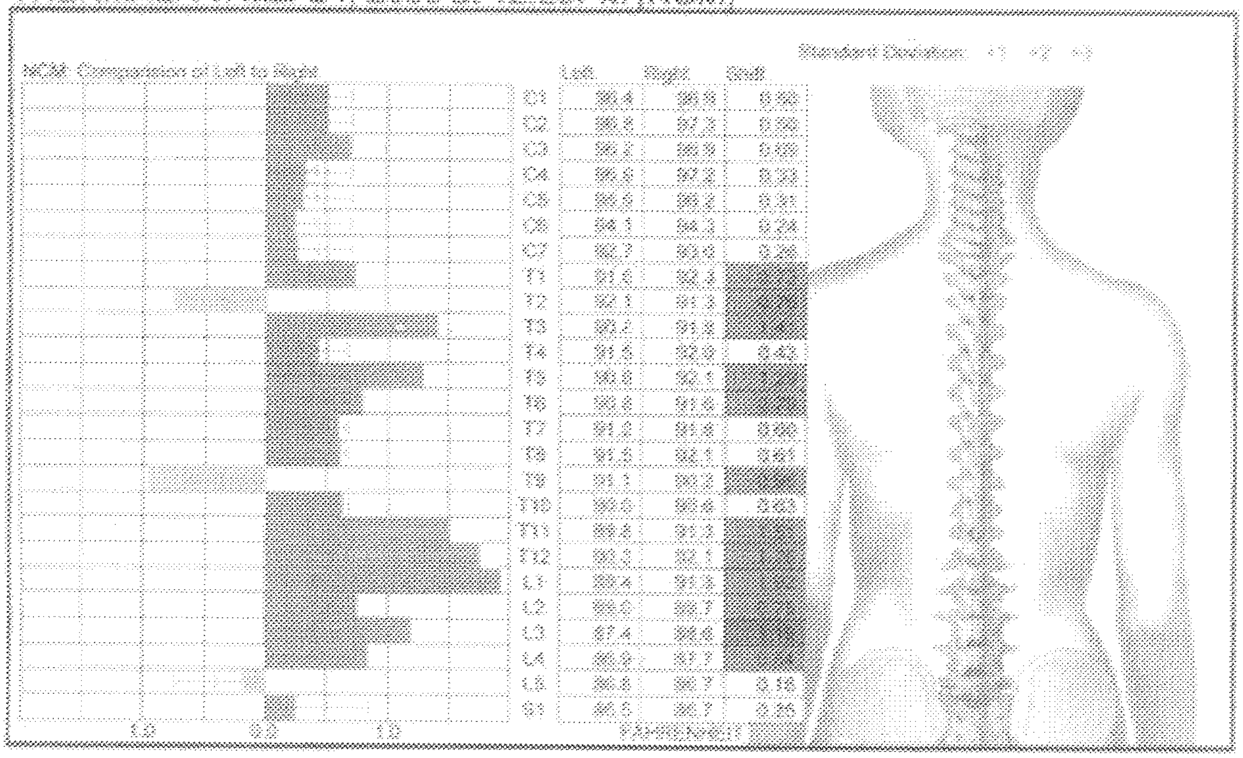


TABLE 2A

THERMAL: Wed May 10, 2000 at 12:25PM [Chart]

Asymmetry Table, degrees FAHRENHEIT

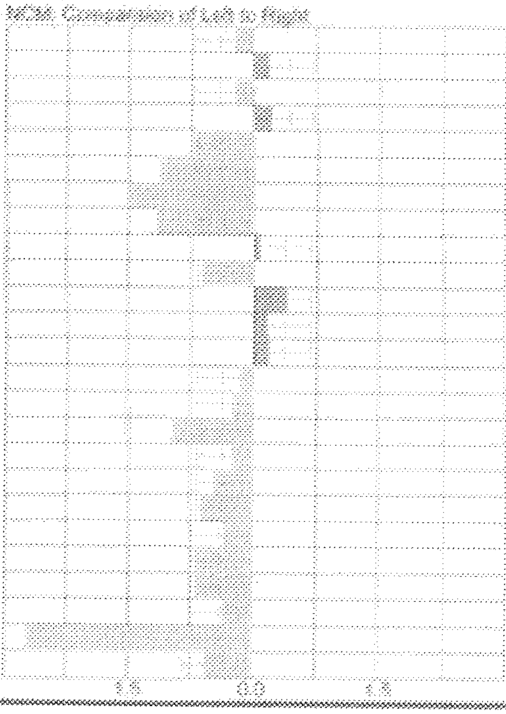
DIF	PSD	NSD	NORM	TEMP	SITE	TEMP	NORM	NSD	PSD	DIF
0.22		0.29	0.41	93.5	C1	93.3				<<<
>>>				94.7	C2	94.9	0.41	0.29		0.18
0.22		0.29	0.41	94.5	C3	94.3				<<<
>>>				94.3	C4	94.5	0.41	0.29		0.21
0.72	*	0.29	0.41	93.6	C5	92.9				<<<
1.13	**	0.29	0.41	93.0	C6	91.9				<<<
1.47	***	0.29	0.41	92.4	C7	91.0				<<<
1.17	**	0.31	0.38	90.8	T1	89.7				<<<
>>>				89.6	T2	89.7	0.38	0.31		0.08
0.62		0.31	0.38	91.1	T3	90.5				<<<
>>>				90.1	T4	90.5	0.38	0.31		0.39
>>>				89.9	T5	90.1	0.38	0.31		0.18
>>>				89.5	T6	89.7	0.38	0.31		0.19
0.16		0.31	0.38	90.5	T7	90.4				<<<
0.28		0.31	0.38	90.0	T8	89.7				<<<
0.96	*	0.31	0.38	89.1	T9	88.1				<<<
0.24		0.31	0.38	88.9	T10	88.7				<<<
0.47		0.31	0.38	90.3	T11	89.9				<<<
0.61		0.31	0.38	91.0	T12	90.4				<<<
0.34		0.34	0.40	89.9	L1	89.5				<<<
0.70		0.34	0.40	89.1	L2	88.4				<<<
0.67		0.34	0.40	87.9	L3	87.2				<<<
0.36		0.34	0.40	86.8	L4	86.4				<<<
2.73	******	0.34	0.40	87.3	L5	84.6				<<<
0.58		0.34	0.50	85.6	S1	85.1				<<<

REF: [illegible]

THERMAL: Wed May 10, 2000 at 12:25PM [NCM]

NCM Comparison of Left to Right

Standard Deviations: +1 +2 +3



	Left	Right	Diff
C1	93.5	93.3	0.22
C2	94.7	94.9	0.18
C3	94.5	94.3	0.22
C4	94.3	94.5	0.21
C5	93.6	92.9	[illegible]
C6	93.0	91.9	[illegible]
C7	92.4	91.0	[illegible]
T1	90.8	89.7	[illegible]
T2	89.6	89.7	0.08
T3	91.1	90.5	0.62
T4	90.1	90.5	0.39
T5	89.9	90.1	0.18
T6	89.5	89.7	0.19
T7	90.5	90.4	0.16
T8	90.0	89.7	0.28
T9	89.1	88.1	[illegible]
T10	88.9	88.7	0.24
T11	90.3	89.9	0.47
T12	91.0	90.4	0.61
L1	89.9	89.5	0.34
L2	89.1	88.4	0.70
L3	87.9	87.2	0.67
L4	86.8	86.4	0.36
L5	87.3	84.6	[illegible]
S1	85.6	85.1	0.58

FAHRENHEIT

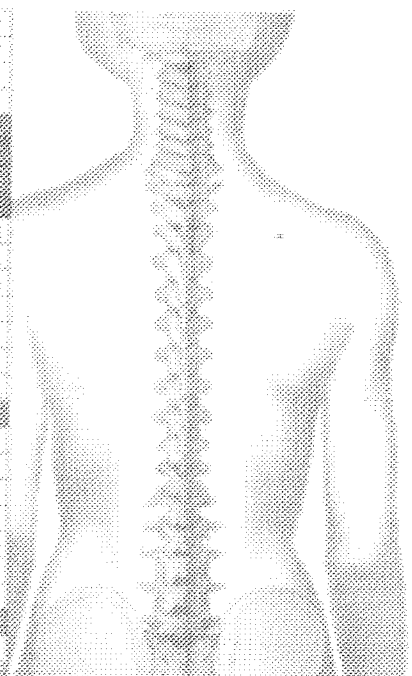


TABLE 3A

THERMAL: Fri Oct 13, 2000 at 11:56AM [Chart]

Asymmetry Table: degrees FAHRENHEIT

DIF	PSD	NSD	NORM	TEMP	SITE	TEMP	NORM	NSD	PSD	DIF
>>>				94.9	C1	95.7	0.41	0.29	*	0.81
0.32		0.29	0.41	96.3	C2	96.0				<<<
0.77	*	0.29	0.41	96.3	C3	94.5				<<<
>>>				94.3	C4	95.5	0.41	0.29	**	1.24
>>>				92.9	C5	93.9	0.41	0.29	*	0.96
0.63		0.29	0.41	93.3	C6	92.6				<<<
0.34		0.29	0.41	91.6	C7	91.3				<<<
0.43		0.31	0.38	90.9	T1	90.5				<<<
>>>				90.9	T2	91.4	0.38	0.31		0.48
>>>				92.6	T3	92.2	0.38	0.31		0.17
0.42		0.31	0.38	91.9	T4	91.5				<<<
>>>				91.7	T5	92.3	0.38	0.31		0.55
>>>				91.4	T6	91.8	0.38	0.31		0.41
>>>				91.2	T7	91.8	0.38	0.31		0.64
>>>				91.3	T8	92.1	0.38	0.31	*	0.78
>>>				91.3	T9	91.8	0.38	0.31		0.48
0.18		0.31	0.38	90.5	T10	90.3				<<<
>>>				89.4	T11	90.6	0.38	0.31	**	1.17
>>>				90.1	T12	90.6	0.38	0.31		0.48
>>>				90.3	L1	91.1	0.40	0.34	*	0.79
>>>				89.3	L2	90.1	0.40	0.34	*	0.79
0.23		0.34	0.40	88.8	L3	88.6				<<<
0.08		0.34	0.40	88.1	L4	88.0				<<<
0.72		0.34	0.40	88.4	L5	87.7				<<<
1.08	*	0.34	0.33	88.1	S1	87.0				<<<

THERMAL: Fri Oct 13, 2000 at 11:56AM [NCM]

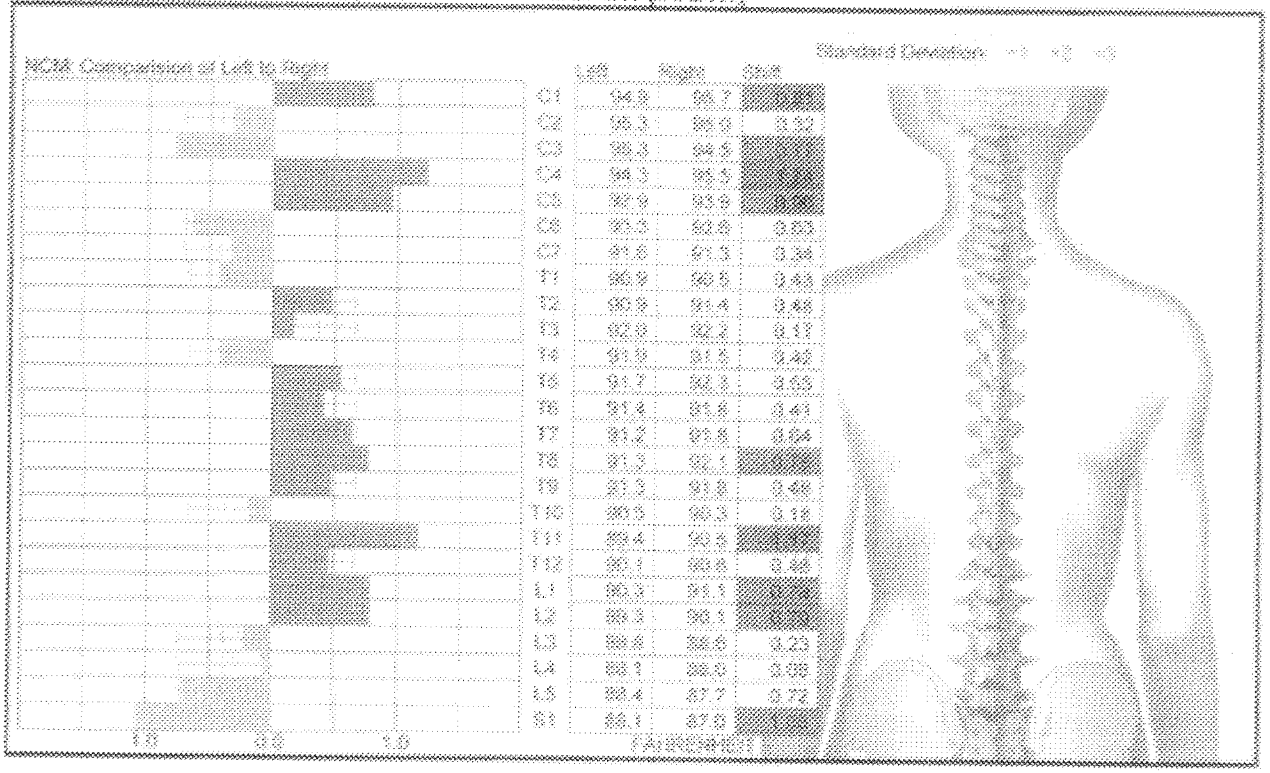


TABLE 4A

THERMAL: Fri Mar 09, 2001 at 09:59AM [Chart]

Asymmetry Table: degrees FAHRENHEIT

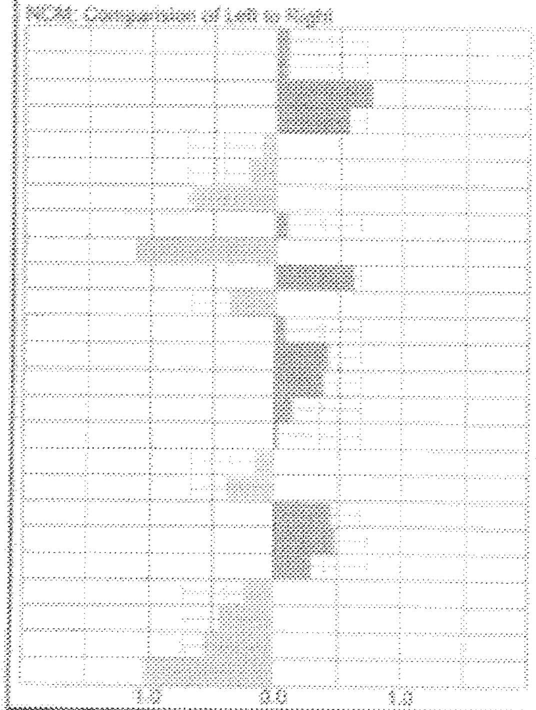
DIF	PSD	NSD	NORM	TEMP	SITE	TEMP	NORM	NSD	PSD	DIF
>>>				95.8	C1	95.8	0.41	0.29		0.09
>>>				95.9	C2	96.0	0.41	0.29		0.09
>>>				95.5	C3	96.3	0.41	0.29	*	0.78
>>>				95.0	C4	95.6	0.41	0.29		0.57
0.12		0.29	0.41	93.8	C5	93.7				<<<
0.21		0.29	0.41	93.0	C6	92.8				<<<
0.68		0.29	0.41	92.4	C7	91.7				<<<
>>>				90.7	T1	90.8	0.38	0.31		0.08
1.13	**	0.31	0.38	91.2	T2	90.1				<<<
>>>				90.7	T3	91.3	0.38	0.31		0.61
0.36		0.31	0.38	92.2	T4	91.8				<<<
>>>				91.1	T5	91.2	0.38	0.31		0.08
>>>				91.1	T6	91.5	0.38	0.31		0.41
>>>				90.3	T7	90.7	0.38	0.31		0.38
>>>				90.7	T8	90.8	0.38	0.31		0.14
>>>				90.8	T9	90.9	0.38	0.31		0.03
0.16		0.31	0.38	90.2	T10	90.0				<<<
0.39		0.31	0.38	89.3	T11	88.9				<<<
>>>				88.9	T12	89.3	0.38	0.31		0.45
>>>				89.5	L1	90.0	0.40	0.34		0.47
>>>				88.8	L2	89.1	0.40	0.34		0.30
0.24		0.34	0.40	88.1	L3	87.9				<<<
0.46		0.34	0.40	87.9	L4	86.6				<<<
0.56		0.34	0.40	86.6	L5	86.0				<<<
1.03	*	0.34	0.50	85.2	S1	84.2				<<<

[illegible]

THERMAL: Fri Mar 09, 2001 at 09:59AM [NCM]

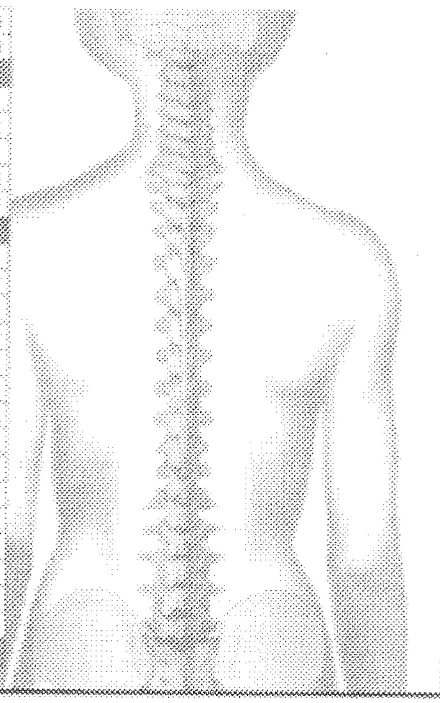
NCM: Comparison of Left to Right

Standard Deviation: +1 +2 +3



	Left	Right	Diff
C1	95.8	95.8	0.09
C2	95.9	96.0	0.09
C3	95.5	96.3	[illegible]
C4	95.0	95.6	0.57
C5	93.8	93.7	0.12
C6	93.0	92.8	0.21
C7	92.4	91.7	0.68
T1	90.7	90.8	0.08
T2	91.2	90.1	[illegible]
T3	90.7	91.3	0.61
T4	92.2	91.8	0.36
T5	91.1	91.2	0.08
T6	91.1	91.5	0.41
T7	90.3	90.7	0.38
T8	90.7	90.8	0.14
T9	90.8	90.9	0.03
T10	90.2	90.0	0.16
T11	89.3	88.9	0.39
T12	88.8	89.3	0.45
L1	89.5	90.0	0.47
L2	88.8	89.1	0.30
L3	88.1	87.9	0.24
L4	87.8	88.6	0.46
L5	86.6	86.0	0.56
S1	85.2	84.2	[illegible]

Fahrenheit



(Continued From Page 7)

2) May 10, 2000 First Re-exam - An elevation one or two standard deviations above the mean was observed at C1 (L&R). This is indicative of a mild elevation. Areas of significant asymmetry were noted at the following sites: L1, L5. (See Table 2b, page 8).
3) October 13, 2000 Second Re-exam - Elevations one or two standard deviations above the mean were observed at C1(L), C5(L), T2(L). This is indicative of a mild elevation. Areas of significant asymmetry were noted at the following sites: C1, C7, T2, S1. (See Table 3b, page 8).
4) March 9, 2001 Third Re-exam - Elevations one or two standard deviations above the mean were observed at C1(R), C3(L), C5(L). This is indicative of a mild elevation. An elevation two or three standard deviations above the mean was observed at C1(L). This is indicative of a moderate elevation. Areas of significant asymmetry were noted at the following sites: C3, T4, S1. (See Table 4b, page 9).

Chiropractic Care Rendered: For the first three months (21 visits) of care the practice member received Diversified chiropractic adjustments. Diversified technique is a segmental model; subluxations are described as alterations in specific intervertebral motion segments.[16] The practice member was assessed at each visit to detect the area(s) of subluxation. Motion and static palpation, visual observation, Deerfield leg check and cervical syndrome test were performed. Upon detection of the vertebral subluxation(s) location, a specific manual chiropractic thrust was given with the appropriate angle, drive and force. The practice member received care 12 times in my office between March 24–May 8, 2000. On May 10, 2000 she had a re-evaluation (see above results). May 10-June 23, 2000 the practice member had nine office visits and continued to receive diversified adjustments.

During the year 2000 and at the time the practice member was receiving care, I was in the process of changing my adjusting technique to a tonal model (Network Spinal Analysis-NSA[17]). Tonal models are generally based on meningeal and dural tension. As I had a segmental model practice for 14 years, I converted my practice members over during the summer and fall months. I initially incorporated the Torque Release Technique (TRT) which utilizes the Intergrator™, a torque and recoil release adjusting instrument. TRT is a tonal model approach, which is non-mechanistic and non-linear. The practice member received Torque Release adjustments for 12 office visits from July 5-October 23, 2000. The practice member was assessed at each visit using the TRT phasing systems and observations. On October 13, 2000 a re-evaluation was performed (table 3a and 3b)and a pattern of recurrent coccyx subluxations was noted at that time.

(Continued On Page 9)

TABLE 1B

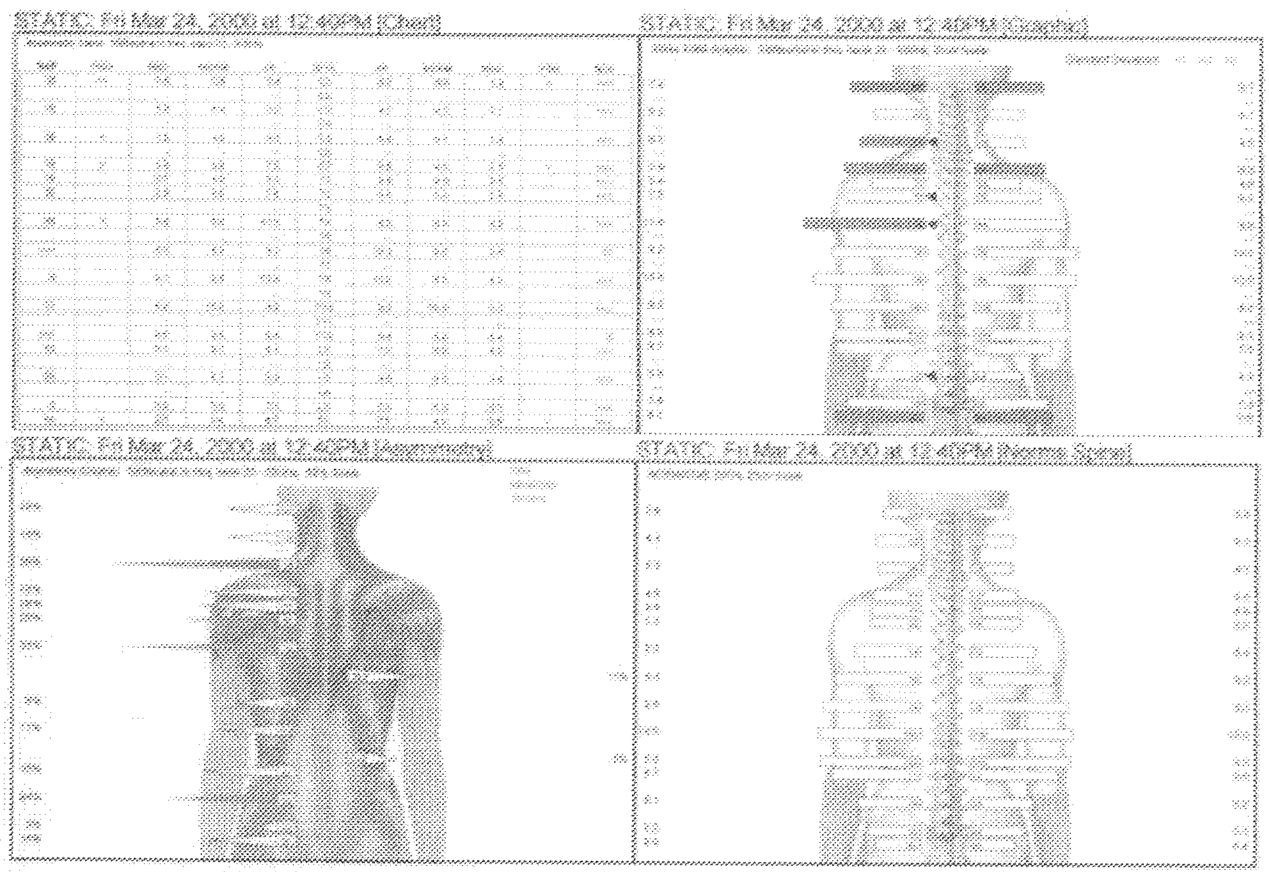


TABLE 2B

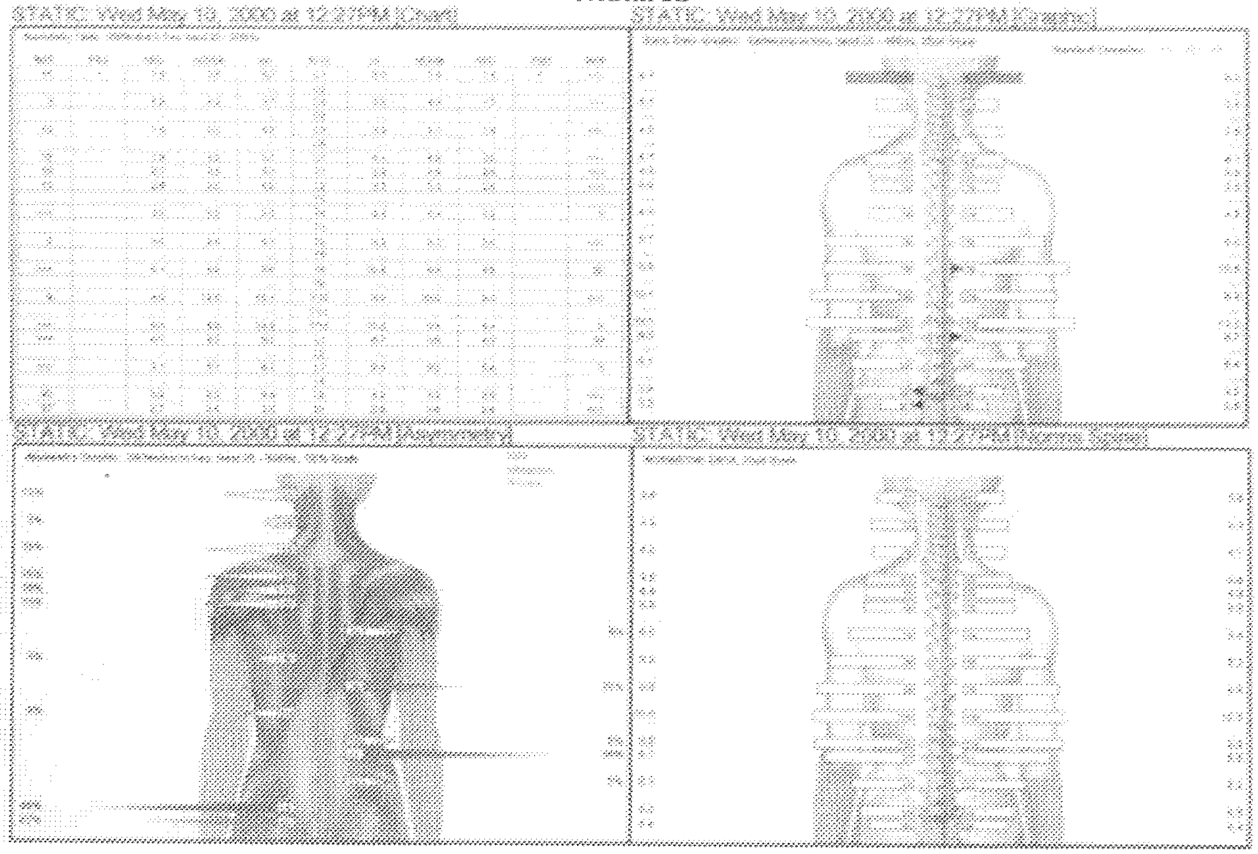
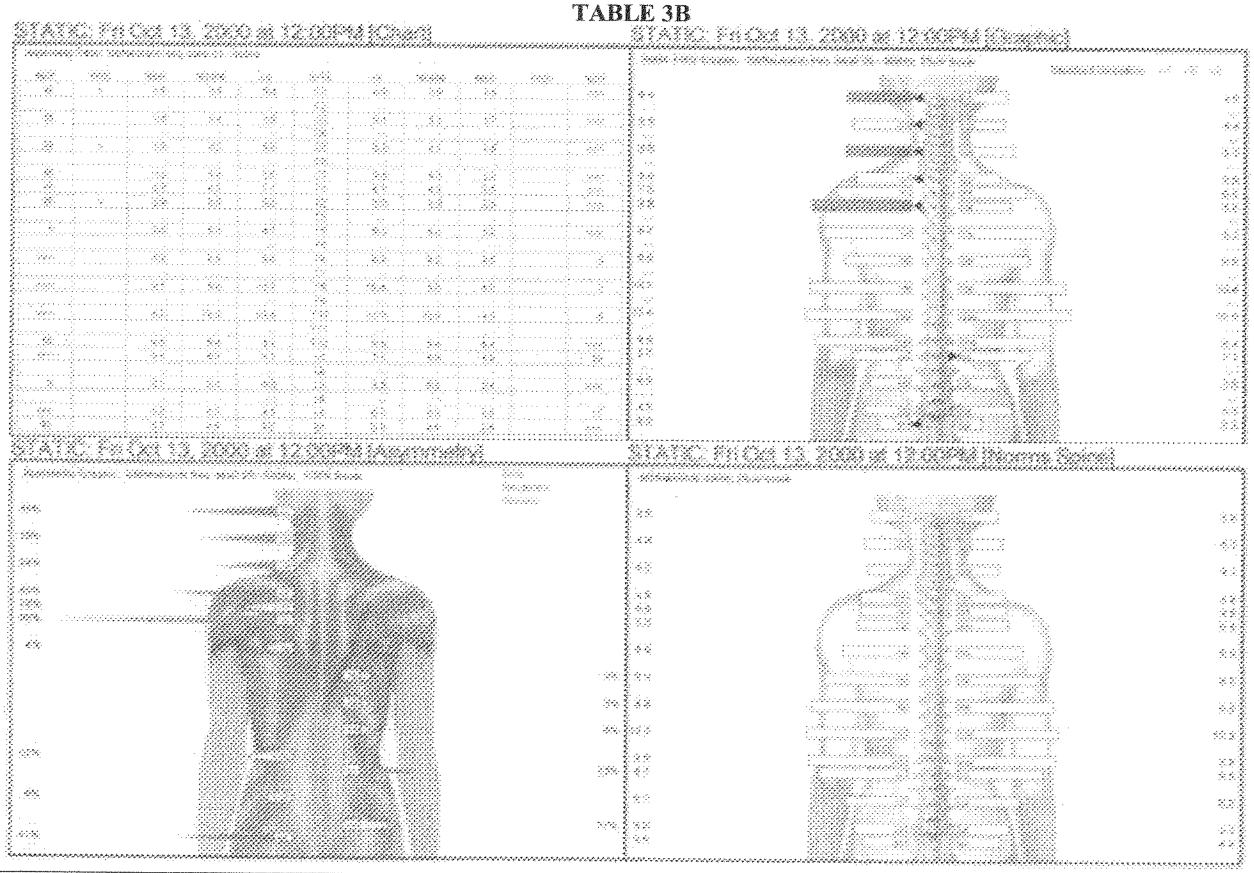


TABLE 3B



(Continued From Page 7)

Results of Care: The practice member chose to stop taking the ovulation stimulating drug, clomid, one month into care. She was not happy taking the medication due to the side effects[18] and wanted to allow her body to function naturally. By the third month of care she reported her menstrual cycle had been normal for two months. On July 17, 2000, she felt she had (drug-free) ovulated on her own. Although pregnancy did not occur by September, the practice member continued to have normal cycles. Her medical doctor recommended she have a Laparoscopy due to continued infertility. Her initial reaction was not to have the procedure. Although she experienced high stress over the procedure she conceded and had it done at the end of October 2000. The results were negative. At the beginning of November the practice member had some personal commitments and was unable to continue regular care for a couple of months. At her March 9, 2001 office visit, she reported she was nine weeks pregnant. Nine months after receiving initial chiropractic care the practice member conceived naturally and then carried the baby to term without complications.

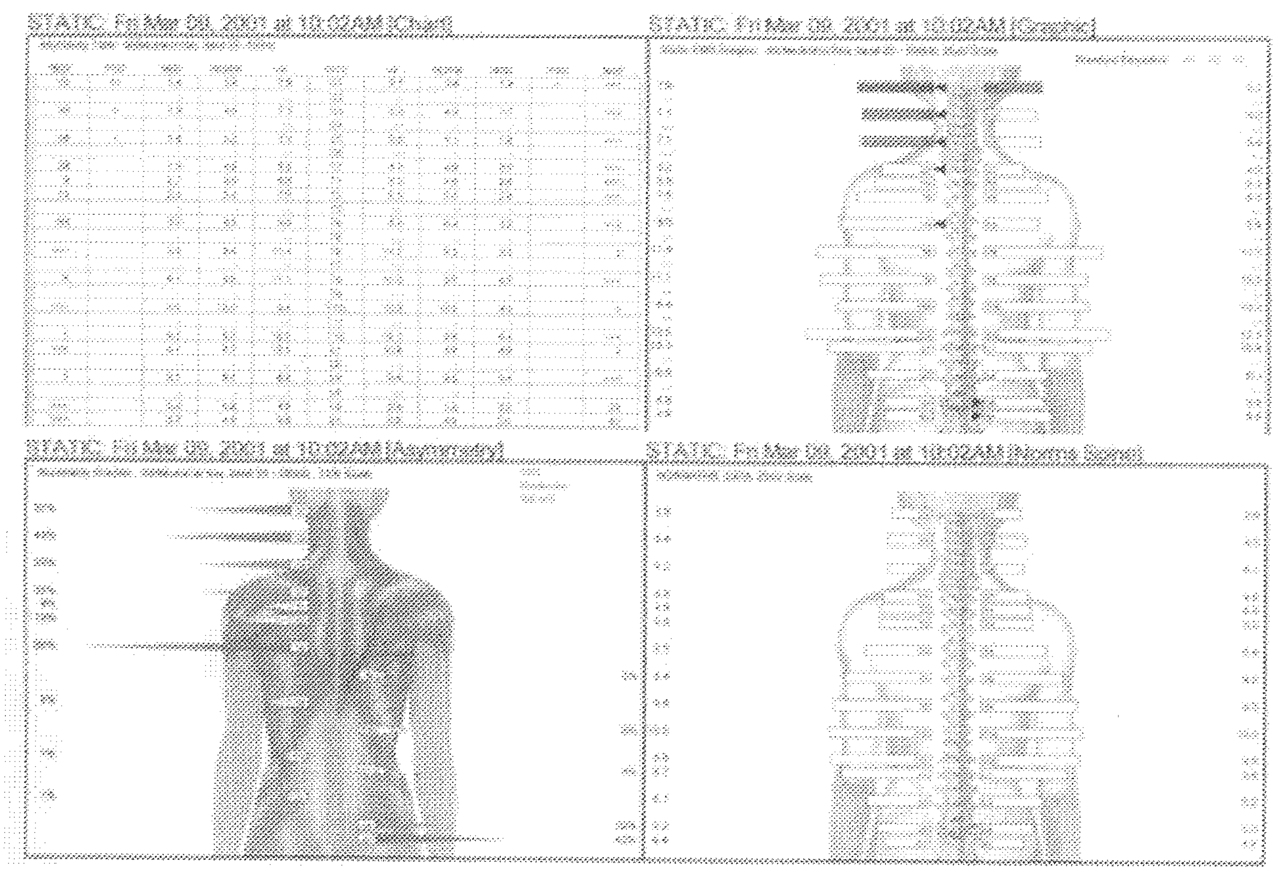
Thermograpy[19] and sEMG[20] scans are important objective tests in observing the change and improvement of the autonomic and motor systems while under subluxation based chiropractic care.

Upon evaluating the thermal and sEMG scans of this practice member we can see a definite overall improvement and continued change. Considering the presenting concern was infertility the thermal scans demonstrate interesting results, the areas of significant change have sympathetic nerve connections to the reproductive organs and adrenal glands. The readings on Figure #4a show a more balanced autonomic system. The practice member was able to conceive naturally and was nine weeks pregnant at the time of the March 9, 2001 scan.

Discussion

Chiropractic does not treat symptoms nor claim to cure medical conditions; however, this study demonstrates the impact of improved autonomic nervous system function while under care. Prior to subluxated based chiropractic care the practice member's menstrual and ovulation cycles were irregular. She was trying to conceive for over one year, was experiencing infertility, and medical treatment had been unsuccessful. After the application of chiropractic care, she experienced normal menses and was able to ovulate without the use of drugs within three months of regular care. The practice member received segmental diversified chiropractic adjustment for the first three months followed by four months of tonal adjusting utilizing the Torque Release Technique. Thermal and sEMG scans were performed at the initial examination and three reevaluations. As the thermal scans showed decreased overall asymmetry, indicating improved sympathetic nerve function, the practice member's previously diagnosed "lazy (reproductive) system" returned to normal func-

TABLE 4A



tion. Natural conception occurred nine months after onset of wellness chiropractic care.

In addition, reports and case studies regarding gynecological conditions and chiropractic were found. Dr. J.E. Browning[12,13] wrote about the positive effects of chiropractic on pelvic disorders, including gynecologic and sexual dysfunction. A case study by McNabb[21], documents the restoration of female fertility after receiving chiropractic care.

The practice member continued chiropractic care throughout her pregnancy. Her labor (six hours) and delivery were uncomplicated.

Conclusion

Increased function of the autonomic nervous system as a result of chiropractic care appears to benefit normalization of the menstrual cycle, in this case regular ovualtion occurred and subsequent pregnancy. Infertility effects 15% of the United States population, and current medical care involves significant expense and potentially severe side effects. As a matter of Public Health, natural approaches which promote health and wellness, and their subsequent results, warrant study on their benefits, safety, and cost-effectiveness. This article serves as a foundation in consideration of chiropractic as an integral part of further formal research.

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CASE STUDY

Upper Cervical Chiropractic Care For A Nine-Year-Old Male With Tourette Syndrome, Attention Deficit Hyperactivity Disorder, Depression, Asthma, Insomnia, and Headaches: A Case Report

Erin L. Elster, D.C.

ABSTRACT

Objective: To review the effectiveness of chiropractic care using an upper cervical technique in the case of a nine-year-old male who presented with Tourette Syndrome (TS), Attention Deficit Hyperactivity Disorder (ADHD), depression, asthma, insomnia, and headaches.

Clinical Features: This nine-year-old boy suffered from asthma and upper respiratory infections since infancy; headaches since age 6; TS, ADHD, depression and insomnia since age 7; and neck pain since age 8. His mother reported the use of forceps during his delivery. His medications included Albuterol, Depakote, Wellbutrin, and Adderall.

Intervention: During the patient's initial examination, evidence of a subluxation stemming from the upper cervical spine was found through thermographic and radiographic diagnostics. Chiropractic care using an upper cervical technique was administered to correct and stabilize the patient's upper neck injury. Diagnostics and care were performed in accordance with the guidelines of the International Upper Cervical Chiropractic Association.

Outcome: Evaluation of the patient's condition occurred through doctor's observation, patient's and parents' subjective description of symptoms, and thermographic scans. After six weeks of care, all six conditions were no longer present and all medications were discontinued with the exception of a half-dose of Wellbutrin. At the conclusion of his case at five months, all symptoms remained absent.

Conclusion: The onset of symptoms soon after the boy's delivery; the immediate reduction in symptoms correlating with the initiation of care; and the complete absence of symptoms within six weeks of care; suggest a link between the patient's traumatic birth, the upper cervical subluxation, and his neurological conditions. Further investigation into upper cervical trauma as a contributing factor to Tourette Syndrome, ADHD, depression, insomnia, headaches, and asthma should be pursued.

Key Indexing Terms: *upper cervical spine, chiropractic, Tourette Syndrome, depression, asthma, Attention Deficit Hyperactivity Disorder, headaches, trauma, thermography*

INTRODUCTION

The following case report describes the symptoms of a nine-year-old male with Tourette Syndrome (TS), Attention Deficit Hyperactivity Disorder (ADHD), depression, asthma, insomnia, headaches, and neck pain; the intervention of upper cervical chiropractic care; and the patient's symptomatic response. Reports depicting the use of chiropractic care with patients with the aforementioned diagnoses are extremely limited. This paper serves to establish a foundation for future research.

B.J. Palmer, D.C., reported upper cervical chiropractic management of patients with headaches, asthma, insomnia, tics, and depression as early as 1934.[1] Palmer's chiropractic care included paraspinal thermal scanning using a neurocalometer (NCM), a cervical radiographic series to analyze upper cervical misalignment, and a specific upper cervical adjustment performed by hand. Positive results (symptoms were improved and/or eliminated) were achieved in hundreds of patients whose upper cervical subluxations were corrected.

General chiropractic (adjustments throughout a patient's spine) management of asthma, headaches, and ADHD has been reported only occasionally and has shown varied results.[2-5] In controlled studies using spinal manipulation therapy (SMT), results either were inconclusive or showed a slight percentage improvement in the SMT group compared to the control group.

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During the past several decades, no references were found linking upper cervical chiropractic and the six conditions discussed in this report, except for an asthma study, in which the results were overwhelmingly positive.[6-7] While that study was uncontrolled, approximately 47 asthma patients were treated with specific upper cervical chiropractic care aided by upper cervical radiographs and thermal imaging. The upper cervical chiropractic care administered was based upon the original upper cervical work performed by Palmer.[1,8] The care was implemented as taught by the International Upper Cervical Chiropractic Association (IUCCA) through their Applied Upper Cervical Biomechanics (AUCB) program.[9] The author reported that in all 47 cases, upper cervical subluxations were discovered and all patients showed improvement and/or correction of asthma symptoms after the intervention of upper cervical chiropractic care.


Figure 1: A patient being scanned with the Tytron C-3000 system

To the author's knowledge, the case discussed in this report is the first documented for TS, ADHD, depression, insomnia, or headaches using specific upper cervical care (cervical radiographs, thermal imaging, and knee-chest adjustments) since Palmer's research seventy years ago. The rationale for the use of upper cervical chiropractic care in this case was to correct the patient's upper cervical subluxation that was discovered during cervical radiographic and thermal imaging procedures. Similar upper cervical subluxations were found in patients with neurological conditions such as Parkinson's disease, Multiple Sclerosis, epilepsy, and fibromyalgia, who responded favorably after upper cervical chiropractic intervention.[10-15] This report's purpose is to document the symptoms in the nine-year-old patient before and after the intervention of upper cervical chiropractic care and to detail the upper cervical chiropractic procedure and technologies employed.

CASE REPORT

At this nine-year-old male's initial chiropractic evaluation, his medical history was recorded. His history was recalled by both parents and was confirmed by his medical records (obtained from his physicians who treated him since birth). His mother reported that his birth occurred six weeks prematurely, required forceps, and rendered her son "extremely bruised." When discussing the boy's medical history, his mother described her son as being "constantly sick since birth." He was hospitalized for 10 days after birth for respiratory distress and jaundice. At age 8 months, he began wheezing and was diagnosed with Reactive Airway Disease (RAD) and prescribed robitussin and ventolin. At age 1, he fell down the stairs. In addition, he was hospitalized at age 1 for Respiratory Syncytial Virus (RSV) pneumonia. His mother indicated that he suffered multiple infections during his first several years including chronic ear infections, frequent tonsillitis, and pneumonia every year for 5 years and concluded that perhaps he had a weak immune system. He was prescribed many doses of antibiotics (amoxicillin, pediazole). Each time he suffered an infection, wheezing returned, so frequently he was prescribed ventolin, proventil, and phenergan with codeine.

By age 2, he was diagnosed with asthma and prescribed albuterol. The asthma attacks occurred during infections, weather changes, humidity, and physical activity. Eventually, he was prescribed claritin to assist in his allergic/asthmatic symptoms.

At 6 years, he began suffering with migraine headaches approximately every two weeks. His mother said he awakened in the night screaming, complaining of headache and sensitivity to light. She routinely gave him Tylenol and rubbed his back until he resumed sleep.

By age 7, his parents noticed that their son was becoming increasingly emotional, that he cried more often than normal, and that little things seemed to bother him more. They also noticed that he developed facial and hand contortions before beginning handwriting and was unable to write properly. Eventually, tics occurred continuously on a daily basis from head to toe and involved his eyes, neck, voice, tongue, rolling of his toes and ankles, flinching of his side, and lifting of his arms overhead. His mother stated that the tics worsened during periods of stress or fatigue. In addition, he was overly aggressive, irritable, and prone to outbursts of five or ten minutes of mean, rude, belligerent, sassy and surly behavior. He also made many guttural clicking sounds but no inappropriate corpora alalia (swearing).

Because of his physician's concern over possible Tourette Syndrome and Attention Deficit Disorder, the boy was referred to a neurologist who evaluated him using an attention deficit profile worksheet. The positive findings were as follows: he had a short attention span; he was slightly impulsive; he was easily upset emotionally; he had a frenetic tempo; he bounced around; he fidgeted; he rarely sat still; he was easily distracted; he could not remember his original purpose for many activities; he was inconsistent in his school performance in that he performed well one week and missed the same material the following week; he was demanding; he had problems working toward goals; he interrupted group discussions; he lacked fine motor skills for writing; he exhibited significant anxiety including separation anxiety and some anxiety about school; and he had difficulty coping with transitions and could become irate. Consequently, he was diagnosed with Tourette Syndrome, Attention Deficit Hyperactivity Disorder (ADHD), finger agnosia (graphomotor problems with writing), and a mood disorder at age 7. His physician prescribed Klonopin to treat anxiety and recommended therapy for his writing problems.

After three weeks of Klonopin, the boy showed some improvement in his attention span and tics but began suffering from insomnia, fatigue, and increased irritability. He became belligerent and his hyperactivity worsened so his Klonopin prescription was discontinued and was replaced with Wellbutrin. The Wellbutrin helped the boy's moods but had no effect upon the tics and worsened the insomnia. He would go to bed at 8 and rarely fall asleep before 10. Consequently, the Wellbutrin dosage was decreased, which helped the insomnia somewhat but aggravated his behavior.

By age 8, the boy's mood swings became severe, his self-esteem decreased, and his mother reported that he was being picked on by other kids in school. His physician prescribed Adderall in addition to Wellbutrin but his behavioral problems continued. His mother described behavioral flare-ups, which occurred approximately every three weeks and lasted 5 to 7 days, and involved aggressive behavior, with some manic-depressive swings, as well as overemotional, crying episodes. His obsessive-compulsive behaviors became dramatic, and he suffered recurrent fears and anxieties. Because of the aggressive behaviors, he was prescribed Depakote.

His mother also reported that her son complained to her of neck pain and headaches approximately three times per week since age 8.

While recording the patient's medical history, the author was able to note the boy's frequent tics involving his eyes, neck, face, and speech. Wheezing was apparent. In addition, the patient was fairly morose and lacked any observable personality. He only spoke when asked a question and looked quietly at the floor while his parents described his history. When ask where he felt the pain in his neck, he pointed to the left side of his neck under his skull and stated that he currently had a headache.

The chiropractic care described below is based upon the original work performed by Palmer from the 1930's through the 1950's in the Palmer Research Clinic.[8] The care was administered as taught by the International Upper Cervical Chiropractic Association (IUCCA) through their Applied Upper Cervical Biomechanics (AUCB) program (as was the care depicted in the asthma study in the introduction of this paper).[9]

Figure 2
Tytron C-3000 Thermographic Protocols

Environmental Controls —

- The temperature of your office should be held around 70 degrees Fahrenheit.
- No direct cooling or heating vent drafts should bear on the scanner.
- The scanner should not be placed in direct sunlight.
- Place the scanner holder away from the computer monitor and CPU.

Patient Preparation —

- 15 minutes of office acclimation time must occur before scanning the patient.
- The patient's spine must be disrobed or loosely gowned during acclimation.
- The patient must remain free from direct heating or cooling drafts.
- No direct sunlight should bear on the patient while in the office.
- No EMS, TENS, US, hot or cold packs, or acupuncture before scanning.
- The patient must be free from sunburn.

After the patient's medical history was recorded, a paraspinal thermal analysis was performed with the Tytron C-3000 (Titronics Research and Development, Figure 1) from the level of C7 to the occiput according to thermographic protocol.[16-18] (Figure 2) Paraspinal digital infrared imaging, which measures cutaneous infrared heat emission, is a form of thermography, a neurophysiological diagnostic imaging procedure. Thermography has been established in chiropractic as a practical and sensitive test for spinal nerve root irritation, articular facet syndromes, peripheral nerve injuries, sympathetic pain syndromes, and the vertebral subluxation complex.[19-21] Since the amount of blood passing through the skin is directly controlled by the sympathetic nervous system (through control of dilation or constriction of blood vessels), the temperature of any one area of the skin reflects the neurological control of that area. Normal or abnormal skin temperature then becomes an indicator of normal or abnormal neurological function. In blind studies comparing thermographic results to that of CAT scan, MRI, EMG, myelography, and surgery, thermography was shown to have a high degree of sensitivity (99.2%), specificity (up to 98%), predictive value, and reliability.[22-24] Thermography has been effective as a diagnostic tool for breast cancer, repetitive strain injuries, headaches, spinal problems, TMJ conditions, pain syndromes, arthritis, and vascular disorders, to name a few.[25-34] A limited number of articles have been published demonstrating the use of paraspinal thermal imaging as an integral part of upper cervical protocol, including reports of patients with Parkinson's Disease, Multiple Sclerosis, seizures, and fibromyalgia, to name a few.[6-7,10-15] Of the six conditions suffered by this subject, thermal imaging had been previously used with headaches and asthma.[6-7,27,33] This is the first case reporting use of paraspinal thermal imaging for a patient with TS, ADHD, depression, and insomnia.

Compared to established normal values for the cervical spine, the nine-year-old subject's paraspinal scans contained thermal asymmetries of 0.5°C. (Figure 3) According to cervical thermographic guidelines, thermal asymmetries of 0.5°C or higher indicate abnormal autonomic regulation or neuropathophysiology.[35-38]

In addition to revealing thermal asymmetries, the subject's scans displayed static thermal differences. (Figure 4) Thus, a thermal "pattern" was established. "Pattern analysis" of paraspinal temperatures, first developed by Palmer, has received increased attention in chiropractic research.[8,38-48] Pattern work, in conjunction with upper cervical chiropractic care, recently has been used with Parkinson's disease, Multiple Sclerosis, fibromyalgia, epilepsy, and asthma.[6-7,10-15]

Because upper cervical misalignments were suspected in this patient, a precision upper cervical radiographic series was performed.[51] The x-ray equipment included a laser-aligned frame (American X-ray Corporation) to eliminate image distortion. To maintain postural integrity, this subject was placed in a positioning chair using head clamps. In addition, the patient was aligned to the central ray using a laser (Titronics Research and Development) mounted on the x-ray tube. The four views (lateral, anterior-posterior, anterior-posterior open mouth, and base posterior) enabled examination of the upper cervical spine in three dimensions: sagittal, coronal, and transverse.

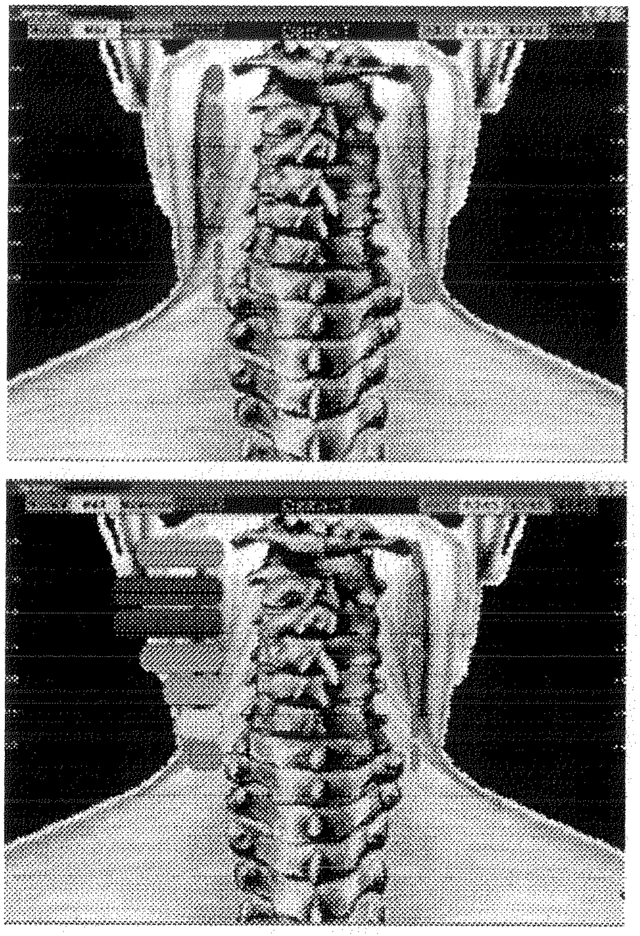


Figure 3: Example of cervical side to side thermal comparison. Normal scan (top), Thermal Asymmetries at multiple levels (bottom).

Analysis of the four views was directed towards the osseous structures (foramen magnum, occipital condyles, atlas, and axis) that are intimately associated with the neural axis. Laterality and rotation of atlas and axis were measured according to each vertebra's deviation from the neural axis.[51] (Figure 5) Left laterality of atlas was found. (Figure 6)

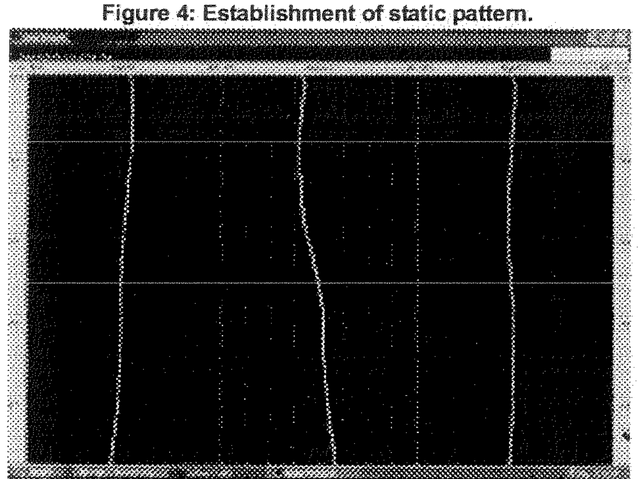
In accordance with AUCB upper cervical protocol, the two criteria used to determine subluxation in this case were thermal asymmetry (measured by paraspinal thermal imaging) and vertebral misalignment (measured by cervical radiographs). Because both criteria (0.5°C thermal asymmetry and left laterality of atlas) were met, a treatment plan was discussed with the patient and his parents. In addition, it was recommended that the subject continue his medical treatment and medications unless otherwise advised by his physicians.

After the subject and his parents consented, chiropractic care began with an adjustment to correct the left laterality of atlas. To administer the adjustment, the patient was placed on a knee-chest table with his head turned to the left. (Figure 7) The knee-chest posture was chosen because of the accessibility of the anatomy to be corrected. Using the left posterior arch of atlas as the contact point, an adjusting force was introduced by hand.61 The adjustment's force (force = mass X acceleration) was generated using body drop (mass) and a toggle thrust (acceleration).

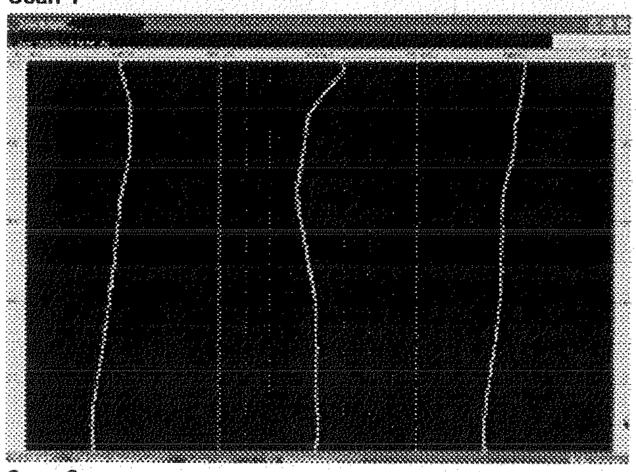
Then, the patient was placed in a post-adjustment recuperation suite for fifteen minutes as per thermographic protocol.[16-18] (Figure 2) After the recuperation period, a post-adjustment thermal scan was performed. The post-adjustment scan revealed a thermal difference of only 0.1 °C, which was considered normal according to established cervical thermographic guidelines (compared to the pre-adjustment differential of 0.5 °C). Therefore, resolution of the patient's presenting thermal asymmetry (elimination of the thermal "pattern") was achieved. (Figures 8 & 9, pages 7 & 8)

All subsequent office visits began with a thermal scan. An adjustment was administered only when the patient's presenting thermal asymmetry ("pattern") returned. If an adjustment was given, a second scan was performed after a fifteen-minute recuperation period to determine whether restoration of normal thermal symmetry had occurred. This subject's office visits occurred two times per week for the first two weeks of care, one time per week for the following two weeks, and one time per month thereafter. After the initial adjustment, only one other adjustment was administered to the patient during five months of upper cervical chiropractic care.

Figure 4: Establishment of static pattern.



Scan 1



Scan 2

Figure 5, Drawing Lines of Mensuration
(See Figure 6, page 6)

To determine laterality from the anterior-posterior open mouth film, a horizontal line was drawn across the upper one-third of the foramen magnum's arch from cortex to cortex. The foramen magnum line was bisected with a vertical median line from the film's top to bottom.

Using a compass's point on the vertical line, arcs were drawn through each lateral mass of atlas. Using the left lateral mass as the constant, if the right lateral mass stayed within the right arc, the atlas was listed as "left". If the right lateral mass extended beyond the right arc, the atlas was listed as "right".

Axis laterality was determined by locating the position of the odontoid and spinous processes according to the vertical median line. To determine atlas rotation from the base-posterior film, an atlas plane line was drawn through the transverse foramen of atlas. The next line was drawn horizontally across the cortical borders of the clivus (ossification center of the skull) from cortex to cortex. This skull line was bisected.

Atlas rotation was determined by using a protractor to measure the difference between the bisected skull line and the atlas plane line. An angle less than 90 degrees represented "anteriority". An angle more than 90 degrees represented "posteriority".

Outcome of Care

The following discussion describes the symptomatic changes observed by the boy's family members and the author and reported by the patient himself throughout the five months of upper cervical chiropractic care. Incidences of tics, asthma attacks, headache complaints, neck pain complaints, irritability, inattention, inability to sleep, etc. were observed by the author, the patient's parents and/or were reported by the patient and were recorded at each office visit.

Two days after the patient's first adjustment, the subject's mother reported observing a 50% reduction in tics. The boy had not complained of headaches, neck pain, or wheezing the past two days. During the office visit, the boy stated that his neck was feeling better. His mother reported that he easily had fallen asleep the past two nights and had slept through the night. His mother also commented that he displayed a happier, more excited mood overall. During that office visit, it was apparent to the author that the boy's tics occurred less frequently and the patient appeared more engaging and communicative than on his previous visit.

During the second week of care, his mother reported that the subject fell on his head while playing and experienced a slight reoccurrence in tics. Tics were observable by the author. A thermal scan was performed indicating a return in the patient's presenting thermal asymmetry ("pattern") so an adjustment was administered. The post-adjustment thermal scan indicated restoration of normal thermal symmetry.

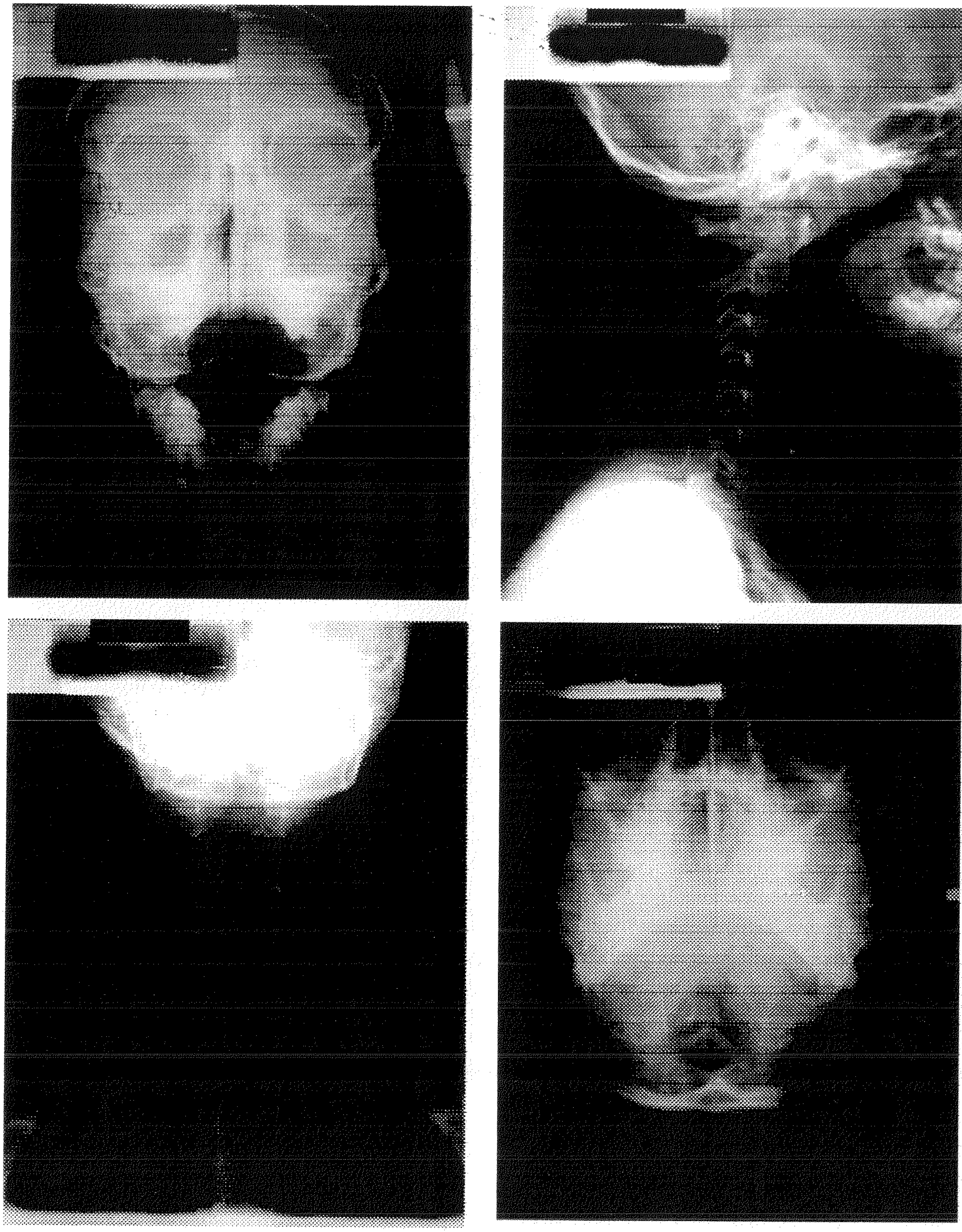
Two and one-half weeks after the first adjustment and a week after the second adjustment, the patient entered the treatment room with a big smile and a loud greeting of hello to the author. His mother stated that her son's personality and mood had improved substantially. She also reported observing an 80% reduction in tics. During the office visit, no tics were observed by the author. His mother also commented that even with weather changes during the past week, her son had not experienced any wheezing or asthma attacks. Likewise that lack of wheezing as compared to visible breathing difficulty at the boy's initial evaluation was apparent to the author. His mother reported that he had not needed his inhaler since upper cervical care began. Besides the absence of wheezing, the boy also had not complained of any headaches or neck pain and he confirmed that when asked. His mother said he continued to sleep well and seemed to have better energy and less fatigue. He was beginning to show greater emotion and affection with family members and had a much happier disposition overall. His improved temperament prompted his mother to consult with her son's physician in order to discontinue his Depakote and Adderall prescriptions.

Three weeks after the first adjustment, the boy's mother reported the absence of all motor tics except an occasional verbal tic while eating. No tics were observed by the author at that visit. Due to continued improvement in the boy's behavior, personality, and mood, his mother consulted with her son's physician and cut his Wellbutrin dosage in half. The boy's improved temperament continued to be observed by the author at this office visit in that the boy participated in conversation, showed happiness, and gave warm greetings. His mother reported that he continued to sleep well and was sleeping longer than he had in years. In addition, she commented that he would awaken easier and faster and she had little difficulty getting him out of bed in the morning. He confirmed that he still had no complaints of wheezing, headaches, or neck pain. No wheezing was observed by the author. All thermal scans performed during the third week of care showed normal thermal symmetry. Therefore, no adjustments were administered.

Six weeks after the first adjustment, the subject's mother reported complete absence of tics, asthma, insomnia, hyperactivity, headaches, depression, and neck pain. When questioned, the patient also did not recall experiencing any neck pain, headaches, or asthma attacks. No tics or wheezing were observed by the author during the office visit. There had been no use of inhalers for the entire six weeks. Changes in personality and behavior described by the subject's parents and grandparents included "he now shows a happy and excited mood; he has better eating habits; he shows more affection with family members; he shows greater emotion; and he exhibits better memory and more attention to school work and chores." All thermal scans performed during weeks four through six showed normal thermal symmetry. Therefore, no adjustments were performed.

Five months after the first adjustment, the patient remained asymptomatic (according to the family members' and patient's reports and the author's observations). No tics or wheezing were observed by the author. The patient had not reported any complaints of asthma, headaches, or neck pain since the first adjustment was performed. All family members remarked that he had become a completely different, happy, and healthy child. Since the third week of upper cervical care, all thermal scans showed normal thermal symmetry, so no adjustments were necessary during the past four and one-half months of care. Accordingly, since the patient's upper cervical subluxation had

Figure 6: Patient XRays with Lines of Mensuration



See Figure 5, page 5 for explaination of how lines of mensuration were drawn.

Figure 7: Example of patient positioning for knee-chest adjustment.

stabilized and the patient's symptoms had remained absent, upper cervical care was concluded.

One year after this patient's first upper cervical adjustment, he was re-examined using thermal imaging. Normal thermal symmetry was still present so an adjustment was unnecessary.

During the seven months since he had last been examined, no asthma attacks, headaches, neck pain, insomnia, behavioral trouble, or tics had occurred. He had not suffered any infections, nor had he used any medications other than his half-dose of Wellbutrin. His mother reported that her son's only "problem" was becoming accustomed to being a "normal" child who was required to complete chores, walk home from school by himself, complete school work during allotted time, etc.

During the upper cervical treatment period, no other intervention was reported that could have provided an alternative explanation for the dramatic improvement of the patient's conditions. Since this is the first case to be reported on this topic, it is necessary to confirm that this positive outcome could be replicated in additional patients. Therefore, it is recommended that a more extensive study with a large sample group and control subjects be performed.

DISCUSSION

Tourette Syndrome

Tourette Syndrome (TS) is a debilitating tic disorder characterized by frequent motor and phonic tics. Diagnostic criteria include onset before the age of 21; recurrent, involuntary, rapid, purposeless motor movements affecting multiple muscle groups; one or more vocal tics; variations in the intensity of the symptoms over weeks to months; and a duration of more than one year.[52]

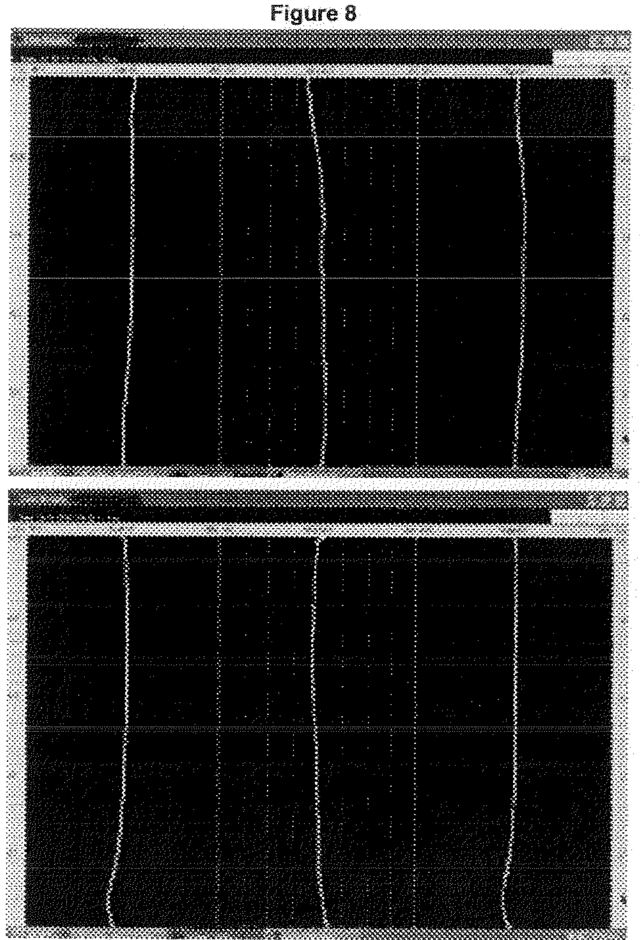
Tourette Syndrome sufferers commonly experience other behavioral and neurological complaints such as attention deficits, depression, self-injurious behaviors, obsessive-compulsive behaviors, and irritability.[52] In fact, 50% of all children with TS also have Attention Deficit Hyperactivity Disorder (ADHD) and/or Obsessive Compulsive Disorder (OCD).[52] These neurological symptoms are thought to be due to the same central nervous system malfunction that causes TS: neurochemical alterations in the brain.[52]

While researchers generally consider TS to be a genetic disorder (TS vulnerability is transmitted from one generation to the next), approximately 15% of TS patients do not show genetic susceptibility (no genetic links were found).[52] In addition, individual variations in character, course, and degree of severity of TS cannot be explained by genetic hypotheses alone.[52] Consequently, researchers have focused upon stressful events during perinatal or early life that may trigger the onset of TS. Traumatic head injury (in particular concussive injury to the head, neck, and upper back) has been implicated as a possible trigger not only of TS, but also for ADHD, depression, insomnia, and headaches.[53-90]

Attention Deficit Hyperactivity Disorder

Attention Deficit Hyperactivity Disorder (ADHD) is a behavioral disorder characterized by inattention, hyperactivity, and impulsivity. The ADHD diagnosis, based solely on an individual's behavioral history, is made when several of the following characteristics are detected: fidgeting with hands or feet or squirming in seat; difficulty remaining seated; running about or climbing excessively; difficulty engaging in activities quietly; acting as if driven by a motor; talking excessively; blurting out answers before questions have been completed; difficulty waiting in turn taking situations; interrupting or intruding upon others.[91] No definitive diagnostic test (lab test, blood test, physical exam) exists for ADHD. Attention Deficit Hyperactivity Disorder is thought to be caused by alterations in dopamine levels in the brain and frequently occurs following traumatic brain injury.[91,62-70] ADHD is typically treated with Ritalin,

Figure 8



These graphs demonstrate when the patient was not "in pattern" and no adjustment was given on those days.

or similar stimulant drugs, but Ritalin cannot be used with TS due to an increased risk of tics.[52]

Depression

Depression is thought to be caused by alterations in serotonin levels in the brain and also frequently occurs following head injury (concussive injury to the head, neck, or upper back).[71-77] Symptoms of depression include persistent sad or irritable mood; loss of interest in activities once enjoyed; significant change in appetite or body weight; difficulty sleeping or oversleeping; psychomotor agitation of retardation; loss of energy; feelings of worthlessness or inappropriate guilt; difficulty concentrating; and recurrent thoughts of death or suicide.[92] Depression is commonly treated with a combination of psychotherapy and medication to control alterations in brain chemistry.

Insomnia

Insomnia is the perception or complaint of inadequate or poor-quality sleep because of one of more of the following: difficulty falling asleep, waking up frequently during the night with difficulty returning to sleep, waking up too early in the morning, and/or unrefreshing sleep.[93] Insomnia is frequently associated with depression and has been linked to head trauma.[78-81] Common therapies for chronic insomnia include relaxation therapy (reducing anxiety and body tension); sleep restriction (restricting sleep time until a more normal night's sleep is achieved); and reconditioning (training a person's body to associate bed and bedtime with sleep).[93]

Headaches

Headache categories include migraine with aura, migraine without aura, tension, and chronic daily headaches.[94] While medical science has not determined the exact cause of headaches, recent research is pointing towards a likely trauma-induced origin for many types of headaches. Evidence supports that trauma (in particular mild concussive injury to the head, neck or upper back) increases the risk of headache onset.[82-90] In addition, researchers have labeled some headaches as being "cervicogenic" in origin (they are triggered by neck dysfunction).[95-105] Headaches are often treated with medication targeted to reduce the inflammation of nerves and blood vessels once the headaches have started.

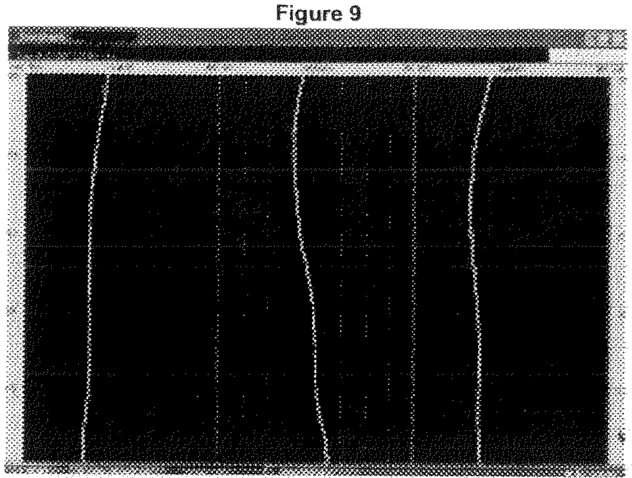
Asthma

Asthma is defined as a chronic inflammatory disorder of the airways causing recurrent episodes of wheezing, breathlessness, chest tightness, and coughing. The condition is characterized by airway obstruction, airway inflammation, and airway hyper-responsiveness to a variety of environmental stimuli. Studies into the pathophysiology of asthma have focused on immune, neurogenic, and vascular abnormalities.[106-109] Drug treatment targets the two main aspects of the disease: bronchospasm (fast-acting inhalers elicit bronchial smooth muscle relaxation) and inflammation (corticosteroids reduce airway inflammation).

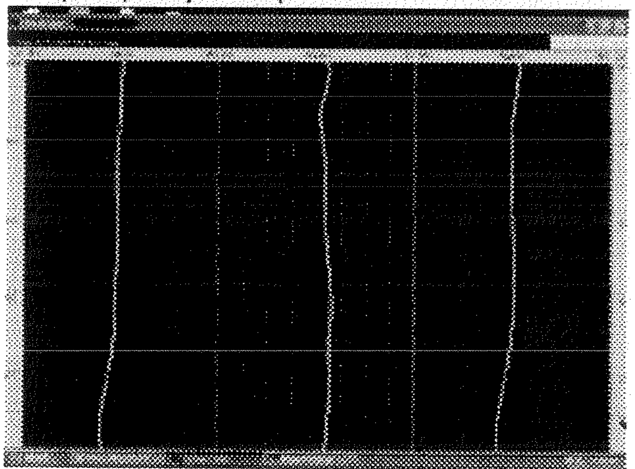
Trauma and Neurological Disease

Most of the conditions suffered by this patient were linked to traumatic head injury and/or whiplash in medical literature.[53-90] Not only did researchers name trauma (mild concussive injury to the head, neck, or upper back) as a risk factor for the onset of neurological conditions such as TS, ADHD, depression, insomnia, and headaches, but they also recognized that many of these conditions consequently arose from neurochemical alteration after the trauma.[52,91-94] However, researchers were unable to pinpoint the mechanism that caused trauma-induced brain malfunction. It is the author's hypothesis that the missing link is the trauma-induced injury to the upper cervical spine (upper cervical subluxation).

Figure 9



Example of pre-adjustment pattern.



Example of post adjustment scan with loss of pattern.

While the exact cause of this patient's upper cervical subluxation was impossible to determine, some speculation could be made from the boy's medical history. When questioned as to past traumatic events in their son's history, his parents recalled the forceps birth and the fall down the stairs, although other unreported traumatic incidences could have caused the cervical injury.[110]

Possible Mechanisms

Since neurochemical alteration (abnormal levels of dopamine, serotonin, etc.) has been identified as the pathological process involved in TS, ADHD, depression, and insomnia, it follows that normalization of chemical levels in the brain would eliminate these conditions and their symptoms. Since upper cervical care appeared to stimulate the boy's symptomatic improvements, then it would seem that upper cervical care generated improvement in the boy's neurochemistry. The exact mechanism for upper cervical chiropractic care's impact upon the patient's brain chemistry is unknown. Two possible theories, which have been proposed and published by upper cervical chiropractors to explain profound changes seen in their patients, are discussed below.[6-7,10-15]

The first mechanism, central nervous system facilitation, can occur from an increase in afferent signals to the spinal cord and/or brain coming from articular mechanoreceptors after a spinal injury.[111-115] The upper cervical spine is uniquely at risk for this problem because it possesses inherently poor biomechanical stability (lacks intervertebral discs and vertical zygapophyseal joints) along with the greatest concentration of spinal mechanoreceptors.

Hyperafferent activation (through central nervous system facilitation) of the sympathetic vasomotor center in the brainstem and/or the superior cervical ganglion may lead to the second mechanism, cerebral penumbra, or brain hibernation.[116-124] According to this theory, a neuron can exist in a state of hibernation when a certain threshold of ischemia is reached. This ischemia level (not severe enough to cause cell death) allows the cell to remain alive, but the cell ceases to perform its designated purpose. The brain cell may remain in a hibernation state indefinitely, with the potential to resume function if normal blood flow is restored. If the degree of ischemia increases, the number of functioning brain cells decreases and the disability worsens.

It is possible that this patient sustained an injury to his upper cervical spine (visualized on cervical radiographs) either during one of the traumatic incidences his parents recalled or some other episode. It is also possible that because of the injury, through the mechanisms described previously, sympathetic malfunction occurred (measured by paraspinal digital infrared imaging), potentially causing a decrease in cerebral blood flow. If blood supply to the patient's brain was compromised, it is possible that a certain percentage of brain cells were existing in a state of hibernation rather than cell death. Therefore, the combination of theories suggests that when blood supply was restored to the hibernating cells that produce dopamine and serotonin (from upper cervical chiropractic care), the cells resumed their chemical-producing function. Therefore, conditions such as TS, ADHD, depression, and insomnia (caused by abnormal levels of serotonin and dopamine) could have been reversed or at least improved when normal chemical levels were restored. A similar mechanism appeared to occur in patients with Parkinson's disease (caused by decreased dopamine levels) whose upper cervical subluxations were corrected with upper cervical chiropractic care.[11-12]

CONCLUSION

This case report details the medical history and symptoms of a nine-year-old patient suffering from Tourette Syndrome, Attention Deficit Hyperactivity Disorder, depression, asthma, insomnia, and headaches; the five-month intervention of upper cervical chiropractic care; and the patient's symptomatic response. At this patient's initial evaluation, evidence of an upper cervical subluxation was found using paraspinal digital infrared imaging and upper cervical radiographs. The upper cervical subluxation was corrected by performing a specific adjustment by hand to the first cervical vertebra according to radiographic findings. All six conditions were absent following six weeks of upper cervical chiropractic care and remained absent five months later at the conclusion of care. To confirm that this positive outcome could be replicated in additional patients, it is recommended that a more extensive study be performed. In addition, further investigation into upper cervical injury and resulting neuropathophysiology as a possible etiology or contributing factor to TS, ADHD, depression, asthma, insomnia, and headaches should be pursued.

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CASE REPORT

Upper Cervical Chiropractic Management of a Multiple Sclerosis Patient: A Case Report

Erin L. Elster, D.C.

Abstract— This article reviews the upper cervical chiropractic management of a single patient with Multiple Sclerosis (MS). This 47-year-old female first experienced symptoms of MS at age 44, when she noticed cognitive problems and loss of bladder control. After viewing multiple lesions on MRI (MS plaques), her neurologist diagnosed her with MS. Two years later, she noticed additional symptoms of leg weakness and paresthesias in her arms and legs. Her symptoms progressively worsened without remission, so her neurologist categorized her as having chronic progressive MS and recommended drug therapy (Avonex). Upon initial examination of this patient, evidence of an upper cervical subluxation was found using precise upper cervical radiographs and paraspinal digital infrared imaging. The patient's medical history included one possible mechanism (a fall approximately ten years prior), which could have caused her upper cervical subluxation. The patient was placed on a specially designed knee-chest table for adjustment, which was delivered by hand to the first cervical vertebra according to radiographic findings. Monitoring of the patient's progress was through doctor's observation, patient's subjective description of symptoms, thermographic scans, neurologist's evaluation and MRI. The patient was managed with upper cervical chiropractic care for two years. After four months of upper cervical chiropractic care, all MS symptoms were absent. A follow-up MRI showed no new lesions as well as a reduction in intensity of the original lesions. After a year passed in which the patient remained asymptomatic, another follow-up MRI was performed. Once again, the MRI showed no new lesions and a continued reduction in intensity of the original lesions. Two years after upper cervical chiropractic care began, all MS symptoms remained absent. This case report revealed that this specific upper cervical procedure (thermal imaging, cervical radiographs, and knee-chest adjustments) was associated with a successful outcome for a patient with Multiple Sclerosis. Post MRI's, post thermographic scans, and the patient's neurologist's evaluation all suggested the intervention of upper cervical chiropractic care may have stimulated a reversal in the progression of Multiple Sclerosis.

Key Words: upper cervical spine, chiropractic, Multiple Sclerosis, vertebral subluxation, trauma, thermography, adjustment, manipulation

Introduction

Multiple Sclerosis (MS) is the foremost disabling neurological disease among adults between 20 and 50 years of age, afflicting 250,000 people in the United States. It strikes women twice as often as men and Caucasians more frequently than other ethnic groups. The occurrence of MS is greater in northern temperate zones.[1]

The pathological process involved in MS, a demyelinating disease, is the loss of myelin sheaths surrounding axons in the central nervous system (brain and spinal cord). Demyelination is thought to result either from damage to the oligodendrocytes (white matter cells) that produce the myelin or from a direct, immunologic (auto-immune) assault on the myelin itself.[2]

Common early manifestations of MS include paresthesias (numbness / tingling in extremities), optic neuritis (vision loss), mild sensory or motor symptoms in a limb, and cerebellar incoordination (balance loss). Although the most common course of the condition is a relapsing and remitting pattern over many years, the manifestation in each patient varies. In most cases, as the disease progresses, remissions become less complete. Some patients have only a few brief episodes of disability, whereas others have a relentless downhill course over months or weeks.

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Although not all patients become disabled, the end stage often can include ataxia (inability to coordinate voluntary movement), incontinence, paraplegia, and mental dysfunction due to widespread cerebral and spinal cord demyelination.[3]

The MS diagnosis, primarily a clinical one, is usually rendered based on neurological history and examination. The diagnosis can be confirmed by specialized evaluation techniques including magnetic resonance imaging (MRI), evoked potentials, and cerebrospinal fluid (CSF) analysis, although none show findings pathognomonic for MS.[3-5]

Medical treatment for MS focuses upon the use of medications to regulate the severity of symptoms such as depression, pain, bladder impairment, and sexual dysfunction. Other drugs may accelerate recovery from acute exacerbations of MS or reduce the frequency of exacerbations, but they neither alter the long-term course of the condition nor reverse any existing MS symptoms.[6]

B.J. Palmer, D.C., reported management of Multiple Sclerosis patients with upper cervical chiropractic care as early as 1934.[7-8] In his writings, Palmer listed improvement or correction of symptoms such as "spasticity, muscle cramps, muscle contracture, joint stiffness, fatigue, neuralgia, neuritis, loss of bladder control, paralysis, incoordination, trouble walking, numbness, pain, foot drop, inability to walk, and muscle weakness." His chiropractic care included paraspinal thermal scanning using a neurocalometer (NCM), a cervical radiographic series to analyze upper cervical misalignment, and a specific upper cervical adjustment performed by hand.

Figure 1: A patient being scanned with the Tytron C-3000 system

While few of Palmer's Research Clinic cases were published, Palmer described one case of Multiple Sclerosis in detail.[8] The patient, a 38-year-old male, went to the Palmer Research Clinic in Davenport, Iowa in 1943, after a diagnosis of MS by the Mayo Clinic. At the time of admission into the Palmer Clinic, this subject was "...helpless; he could not feed nor take care of himself." His medical history included a head / neck trauma at age 16 in which "...he fell ten feet off a building, landing on his head." The fall rendered him unconscious for thirty minutes and he reported having a sore neck for several days. At the Palmer Clinic, upper cervical radiographs showed a misalignment of the atlas to the right. After upper cervical chiropractic care, the patient remarked, "I am happy to say that through chiropractic, I have been made almost well. Today, I have just a little numbness left in my hands. I have the full use of my hands, feet, and my whole body."

During the past several decades, only three references were found linking chiropractic and Multiple Sclerosis: two single case studies and one five-patient report. Of the two single cases, one patient was adjusted with an instrument, while the other was managed with thoracolumbar manual chiropractic adjusting procedures.[9-10] Both cases responded favorably. Of the five-patient report, five subjects were managed with upper cervical chiropractic care aided by cervical radiographs and thermal imaging.[11] In all five cases, upper cervical subluxations were discovered and all patients showed improvement and/or correction of MS symptoms after the intervention of upper cervical chiropractic care.

The rationale for the use of upper cervical chiropractic care in this case was to correct the patient's upper cervical subluxation that was discovered during cervical radiographic and thermal imaging procedures. Similar upper cervical subluxations were found in other patients (with conditions such as Parkinson's disease, asthma, epilepsy, and fibromyalgia) who responded favorably to upper cervical chiropractic care (aided by cervical radiographs and thermal imaging).[11-17] This case report reviews the patient's symptoms and objective findings before and after the intervention of upper cervical chiropractic care.

Case Report

This 46-year-old female first experienced MS symptoms at age 44. She noticed inability to formulate words when talking to her two-year-old daughter and difficulty processing complex thoughts or tasks at work. In addition, she had trouble with muscular control to begin and end urination. Her neurologist told her that loss of bladder control and cognition were symptoms of MS and ordered an MRI. After viewing white-matter lesions on MRI (MS plaques), her neurologist rendered an MS diagnosis. A cerebrospinal fluid analysis was also performed, which appeared normal. Two years after her diagnosis, she noticed additional symptoms of leg weakness that she described as a "rubbery feeling" and continuous, painful paresthesias (tingling and loss of sensation) in both arms and legs often awakening her at night. In addition, the patient reported suffering from a stiff and achy neck for many years before noticing MS symptoms and demonstrated reduced and painful cervical extension. When questioned about her recollection of any past accidents, falls, head injuries, or whiplashes, the patient recalled a single fall over a decade prior to the onset of MS symptoms. Instead of the typical relapsing-remitting pattern, this patient's neurologist considered her MS symptoms chronic and progressive, so he recommended drug therapy (Avonex) to slow the progression. Due to her concerns over long-term drug use, this subject chose to undergo upper cervical chiropractic care before beginning drug therapy.

The chiropractic care described below is based upon the original work performed by Palmer from the 1930's through the 1950's in the Palmer Research Clinic.[8] The care was administered as taught by the International Upper Cervical Chiropractic Association (IUCCA) through their Applied Upper Cervical Biomechanics (AUCB) program.[18]

After the patient's medical history was recorded, a paraspinal thermal analysis was performed with the Tytron C-3000 (Figure 1 - Titronics Research and Development) from the level of C7 to the occiput according to thermographic protocol.[19-21] (Figure 2) Paraspinal digital infrared imaging measures cutaneous infrared heat emission and is a form of thermograpy. Thermography is a neurophysiological diagnostic imaging procedure with over 6000 peer-reviewed and indexed papers in the past 20 years.[23-34] Thermography has been established as a practical and sensitive test for spinal nerve root irritation, articular facet syndromes, peripheral nerve injuries, sympathetic pain syndromes, and the vertebral subluxation complex.[23-34] Since the amount of blood passing through the skin is directly controlled by the sympathetic nervous system (through control of dilation or constriction of blood vessels), the temperature of any one area of the skin reflects the neurological control of that area. Normal or abnormal skin temperature then becomes an indicator of normal or abnormal neurological function. In blind studies comparing thermographic results to that of CAT scan, MRI, EMG, myelography, and surgery, thermography was shown to have a high degree of sensitivity (99.2%), specificity (up to 98%), predictive value, and reliability.[25-27] Thermal imaging has been effective as a diagnostic tool for breast cancer, repetitive strain injuries, headaches, spinal problems, TMJ conditions, pain syndromes, arthritis, and vascular disorders, to name a few.[28-37]

Compared to established normal values for the cervical spine, the subject's paraspinal scans contained thermal asymmetries of 0.5°C (Figure 3). According to cervical thermographic guidelines, thermal asymmetries of 0.5°C or higher indicate abnormal autonomic regulation or neuropathophysiology.[38-41]

In addition to revealing thermal asymmetries, the subject's scans displayed static thermal differences (Figure 4), thus, a thermal "pattern" was established. "Pattern analysis" of paraspinal temperatures was first developed by Palmer[8] and paraspinal thermal analysis and pattern work are receiving increased attention in chiropractic research.[43-53] Pattern work has been used recently in conjunction with upper cervical chiropractic care with Parkinson's disease, Multiple Sclerosis, fibromyalgia, epilepsy, and asthma.[11-17]

Because upper cervical misalignments were suspected in this patient, a precision upper cervical radiographic series was performed.[54] The x-ray equipment included a laser-aligned frame (American X-ray Corporation) to eliminate image distortion. To maintain postural integrity, this subject was placed in a positioning chair using head clamps. In addition, the patient was aligned to the central ray using a laser (Titronics Research and Development) mounted on the x-ray tube. The four views (lateral, anterior-posterior, anterior-posterior open mouth, and base posterior) enabled examination of the upper cervical spine in three dimensions: sagittal, coronal, and transverse. Analysis of the four views was directed towards the osseous structures (foramen magnum, occipital condyles, atlas, and axis) that are intimately associated with the neural axis. Laterality and rotation of atlas and axis were measured according to each vertebra's deviation from the neural axis (Figure 5).[55] Right laterality of atlas and axis and right posterior rotation of atlas were found (Figure 6).

The two criteria used to determine subluxation in this case were thermal asymmetry (measured by thermal imaging) and vertebral misalignment (measured by cervical radiographs). Because both criteria (0.5°C thermal asymmetry and right laterality and right posterior rotation of atlas) were met, a care plan

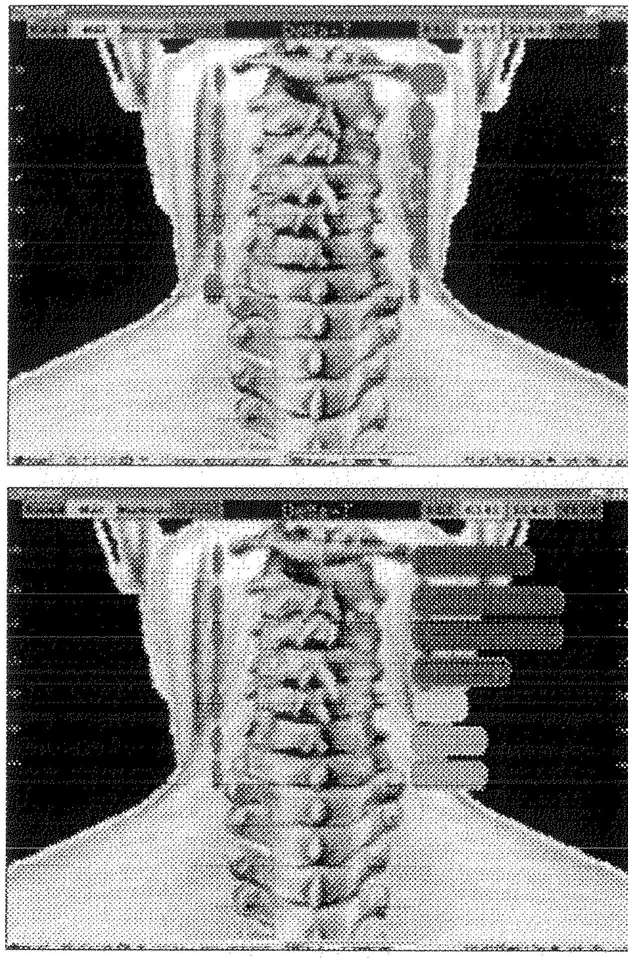


Figure 3

Example of cervical side to side thermal comparison. Normal scan (top), Thermal asymmetries at multiple levels (bottom).

Figure 2

Tytron C-3000 Thermographic Protocols

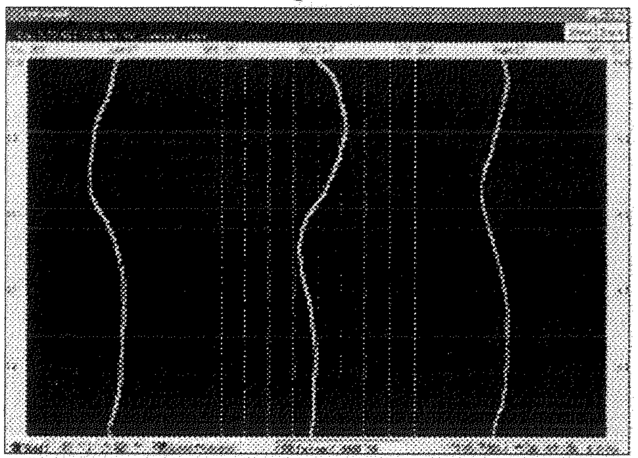
Environmental Controls —

- The temperature of your office should be held around 70 degrees Fahrenheit.
- No direct cooling or heating vent drafts should bear on the scanner.
- The scanner should not be placed in direct sunlight.
- Place the scanner holder away from the computer monitor and CPU.

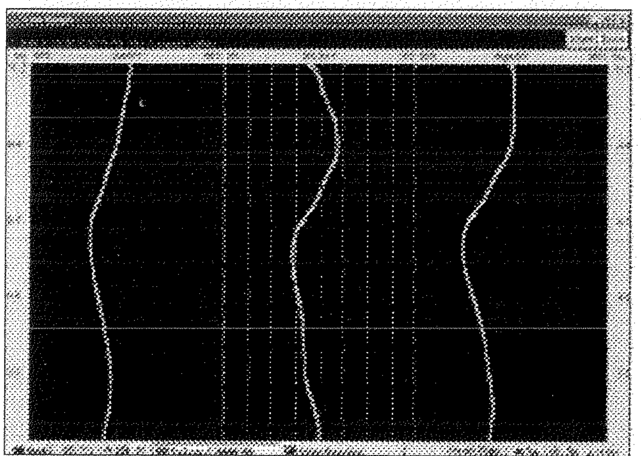
Patient Preparation —

- 15 minutes of office acclimation time must occur before scanning the patient.
- The patient's spine must be disrobed or loosely gowned during acclimation.
- The patient must remain free from direct heating or cooling drafts.
- No direct sunlight should bear on the patient while in the office.
- No EMS, TENS, US, hot or cold packs, or acupuncture before scanning.
- The patient must be free from sunburn.

Figure 4



Scan 1



Scan 2

Establishment of a static pattern. The center graph represents the temperature differential (Delta-T) or difference in temperature between either side of the spine. The right and left side graphs denote the direct temperatures (DT) or actual surface temperatures over the paraspinal skin. Note how the line graphs follow a similar thermographic pattern.

was discussed with the patient. In addition, it was recommended that the subject continue consulting with her neurologist. After the patient consented, upper cervical chiropractic care began with an adjustment to correct the right laterality and posterior rotation of atlas. To administer the adjustment, the patient was placed on a knee-chest table with her head turned to the right (Figure 7). The knee-chest posture was chosen because of the accessibility of the anatomy to be corrected. Using the right posterior arch of atlas as the contact point, an adjusting force was introduced by hand.[35] The adjustment's force (force = mass X acceleration) was generated using body drop (mass) and a toggle thrust (acceleration).

Then, the patient was placed in a post-adjustment recuperation suite for fifteen minutes as per thermographic protocol (Figure 2).[19-21] After the recuperation period, a post-adjustment thermal scan was performed. The post-adjustment scan revealed a thermal difference of only 0.1 °C, which was considered normal according to established cervical thermographic guidelines (compared to the pre-adjustment differential of 0.5 °C). Therefore, resolution of the patient's presenting thermal asymmetry (elimination of the thermal "pattern") was achieved (Figures 8 & 9).

All subsequent office visits began with a thermal scan. An adjustment was administered only when the patient's presenting thermal asymmetry ("pattern") returned. If an adjustment was given, a second scan was performed after a fifteen-minute recuperation period to determine whether restoration of normal thermal symmetry had occurred. This subject's office visits occurred two times per week for the first four weeks of care. After the initial adjustment, two other adjustments were administered during the first month. Visits were reduced to once per week for the second month of care. Adjustments were necessary on two of the four visits. By the third month of care, thermal asymmetry was rarely present, so visits were reduced to once per month.

Figure 7: Example of patient positioning for knee-chest adjustment

Within the first week of upper cervical care, this subject reported improved bladder control (resumption of muscular control to begin and end urination) and a decrease in numbness,

Figure 5 (see Figure 6, page 26)

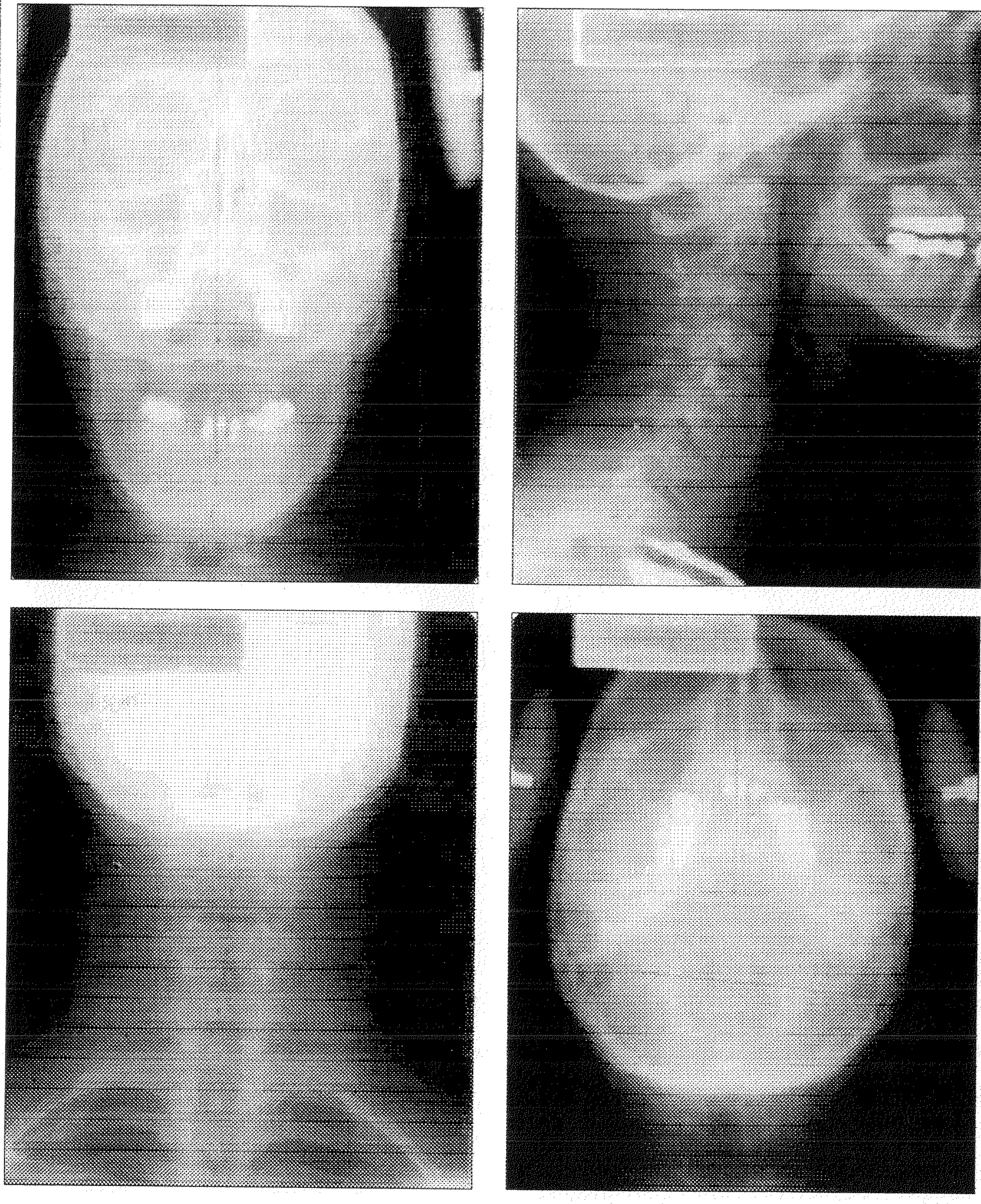
To determine laterality from the anterior-posterior open mouth film, a horizontal line was drawn across the upper one-third of the foramen magnum's arch from cortex to cortex. The foramen magnum line was bisected with a vertical median line from the film's top to bottom.

Using a compass' point on the vertical line, arcs were drawn through each lateral mass of atlas. Using the left lateral mass as the constant, if the right lateral mass stayed within the right arc, the atlas was listed as "left." If the right lateral mass extended beyond the right arc, the atlas was listed as "right."

Axis laterality was determined by locating the position of the odontoid and spinous processes according to the vertical median line. To determine atlas rotation from the base-posterior film, an atlas plane line was drawn through the transverse foramen of atlas. The next line was drawn horizontally across the cortical borders of the clivus (ossification center of the skull) from cortex to cortex. This skull line was bisected.

Atlas rotation was determined by using a protractor to measure the difference between the bisected skull line and the atlas plane line. An angle less than 90 degrees represented "anteriority". An angle more than 90 degrees represented "posteriority."

Figure 6



(See Figure 5, page 25, for explanation on how lines of mensuration were drawn.)

tingling, and pain in her left leg and right hand. One month later, her leg strength returned ("rubbery feeling" was absent) and numbness was noted only in her left hand. In addition, she reported experiencing normal cognitive ability in that she could formulate words and process complex thoughts. After two months of care, bladder control, sensation, and strength in her extremities returned to normal. After four months of upper cervical care, this subject reported the absence of all MS symptoms. A follow-up MRI five months after the first showed no new lesions as well as a reduction in intensity of the original lesions.

During the subsequent year, this patient was examined once per month with paraspinal digital infrared imaging. During three of the twelve visits, thermal asymmetry ("pattern") was present so an adjustment was administered. No MS symptoms reoccurred during the year. A third MRI performed ten months after the second once again showed no new lesions and continued reduction in intensity of the original lesions. The patient's neurologist considered her case stable, no longer recommended drug treatment, and suggested she be reexamined once per year with MRI. Two years after the first adjustment was administered, the patient remained asymptomatic. During the two-years of upper cervical care, no other intervention was reported that could have provided an alternative explanation for the dramatic improvement of the patient's condition.

Discussion

An important aspect of this patient's medical history was her recollection of a fall, which could have caused her upper cervical subluxation. The body of medical literature detailing a possible trauma-induced etiology for MS, or at least a contribution, is substantial.[56-66] Trauma also has been implicated as a cause of other similar degenerative neurological disorders such as Parkinson's disease and Amyotrophic Lateral Sclerosis.[62-64] When Parkinson's disease patients were examined with thermal imaging and cervical radiographs, they too showed evidence of upper cervical subluxations and responded favorably to upper cervical chiropractic care.[16-17]

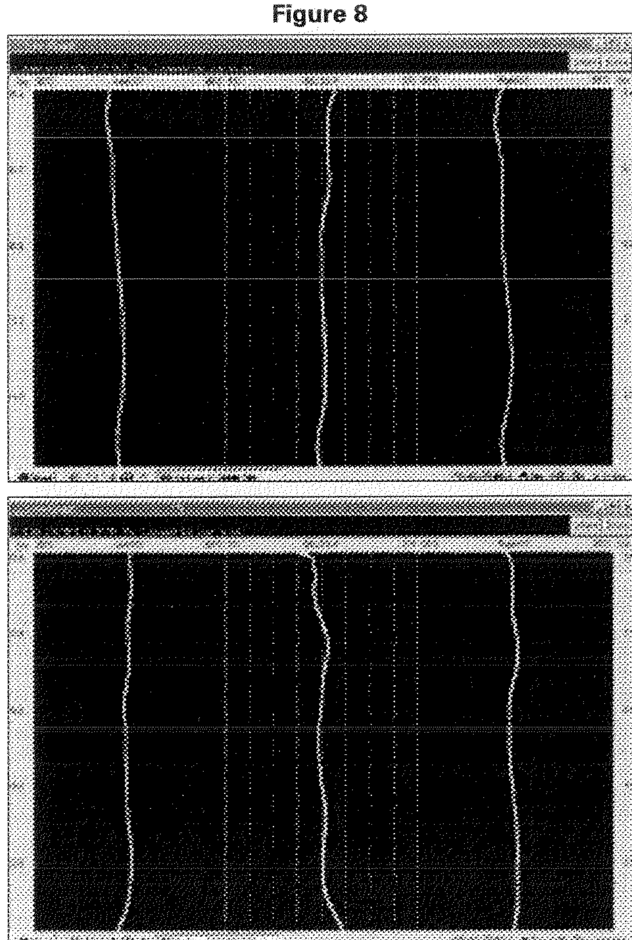
Recent research has suggested that an alteration of the blood-brain barrier (BBB) is an obligatory step in the pathogenesis of MS lesions.[58-60] Evidence supports that trauma (in particular mild concussive injury to the head, neck or upper back) impinges on the brain and spinal cord, and may result in an increase in BBB permeability.[58-60] While medical research shows that trauma may lead to MS, no mechanism has been defined. It is the author's hypothesis that the missing link may be the injury to the upper cervical spine.

While various theories have been proposed to explain the effects of chiropractic adjustments, a combination of several theories seems most likely to explain the profound changes seen in this MS patient due to upper cervical chiropractic care. After a spinal injury, central nervous system (CNS) facilitation can occur from an increase in afferent signals to the spinal cord and/or brain coming from articular mechanoreceptors.[70-74] The upper cervical spine is uniquely at risk for this problem because it possesses inherently poor biomechanical stability (lacks intervertebral discs and vertical zygapophyseal joints) along with the greatest concentration of spinal mechanoreceptors.

Hyperafferent activation (through CNS facilitation) of the sympathetic vasomotor center in the brainstem and/or the superior cervical ganglion may lead to changes in cerebral blood flow, including ischemia.[75-81] Because of the close association between the nervous and immune systems (the immune system is commonly classified as the neuroimmune system),[82-83] upper cervical injuries affecting sympathetic function consequently may cause a cascade of non-favorable immune responses.[84-87] Among these are uncoordinated immune tissue responses (auto-immune responses) and the release of cortisol, which ultimately can result in decreased immune function.

It is possible that this MS patient sustained an injury to her upper cervical spine (visualized on cervical radiographs) during the spinal trauma she experienced. It is also possible that due to the injury, through the mechanisms described previously, sympathetic malfunction occurred (measured by paraspinal digital infrared imaging), possibly causing decreases in cerebral blood flow. Consequently, because the nervous and immune systems are so closely intertwined, it is possible that CNS facilitation and cerebral ischemia could have stimulated an auto-immune response such as myelin destruction or an increased permeability of the blood-brain barrier. According to the symptomatic improvement and the objective changes via MRI and thermogra-

Figure 8



These graphs demonstrate when the patient was not "in pattern" and no adjustment was given on those days.

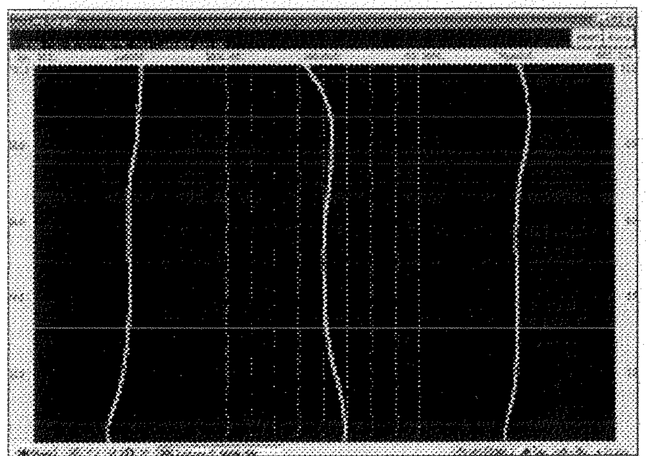
phy in the patient discussed in this report, it seems that adjustment of the upper cervical subluxation had a beneficial effect possibly stopping and perhaps even reversing the MS. Similar results occurred in five other MS patients whose upper cervical subluxations were corrected with upper cervical chiropractic care.[11]

Conclusion

This case report details the medical history and symptoms of a 46-year-old female suffering from Multiple Sclerosis; the two-year intervention of upper cervical chiropractic care; and the patient's symptomatic response. At this patient's initial evaluation, evidence of an upper cervical subluxation was found using paraspinal digital infrared imaging and upper cervical radiographs. The upper cervical subluxation was corrected by performing a specific adjustment by hand to the first cervical vertebra according to radiographic findings. The patient's medical history included one possible mechanism (a fall) for her upper cervical subluxation. After four months of upper cervical chiropractic care, all previous symptoms of MS were absent. A follow-up MRI showed no new lesions as well as a reduction in intensity of the original lesions. After a year passed in which the patient remained asymptomatic, another follow-up MRI was performed. Once again, the MRI showed no new lesions and a continued reduction in intensity of the original lesions. Two years after upper cervical chiropractic care began, all MS symptoms remained absent. Further investigation into upper cervical trauma and resulting neuropathophysiology as a possible etiology or contributing factor to Multiple Sclerosis should be pursued. To confirm that this positive outcome could be replicated in additional patients, it is also recommended that a larger study be performed because few conclusions can be drawn from a small number of cases.

Figure 9

Example of pre-adjustment pattern.



Example of post adjustment scan with loss of pattern.

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Sherman College Notes

INSTRUMENTATION
906

SHERMAN COLLEGE OF STRAIGHT CHIROPRACTIC

HISTORY OF CHIROPRACTIC ANALYSIS

1. EARLY PALPATION:

    1. Bony palpation: irregularities, bumps, spinous rotation
    2. Hot boxes: back of hand seeking hot spots
    3. Gliding fingers over transverse processes to locate taut and tender fibers.

    The objective was to determine the location of subluxations and to analyze the direction of misalignment.

2. NERVE TRACING: from spine to organ and back to spine, in order to determine exit and entrance of sensitive nerves to aid in locating subluxations.

3. MERIC SYSTEM: developed out of nerve tracing. A systematic categorization of zones or meres of the spine with certain organs Had to ascertain which organ was abnormal and refer to meric chart to know which segment to adjust.

4. MAJORS AND MINORS: A development from the Meric System A deductive method of separating the most vital organic conditions from those of lesser importance to prolong life. Adjusting majors first permitting innate to concentrate reparation on most vital area, then later adjusting what minors were left.

5. SPINOGRAPH 1910: original purpose was to verify, prove or correct digital palpations.

6. N. C. M. 1924: Dr. Dossa D. Evins invented. Break system of analysis: It was thought that each break indicated a subluxation.

7. HIO concepts introduced by B. J. in 1930. Generally accepted by the profession by 1935 but not totally.
    Break system of analysis still used at first. Pattern NCM analysis then developed. This system was especially boosted by the development of the neurocalograph in 1940 by P. S. C. 's consulting engineer Otto Schiernbeck. Schiernbeck also developed the posture constant chair and neurotempometer or pacer. (Murdock - constant glyde)

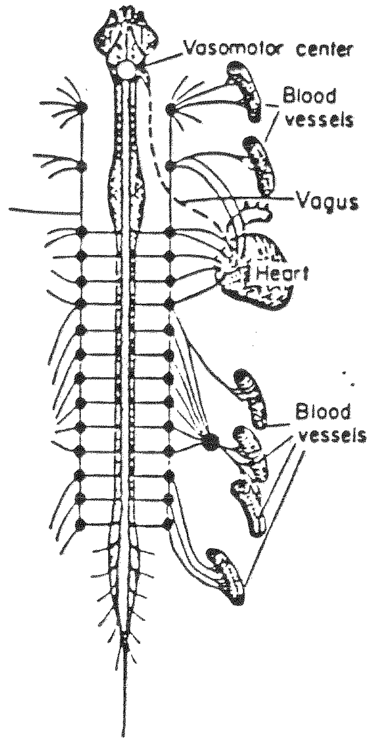


Figure 20–6. The vasomotor center and its control of the circulatory system through the sympathetic and vagus nerves.

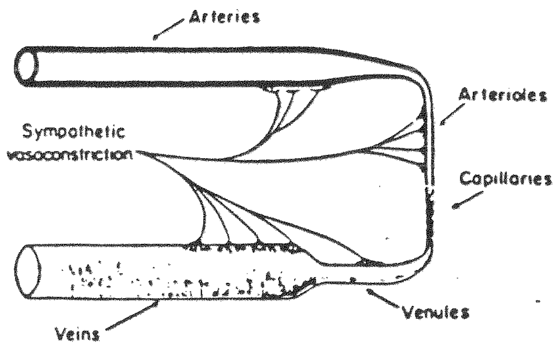


Figure 20–7. Innervation of the systemic circulation.

out the body: (1) through the *peripheral sympathetic nerves* and (2) through the *spinal nerves*. The precise pathways of these fibers in the spinal cord and in the sympathetic chains will be discussed in Chapter 56. It suffices to say here that, with rare exceptions, all vascular areas of the body are supplied with sympathetic nerve fibers.

Distribution of Sympathetic Nerve Fibers to the Peripheral Vasculature. Figure 20–7 illustrates the distribution of sympathetic nerve fibers to the peripheral blood vessels and shows that all the vessels, except the capillaries, sphincters, and most of the metarterioles, are innervated.

The innervation of the small arteries and arterioles allows sympathetic stimulation to increase the *resistance* and thereby to change the rate of blood flow through the tissues. The innervation of large vessels, particularly of the veins, makes it possible for sympathetic stimulation to change the volume of these vessels and thereby to alter the volume of the peripheral circulatory system, which plays a major role in the regulation of cardiovascular function, as we shall see later in this chapter and subsequent chapters.

Sympathetic Nerve Fibers to the Heart. In addition to sympathetic nerve fibers supplying the blood vessels, these fibers also go to the heart. This innervation was discussed in Chapter 13. It will be recalled that sympathetic stimulation markedly increases the activity of the heart, increasing the heart rate and enhancing its strength of pumping.

Parasympathetic Control of Heart Function, Especially Heart Rate. Though the parasympathetic nervous system is exceedingly important for many other autonomic functions of the body, it plays only a minor role in regulation of the circulation. Its only really important effect is its control of heart rate. It also has a slight effect on control of cardiac contractility; however, this effect is far overshadowed by the sympathetic nervous system control of contractility. Parasympathetic nerves pass to the heart in the vagus nerve, as illustrated in Figure 20–6.

The effects of parasympathetic stimulation on heart function were discussed in detail in Chapter 13. Principally, parasympathetic stimulation causes a marked *decrease* in heart rate and a slight decrease in contractility.

The Sympathetic Vasoconstrictor System and Its Control by the Central Nervous System

RELATIVE TO NCM HEAT DIFFERENT

The sympathetic nerves carry both vasoconstrictor and vasodilator fibers, but by far the most important of these are the *sympathetic vasoconstrictor* fibers. Sympathetic vasoconstrictor fibers are distributed to essentially all segments of the circulation. However, this distribution is greater in some tissues than in others. It is less potent in both skeletal and cardiac muscle and in the brain, while it is powerful in the kidneys, the gut, the spleen, and the skin.

The Vasomotor Center and Its Control of the Vasoconstrictor System — Vasomotor Tone. Located bilaterally in the reticular substance of the lower third of the pons and upper two-thirds of the medulla, as illustrated in Figure 20–8, is an area called the *vasomotor center*. This center transmits impulses downward through the cord and thence through the vasoconstrictor fibers to all the blood vessels of the body.

SUBLUX → SKIN TEMP. DIFFERENT

Motion, not immobility, advocated for healing synovial joints

Orthopedic surgeons who "make a fetish out of applying plaster casts" should instead look to the use of motion to heal injured or diseased synovial joints.

They should also realize, says Robert B. Salter, MD, professor and head of orthopaedic surgery at the University of Toronto Faculty of Medicine, that it is possible to regenerate articular cartilage with relative comfort and little inconvenience to the patient if one is willing to set aside plaster of Paris.

Speaking to the 50th annual meeting of the Royal College of Physicians and Surgeons of Canada in Toronto, Salter said that the traditional concept that tissue, including cartilage, must be rested in order to heal "really is not valid" and the concept itself "must be put to rest."

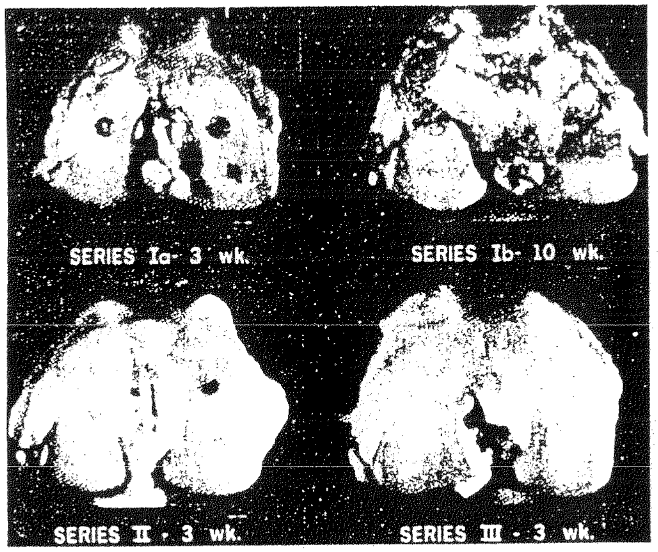
Salter was reporting not only on his long-term experimental investigations on the healing of full-thickness defects in articular cartilage in animals, but also on his subsequent clinical experience, which has shown that continuous passive motion (CPM) can have a dramatic effect on the healing of injured and diseased joints in humans.

Continuous passive motion is provided by a specially designed mechanical device that slowly and consistently moves the injured joint through a preset range of motion during a specified time period, eg, one cycle every 40 s. This movement allows the continued flow of synovial fluid, which Salter said is the only source of nutrition available to articular cartilage.

When synovial fluid is prevented from entering articular cartilage by pressure, immobilization, or both (when a cast is used), degeneration is likely since articular cartilage has neither blood vessels, lymphatics, nor nerves, said Salter. He added that with immobilization the synovial membrane gradually adheres to the cartilage like a piece of cellophane tape. Eventually it obliterates the joint, prevents the nutrition of the cartilage, and aids subsequent degeneration.

Salter noted that in rabbit studies, the first of which were reported in 1974, exertion of constant pressure across the animals' femoral condyles resulted in pressure necrosis. When the rabbits were allowed to run free, arthritis developed in the area.

The same lesion can be achieved by putting the human knee joint in a set position. The result is



Gross appearance of typical defects in three experimental groups of adolescent rabbits. Series Ia (immobilization for three weeks): granulation-like tissue seen in defects. Series Ib (immobilization for ten weeks): numerous intraarticular synovial adhesions seen in region of each of three defects in femoral condyles. Series II (intermittent active motion for three weeks): somewhat better healing than in series Ia but still incomplete. Series III (continuous passive motion for three weeks): considerably more complete healing by tissue grossly resembling articular cartilage. (Photograph reproduced with permission from The Journal of Bone and Joint Surgery *[1980;62-A:1235].)*

degenerative disease and arthritis, according to Salter, who added: "We have evidence that this lesion [pressure necrosis] has been produced by orthopedic surgeons who are heavy-handed in the application of casts."

In other rabbit studies, the Toronto team—using a dental drill—produced full-thickness cartilage defects in each of four standard sites: the patellar groove, the anterior and middle parts of the medial femoral condyle, and the middle part of the lateral femoral condyle. They then reduced the previously dislocated patella, sutured the medial capsular incision and ... and applied a light dressing.

The animals—three series of 40 adolescent rat...

continued on next ...

continued from previous page

and three series of nine adult rabbits—were subsequently placed in one of three treatment groups: (1) immobilization with a cast, (2) intermittent active motion (allowed to move freely within a cage), or (3) the CPM regimen.

A special apparatus was used for CPM—a padded sling on which the animals were placed while still anesthetized and from which their hind limbs protruded. Food and water containers were positioned at one end of the area; at the other was a chain-driven vertical rod with a cylindrical plastic cup to which the rabbit's treated foot was attached via a plaster of Paris cast. This rod moved up and down slowly, completing one cycle every 40 s. The knee joint was thus moved through a range of 40 to 110 degrees of flexion. Treatment was begun immediately after surgery. Salter said that the animals appeared to be comfortable and free of pain during the time they were in the device, some for up to four weeks.

Healing of defects was assessed by light microscopy and by gross examination after the animals were killed (Figure, previous page).

After three weeks of immobilization in casts, the knees of that group of animals were marked by "very poor" healing and restricted motion, Salter said. In half of the defects, filmy adhesions joined the synovial membrane to the femoral condyle. After ten weeks, the joints were stiff and "almost destroyed by adhesions," according to Salter.

The knees of the rabbits in the intermittent active motion group showed some healing after three weeks of cage activity. In four of 40 defects in adolescent rabbits, there was healing by hyaline articular cartilage. There were no substantial differences in healing between adolescent and adult animals.

But among those animals on CPM—both adolescent and adult—approximately 50% showed healing at three weeks.

Assessment of joint mobility showed that the sooner the joint was given motion, the better the result. Among the immobilized rabbits, the knees of those evaluated three weeks postoperatively had half the normal range of motion. At ten weeks, the knees were very stiff with only a few degrees of motion.

Among those rabbits permitted intermittent active motion, there was pain and limited motion in the knees during the first week. But by the end of the second postoperative week, there was improvement to a near normal range of motion.

In the CPM animals, there was nearly a complete range of motion in the knees at one, two, three, and four weeks postoperatively.

These studies clearly showed the value of CPM in the regeneration of cartilage, said Salter. The next step was to develop a device that would facilitate CPM in humans. Such devices were built with the cooperation of the University of Toronto's mechanical engineering department.

Human Studies

To date, ten Toronto patients with cartilage degeneration have undergone CPM to facilitate joint healing. The results have been gratifying, says Salter.

The first of these patients, a teenaged girl, came in almost two years ago with adhesions in her knee from a previous injury. The range of motion was extremely limited.

The girl underwent surgery to remove the adhesions and awoke already on the CPM device. Her knee was moving constantly and she felt no pain. She underwent CPM for ten days and went on to regain a full range of motion in her knee. One year later she was back to full activity, including water skiing.

So far, all patients given CPM have been comfortable during recovery and have regained an "excellent" range of motion, says Salter.

It is "remarkable," he told the Royal College meeting, that there should still be controversy about how long a joint should be rested after injury or disease. Rest and motion are two of the most commonly prescribed modalities for patients with musculoskeletal problems, he said. The popularity of rocking chairs among elderly, arthritic people may even stem from the fact that the rocking eases some pain and stiffness in their joints, he speculated.

Salter also pointed out that in animals, who seldom get casts for broken limbs, it is unusual for a nonunion to occur. Malunion may be a problem, he said, but rarely nonunion.

Moreover, the lowest incidence of degenerative arthritis of a joint is found in the costal vertebral joints, which move continuously with every breath. This is further justification for CPM, Salter said.

It is time to challenge the tradition of immobilization for injured joints, concluded Salter. "What we should be doing is freeing man from this terrible iatrogenic disease of applying plaster casts."

—by Milan Korcok

A leveling off in the 26-year downward trend of reported cases and case rates for tuberculosis in this country is reported by Centers for Disease Control (CDC) epidemiologists in Atlanta.

One factor, according to the CDC's Tuberculosis Control Division, "is the number of Indochinese refugees in the United States who have tuberculosis." However, officials say, the leveling-off would have occurred even without that influx for reasons that are not clear.

Last year, 27,749 cases were reported to the CDC, an increase of 80 cases over 1979. So far this year, the number of reported tuberculosis cases is greater than for the same period of 1980.

TAKING ACCOLADE READINGS

The importance of proper technique in making Accolade System III readings cannot be stressed enough. If the reading technique is not proper, the data collected will be of little value. The operator must concentrate on technique during every glide. Practice should make you better, but as Knute Rockne said, "Practice does not make perfect, perfect practice makes perfect." If you lose sight of the importance of technique or fail to concentrate each time you take a reading, you will gradually develop bad habits, and your technique will gradually produce less meaningful results.

It is best to post the sign, "PLEASE DO NOT TALK WHEN ACCOLADE SYSTEM III's READINGS ARE BEING MADE", in a place close to the **Accolade System III** reading area. If the patient should talk, stop and instruct the patient about the need for quiet concentration, and begin again.

PREPARATION OF THE PATIENT

The patient should be in your reception or examining room for approximately ten minutes prior to making the **Accolade System III** reading. This period of temperature adjustment is particularly important when a considerable difference exists between the temperature of the patient's former environment and the examining room. The patient should not be exposed to cold or hot drafts while in your reception room and examining room. If the patient is rested following a vertebral adjustment, allow time for the heat that was generated when the patient rested on a mattress to dissipate.

When the reading is being made, the patient should be sitting up tall on a comfortable chair with legs straight down and feet flat on the floor. No crossed legs. The area of the spine to be read should be fully exposed.

CERVICAL READINGS

When reading the cervical spine, it is best that the patient be in a "posture constant" chair, with the head in its natural relationship to the body, or very slightly tilted forward, resting in the head piece. If you do not have a "posture constant" chair, support the patient's forehead with the knife edge of your hand. Because **Accolade System III** readings put very little pressure on the patient's neck, most adults will be able to sit still with their head unsupported. The patient's arms should be at the side and hands should be flat on the lap.
**** Dealing with hair is discussed later. ****

HOLDING AND GLIDING THE ACCOLADE

These instructions are for right-handed people. If you are left-handed, substitute left for right and right for left.

Before you begin, be certain that (1) there is adequate thermal paper in the printer; (2) the Accolade System III is plugged in and turned on; (3) the terminals are adjusted to accommodate the size of the patient's spine; (4) the guide wheels are extended one-fourth inch beyond the terminals (you can vary this to suite different shaped spines and your own preferences); and (5) the area of the spine to be read, pre or post, and the patient's I.D. number are entered.

DUAL PROBE TECHNIQUE

HOLDING THE INSTRUMENT

The dual probe instrument should fit comfortably into the gripped hand. The wrist should not be flexed or extended when making a reading except when the area of the spine being read is in curvature.

STANCE

Stand erect, approximately eighteen inches behind and far enough to the left of your patient so that your right arm is in line with the patient's spine. This is very important, for if you are off to either side of the patient's spine, the terminals will be at an angle, rather than parallel, to the surface of the patient's spine. Move your left foot about ten inches forward so your weight is comfortably distributed on both legs. Keep your shoulders parallel to your patient's shoulders.

When making the reading, your right arm should hang straight down from the shoulder and be kept close to your body. The angle of the elbow should be as close to 90 degrees as possible. The angle may be a little more than 90 degrees when reading the lower spine of an adult. Never flex or extend your wrist when making a reading. Your hand and instrument should be in front of (never to either side of) your elbow. The palmar and volar surfaces of the hand should be perpendicular to the floor except when guiding the Accolade over vertebrae that are in curvature.

When making the reading, lean forward slightly (never backwards). You should control the elevation of the instrument mainly by the bend in your knees and only to a slight extent by the angle of your elbow, the superior or inferior deviation of the wrist or the bending of your spine.

MAKING THE READING

If you are accustomed to making readings using one of the bi-polar thermocouple instruments, you will have to adapt to a somewhat different reading technique. The **Accolade System III** reads in about one-half the time, and being "non-contact", the glide has quite a different "feel". In the beginning, it will seem as strange as going from regular steering to power steering when driving a car. Once you get used to the difference, you will never want to go back to the slow, digging-in of thermocouples. Your patients will also appreciate the difference.

The art to gliding the **Accolade System III** dual probe along the spine so that you obtain repeatedly accurate readings takes a period of time to learn. So, be patient and know that with a little time and practice you will get the knack of making accurate **Accolade System III** dual probe readings every time.

All readings should be made by gliding from the inferior to the superior. Start by placing the terminals slightly below the area to be read. The terminals should be equidistant on the right and left of the spinous processes or center of the spine. The terminals should be on the same plane as that of the vertebra which lies between them (this is usually the horizontal plane). Looking from the side, the terminals should be about 90 degrees to the vertebra that lies beneath them. Keep the terminals as close to the skin as possible without touching. However, this is not as great of an importance as with thermocouple instruments because Accolade System III reads accurately even when the distance varies (up to 3/8 inch).

When you are ready to begin, press in the on/off switch on the handle of the **Accolade System III** dual probe and hold it in throughout the entire reading. When you hear the first loud beep (there is a soft "beep" when you first press the on/off switch), begin the glide. Keep your eyes on the terminals throughout the reading and monitor their relationship to the patient's back.

To make accurate readings for comparative purposes, you must observe two rules:

1. Always start at the same place and end at the same place.

2. Always glide at an even rate of speed.

RATE OF SPEED

Practice gliding at a constant rate of speed, one that falls within the proper range for the area of the spine being read. The times shown below are the suggested rates of speed for the different areas of the spine. The infant mode is for the cervical spine of an infant. Other areas of the infant spine can be read with the "spot" mode.

	Minimum	Maximum
Cervical	10 seconds	20 seconds
Full Spine	16 seconds	32 seconds
Lumbar	10 seconds	32 seconds
Thoracic	12 seconds	24 seconds
Spot	2 seconds	unlimited
Infant	6 seconds	14 seconds

Start practicing the glide. Note that the "beeps" occur two seconds apart. When you feel comfortable and can keep the probes on the same horizontal plane line as the vertebrae, you are ready to proceed with your practical application of the Accolade System III. Evenness of the glide speed is most important and relatively easy to achieve with a little practice.

SINGLE PROBE TECHNIQUE

TAKING THE FOSSA READINGS

Have the patient sitting tall and looking straight ahead. You must read the right fossa first, as the **Accolade System III** will record the first fossa reading as being on the right side. Holding the probe in your right hand with your index finger on the switch, place the terminal in the fossa but do not touch the end of the terminal against the skin. The terminal should be perpendicular to the areas being read. Do not angle the instrument as you would a thermocouple device. When the instrument is facing an area to be read, press the switch and move the distal end of the terminal so as to collect data (samples) over a 10-12 millimeter area. The **Accolade System III** will take numerous samples per second and compare the highest sample of each fossa.

It is most important that the **Accolade** be reading the same thing on both sides. You want to read the temperature between the mastoid and the mandible. You do not want to read the temperature of the mandible or the mastoid. A temperature difference of more than one degree, while possible, should be looked upon with suspicion, as it is quite unusual. When a difference does occur, it is usually less than three-fourths of a degree.

TAKING READINGS ON INFANTS

Remember, that because you are reading temperature, it is important to guard against extraneous sources of hot or cold which could distort the true reading. Be sure the baby has not been held with one ear against someone's body, and that there are no other extraneous sources affecting the fossae temperatures.

It is best to have two persons assist in making a dual probe reading on an infant. The (parent) first assistant will sit on something low, preferably the height of a side-posture table. He/she will hold the infant over his/her shoulder so that the infant's shoulders are slightly higher than that of the one holding the child. The second assistant should stand behind the one holding the infant and face the infant. The second assistant holds the child's head in their hands, cupping the hands over the child's ears, but not touching the ears (blocking the child's ears will disturb the child and cause it to squirm). It is important that the second assistant has his/her hands so that the fingers are pointing toward the child's shoulders. Gently hold the child's head slightly tilted over the first assistant's shoulders. The doctor stands behind the child and makes the reading. The less pressure that the second assistant uses in holding the child's head, the less the child will squirm. If the child has hair that needs to be held up, the second assistant can do so with each of its index fingers.

MAKING A FOSSA READING ON AN INFANT

The infant should be placed supine on a flat surface, ideally the side-posture table or examining table. The doctor would sit straddling the side-posture table or stand at the end of the examining table. The infant would lie supine, with his/her head toward the doctor and facing toward the ceiling. An assistant may have to gently hold the child's hands if the child grasps for the instrument. General principle: The less force used in holding an infant, the better the infant will do. Sometimes a parent can distract a child just long enough for the doctor to take a reading. The doctor uses the same technique he would use on a person in the sitting position.

TECHNIQUE FOR TAKING DUAL PROBE READINGS ON A CHILD

Have the child sit in a booster chair so that the technician can maintain proper posture when making a reading. Adjust the terminals on the dual probe so that they are closer together. Do not use a posture constant on children much younger than eight to ten years of age. Have a CA or parent hold the child's head. See that the erector muscles are relaxed or have even tension. If they are not, it may be due to the head being flexed or rotated to one side or the other. The child should be sitting up tall in a comfortable position, as if he/she is looking at the horizon or at a place ten feet away on the floor. The assistant should also hold the hair out of the way. The fossa reading is taken on a child the same way it is on an adult.

INTERPRETATION OF REPORTS - PATTERNING ACCOLADE SYSTEM III

What Does the Accolade Dual Probe Do?

- It measures the relative difference in temperature between two points.
- It provides evidence to the chiropractor as to when or when not to adjust the patient.

What Does It Not Do?

- It does not find nerve interference, locate pinched nerves, locate vertebra out of position, or locate subluxations.
- It does not tell the chiropractor where to adjust. "Where" is determined by x-ray.

What is an Accolade Graph?

- A bipolar skin temperature differential comparative reading indicating horizontal temperature differences in a single vertical line.

What Can Be Learned from an Accolade Graph?

1. One reading will show a heat line and usually lateral deviations from the heat line which are referred to as "breaks".
2. The second and subsequent graphs can be compared to the first to establish whether a persistent and consistent pattern of breaks is present. i.e., same direction and same level.
3. If a pattern is present, this is evidence of a static unchanging state which indicates that the patient may not be adapting successfully to his environment.
4. Subluxation is a factor which limits an individual's ability to adapt and is a very likely cause of this persistent and consistent graph pattern.

5. If other patterns of findings are present such as leg imbalances, palpation findings, fossa readings, etc., this confirms the presence of unsuccessful adaptation.

6. In determining whether subluxation is the cause of pattern, palpation and other checks must be correlated with x-ray listings and all likely variables must be taken into consideration, such as menstruation, ovulation, fatigue, autotoxicity and sometimes emotional state.

Factors, other than subluxation, that can cause a consistent and persistent difference in temperature at the same segmental level:

1. Scar tissue on one side of the spine.

2. a boil, pimple, wart or mole.

3. An exostosis on one side of the spine.

4. A bent spinous process or enlarged bifurcation.

5. Hair on one side of the spine in a clump.

6. Hair growing in different directions on each side.

7. A deep crevice or wrinkle in the skin.

8. Sunburn around the top of a collar on one side.

Other variables:

1. Drugs may increase or decrease intensity.

2. Poor glide technique.

3. Hair improperly arranged interfering with heat reading.

4. Allow time for patient to assume a rested state of basal metabolic rate and to adapt to clinic environment.

5. Skin hyperemia caused by touching or rubbing the glide area previous to the reading.

6. Irritation of skin after adjustment in some cases may influence post check.

7. Lack of concentration leads to poor technique.

8. Begin and end glide at same place each time.

9. Patient should not talk during the glide and neither should the chiropractor as this distracts you from your work.

What is an Accolade Report?

An accolade "report" is the printout produced by the printer on a single patient visit. It is called a report because of the quantity of information provided which is as follows:

a. "Pre" or "Post" check.

b. Date and time (automatically included on every printout).

c. Area of spine being read: cervical, full spine, thoracic, lumbar, infant spine, spot check.

d. Patient's identification number.

e. Actual temperatures along both sides of the spine in whole Fahrenheit degrees.

f. Differences (in graph form) between the temperatures on both sides of the spine in tenths of degrees.

g. Temperature at right and left mastoid-mandibular fossae in tenths of degrees.

h. Temperature difference between the left and right mastoid- mandibular fossae in tenths of degrees shown numerically and with bar graph.

i. Temperature at right and left PSI joint in tenths of degrees.

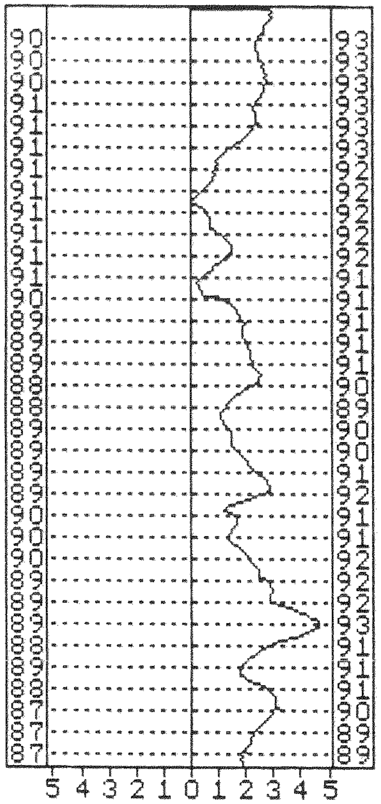
j. Temperature difference between left and right PSI joints in tenths of degrees and shown numerically and with bar graph.

k. Listings of all adjustments given.

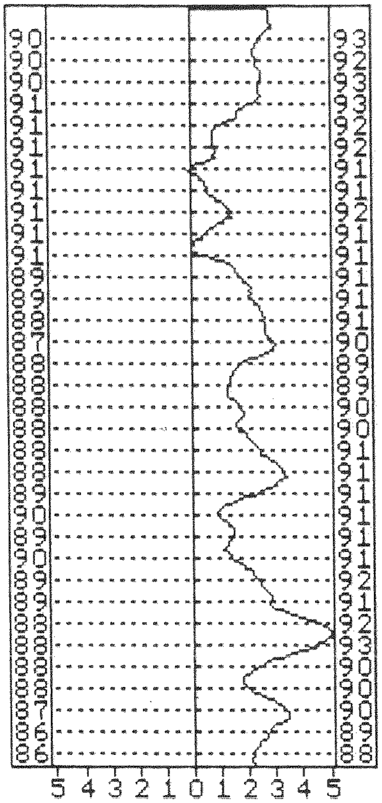
What is the difference between an accolade report and an accolade graph (or graph reading)?

A "report" consists of all information listed from a. through k. A "graph" refers to item f. in particular

A chiropractor is provided the option of excluding some items from the report unnecessary to his *particular* package. The PSI joint reading (items i. and j.) is infrequently used in chiropractic analysis but is an available option.



PATIENT ID #:
PRE-FULL SPINE
02/07/91 10:52 AM



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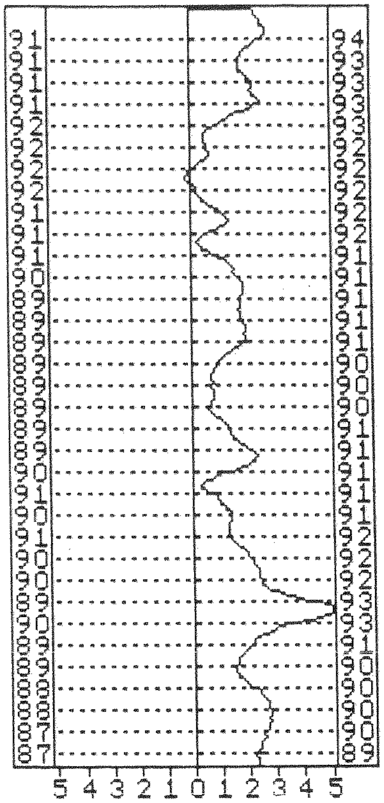
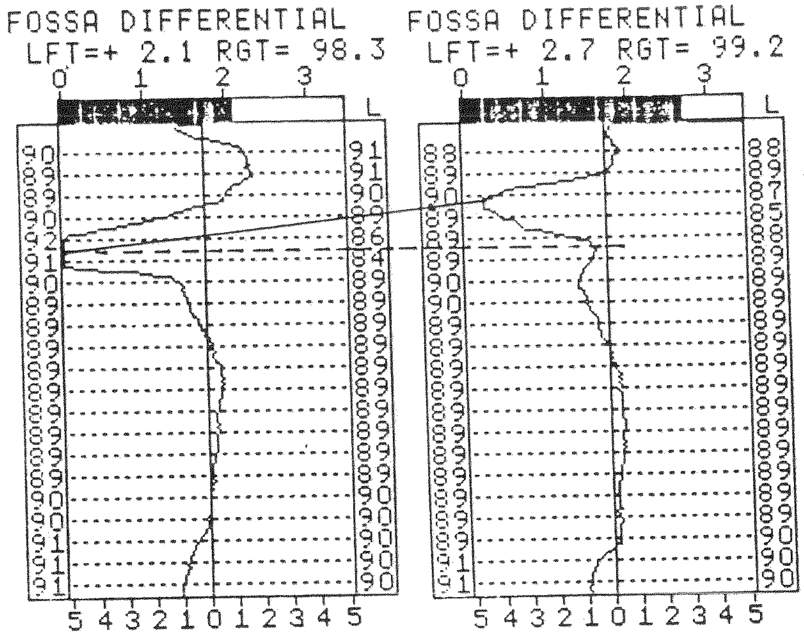


PATIENT ID #:
PRE-FULL SPINE
02/07/91 10:55 AM

TECHNIC CONSIDERATIONS

PROBLEM

INCONSISTENT BREAK LEVELS

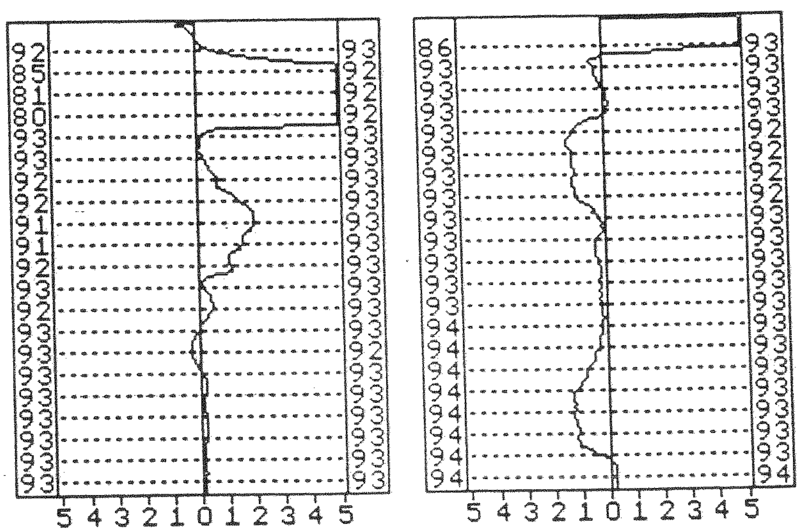


POSSIBLE CAUSE

- INSTRUMENT ANGLE VARIED
- INCONSISTENT GLIDE TRAVEL RATE

PROBLEM

LARGE TECHNIC SWINGS

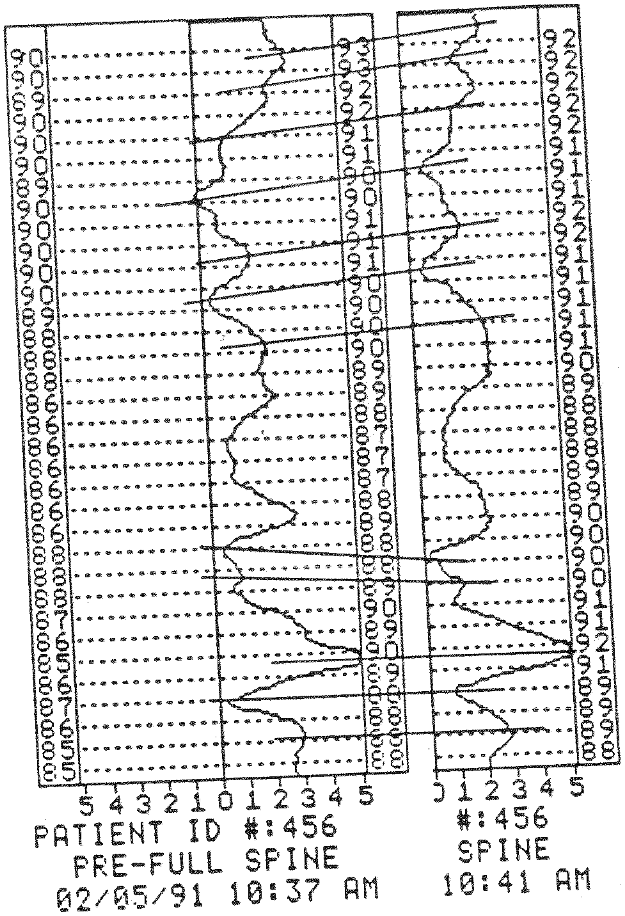


POSSIBLE CAUSE

HAIR UNDER TERMINAL

TECHNIC CONSIDERATIONS

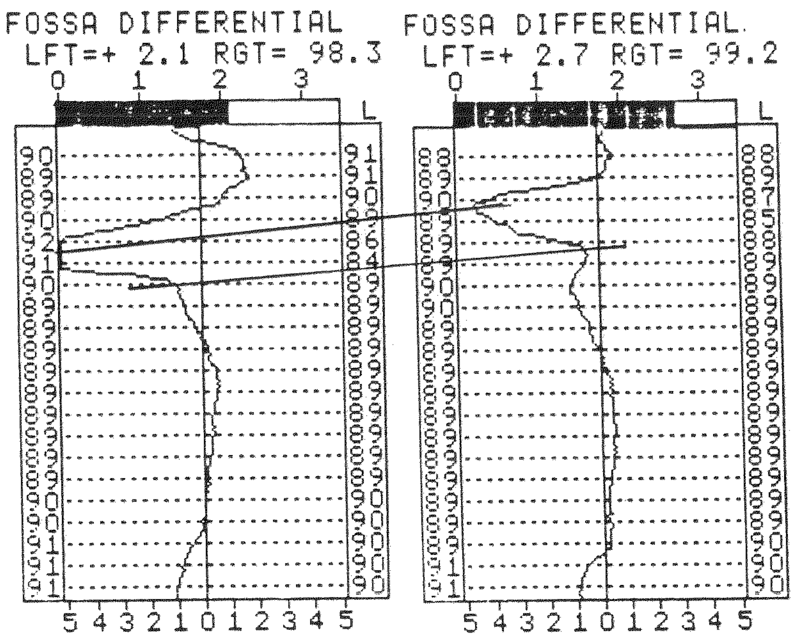
ALL OTHER FACTORS BEING CORRECT, NOTICE HOW INCONSISTENT RATES OF GLIDE TRAVEL WILL RAISE OR LOWER THE LEVEL AT WHICH PATTERN BREAKS WILL OCCUR. ALTHOUGH PATTERN IS OBVIOUS IN THE FOLLOWING GRAPHS, TECHNICALLY PATTERN BREAKS MUST OCCUR IN THE SAME DIRECTION AND AT THE SAME LEVEL.

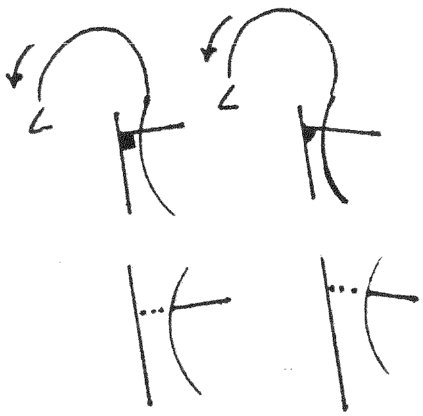


ALL OTHER FACTORS BEING CONSISTENT THE RATE OF GLIDE TRAVEL MAY VARY FROM ONE GRAPH TO ANOTHER SO LONG AS THE GLIDE RATE REMAINS THE SAME FROM START TO FINISH ON ANY SINGLE GLIDE.

TECHNIC CONSIDERATIONS

THE BREAKS ARE NOT LEVEL. THEY SHOULD BE.
WHAT TECHNIC PROBLEM PRODUCED THIS INCONSISTENCY?





IF THE ANGLE OF THE INSTRUMENT IS NOT CONSISTANT FROM ONE GRAPH TO THE NEXT THE LEVEL OF THE BREAKS WILL LIKEWISE BE INCONSISTENT.

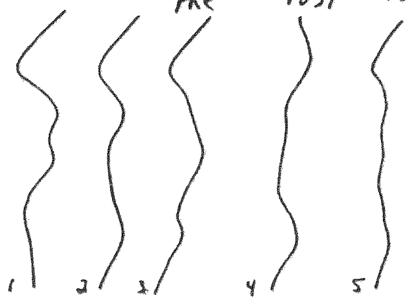
A GOOD RECOMMENDATION WOULD BE TO KEEP THE INSTRUMENT PERPENDICULAR TO THE SPINE. (NOT THE SKIN)

KEEP IN MIND THAT WHEN THE CHIN IS TUCKED FOR CERVICAL READINGS THE LORDOTIC CURVE STRAIGHTENS.

ESTABLISH CONSTANTS! ELIMINATE VARIABLES!

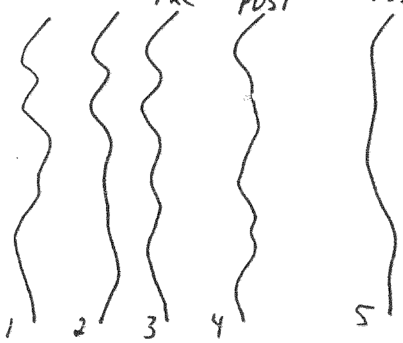
TOTAL CONSTANTS BEFORE ADJUSTMENT?			AFTER?	SHOULD YOU READJUST AFTER #5?
IN LEGCHECK	GRAPH	BOTH		

PRE — 30 MIN. POST — 24 HR. POST



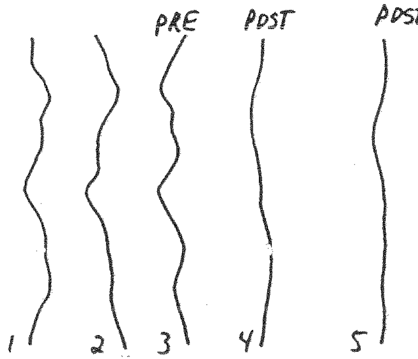
① ½ RPP-LCS
② ½ RPP-LCS
③ ½ RPP-LCS
④ ½ RPP-BAL
⑤ ½ RPP-LCS

PRE — 30 MIN. POST — 24 HR. POST



① ½ RPP-LCS
② ¼ RPP-LCS
③ ¾ RPP-LCS
④ ⅛ RPP-BAL
⑤ 0 BAL-LCS

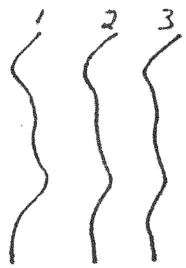
PRE — 30 MIN. POST — 24 HR. POST



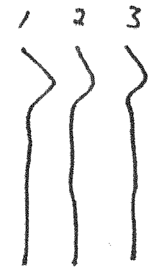
① ½ RPB-LCS
② ½ LPN-RCS
③ ¼ RPN-LCS
④ 0 BAL-BAL
⑤ 0 BAL-BAL

SPECIFIC PATTERN

A.
1. ½ LPP-RCS
2. ½ LPP-RCS
3. ½ LPP-RCS

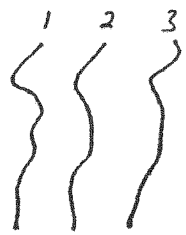


B.
1. ¼ RPN-LCS
2. ¼ RPN-LCS
3. ¼ RPN-LCS



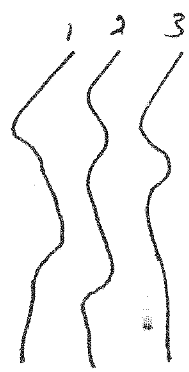
LESS SPECIFIC PATTERN

A.
1. ½ LPN-RCS+
2. ¼ LPN-RCS SLIGHT
3. ¾ LPN-RCS

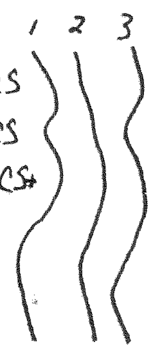


GENERAL PATTERN

A.
1. ½ LPP-RCS
2. ¾ RPN-RCS
3. ¼ LPN-LCS

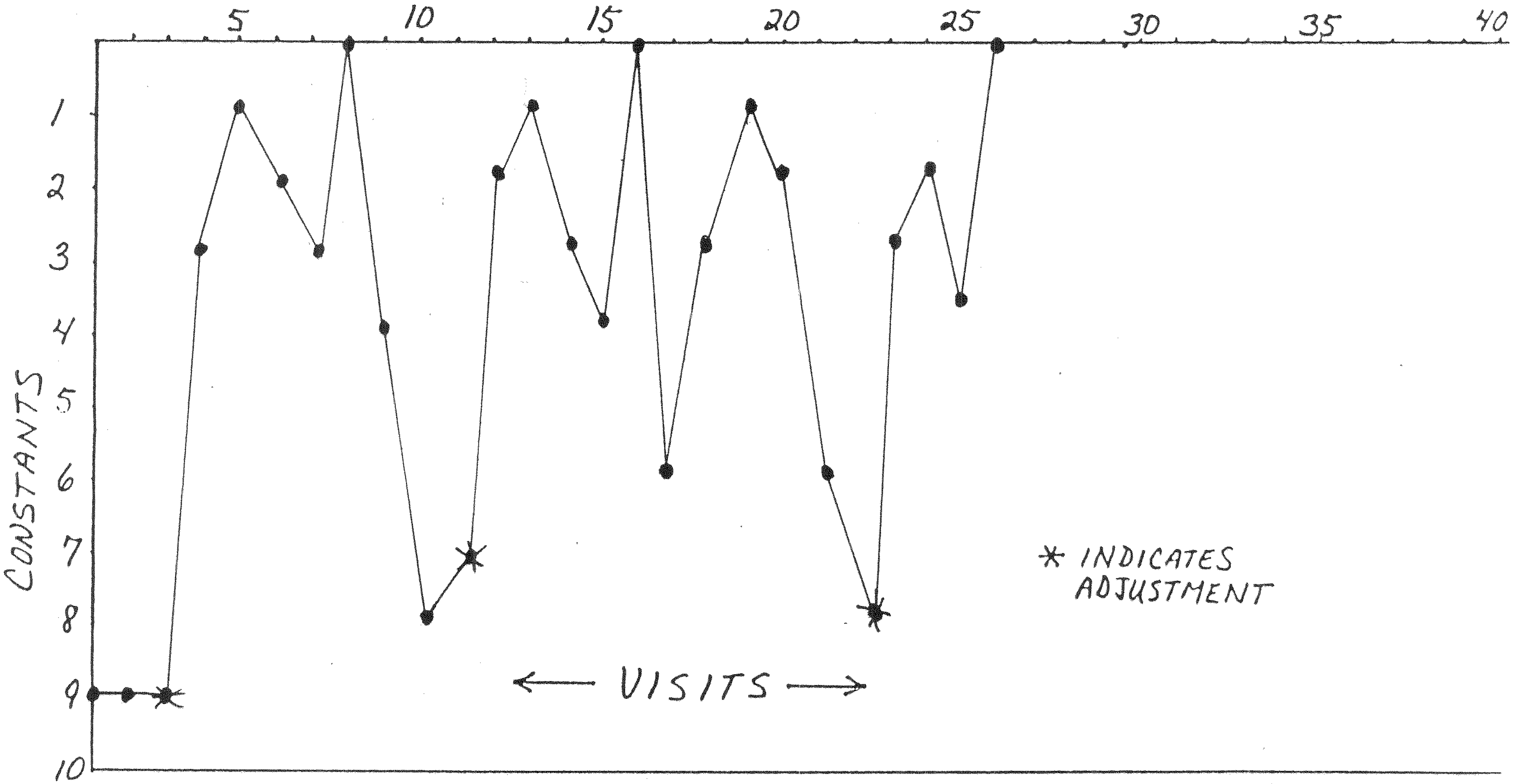


B.
1. ¼ LPP-RCS
2. ¼ RPP-RCS
3. ½ RPP-RCS+



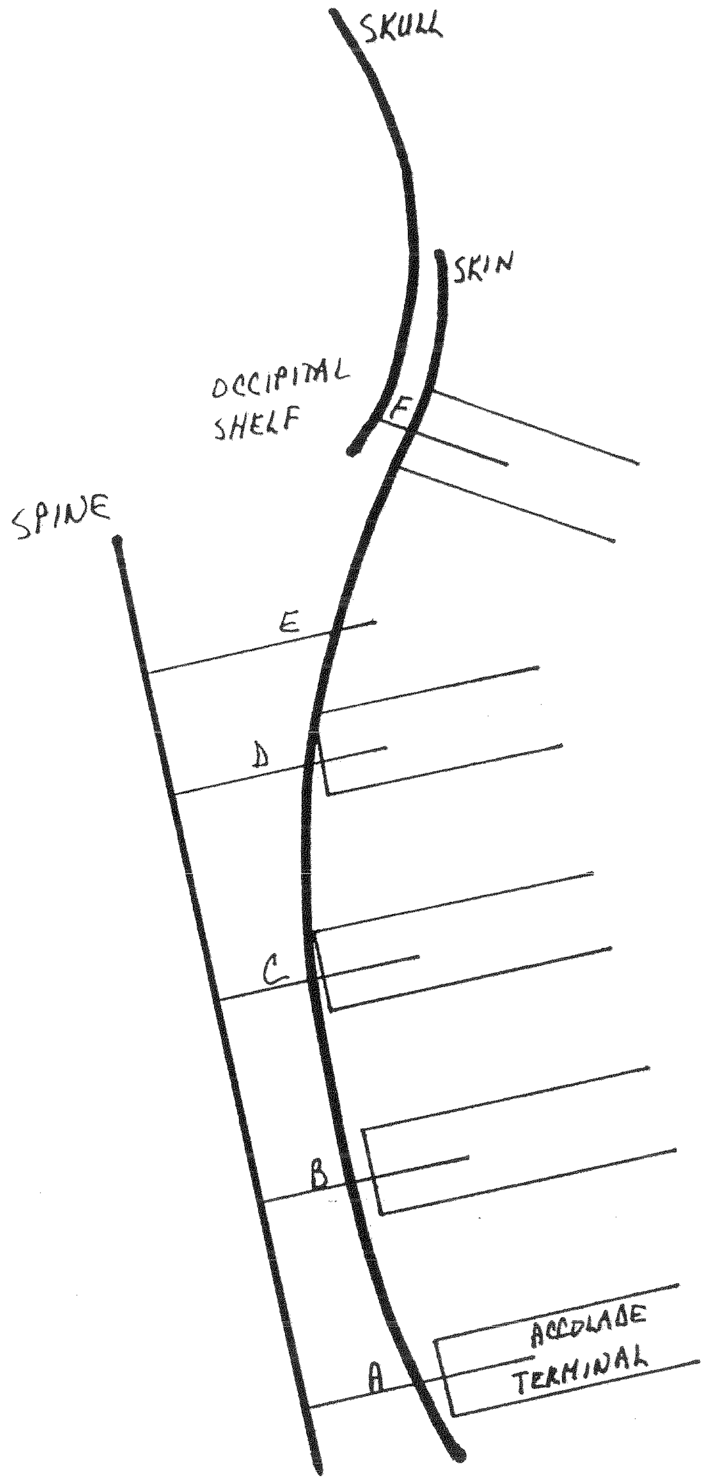
NAME PATIENT "A"
DATE
AGE 45

PROGRESS CHART



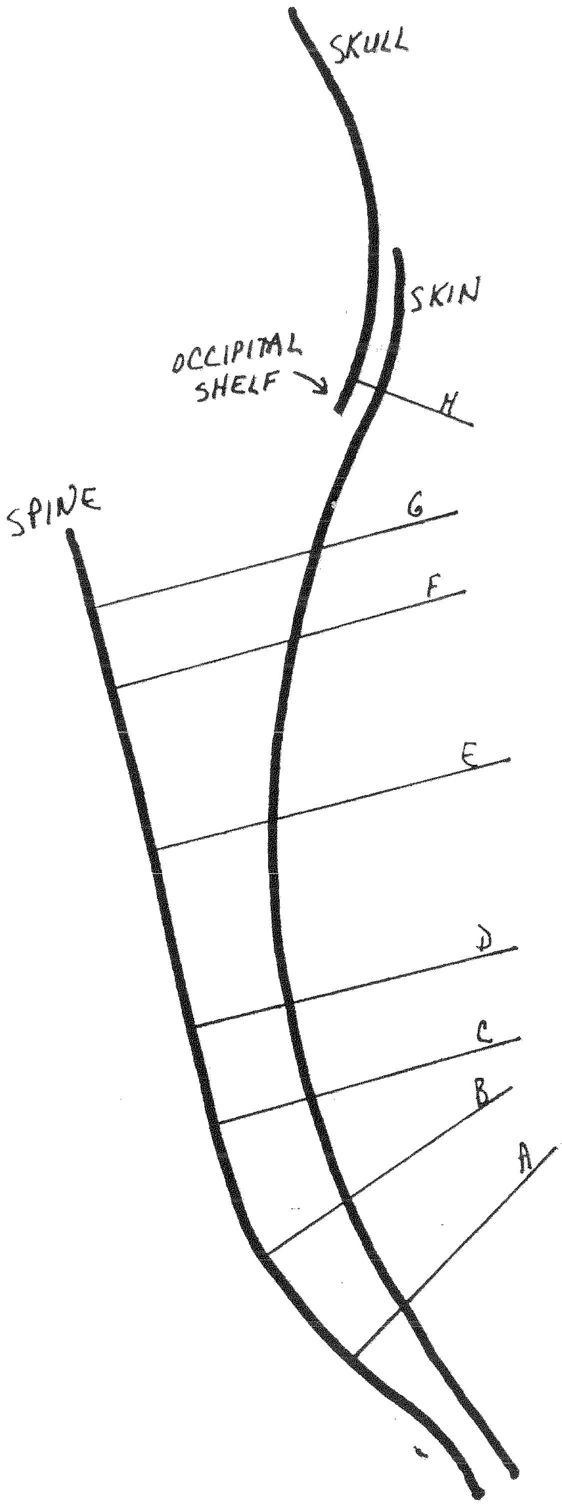
EXAMPLE A

PROPER ACCOLADE ANGLE
DURING CERVICAL GLIDE



EXAMPLE B

PROPER ACCOLADE ANGLE
DURING A CERVICAL GLIDE



KYPHOTIC CURVE
- LOWER NECK

Miscellaneous Thermography Articles

Dynamic Chiropractic
December 4, 1992, Volume 10, Issue 25

Protocols and Standards for Thermography Imaging, Part II

The Academy of Neuromuscular Thermography/American Academy of Thermology Guidelines and Indications for Neuromuscular Thermography

"On September 22, 1988, the Executive Committee of the Academy of Neuromuscular Thermography (ANMT) approved the guidelines and indications for neuromuscular thermographic exams as set forth below." (Since then the ANMT has merged with the American Academy of Thermology.)

"The indications below are intended as guidelines for the physicians contemplating ordering a neuromuscular thermogram. It should be clearly understood that the physician should obtain the thermogram as he deems necessary if prudent clinical judgment, based on history, physical examination, and clinical course, so indicate.

"Follow-up or repeat thermograms on the same patient should only be done for good clinical reasons, i.e., persistent treatment failure, or to monitor the effects of treatment when tangible benefit can be expected from the examination.

"The following are uses of neuromuscular thermography when anatomic tests (CT, myelogram, and/or MRI) have not been performed, or are negative:

1. To evaluate sensory/autonomic peripheral nerve injury
2. To evaluate for the possibility of reflex sympathetic dystrophy or other autonomic dystrophy and to follow the treatment of same.
3. To evaluate and monitor soft tissue injury, e.g., tendinitis, trigger points, compartment syndromes, etc.
4. Early diagnosis of possible extremity stress fracture.
5. Differentiate, document, and monitor any injury that does not respond to clinical treatment.
6. To identify occult soft tissue conditions or symptom magnification.
7. To evaluate facial pain when other tests are unrevealing.

If the tests of neurophysiology (thermogram and EKG) have been done first, and are negative, the need for anatomic testing may be reconsidered.

"The following are uses of neuromuscular thermography when anatomic tests (CT, Myelogram, and/or MRI) have been performed and are positive:

1. To evaluate the significance of positive findings when the physical exam or history do not concur, i.e., a lesion may be present anatomically, but have no significance physiologically.
2. To look for hidden or missed lesions. Examples:

a. The CT may be abnormal at one level, but the thermogram may show abnormality at this and an adjacent level, leading the physician to order another test, such as a myelogram or MRI, which may uncover a second lesion.

b. The patient may have nerve root dysfunction and reflex sympathetic dystrophy, with only one set of presenting symptoms.

c. The patient may have both nerve problems (disc), and trigger points or facet joint problems, with overlapping or masking of symptoms. Under these circumstances, history and/or symptoms can be masked by the predominant lesion.

3. To evaluate the significance of equivocal or mild disc bulges or herniations on myelograms, CT or MRI scans if clinically indicated.

4. To evaluate for the possibility of reflex sympathetic dystrophy, and to follow treatment of same if clinically indicated.

5. Differentiate, document, and monitor any injury that does not respond to clinical treatment."

The ICA has recently formed their own council on diagnostic imaging, but has not yet published standards and protocols from their college of thermography.

In an article published by Dr. Susan Vlasuk in the ACA Council on Diagnostic Imaging journal, the overall value of thermography was clearly presented. Indications for the use of this imaging test included:

1. Evaluation for reflex sympathetic dysfunction.

2, Differentiation between neurologic and myofascial causation of persistent pain.

3. Differentiation between neurological and vascular involvement.

4. Differentiation between radicular compartment and peripheral neuropathy.

5. Evaluation for myofascial trigger points.

6. Evaluation for thoracic outlet syndrome.

7. Evaluation of physiological significance of minor anatomic findings noted on CT or MRI.

8. Evaluation in cases of clinically suspected radiculopathy when CT or MRI is negative.

9. Chronic pain of undetermined origin particularly when the clinical picture has few or no positive orthopedic or neurologic

findings.

10. Evaluation of chronic or severe headache.

11. Differentiation between primary joint dysfunction (sprain capsulitis, arthritis) and neurologic or myofascial disorders.

12. Evaluation of chronic non-responsive pain.

13. Evaluation for reflex sympathetic dystrophy.

14. Evaluation of sports injuries.

15. Differentiation of vascular headache, posttraumatic cephalgia, and TMJ syndrome.

Dr. Vlasuk's paper also pointed out that thermography is:

1. A window to the autonomic/sympathetic nervous system.
2. Risk free.
3. Cost effective.
4. Scientifically valid.
5. A monitoring device for treatment efficacy and case management.
6. A test of physiology requiring medical necessity to:

a. formulate/confirm a diagnosis

b. determine type, frequency duration or end of care

c. determine impairment

d. determine prognosis

In the recently published book by Herbert Vear, D.C., Chiropractic Standards of Practice and Quality Care, Dr. Susan Vlasuk wrote a chapter detailing indications, standards, timing and protocols for infrared imaging.

She lists under "Timing for Thermographic Evaluation" that scanning may be done immediately or shortly after injury when there is clinical suspicion of:

1. Reflex sympathetic dysfunction/causalgia or sympathetic maintained pain.

2. Vascular injury.

Thermal imaging may be necessary shortly after injury for evaluation of clinically suspicious segmental or peripheral neuropathy if the treating doctor believes case management is dependent on results. Full protocol thermograms may not be routinely necessary shortly after injury, and should be done after a course of care when the patient is slowly or poorly responsive.

Conclusion

Infrared thermography or high resolution infrared imaging has proven itself over and over again to be a reliable, sensitive tool for documenting pathoneurophysiology and autonomic/sympathetic dysfunction associated with neuromusculoskeletal disease. It is a useful differential diagnostic technique, treatment assessment tool, and prognostic tool. A doctor utilizing thermography in practice should have adequate training in both technique and interpretation and should follow the strict protocols outlined within.

References

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3. Position Paper on Thermography -- Congress of Neurological Surgeons.

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5. Position Paper on Thermography -- American Academy of Pain Management

6. Thermography Protocols -- International Thermographic

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10. Vlasuk S: What good is thermography? Journal of the ACA Council on Diagnostic Imaging, pp 15-16, July 1991.

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Spinal Rounds

Arthur C. Croft, DC, MS, DABCO

Thermography in Soft Tissue Trauma: Does It Have a Place?

Several years ago I advocated the use of thermography in the evaluation of cervical acceleration/deceleration (CAD) trauma. Most of the research available in the early part of the 1980s favored thermography as a noninvasive method of evaluating a number of musculoskeletal disorders. More recently, in the evaluation of certain neuropathies, it was found to compare favorably, in terms of sensitivity and specificity, with CT, MRI, EMG and, in some cases, myelography.1,2 In the final analysis, however, thermography is generally found to be less specific than anatomical tests such as CT or MRI.3,4 Many proponents of thermography have been willing to accept its generally lower specificity on the grounds that it is relatively less expensive, noninvasive, safe, and easy. Some have argued that for certain conditions, such as reflex sympathetic dystrophy (RSD) and myofascitis, thermography offers the only objective means by which to evaluate them.

After sending many hundreds of patients out for thermography, I began to have serious questions about the sensitivity and specificity of thermography. "Recall that sensitivity is a measure of the amount of false negatives (high sensitivity = low false negatives) and specificity is a measure of the amount of false positive (high specificity = low false positive). A test can have high sensitivity and low specificity. Erythrocyte sedimentation rate is an example. It is elevated in dozens of conditions but is specific to none. The specificity of thermography is also significantly lower than its sensitivity.

I began to pour through the literature (medical and chiropractic) in search of the truth. This truth, unfortunately, is as elusive as the Holy Grail. The greatest difficulty lies in the interpretation of the results of what little true research has been done. The majority of these studies suffer from lack of blinding, a lack of control, poor outcome measure, small sample size or misinterpretation of their results. Most authors have addressed the issue of sensitivity and specificity but have made no mention of one measure of a test's worth which would be most meaningful to clinicians -- predictive value. Sensitivity and specificity are limited because they cannot answer two important questions: 1) If the test is abnormal (positive) how likely is it that the individual is diseased? 2) If the test is normal (negative), how likely is it that the individual is disease-free? Predictive value answers these questions.

The magnitude of this problem is illustrated by Hoffman et al.5 who analyzed all of the studies of thermography related to low back pain listed through MEDLINE between 1971 and 1990. From 81 relevant citations, 28 studies could be analyzed for diagnostic-accuracy data (sensitivity and specificity) and method. Diagnostic accuracy varied so significantly that meaningful interpretation was difficult. Twenty-seven of the 28 suffered from major methodological flaws and the only study which was of reasonably high quality found no discriminant value for liquid-crystal thermography. Most of the research in thermography has centered on the low back.

It is important to note that very little research on thermography has been done in our own profession despite the deluge of articles extolling its benefits. These latter authors often base their opinions on assumptions that have not been proven and make statements like, "Clinical thermography is, however, the only reliable method for the detection and monitoring of sensory nerve root irritation, allowing us to document the cause of the pain." In truth, several studies have shown that thermography is not highly reliable for detecting this condition,3,4,6-8 and there are other ways of detecting sensory nerve root irritation, such as dermatomal somatosensory evoked potentials (DSSEP), which, incidentally, are also noninvasive and safe. Whether they are more reliable than thermography is not known.

Some authors state that thermography is "highly precise," alluding to the ability of most infrared units to discriminate fractions of degrees of temperature. While this level of precision is not arguable, this statement is somewhat misleading because the "interpretation" of temperature variations is much less precise. Questions regarding the exact meaning of variations in skin temperature continue to surface. Recently Bennett and Ochoa9 experimented with rats by creating a lesion in the sciatic nerves of one group. A control group had no lesion. Over subsequent days, a pattern characteristic of neuropathic pain developed (as expected) in the experimental group. Analysis by thermography revealed two curious things. Fully 59 percent of the nerve-lesioned rats had normal thermograms and, of the nerve lesioned group with thermographic abnormalities, the paw temperature varied from day to day between hot and cold.

This study raises several serious questions, I think: 1) If relatively serious nerve lesions cause thermographic abnormalities in rats only 41 percent of the time, how often would these thermographic abnormalities be present with less severe nerve trauma? And how would these findings relate to similar mild injuries or trauma seen in man? 2) If the temperature of the skin varied from hot to normal to cold on different days in the abnormal thermogram experimental group of rats, how likely is it that the same phenomenon might be present in humans in some instances? And, if this is the case, would we not need to obtain thermograms on several different days to have a clear picture of the true physiology? And, if it turns out that this is the case (no studies, that I am aware of, have tested this hypothesis in humans) how does this effect our current model of thermographic interpretation? Most authorities, for example, draw different conclusions for hot vs. cold findings. Perhaps it is as pointless to record a thermogram on a single occasion as it is to measure the ocean's tide on only one occasion.

Gerow et al.10 produced a complete sciatic lesion in rats and found a statistically significant thermographic abnormality. It is difficult to extrapolate this data to humans since complete lesions of the sciatic nerve are quite rare. Curiously though, the authors found a return to symmetry in 63 days, raising a question about the possible affect of time on obtaining meaningful and reliable information from thermography.

So What?

This article is not meant as a review of thermography. Space is too limited and such articles are legion. Nor is it intended as a requiem. However, thermography, in my opinion, stands at the virtual escarpment of oblivion. It has failed to weather the storm of critical research and has failed to successfully grab a niche in the management paradigm of soft tissue trauma. Other factors have also helped push it towards its destiny: unscientific and unsubstantiated claims made usually by non-physicians, poorly designed research, the medical-legal connection, and fear of malpractice claims, to name but a few. More and more these days, it seems that rather than the diagnostic nirvana which was promised to us by thermography pundits, all that we have is more questions.

This article is designed to ask the question "Where does thermography fit in?" For example, if a patient comes to us complaining of low back and leg pain (or neck and arm pain), and after some period of treatment, fails to respond, we find ourselves at a common decision tree. Do we, a) send the patient out for an anatomical study such as CT or MRI, which might shed light on our patient's condition, b) send the patient for an electrodiagnostic test such as DSSEP or EMG, or c) send the patient for thermography? Consider the possible scenarios if we choose c: 1) The thermogram is normal. Given the inferior sensitivity and specificity of thermography to MR and CT, and in view of the high rate of malpractice claims arising out of disc herniation, do we feel comfortable continuing our care of this patient? If it turns out that this thermogram was a false negative and our patient later undergoes MRI which reveals a disc herniation, we may find ourselves in the rather unenviable position of explaining our logic in court. (Remember that the AMA's most recent position is that thermography is not useful as a diagnostic test.11 On the other hand, since we are also concerned about the real diagnosis, shouldn't we, given a normal thermogram, order the MRI or CT now? If so, in retrospect then, the thermogram was an unnecessary procedure.

Now consider, 2) the original thermogram is abnormal. Knowing that the thermogram is less specific than MRI or CT, wouldn't we now turn to one of these tests to discover the exact location and nature of the lesion? That would constitute the standard of care in most communities. If so, in retrospect we might just as easily have skipped the thermogram and ordered the equally safe, equally noninvasive, somewhat more expensive, and significantly more sensitive and specific MRI. At least four case studies have been published in our literature which have advocated thermography in musculoskeletal disorders.12-15 In these instances, thermography was performed in conjunction with other diagnostic procedures (CT, MRI, etc.) and provided no unique or special insight into the patient's condition. The authors, however, felt that it was valuable.

Finally, thermography has been advocated as one of the only means of demonstrating myofascial trigger points (TP) and reflex sympathetic dystrophy (RSD).16-20 In both instances, however, the diagnosis is made primarily on clinical grounds. First year chiropractic students generally have little difficulty in finding TPs. Presumably, a hands-on examination would not only yield more TPs than would thermography, but would allow categorization as to active vs. latent varieties. Ash et al.21 have found that irregular curved surfaces may result in artifacts of local increases of temperature virtually the same as those seen with thermography, which are said to represent TPs. The authors filled balloons with water heated to 26oC and discovered that, on thermography, there was a central area 1oC higher than that of the periphery. Whether this type of artifact occurs in clinical thermography is uncertain. In the case of RSD, careful examination will allow this diagnosis to be made in all but the earliest of cases. Since bone involvement is a common complication, serial x-ray and scintigraphy are the methods of choice in following the progress of the disorder. The usefulness of thermography as an adjunct to these procedures is questionable.

Based on the questions raised, I believe that further investigation of thermography will be necessary before we accept it within the management paradigm of soft tissue injury care. It does not, in my opinion, have an important role to play in the diagnostic framework.

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Editor's Note:

For more on personal injury, consult Dr. Croft's video, "Advances in Personal Injury Practice," #V-435, on the Preferred Reading and Viewing List, pages xx.

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Thermography: A New Perspective on an Old Test

Its Value in the Clinical Chiropractic Practice

by Keith Knowitz,DC,DABCO

The presence of thermography in chiropractic practice has diminished over the last several years with the fall in its reimbursement. This is an unfortunate circumstance, because the medical profession and dental profession have embraced thermography. This article will help the reader understand the practice and its value in the chiropractic profession today.

Thermography has been utilized in medical practice since the beginning of medicine itself. In fact, the father of medicine, Hippocrates first used thermography by covering a person in mud, then observing where on the anatomy the mud dried first, thus establishing the site of the pathology.[1] D.D. Palmer used skin surface temperature to aid in diagnosis. He referred to these "hot boxes" by using the dorsal aspect of his hand to locate areas of subluxation.[2]

Fortunately, thermography has become much more sophisticated. It cannot be overstated how valuable its application is in the chiropractic practice. Because it is unique in accurately assessing the physiological state of the patient's sympathetic nervous system, it is an extremely valuable tool in the diagnosis and management of many conditions.

Thermography is used as much in veterinary medicine as in allopathic medicine. It is used in small animal medicine and with equine and large animal practice. One study was used to help diagnose a traumatic coccygeal muscle injury in English Pointers (limber tail). Thermography was used to help diagnose the problem.[3] Another study used heat to detect back pain in horses. The authors of this study stated that "infrared thermographic imaging is the most sensitive objective imaging currently available for the detection of back disease in horses."[4] The author of this study says that this same procedure, or ITI, is a physiologic test that identifies vasomotor tone overlying other superficial tissue factors. Chronic back pain usually involves vasoconstriction at the affected sites.

Diagnosis through heat also has broad applications in medicine and dentistry. Dentists use thermography to assess facial pain, TMJ conditions, implants, root canals, facial nerve injuries and other ailments. Suspected pathology of teeth or gums, which cannot be identified clinically or radiographically, but possibly through ITI, warrants investigation. Neuropathic facial pain is still too often misdiagnosed as tooth pain of dental origin, resulting in unnecessary dental extraction or endodontic therapy.[5] Thermography is used to diagnose TMJ conditions. Computer measurements using facial thermography distinguish normal patient populations from symptomatic patients with acute TMJ pain.[6] Vascular heat emissions can identify facial pain syndromes where other diagnostic tests may not be as beneficial.[7]

Thermography is being used to identify reflex sympathetic dysfunction, and is one of only three diagnostic tests to diagnose this condition. It is shown to be an effective way to monitor near-surface blood flow in the limbs of RSD patients and to be sensitive to changes accompanying painful conditions.[8,9] An article in the Journal of Pain describes the use of infrared thermography (IRT) to analyze sympathetic vasoconstriction in CRPS patients.[10]

For patients experiencing back pain, thermography is being used to assess conditions of the facet joints, discs, myofascial conditions, nociceptive ones and nerve entrapments. A study by the UCSF Department of Radiology concludes that lumbar thermography is a "sensitive examination for detecting those patients who will demonstrate lumbar spinal CT abnormalities, and should play an important role in the diagnostic screening of low back pain syndrome patients."[11]

Thermography is also an important adjunctive diagnostic tool in the assessment of radicular symptoms. In a study comparing IRT to CT, MRI and myelography, IRT was able to accurately assess radicular involvement in all of the involved cases.[12]

The measurement of blood flow through heat is also a test that is specific to its findings. A study in *Spine* (1994) notes that its utilization has relatively high specificity. Symptomatic severity of lumbar radiculopathy may be assessed by measuring the magnitude of thermal deficit in the affected limb.[13]

Thermography is also being used to assess tension headaches, migraine headaches, myofascial syndromes, deep vein thrombosis, bone and joint traumatic injuries and a host of other pain syndromes.[14-19]

Unfortunately, thermography has developed a tarnished reputation in the chiropractic profession. This is due in part to the many practitioners that took advantage of the procedure by overbilling insurance companies, and by the medical profession's portrayal of the value of thermography during the 1980s. Its practice has been directly proportional to the reimbursement for the test. This is unfortunate, because this very important examination has become almost nonexistent in chiropractic. The American College of Neurology has not reversed their decision of the use of thermography in a formal statement, but many practitioners of medicine condone its use for certain types of conditions.

This paper will help demonstrate the use of IRT in modern chiropractic practice and its role in the general medical profession. The validity of this examination has been well-established in literature. Over 30 years of research and **over 4,300 papers in all types of medical journals unequivocally support the efficacy of thermography use as a valid diagnostic test of global neurophysiology.** More than 98 percent of these papers are presented in peer review journals. These include but are not limited to: *Pain Journal; Spine Journal; Journal of the American Medical Association; British Medical Journal; Biomedical Matter Engineering; Anesthesia; Journal of Orofacial Pain; Journal of*

Muscle and Nerve; Journal of Manipulative and Physiological Therapeutics; Archives of Physical Medicine and Rehabilitation; Journal of the American Chiropractic Association; and the Journal of the American Dental Association, to name a few.

There are numerous medical associations who support the use of thermography: the AMA Council on Scientific Affairs; American Academy of Medical Imaging; ACA Council on Diagnostic Imaging; ICA Council on Diagnostic Imaging; American Academy of Pain Management; American Academy of Head, Neck and Facial Pain; and TMJ Orthopedics have all issued statements confirming its efficacy as a valid diagnostic tool.

The medicolegal system allows thermography to be introduced as evidence in court cases, and it is accepted by federal agencies as being valid and useful. **In fact, the Supreme Court of New Jersey ruled that thermography is a valid diagnostic test.** The high court ruled in a unanimous opinion that insurance companies should be required to reimburse claimants for the procedure.

Thermographic imaging is used across the country in prestigious institutions, such as the Johns Hopkins University School of Medicine; Georgetown University of Medicine; Cedars-Sinai Medical Center; Tulane University; and the University of Medicine and Dentistry of New Jersey to name a few. Overseas, it has also been used at the Louis Pasteur Institute in Paris; University of Copenhagen; Verona University Hospital (Italy); and the Yeshiva University Medical School in Tel Aviv. The weight of evidence clearly supports thermography as a valid scientific diagnostic modality.

Although thought of as somewhat controversial in the past, the latest documentation reviewed on thermography is overwhelmingly positive on its efficacy. In fact, the American Chiropractic Association states in its '98-'99 membership guide on page 262:

> High resolution infrared (HRI) Imaging (electronic infrared thermography) is a diagnostic procedure which measures skin surface temperature. It is germane to chiropractic practice in cases where physiologic tests required for the diagnosis of selected neurological and musculoskeletal conditions.
>
> High resolution infrared imaging requires a high level of

operator and interpreter competency and an adherence to established and consistent protocol.

The results of high resolution infrared imaging must be properly correlated with a thorough history, an appropriate clinical examination, and other diagnostic studies/tests as may be indicated by clinical necessity. In this setting, high resolution infrared imaging may be an aid in establishing differentiated diagnosis and in determining a prognosis.

The treating doctor shall certify as to the medical necessity of the thermographic study based upon a diagnostic clinical question and the effect of the results on case management decisions. The referring doctor shall certify to the medical necessity by prescription.

HRI imaging is of value in the diagnostic evaluation of patients when clinical history suggests the presence of one of the following situations:

1. Early diagnosis and monitoring of reflex sympathetic dystrophy syndromes.

2. Evaluation of spinal nerve root/fiber irritation and distal peripheral nerve fiber pathology for detection of sensory/autonomic dysfunction.

3. To evaluate and monitor soft tissue injuries, including segmental dysfunction/subluxation, sprain and myofascial conditions (strains and myofascial pain syndromes) not responding to clinical treatment.

4. To evaluate for the physiological significance of equivocal or minor anatomical findings seen of Myelogram, CT and/or MRI.

5. To evaluate for foreign disorders.

Because of the detailed knowledge, training, and skill level required, thermographic studies ordered, produced or interpreted by chiropractic physicians must be reviewed by only a licensed chiropractor who holds appropriate credentials with regard to knowledge, skill and experience in thermography. Only licensed chiropractors holding such credentials can claim sufficient competence to make valid judgments of comments regarding appropriateness, necessity, or accuracy of thermographic studies, and their relevance to chiropractic case management.[20]

Thermography is clearly a valuable test when used appropriately. Patients should have the right to have this test performed when necessary to aid in diagnosis and management to the same extent as other tests such as MRI, CT, bone scan or x-ray. Its efficacy is clearly evident in the volume of research articles that have been written. I believe that electronic infrared imaging, when used under mandated guidelines and protocols, is an invaluable test to have in the arsenal of diagnostic modalities. It would be a tragedy to lose the ability to utilize this in medical/chiropractic practice.

For more information about the usage in practice and certification to read thermograms, contact the International Thermography Society, Dr. Beth-Ann Loveless at 815-667-4819, or log onto http://www.thermography.org

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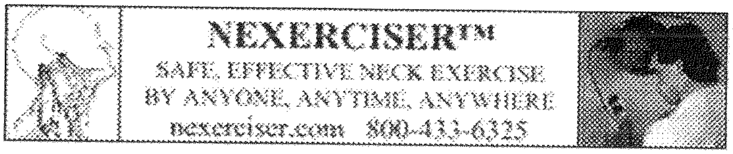

Dynamic Chiropractic
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Thermography

Clinical Utility of Infrared Imaging in Pregnancy

Infrared thermal imaging can be a very useful diagnostic tool for the pregnant patient who suffers from spinal pain with or without radicular complaints. It is especially useful in a patient who has suffered a cervical or spinal acceleration/deceleration injury (whiplash).

Infrared imaging or thermography (IRT) is non-invasive, painless, and risk free. Interside cutaneous temperature differences has been documented by several authors to be very small when temperature differences exceed 0.8oC from right to left homologous parts it is considered abnormal. Other authors have been published in peer reviewed scientific journals on the good reliability, predictive value, sensitivity and specificity of IRT. IRT is reflective of sympathetic dysautonomia which can accompany articular, myofascial, peripheral nerve and nerve root injury. Most of these syndromes can reflect different patterns which makes IRT useful to differentially diagnose articular, myofascial and radicular origins of pain. This then helps the clinician better direct treatment options. Since the pregnant patient cannot have x-rays, MRI, CT or other invasive tests, IRT is well equipped as a diagnostic tool for this population of patients.

In the case of whiplash injuries, where multiple structures can be affected (i.e., disc, muscle, ligament, joint, nerve, etc.), IRT is very helpful. However, as with any test, thermography does not stand alone and must be correlated with the clinical exam findings and patient history, much like x-ray, CT, or MRI.

IRT findings can be utilized in the pregnant patient not only to help formulate a diagnosis but also to help monitor and clinically assess the patient's progress and response to care.

Figures 1,2,3 are scans of a patient who was pregnant and suffered from low back and leg pain. As the scans show, there are thermal asymmetries in the lower extremities suggestive of nerve fiber dysfunction secondary to a disc protrusion. Subsequently, a lumbar CAT scan disclosed an L4/L5 disc herniation.

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****

Figures 4,5,6 are thermography scans of a pregnant patient who also complained of back and leg pain. The scans display relative thermal symmetry. Subsequent to delivery, a lumbar MRI scan was essentially normal.

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Conclusion

Thermography is a useful noninvasive, risk free, pain free, diagnostic took for the pregnant patient who suffers from spinal pain and/or radiculopathy.

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Dynamic Chiropractic
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Thermography

Thermography in Clinical Practice: The Rebuttal

Editor's note: We've received a mountain of mail reacting to Dr. Croft's May 7th column in Dynamic Chiropractic, "Thermography in Soft Tissue Trauma: Does It Have a Place?" While we can't print all those letters (we did print one in the 6-18 issue), our columnist on thermography Dr. BenElyahu has chosen to respond to Dr. Croft's article.

Referring out for many studies and not being pleased with the interpretation is something that happens in all fields. I have referred out for hundreds of EMGs and auditory and visual evoked response testing, whose results often do not match the clinical picture or correlate with MRI/CT findings. Many doctors I speak to have made the same observation. With Dr. Croft's rationale, should we now discontinue the use of those tests as well?

In raising the question of lack of specificity, sensitivity, and most of all Dr. Croft's biggest alleged concerns of predictive value, it is clear that his literature review was very limited in scope and that maybe "drip" would be a better descriptive term than "pour" for his literature review. Twenty-one references are hardly an exhaustive effort. Sensitivity and specificity studies have been published throughout the literature showing the unequivocal value of thermography in clinical practice. Simply saying those studies are all inferior is analogous to the medical profession stating the British study and RAND study were all inferior and do not prove anything about chiropractic efficacy.

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Brainstem auditory evoked response and bone scan both have low specificity but are established in clinical practice. Thermography which has proven itself over and over for its specificity of dysautonomia and vasomotor dysfunction, has had an unparalleled double standard of research rigor applied to its acceptance. While scientific scrutiny and questions are healthy for the continued growth of a science, scientific prejudice and bias have no place, but all too often permeate to the disadvantage of the patient's welfare. What I also find interesting is the conspicuous absence of Uematsu's work on low back pain and sciatica where he describes thermography's predictive value of 94.7 percent. Dr. Croft was so interested in predictive value, yet could not find it in his own quoted reference.1 As a matter of fact, it was on page 556. Uematsu's article also points to thermography's specificity for nerve impingement at a very respectable 87.5 percent. It should be noted that this work was published in the Journal of Neurosurgery and passed through their rigorous peer review process.

In another study published in Orthopedics, by Green et al., 80 patients were studied with thermography and myelography.2 Negative thermograms were predictive of negative myelograms in 71 percent. Overall, predictive value was at a very respectable 82 percent. In a study I published in the American Journal of Chiro Medicine, correlating MRI and thermography in cases of cervical disc herniation, we found an 84 percent sensitivity and 78 percent predictive value.3 This was a single blinded study. The paper also described autonomic referred pain zones in the extremities not confluent with dermatomes. Double blinded studies are not possible without the patient knowing the study is being done. Even MRI does not lend itself to double blinded studies.

In an article published in the British Medical Journal by David Eddy of Duke Medical, he stated that in deciding the utility of medical procedures, usually the best evidence is something less than a random controlled trial.5 The metanalysis published by Hoffman, et al., in Spine was nothing more than a statisticians literature review.4 They select their own criteria for exclusion or inclusion, and bias, like in anything else, can enter into the picture. Furthermore, in an article published in Lancet, the very validity of metanalysis is seriously questioned.6 They concluded that "metanalysis is not an exact science and does not provide definitive simple answers to complex clinical problems." In other words, are we to believe the opinions of one paper versus the thousands of articles and studies published in not only the United States literature but the international literature as well? Are we to believe that the peer reviewers of some of the most prestigious journals in the world (i.e., Journal of Neurosurgery, British Journal of Rheumatology, Spine, Physical Medicine, Journal of Orofacial Pain, Journal of Craniomandibular Practice, Physician and Sports Medicine, and JMPT) all overlooked poor quality papers, research and methodology flaws? Hardly! Thermography is utilized without bias or prejudice in many European and Asian countries because of its value in clinical medicine. Are we naive enough to believe that we know more than our international colleagues?

Dr. Croft states that very little research has been done in our profession on thermography, while it is true that there is not a ton of research articles, the same can be said about research on the efficacy of chiropractic care for such notable conditions as whiplash. The same can be said about most medical procedures. It is estimated only 15 percent are supported by solid scientific evidence.5 However, research has been done in this profession on thermography, some of which has been published by me, but conspicuously is absent from his literature search and reference list.7,8 Research by Green, et al., was published in Pain Digest where 28 patients with low back pain and sciatica had MRI, EMG, NCV, SEP, and thermography. Thermography was found to have the highest sensitivity and specificity.18

References are provided by Dr. Croft for the statement that several studies show thermography is not reliable for sensory nerve root irritation. Of course, again no balance or reference to the many studies that state thermography is sensitive for these disorders. It is of interest to note that some of the authors (Aminoff) he referenced, also have published that S-SEP is not that sensitive for sensory nerve dysfunction, yet there are studies in the literature that state SEP is sensitive for that diagnosis.9,10,11

In previously published articles in Dynamic Chiropractic, Dr. Croft extols the benefits of S-SEP as the up and coming test, yet it too is surrounded by controversy in the literature. The author's very own arguments against thermography exist for SEP as well.

What really puzzles me in Dr. Croft's attack on thermography is his attempt to gain support from the work of Bennett and Ochoa on rats. Ochoa and Bennett are major proponents of the use of thermography and have labeled thermography the test of choice to test the integrity of the autonomics. It is also important to realize that people are not rats and that patients rarely if ever present to the doctor with sciatic nerve ligatures. The conclusion of Bennett and Ochoa's work states thermography is useful to help understand skin temperature abnormalities and sympathetic activity in human neuropathic pain.

While Dr. Croft brings up research questions that should be studies in the future, it does not negate the benefits of thermographic data in treating patients and its continued use. To stop its use because of research questions is like telling chiropractors to stop practicing or treating conditions like cervical spine pain or whiplash until the academicians prove chiropractic efficacy for these conditions. In Dr. Croft's discussion of the scenario of a patient with low back and leg pain and where thermography fits in, thermography "pundits" have always stated it to be a complementary test. Thermography, a test of physiology and MRI, a test of structure and morphology, are not competitive nor comparable, but are complementary. Surely, the author understands the difference. Clearly, not all patients with MRI evidence of herniated disc are suffering with pain secondary to that herniated disc.

Studies published by Weisel and others showed that CT/MRI have false positive rates of 39-45 percent when studying the normal population. It has a large number of false positives, not to mention some of the false negatives when there are annular tears or internal disc disruption which MRI cannot pick up yet. Yes, MRI is very important in clinical practice but is not a panacea and neither is thermography or electrodiagnostic studies. So clearly CT/MRI cannot stand alone; it must be coupled with clinical findings and neurophysiologic testing. No test should stand alone for that matter.

So do we order an EMG which is invasive, painful, poorly tolerated, and has a sensitivity on the order of 70-80 percent? Do we order a thermography which has equal sensitivity to EMG, is noninvasive, painless, and well tolerated by the patient? Thermography can depict and differentiate articular patterns, neurologic patterns, and myofascial patterns, with the common denominator of autonomic dysfunction. Or do we order both, since EMG can sometimes document motor nerve dysfunction and thermography documents the autonomic component. Let us not forget that there are three components to the spinal nerve: sensory, autonomic , and motor (SAM). It's illogical that only sensory and motor are important to document and the autonomic components are not. Many patients who are failed back surgery cases may not be have been had the clinician done a thermogram and found that perhaps the patient's pain was of articular (S1, facets) or myofascial origin.

While this has not been published anywhere, and is my opinion, I believe it to be true, based on patients of mine who were told to have surgery due to positive MRI/CT/EMG and myelography, yet had negative thermograms for radiculopathy. These patient's myofascial and articular problems were treated conservatively, medically and chiropractically, and got better. Dr. Croft's concern that the AMA does not approve of thermography is not entirely true. While it is true that the Council on Scientific Affairs of the AMA released a favorable report on thermography in 1987, the AMA's House of Delegates has asked the Council to reconsider its opinion. I do not believe the political flux of the AMA should be our concern. If you recall the AMA was found guilty of conspiracy to limit and eliminate the chiropractic profession.

It should also be noted that both ACA and ICA Councils on diagnostic imaging have colleges of thermography and have very favorable position statements for the use of thermography in clinical chiropractic practice. Patients complaining of chronic low back and leg pain may have radiculopathy, reflex sympathetic dysfunction (RSD) or articular dysfunction. Some of the above mentioned conditions can co-exist and thermography in my significant experience has been helpful in revealing these patterns.16

Often the primary diagnosis is so predominant symptomatic that secondary diagnoses are overlooked or missed, and may be responsible for chronic pain syndromes. Thermal imaging often helps identify these secondary etiologies of pain. In the case of RSD, it is unfortunate and apparent, Dr. Croft does not fully comprehend the severity of the condition. It is when RSD is in its earliest stage that confirmative diagnosis is mandatory for successful management and prevention of a lifelong disability. In my years of clinical practice, I have seen so many cases that not only did MDs miss the RSD diagnosis, but so did DCs, and what was left was a crippled patient with Stage III RSD. Bone complication occurs late in the second stage to third stage, and it is just that, a complication worth trying to prevent. Serial x-rays and scintigraphy are not the method of choice. Bone scans are nonspecific and often reveal abnormalities on the normal side.

In an article published in the British Journal of Rheumatology, thermography was found to be definitively helpful, especially with dynamic cold stressor testing.17 Why would any caring doctor subject a patient to multiple ionizing radiation x-rays or bone scans when a noninvasive, pain free, very tolerable test like thermography can be done and is much more sensitive? Why would any caring doctor allow the conditions to progress and watch and wait for the bone osteoporotic changes to occur by doing serial x-rays, which is an irreversible and a preventable event I might add.

I find it interesting that Dr. Croft would advocate the use of bone scans for RSD in one sentence and then just "clinical grounds" in another. The usefulness of thermography is not questionable to those who understand RSD and have seen and diagnosed RSD. It is not questionable to the pain clinics in the nation such as the Mayo Clinic, Mass General Hospital, Johns Hopkins, Cleveland Clinic, Mt. Sinai School of Medicine, NYU School of Medicine, among many others that use thermography in the diagnosis and management of RSD. The magnitude of the problem was recently discussed in a new book authored by Dr. Hooshmand, a neurologist, who treats RSD.19 His research found that thermography increased the diagnosis of RSD by four times; in other words, without thermography, it has been often misdiagnosed. Many patients could have been saved from lifelong disabilities if RSD had been diagnosed early with the help of thermography.

Thermography measures surface temperature which is reflective of the autonomics, specifically the sympathetics. It is an absolute truth like a thermometer measuring core body temperature. If thermography is unscientific so is the thermometer. No one disputes the validity of fever in disease, we all search for the etiology of the fever and do not say it is a false positive if we cannot readily identify its etiology. "Scientific, unsubstantiated," sounds like the AMA and its Health Fraud Chairman Barrett discussing the merits and benefits of chiropractic care; we all know how unbiased and objective he is.

Thermography, like chiropractic, is a true science, both need ongoing research, both need to be understood better by others who do not understand it or use it, and both will survive and continue to be utilized no matter how hard its political detractors attempt to discredit it.

In conclusion, I will quote Themas Laborcle, MD, who published an article in Pain:

"Despite scientific validation and proven use in a clinical setting, neuromuscular thermography has met with much criticism and skepticism. The emotional and political controversy surrounding thermography has distracted the medical community to such an extent that the real issue of utmost importance to the practicing physician is often ignored. The basic scientific foundation of medicine should preclude the prejudicial influence of emotion, politics, and anecdotes. Scientific investigation for more than two decades now have demonstrated that neuromuscular thermography is of proven value in the clinical evaluation of various pain disorders and neuromuscular conditions including radicular pathology."20

Thermography has a vital role to play in clinical medicine and clinical chiropractic. It should continue to be employed as a diagnostic tool and should continue to be researched as should all medical/chiropractic procedures.

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Protocols and Standards for Thermography Imaging -- Part I

Infrared thermography is a valuable diagnostic imaging modality available to the practicing chiropractor. Thermography is a test of neurophysiology. Cutaneous infrared heat emission is a function of the underlying sympathetic control and local chemical mediators. Thermal imaging is sensitive to detecting abnormalities due to myofascial disorders, spinal nerve dysfunction, peripheral nerve dysfunction, and scleratogenous dysfunction. It is an excellent tool to help the clinician differentially diagnose myofascial, neurologic, and articular sources of pain, as well as temporomandibular joint (TMJ) syndrome and reflex sympathetic dystrophy.

The literature is replete with scientific studies documenting the sensitivity, specificity, predictive value, interexaminer reliability, and clinical efficacy of thermography in clinical practice. Thermography has been considered a favorable technique and diagnostic imaging tool by such groups as the AMA Council on Scientific Affairs, ACA Council on Diagnostic Imaging, ICA Council on Diagnostic Imaging, American Academy of Pain Management, American Academy of Physical Medicine and Rehabilitation, Congress of Neurological Surgeons, and the American Academy of Head, Neck, Facial Pain, and TMJ Orthopedics.

However, infrared thermography is not without controversy. There has been a handful of papers that have criticized thermography's role in neuromusculoskeletal medicine, due to what the authors describe as poor specificity and lack of many controlled double-blinded studies. These authors who, in my opinion, were on a mission to discredit thermography, improperly defined their definition of specificity and ignored the 6,000-7,000 articles published in the world scientific literature that included many blinded studies, specificity/sensitivity studies, and good statistically significant articles published in well-respected peer reviewed journals.

Despite the detractors, thermography is still a helpful, useful tool to the practicing clinician. It stands alone in the diagnosis of Reflex Sympathetic Dystrophy Syndrome and is much more sensitive than bone scan. Thermography is useful in the sports injury practice, as well as for personal injury assessment in practices where soft-tissue injuries are common and need to be documented. It is useful in the orthopedic/neurological specialty practices as a differential diagnostic tool and it is useful in the subluxation-based practice since it documents pathoneurophysiology.

Standards and protocols of infrared imaging have been previously published by the American Chiropractic College of Thermography (ACA), the International Thermographic Society (ITS), the American Academy of Thermology (AAT) and the American Academy of Medical Infrared Imaging (AAMII), (formerly the American Herschel Society). The purpose of this paper is to familiarize the chiropractic profession with the many academies and colleges of thermography in the profession and the protocols and standards associated with infrared imaging. This is just a review paper and should not be construed as a "standards" document, in and of itself.

The following is a 1991 policy statement on thermography from the ACA and the Council on Diagnostic Imaging.

"High resolution infrared (HRI) imaging (electronic infrared thermography) is a diagnostic procedure which measures skin surface temperature. It is germane to chiropractic practice in cases where a physiologic test is required for the diagnosis of selected neurological and musculoskeletal conditions.

"High resolution infrared imaging requires a high level of operator and interpreter competency and an adherence to established and consistent protocol.

"The results of high resolution infrared imaging must be properly correlated with a thorough history; an appropriate clinical examination and other diagnostic studies/tests as may be indicted by clinical necessity. In this setting, high resolution infrared imaging may be an aid in establishing a differentiated diagnosis and in determining a prognosis.

"This policy statement, approved by the ACA House of Delegates on June 13, 1991, supersedes all previous thermography policy statements from the American Chiropractic College of Thermology and ACA Council on Diagnostic Imaging."

Guidelines for Thermography in Chiropractic Practice

Thermographic Description

"Thermography is a diagnostic procedure which measures skin surface temperature distribution."

Thermographic Policy

"This diagnostic imaging procedure is germane to chiropractic practice in cases where a physiologic test is required. High resolution infrared (HRI) imaging is a useful procedure for the diagnosis of selected neurological and musculoskeletal conditions."

Guidelines for Determining Medical Necessity

"The treating doctor shall certify as to the medical necessity of the thermographic study based upon a diagnostic clinical question and the effect of the results on case management decisions. The referring doctor shall certify to the medical necessity by prescription.

"HRI imaging is a value in the diagnostic evaluation of patients when the clinical history suggests the presence of one of the following situations:

1. "Early diagnosis and monitoring of reflex sympathetic dystrophy syndromes.
2. "Evaluation of spinal nerve root/fiber irritation and distal peripheral nerve fiber pathology for detection of sensory autonomic dysfunction.
3. "To evaluate and monitor soft tissue injuries, including

segmental dysfunction/subluxation, sprain, and myofascial conditions (strains and myofascial pain syndromes) not responding to clinical treatment.

4. "To evaluate for the physiological significance of equivocal or minor anatomical findings seen on myelograms, CT and/or MRI.

5. "To evaluate for feigned disorders (symptom magnification)."

Utilization Review

"Because of the detailed knowledge, training, and skill level required, thermographic studies ordered, produced, or interpreted by chiropractic physicians must be reviewed only by a licensed chiropractor who holds appropriate** credentials with regard to knowledge, skill, and experience in thermography. Only licensed chiropractors holding such credentials can claim sufficient competence to make valid judgments or comments regarding appropriateness, necessity or accuracy of thermographic studies, and their relevance in chiropractic case management.

- "Board certified status with the American Board of Thermography or other national thermographic certifying board which restricts its examination to candidates who have completed a prescribed postgraduate syllabus program offered by a chiropractic college having status with a national chiropractic accrediting agency approved by the United States Department of Education (USDE)."

II American Academy of Medical Infrared Imaging

Considerations Must Be Given to the Following:

1. "Environmental Room Factors: Temperature and humidity should be maintained during the procedure. Ideally a 69o F, (Ring, et al.) low humidity, minimal draft, non-reflective walls room is needed. The instrument being used should be capable of compensating for temperature fluctuations in the examining room on line. No heat source other than the patient should be in the optical path of the imaging instrument.

2. "Mechanical Stimulation of the patient's nervous system must be minimized. No physiotherapy, TENS or testing such as

EMG/nerve conduction that day. No braces, splints or use of powder, creams or lotions applied. No sunburn.

3. "Medications: Care must be taken to avoid the influence of vasoactive substances in amounts sufficient to curb autonomic skin responses. No nicotine or coffee in large quantities.
4. "Skin Equilibration: The rate of change of skin temperature to the examining room temperature should come to a relative steady state prior to final imaging.

"(Suggested: The patient should disrobe and remain in the controlled (20o C) examining room for approximately 15-20 minutes prior to the thermogram being made.

5. "Instrumentation: Used for medical diagnostic thermography should, as a minimum, be able to detect and measure temperature differences of 0.1o C over the temperature ranges of the human body. Accuracy, stability, and repeatability of the instrument is a must.

6. "A minimum of one set of entire skin surface images shall be accomplished."

III. International Thermographic Society

Definition

"Clinical thermography is a non-invasive, diagnostic imaging procedure involving the detection and recording of a patient's skin surface thermal patterns, using instruments which can provide visual and quantitative documentation of these temperature measurements. The interpretation of these temperatures and thermal patterns can be important in the development of diagnostic impression.

"Thermography is appropriate and germane to any health care practice whenever the treating physician feels a physiological imaging test is needed for diagnosis or case management. It provides information about acute as well as chronic conditions and can be useful in distinguishing aggravated from residual tissue injury. Thermography is an imaging technology which provides information on the normal and abnormal functioning of the sensory and sympathetic nervous systems, vascular dysfunction, myofascial trauma, and local inflammatory processes. It may contribute to a diagnosis and patient management by aiding in the determination of the site and degree of lesion, the type of functional disorder, and the prognosis for treatment outcomes, as well as assisting in the determination of the most effective course of treatment through continual case evaluation.

"Thermography is an acceptable analytical procedure which may be performed by a licensed or certified professional or under their supervision, in specific cases which demonstrate adequate clinical justification. However, only a certified professional, holding appropriate credentials with regard to knowledge, skill, and exercise in thermography may interpret the results."

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Protocol for Clinical Thermography

Definition

Clinical thermography is a non-invasive, diagnostic imaging procedure involving the detection and recording of a patient's skin surface thermal patterns, using instruments which can provide visual and quantitative documentation of these temperature measurements. The interpretation of these temperatures and thermal patterns can be important in the development of a diagnostic impression.

Thermography is appropriate and germane to any health care practice whenever the treating physician feels a physiological imaging test is needed for diagnosis or case management. It provides information about acute as well as chronic conditions and can be useful in distinguishing aggravated from residual tissue injury. Thermography is an imaging technology which provides information on the normal and abnormal functioning of the sensory and sympathetic nervous systems, vascular dysfunction, myofascial trauma, and local inflammatory processes. It may contribute to a diagnosis and patient management by aiding in the determination of the site and degree of lesion, the type of functional disorder, and the prognosis for treatment outcomes, as well as assisting the determination of the most effective course of treatment through continual case evaluation.

Thermography is an acceptable analytical procedure which may be performed by a licensed or certified professional or under their direct supervision in specific cases which demonstrate adequate clinical justification. However, only a certified professional, holding appropriate credentials with regard to knowledge, skill and

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experience in thermography may interpret the results.

Currently there are two recognized methods of thermographic imaging: infrared thermography (IRT) and liquid-crystal thermography (LCT).

Procedures

Clinic: The temperature of the room should be such that the patient is neither perspiring nor shivering. The preferred temperature range is between 18-23oC (64-74oF). Room temperature changes during the course of an examination must be gradual, so that all parts of the patient's body can adjust uniformly. The temperature should not vary more than 1oC (1.8oF) during the course of a study. The examining room must have an ambient temperature thermometer to monitor the room temperature.

The thermography room should be carpeted and windows should be covered to prevent excess infrared radiation from entering or escaping the room. Shades or blinds may be adequate for this purpose. Windows and doors should be adequately sealed to prevent drafts, especially in the area where the patient is positioned. Standard fluorescent or thoroughly diffused incandescent lighting is adequate, with fluorescent lighting preferred.

Heat and air conditioning sources should be minimized in the room, and must be kept well away from the patient. Vents should be directed away from the patient and should be thoroughly baffled or turned off during any examination.

Patient: The patient should equilibrate with laboratory ambient conditions for sufficient time to approximate a steady state. Further equilibration results in minimal surface temperature changes with little or no effect on clinical impression. The equilibration period should be at least 15-20 minutes. During the equilibration period, and the subsequent examination, the area to be viewed should remain completely uncovered of clothing, jewelry or gowning. A loose gown may be worn, provided that it does not restrict air flow for equilibration and does not constrict or irritate the skin surface in any way which would produce an artifactual result on the thermogram. Special gowning procedures, specific to the clinic or examination, may be required and are permitted, as long as the above stipulations are observed.

The patient may be provided with instructions intended to reduce the likelihood of artifacts or inconclusive thermography. Make-up, vasoactive drugs, and therapy which will produce altered cutaneous blood flow or emissivity are discouraged or restricted for appropriate periods prior to thermography.

Equipment: Liquid-crystal thermography employs a range of interchangeable detector "screens" or "pillows" which are impregnated with cholesteric methylester derivatives and change color as a function of their temperature. The thermal precision of the equipment is generally within 0.2oC -- adequate for clinical interpretation.

Electronic telethermography equipment scans the field-of-view in two dimensions simultaneously via an infrared detector. Temperature repeatability and precision of O.1oC or better is standard for electronic thermography equipment. Absolute temperature measurements are generally not required for a clinical diagnostic impression; relative temperatures and temperature differentials are the relevant parameters.

When multiple views are required for bilateral equivalent areas, the detector selection or equipment settings must not be altered for the two views.

Electronic studies should be performed with the scanner perpendicular to the surface to be viewed. If other than perpendicular views are required, the angle must be kept exactly the same for comparable, bilateral views.

Documentation: Each thermography series should include all or as many body surfaces as possible, which are relevant to the patient's complaint and symptomatology, along with anatomically and physiologically-related areas. These records (views) should contain as much detail as possible for the equipment type used.

Each thermographic image, captured on archival media, should contain an indication of the anatomic view in the image (if not apparent) along with the following minimal information, either included with the original image or immediately traceable to other archived documents:

1. patient's name or identification code
2. clinical facility name and address 3. name of the professional

rendering the thermographic service 4. date the service was rendered

If a patient identification code is used, it must be clearly identifiable on each archived document, whether a single view, a series, or the patient records in the clinic files.

Examination protocol: A thermographic series consists of one or more images, captured on archival medium, which permit the evaluation of the body surface area relevant to the purpose of the examination. Typically, the entire face and upper body, or the lower body is examined. Specific or limited views may be appropriate in the diagnosis or evaluation of a particular disease, lesion or injury.

A single thermographic series is considered adequate if performed by the thermographer under appropriate conditions outlined elsewhere in this document, and if the findings are negative with respect to the clinical impression. If the examination is performed by a technician or if findings are questionable or positive with regard to the clinical impression, a second series is required to rule out artifacts and confirm the abnormal findings. The second and subsequent studies may be done on succeeding days or even later. Stress studies involving symptom exacerbation, autonomic challenge or alcohol spray may be performed following a first, baseline, thermographic series.

International Thermographic Society

Editor's Note:

The International Thermographic Society (ITS) was chartered in 1983. The ITS describes itself as a sponsor of "educational symposia and research grants to foster a greater understanding of the theory and use of thermography. It was one of the first organizations to publish a protocol for the clinical performance of thermography, and it was responsible for the establishment of the first thermography certifying agency in chiropractic, the American Board of Clinical Thermology."

DC

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Thermal Imaging -- The Paradigm Shift

By William Cockburn, DC, FIACT

Inappropriate Training

Because thermography is a noninvasive (no radiation) procedure, there is no specific legislation or regulatory act under which thermography can be scrutinized. Early thermographic pioneers created entrepreneurial training and certification programs for both physicians and technicians. These programs cultivated a host of new course instructors and a variety of organizations and certifications became available. Some courses offered thermographic certifications to people with no health care training at all. For example, injured workers could qualify under vocational rehabilitation laws to become certified and open their own labs. They found any doctor who was willing to read their studies, and few of those doctors were trained or certified in thermography.

The result was a deluge of poor studies, poor interpretation and varying degrees of protocol standards. This has subtly contributed to much of the so-called "false positive" literature. College-based programs, such as the one I formerly taught, are required to insure the quality of study necessary in today's medical climate.

Inappropriate Equipment

There are essentially two types of thermographic equipment utilized in chiropractic: liquid crystal thermography (LCT), and electronic or camera operated thermography. Both of these procedures are valid and have their respective places in diagnosis.

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However, many manufacturers modified thermographic equipment utilized for might vision or military application. Some of these detectors are not of adequate quality to read patterns from human skin. Unaware physicians who desired to use thermography in their practice, purchased scanners and detectors which gave them inconsistent or false positive findings. To further complicate this issue, many manufacturers came up with "slick" software programs that resulted in very impressive looking, yet inaccurate, studies.

Physicians and technicians who operated such equipment, and as a result gave up their faith that thermography was valuable, admitted that they always felt something was not right about their studies and felt badly about abandoning the procedure.

As with any medical technology, the appropriate application of the technology with the correct equipment performed to a consistent protocol by board-certified individuals will result in more accurate yields and satisfactory scientific compliance.

Lack of Regulation

A hallmark in the downfall of thermographic procedures is the fact that no authoritative thermography regulatory board exists in the United States.

While the FDA, the Council of Scientific Affairs of the American Medical Association, the ACA, and the ICA provide proactive policies and statements about thermography, there is virtually no regulation of the procedure. Some state licensing boards for medicine and chiropractic for example, have incorporated various standards and medical necessity guidelines for utilization of thermography, but that is about all.

Anyone can own and operate thermographic equipment. Only licensed health care providers with portal of entry status (primary health care license, MD, DC, DDS, DPM, etc.) are allowed to interpret or make diagnoses of thermographic examinations (see "Inappropriate Training" above). In addition, the above caveat also refers to the ability to bill an insurance carrier and receive payment for services. Thus, entrepreneurs with no formal medical training often sought out and "cut" deals with untrained physicians to read exams just so they could bill an insurance carrier. With this type of unprofessional conduct, a great many badly performed studies found their way into the materia medica and the court system. (See "Personal Injury Model" below)

While many state boards have approved continuing education seminars for certified relicensure hours in thermography, as well as approving board certification programs, I feel that state mandated regulations should be implemented to insure quality control of the procedure. This would not necessarily require separate and fiscal intensive new boards, but could be made the responsibility of existing licensure boards.

Improper Protocol

A major factor in the inconsistency of published works in the thermographic imaging field is the various protocols under which the procedure is performed. Although not difficult, the protocol of the examination, as with x-ray or any other diagnostic device is essential to accurate and reliable study. Examples of thermographic protocols would be: the ambient room temperature at which the examination is performed; the determination of whether the patient has a fever or not at the time of the examination; the type of equipment utilized; the type of floor covering; the presence of windows which allow outside heat to unevenly permeate a room; and the type of window coverings utilized.

When I taught the diplomate program in California for thermography, physicians were asked to submit thermographic studies for review. The vast majority of unacceptable studies (which were used for diagnosis in these clinician practices), were found to contain errors created by poor protocol that were extremely inexpensive and simple to correct. Protocol is everything. Without an established protocol, no comparison of accuracy, double blinded study or evaluation of the procedure and its effectiveness can be made.

Personal Injury Model

An additional and very important factor in the current status of thermography has been its role in personal injury and workers' compensation litigation. As a test of neurophysiology, thermography is unparalleled in its reliability to detect spinal trauma, nerve injury, muscle imbalance and a myriad of other conditions such as the controversial reflex sympathetic dysfunction associated with permanent trauma.

Recognizing the tremendous threat that thermography posed in the form of skyrocketing jury award in trauma/injury cases, the insurance industry declared an all out war on the procedure. Using so-called experts, they picked the procedure apart based on poor studies, innuendo, material out of context, and ripped apart the testimony and diagnosis of unsophisticated and untrained physicians who used the procedure strictly as a means to more practice income. This led to lack of insurance coverage, difficulty for trial lawyers to get thermography admitted into evidence, and the abandonment of the procedure nationwide by physicians who could no longer "get paid for it"!

It is ironic that thermography as a diagnostic tool was so potentially lethal to the auto insurance industry that its diagnostic significance was so easily disregarded due to the damaging effect of deep pockets awards to injury victims.

Anecdotal vs. Scientific Evidence

With the above concepts in mind, it is very important to differentiate scientific fact for anecdotal evidence. For the purposes of this presentation I define anecdotal to mean a myth or a fable not supported by the fact, but accepted because of a common belief or usage.

Many physicians, investigative journalists, and trial lawyers use anecdotal data to support their point of views. An example of this is the often published article in the medical journal that uses 10-20 references by other authors who all have just rewritten an original thesis or premise in order to get published.

Now the materia medica has a number of consistent articles or studies which appear to be powerful when used as an argument for or against a given procedure. In reality, anecdotal evidence is disastrous when not recognized. Thermal imaging is pure science. While prone to misinterpretation by untrained clinicians, its diagnostic accuracy and yield are unparalleled in medicine.

The scientific study and reporting on a world wide basis is overwhelming. Yet for the facts presented previously, mainly financial, the procedure is being abandoned in the United States, save for a handful of very dedicated physicians who see the clinical benefits of thermography for their patients on a daily basis, whether they get "paid" for it or not.

Competition Paradox with Mammography

This is a great irony and source of confusion in medicine. Another antagonist of thermography is the medical radiology community. Many radiologists I have spoken to fear that their investment in mammography equipment will be wasted because they view thermography of the breast as competitive with mammography. This is a classic example of the lack of training and anecdotal arguments I have previously presented.

Mammography is anatomical, and thermography is physiological. One cannot compare apples to oranges. The procedures are complimentary, not competitive. The same holds true for MRI and CT compared to thermography for musculoskeletal conditions.

Rather than hiding behind innuendo and anecdote, radiologists need to understand the tremendous potential of thermography to detect the physiologic manifestation of disease that so often predates the anatomical analysis of same.

The "school of medicine doctrine" in law is relevant here. The AMA originally sent requests for evaluation of thermography to radiologists who were not trained or certified in the procedure instead of to the Council on Scientific Affairs. The radiology bias, or lack of information, created a negative position which exists today.

Conclusion

This brief paper has been aimed directly at the heart of the thermography paradox. Lack of training and certification accompanied by the massive insurance industry attack on the procedure has created its own set of false positives.

These false positives are in the belief and value structures of a procedure which has one of the highest sensitivity and specificity ratings in diagnostic practice and is completely reliable when performed for the right reasons and in the correct protocol.

To reinforce the appropriate level of training and to shift the paradox, we must understand simply, that we are not diagnosing conditions with thermography. In the same way that thermography cannot see cancer, it cannot see nerve or muscle. It can, however, determine the physiologic presence of abnormality associated with these anatomically-based factors.

Thermography is adjunctive, reliable and should be used whenever possible to help patients receive the best analysis of their condition and the best treatment directed at that condition.

Low Resolution Thermogram: The two thermograms above represent low resolution electronic thermography of the female breasts and upper torso. These views utilize a 10 degree window with color blocks approximating 1 degree centigrade per color. Although several additional thermal abnormalities exist, it is clear that the thermogram on the left represents healthy temperature and symmetry of the breasts. The image on the right is a highly abnormal thermogram with intense heat abnormality consistent with tumor neogenesis in the right breast. This is demonstration of breast abnormality physiologically and must be further evaluated with clinical testing, mammography and physician monitoring.

High Resolution Thermogram: The above thermograms are high resolution, often referred to as linear or black and white imaging. The symmetry in the patient on the left versus the asymmetry in the breasts of the patient on the right are much clearer than the resolution displayed in the two color thermograms above. These images are of the same two patients.

While mammotherms cannot identify breast cancer, they do provide the safest and earliest risk marker available. Due to the non-invasive aspect of thermography, this procedure provides reliable and accurate data about the physiologic state, not the anatomic state of human breast tissue.

William Cockburn, DC, FIACT
Whittier, California

About the author: William Cockburn, DC, FIACT, of Whittier, California, has been appointed by the American Board of Medical Infrared Imaging as co-chairman of a national study to determine if thermographic imaging of the breast will be useful as an outcome assessment tool in patients with breast implants. William Hobbins, a thoracic surgeon from Madison, Wisconsin, will co-chair the committee with Dr. Cockburn.

The study will do thermographic examinations of women in three categories:

1. asymptomatic patients with breast implants;
2. symptomatic patients with breast implants;
3. patients who have had breast implants removed.

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Spinal Rounds

Rebuttal on Thermography

Dr. Croft's article "Thermography in Soft Tissue Trauma" in the 5-7-93 issue questioned the role of thermography, sparking many letters to the editor. Dr. David BenEliyahu, who writes a column for "DC" on thermography, rebutted Dr. Croft's article in the 7-2-93 issue.

Because thermography's usefulness is hotly debated, Dr. Croft asked "DC" to print his response to Dr. BenEliyahu's comments, noting that, "Such discourse is the foundation of intellectual and scientific growth."

In his rebuttal, Dr. BenEliyahu complains that my "review" of thermography was one-sided and limited to merely 21 references. I must point out to Dr. BenEliyahu that I specifically stated in that article that it was not meant as a review at all. My purpose was, in fact, merely to ask a question concerning the role of thermography in soft tissue trauma. I ask these questions not out of any ulterior motive but because I believe they are valid.

In a letter to the editor, one doctor suggested that I needed to learn about the subluxation syndrome, and in another, a doctor obtusely accused me of being "medically oriented," a phrase chiropractors use to insult a colleague who doesn't happen to subscribe to their particular ideology. And while some may misinterpret my comment on thermography as tantamount to chiropractic apostasy, I certainly hope I will be labeled as one "scientifically oriented."

Unfortunately, notwithstanding the chorus of praise heaped upon thermography by its ardent devotees, it seems quite clear that a good deal of the more rigorously conducted trials have not been terribly favorable to thermography. And the fact that some of the articles supporting thermography have been published in peer reviewed journals is no guarantee, contrary to Dr. BenEliyahu's suggestion that they are without flaws. In fact a large percentage of articles in such journals are seriously flawed.1

Dr. BenEliyahu rejects the Hoffman et al.,2 meta-analysis rather out of hand, which I think is a bit too convenient, particularly since he feels my comments were one-sided. Meta-analyses do have their practical limitations but they are relied upon increasingly more these days and are considered valid.3-5 Hoffman et al., found most of the thermography articles published in indexed literature to be seriously flawed.

As to the remark that thermography is used without bias in Europe and Asia, I can only suggest that Dr. BenEliyahu may have limited access to world literature. I did not mention Dr. BenEliyahu's research because I was not interested in getting into a personal battle with him. I do, however, appreciate any and all efforts in research, and I commend him for this. He should not consider that I do not read his work, and since he broached the subject, I will point out some of the weaknesses of the work he referenced.6-9

Reference 6: In this case report Dr. BenEliyahu provides an example of how infrared thermography (IRT) proved invaluable for treating a man with disc herniations and chronic back and leg pain; a man previously seen by an orthopedic surgeon who recommended surgery, a neurologist who prescribed medication, and a chiropractor who recommended chiropractic treatment. In addition to clinical signs of nerve root tension, trigger points were noted. An IRT examination revealed evidence of SI joint dysfunction and trigger points. This, according to the author, allowed for appropriate care and precluded the need for surgery. But there are several questions one might ask of the author. For one, how did his treatment differ from that recommended by the other chiropractor? Perhaps that doctor would have had similar success without the need for IRT. Secondly, he gives no information about his follow-up of this patient. I believe he had arrived at the diagnosis of myofascitis after his clinical exam. Did Dr. BenEliyahu also examine this man's SI joint? If so, how did the results correlate with IRT findings? Did the IRT cinch the diagnosis or was it merely an expensive shortcut?

Reference 7: In this paper, the authors propose to measure "the most common levels of disc protrusion seen in clinical practice," and to associate them with IRT findings -- a lofty and ambitious goal for a sample of only 66 cases, some of which had only disc bulge. There are many problems with this paper. Although this takes the form of a clinical trial, there was no control group. The authors consider both herniation and bulge to be encompassed by the term "protrusion" and only for one of four groups of patients do they mention the relative proportions of each. Also, the method of selection is not described. Disc bulges/herniations were neither quantified nor correlated with symptoms, leaving the reader to wonder about the validity of the conclusions about IRT. Correlation between symptoms, CT/MRI and IRT results is not provided. And since the majority of thermographic patterns covered three root levels, one is left to wonder how meaningful the results are. Perhaps the authors should have attempted to predict patients' complaints or CT/MRI findings based on IRT. That would seem a better measure of its real worth. No statistical method was reported; therefore we are left to wonder about the significance of the results. The authors cite Jinkins et al.10 as providing support for their theories about IRT, yet these authors have, if anything, provided evidence of a condemning nature by showing how zones of head overlap necessarily below L2 in cases of autonomic referred pain. Dr. BenEliyahu did not mention that Jinkins et al., never discussed IRT. In fact, they considered mechanisms of pain, not thermoregulation, which involved not only the autonomic system but central mechanisms as well -- mechanisms which probably would not affect the autonomic nervous system. In fact, their theories are based loosely on the work of Kellgren11 which also does not provide any direct support for thermography.

Finally, Dr. BenEliyahu misquotes Uematsu et al.,12 as stating that IRT showed 94.7 percent positive predictive value and a specificity of 87.5. However, it is well to point out that the calculation of positive predictive value is made by dividing the number of true positives (89) by this number added to the number of false positives (5). This calculation is highly influenced by the incidence of disease in the population which, in this study is artificially quite large (72 percent) allowing for the equivalent of a statistical hat trick. Intuitive readers will see that when the real incidence of a condition in a population is low (as is disc herniation) the number of false positives will be higher and the positive predictive value will be correspondingly lower.

Reference 8: In this study, Dr. BenEliyahu evaluated 30 patients with patellofemoral disease (PFD) and 40 controls using IRT and reported a sensitivity of 97 percent and a specificity of 90 percent. These figures should be interpreted with caution. The study design was so narrow as to nearly guarantee this type of result. It is quite likely and predictable that 40 normal volunteers would have mostly 36/40 normal IRT exams. That provides us with the 90 percent specificity figure. In reality, however, there are many conditions of the knee, many of which are difficult to diagnose clinically, which would likely present as hot or cold IRT scans as Dr. BenEliyahu found with PFD. If a mixed group of say 100 patients with various traumatic, rheumatic or orthopedic disorders were included in the study, I would imagine that many would provide for abnormal IRT studies. It is doubtful that a skilled thermographer could differentiate between these disorders based solely upon IRT results. In this setting, thermography would probably be sensitive but not very specific for PTF. The fact that abnormal scans were seen as both hypothermic (86 percent) and hyperthermic (14 percent) leads one to wonder whether surface heat patterns are constantly changing. Do humans with injuries or disorders of the extremities vary with regard to skin temperature from day to day as Bennet and Ochoa13 observed in rats? It seems likely. At least there is no convincing evidence to simply dismiss this possibility out of hand as Dr. BenEliyahu has done. And yes, these authors did suggest that thermography would be a useful tool to understand neuropathic pain. However, their statement was in the context of its usefulness in the experimental animal model, not clinical thermography for humans. Finally, Dr. BenEliyahu concludes that IRT is useful in the diagnosis and management of PFD, yet his results don't support that. His gold standard was a clinical exam and radiographs. His study doesn't provide any evidence that IRT will improve his diagnostic yield nor does he explain its role in management.

Reference 9: This study appears to be seriously flawed in two respects. First, the authors propose to study the overall sensitivity of IRT to detect neurological involvement using as their "gold standard," MRI, an anatomical test which cannot provide any information about neurophysiology. Thus, the authors cannot expect to achieve their stated goal. The EMG, NCV and SSEP would have been more appropriate "gold standards." Secondly, in their group of 62 patients, only 38 had abnormal findings on MRI, and only these were subjected to IRT; all patients should have been subjected to IRT. Since 24 were excluded, the calculations of predictive value, sensitivity, and specificity are invalid.

Regarding comments about SSEP, there is generally much less controversy with this test today than there was five to seven years ago owing to continued improvements in hardware and methods of interpretation -- a trend which thermography does not share. I would be quite happy to share the recent work in SSEP with Dr. BenEliyahu.

The Weisel et al.,14 report on the incidence of positive CT scan findings in asymptomatic persons is frequently misquoted. Dr. BenEliyahu quotes the study as finding 39-45 percent false positive findings on CT/MRI. (The actual figures were 35.4-50 percent). More to the point, the authors did not evaluate MRI at all. Secondly, it should be understood that this work was done in 1982 and 1983 at a time when CT was quite new. With the advent of MRI, improvements in CT hardware and software, and a decade of clinical experience with these technologies, this false positive rate has been reduced significantly, a trend which is not enjoyed by thermography. In a recent edition of the same journal, for example, Parkkola et al.,15 finds an incidence of disc bulging in only 11 of 180 disc spaces (6 percent) in healthy volunteers evaluated by MRI.

A widely accepted belief that myofascial trigger points can be seen with thermography is based on the common finding of trigger points on patients (most people have them) and hot spots on the thermogram. A recent small study (n=11) supports this.16 Yet, in a very carefully executed larger trial, (n=365), Swerdlow and Dieter17 came to the conclusion that trigger points and such hot spots were not associated. So the debate rages on.

Dr. BenEliyahu illustrates one of the great difficulties in understanding and interpreting the divergent pool of literature which seems to either support or refute thermography as a clinical tool. He cites a study by Uematsu et al.,12 in which the authors compared CT myelography with thermography and reported 94.7 percent sensitivity and 87.5 percent specificity. This is a study

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frequently quoted by advocates of thermography because most other such trials have failed to yield such impressive results. Mahoney et al.18 reported a sensitivity as low as 35-48 percent and a specificity of only 20-44 percent. Harper et al.,19 reported a sensitivity ranging from 78-94 percent and a specificity of only 20-

frequently quoted by advocates of thermography because most other such trials have failed to yield such impressive results. Mahoney et al.18 reported a sensitivity as low as 35-48 percent and a specificity of only 20-44 percent. Harper et al.,19 reported a sensitivity ranging from 78-94 percent and a specificity of only 20-44 percent. Since, in the Uematsu et al., study, the authors used primarily failed-back patients who had two or more surgeries, one should be careful in extrapolating these results to patients with less severe back problems. They also pointed out that thermography was not root-specific.

Dr. BenEliyahu did not mention another study of Uematsu et al.,20 in which the authors found that 46 percent of patients with chronic low back pain have normal thermograms. Although an older report, it raises serious questions about the utility of thermography in instances of chronic low back pain not related to disc herniation.

Finally, Dr. BenEliyahu asks why a doctor would expose a patient with RSDS to the ionizing radiation of repeat radiographic examinations. The answer is quite simple: because only this type of serial examination can document and quantify the progressive osteoporosis seen with this condition, and because it is the standard of care in any community for chiropractors and medical doctors alike. Patients in all stages of RSDS are in significant, often excruciating pain. The disease is characterized by pain, edema, decreased motor function, limited ROM, atrophy, spasm, skin changes, nail changes, osteoporosis, joint pain and swelling. It is still difficult for me to understand why, in most cases, the thermogram is necessary to make this rather obvious diagnosis.

Finally, and for the record, I have not argued that thermography, as a procedure, is invalid. Nor have I suggested that many lesions will not be seen as abnormal thermograms. I encourage thermographers, such as Dr. BenEliyahu, to continue they're research, and I welcome their comments regarding the questions that I did raise.

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Editor's Note:

For more on personal injury, consult Dr. Croft's video, "Advances in Personal Injury Practice," #V-435, on the Preferred Reading and Viewing List, pages xx.

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Dynamic Chiropractic
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Thermography

David BenEliyahu, DC, CCSP, DNBCT

Infra-red Thermal Imaging of Sports Injuries

Highlights and When to Refer

1. Reflex Sympathetic Dystrophy

Posttraumatic sympathetic hypertonia can occur after sprain, fracture, or postsurgical. The knee, ankle, and arm are common examples.

FIGURE 1

2. Differentiation of Articular, Myofascial, and Radicular Pain Syndromes

These structures can often cause similar pain patterns. Thermography has a different pattern for these syndromes.

3. Differentiation of Patellofemoral Pain Syndromes and Internal Derangements of the Knee

Patellar problems appear with a cool patella most typically, where as meniscal ligamentous injuries appear hot.

FIGURE 2

4. Myofascial Pain Syndromes

Most typically a focal hot spot on the order of 1-2oC overlying the involved muscles.

FIGURE 3

5. TMJ Syndrome

Most typically a focal hot spot over the involved TMJ with associated myofascial trigger points over the masseter, temporalis, and pterygoids.

6. Shin Splints and Stress Fractures

Both present with anterior calf pain. Stress fractures have a focal hot spot with a "fried egg" appearance with a temperature differential of 2oC. Shin splints have a blush linear increased heat pattern of 0.05 to 1.0oC.

FIGURE 4

7. Stress Studies

When ordering a thermography scan, dynamic stress studies can be very helpful. Stress can be mechanical (raising arms overhead in thoracic outlet cases, sitting, or stooping in low back disc cases, and then repeating the scan compared to the baseline studies). Or the stress can be a cold stressor test by immersing the hands or feet and recording the autonomic vasomotor response with repeat scan.

8. Entrapment Neuropathies

Peripheral nerve entrapments will typically yield an increased thermal emission pattern in the acute stage due to sympathetic ablation. In the chronic stages of the injury a decreased thermal emission pattern will be seen. This can be useful in carpal tunnel syndromes, ulnar nerve entrapments, bikers palsy, and thoracic outlet syndromes.

9. Equivocal Anatomical Testing

Thermographic imaging can determine if an MRI/CT documented disc herniation or bulge has clinical significance, since there can often be false positives in MRI. The thermogram will show asymmetry in annular injury.

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Thermography

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Chiropractic Thermography: Objectifying Subluxation

Since the early days of chiropractic, there have been many attempts to devise systems or instruments that will verify the presence and correction of vertebral subluxations.

In the 1960s, a group of chiropractic researchers put together an overview of the neuropathophysiologic effects of vertebral subluxation on skin temperature.1 This group consisted of chiropractors, students, engineers, physicists, medical doctors, and artists. The chiropractors involved included research pioneers A.R. Petersen, H. Marshall Himes, R.J. Watkins, GM Gleeson, and John Dickins. The work was published under the auspices of the Canadian Memorial Chiropractic College, and so advanced in thought and vision, that it is just now beginning to be understood by chiropractic science.

Here is a quote from their work that may give you a glimpse of the advanced thinking of these men ...

> "The principle of chiropractic, theorized around the outdated classic model of nerve root compression -- the impingement of nerves within the intervertebral canal or foramina of the spinal column as the originating factor in most disease processes -- served well during the developmental era of chiropractic. The concept of this impingement causing a supposed physical interference with the normal transmission of nervous impulses, also served well during this era. Both hypotheses had great merit of providing a plausible explanation on which the actual practice of chiropractic was based.

"Unless advances are made beyond old mechanical concepts, into concepts embracing the neurological factors associated in the disease process, one finds it difficult, if not impossible, to explain the great paradox of chiropractic -- that different adjusting techniques, based on conflicting premises, often produce the same impressive clinical results."

The nerve pathways involved in the control of skin temperature have been well documented in the field of neuroanatomy.2 The biomechanical alteration that occurs in the presence of vertebral subluxation alters the function of these nerve pathway.3 It is because of the abnormal function of these nerve pathways that thermographic asymmetries verify the presence of vertebral subluxations. The chiropractic adjustment corrects the vertebral subluxation and can be observed when the thermograms are returned to normal symmetry.

The chiropractic profession is at a critical crossroads which, depending on the route taken, will determine the future of the profession. The three directions that are at hand are: the direction that the majority of the profession is going, which is the therapeutic treatment of musculoskeletal conditions; and the direction of the philosophical spinal manipulators with routine racks and cracks of the spine; the direction of the triune based chiropractor that is objectively substantiating what the chiropractic principle is built on.

The third direction referred to is the most positive way chiropractic can continue to demonstrate its uniqueness as a separate and distinct healing art. The chiropractor must learn to substantiate the need for chiropractic care for us to be included as a participant in our nation's health care delivery system.

Low resolution electronic chiropractic thermography provides objective monitoring of a patient and is used in conjunction with x-rays, MRI, SEMG, and physical findings. Chiropractic thermography enables the doctor to evaluate the sensory/autonomic neurophysiology which is so critical to the health of the human organism.

Current neurobiological research conducted by David Felten, MD, PhD, at the University of Rochester School of Medicine, has documented nerve fibers that physically link the nervous system and the immune system. Dr. Felton states, "Much to our surprise, we found that if you took the nerves away from the spleen or the lymph nodes, you virtually stopped immune responses in their tracks."4

So now we have it, scientific evidence which confirms what chiropractic has said since 1895. The importance of documenting and monitoring the effect of the chiropractic adjustment is at a magnanimous stage concerning the efficacy of chiropractic care and its impact on the health of the public. Low resolution electronic chiropractic thermography is an economical instrument that enables doctors to be the best they can be at tracking down vertebral subluxations and knowing when they have been corrected.

Case Report

A 40-year old male, while bending, felt a sharp pain in the lower back and shock-like pain at the base of the skull. He was unable to stand unassisted for three days. He complained of pain at L5 area centrally, right anterior thigh pain, lower leg pain, and numbness of the second toe on the left foot.

Laseagues, Braggards, and popliteal press were positive on the right. X-rays of the lumbar spine and pelvis demonstrated a left PI, left ex ilium, low left sacral base. No new cervical x-rays were taken at this point with cervical listing based on previous x-rays. Low resolution chiropractic thermography revealed asymmetrical patterns of the lumbar, dorsal, and cervical spine. Paraspinal line graph temperatures demonstrated a temperature asymmetry of over one degree C in the cervical spine with a decreased heat emission in the lower dorsal spine (Fig 1). Physical findings demonstrated a left negative Derifield leg check and a right cervical syndrome. MRI of the lumbar spine revealed herniated discs at L3/4 on the left and L5/S1 on the right.

ARNETTA: SCAN IN FIG. 1 and FIG. 2

Fig.1: Back scan at beginning of care. Note asymmetrical temperature patterns in cervical, dorsal, and lumbar areas. The line graphs below the scan are segmental paraspinal temperature graphs equal to DTG readings. Note the splits in the graphs and the cold reading in the lower dorsal area. This feature helps identify

asymmetries. The color scale is at right of the scan. White at the top of the scale is the warm end. The resolution is set at .5o C between colors.

At the beginning of care, adjustments of the left ilium and 6th cervical had been made with little change to the thermograms (Fig 2). On the following day, Logan basic was used to correct a sacral base anterior and inferior on the left, and the atlas was adjusted ASRP with a side posture toggle. Again the thermography changed very little (Fig 3), although the patient was feeling some improvement. New cervical x-rays were taken at this point because of failure to normalize the thermogram. New listings of AIRA atlas and C2 spinous right were made. On the next day, adjustment of the atlas made little significant change thermographically. Adjustment of the axis was then made with dramatic thermographic changes (Fig 4). No further adjustments were made at this point.

ARNETTA: SCAN IN FIG. 3 and FIG 4

The following day the patient reported 75 percent improvement of discomfort. Thermography scans exhibited significant improvement with symmetry of the lumbar, dorsal, and cervical areas (Fig. 5). Paraspinal line graphs now were symmetrical with no temperature differences or cold areas. Physical findings demonstrated a balanced leg check and no cervical syndrome. No adjustment was made. The patient has since recovered with minimal adjustments required over the following one month period.

ARNETTA: SCAN IN FIG. 5

Conclusion

The use of low resolution electronic chiropractic thermography provided objective monitoring of how the chiropractic adjustment affected the patient's nerve system. Thermography enables the doctor to know when to proceed with further adjustment or when correction has been achieved. One of the most difficult decisions we as chiropractors must make is where and when to adjust the patient or when to leave them alone. Low resolution electronic chiropractic thermography gives the doctor the knowledge, confidence, and ability to make that decision.

The thermography system used in this case study was a non-contact, low-resolution, computerized electronic chiropractic thermography system.

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Thermography

David BenEliyahu, DC, CCSP, DNBCT

Synopsis of the Annual Symposium: American Academy of Medical Infrared Imaging

On April 1-4, the American Academy of Medical Infrared Imaging held its annual scientific symposium in Orlando, Florida. Papers and posters were presented, and the meeting was attended by multidisciplinary clinicians including DCs, MDs, DDS, PHDs, DOs, and a DVM. The following is a brief description and highlight of some papers presented by various speakers, some of which are nationally and internationally renowned.

Michael Stanton Hicks, MD, director Pain Clinic, Cleveland Clinic

Dr. Hicks presented some of his data and work on the utility of thermography in reflex sympathetic dystrophy (RSD) syndromes and sympathetic maintained pains. Thermal infrared imaging is routinely utilized in the Cleveland Clinic as well as the Mayo Clinic for differential diagnosis. Dr. Hicks stated thermography is utilized in his clinic for the following indications: autonomic dysfunction, myofascial pain syndrome, radiculopathy, deafferentation pain, and sympathetic maintained pain syndromes. Dr. Hicks utilizes thermography and his interpretation criteria for RSD includes temperature asymmetry, abnormal cold-pressor test (autonomic challenge), and autonomic dysfunction on the contralateral side. He believes RSD is a CNS disorder secondary to a minor nerve injury with somatic efferent and visceral efferent spread as well. He points out that unimodal approach for care of patients with RSD is ineffective and care must be delivered with an interdisciplinary approach including but not limited to exercise therapy, blocks, manual treatment, pharmacologic treatment, as well as cognitive behavioral intervention.1 The earlier the intervention (i.e., Stage-I RSD) the more successful the outcome. Thermography by its inherent ability to detect and record sympathetic vasomotor dysfunction is highly sensitive for RSD diagnosis.

William Clewell, PhD, University of Baltimore

Dr. Clewell, a professor in statistics and mathematics, presented the statistical methods utilized in the paper on thermography assessment published in the American Journal of Pain Management.2

Jacob Green, MD, PhD, director, Southeastern Neuroscience Institute

Dr. Green presented the findings of his paper published in Pain Digest, "Efficacy of Neurodiagnostic Studies in Patients with Lumbosacral Single Leg Pain of Sciatic Distribution." In this study of 28 consecutive patients by retrospective review, comparative sensitivity and specificity of EMG, SEP, NCV, MRI, CT and thermography were documented. Thermography was shown to have a 92 percent sensitivity and 85 percent specificity.3 Dr. Green also presented with Dr. Clewell the results of the American Academy of Pain Management's study of thermography assessment by national pain clinics. The study of multidisciplinary pain clinics found that one-third of chronic pain patients had autonomic dysfunction, medical thermography was the most frequently cited test of choice, 80 percent of the clinic directors who used thermography "on-site" found it a valuable tool for patient assessment. Only 34 percent of those who did not use thermography in house believed it to be of value.

Pamela Steed, DDS, MSD, specialist in Oral Medicine/TMJ Dysfunction, Indianapolis, Indiana

Dr. Steed presented her work on the utility of thermal infrared imaging in the diagnosis and management of TMJ syndrome. Dr. Steed finds in acute cases a focal hot spot detectable by thermography over the preauricular region. In chronic cases she finds a focal hot spot over the more recent TMJ area, with hypothermia over the contralateral masseter. She finds a 95 percent sensitivity for thermography in TMJ syndromes.4 In another study, Dr. Steed presented her work on 30 asymptomatic subjects and found that all TMJ thermal patterns demonstrated marked thermal symmetry. The temperature differentials were less than 0.2oC in the TMJ and related facial areas. This work was published in the Journal of Orofacial Pain.5

Nelson Hendler, MD, psychiatrist, Johns Hopkins Medical Center

Discussed the role of thermography in pain management. Discussed the greater sensitivity of thermography in diagnosing RSD syndrome as compared to EMG/NCV studies.

Robert Ford, MD, neurologist, Alabama

Dr. Ford presented his work on thermography and cephalalgia and finds an 85 percent correlation finding.

Emil Zuckerman, MD, neurologist, Brooklyn, New York

Dr. Zuckerman utilizes thermography in his neurologic practice. Dr. Zuckerman demonstrated the utility of thermography for posttraumatic headache syndromes and cerebral vasomotor disorders with nitroglycerin provocation.

Bernard Filner, MD, anesthesiologist, Maryland

Dr. Filner presented his work on the utility of thermal imaging in the diagnosis and management of myofascial trigger points and their association with RSD. Dr. Filner believes that chronic myofascial trigger points can lead to chronic pain and sometimes RSD due to chronic sympathetic efferent discharge.

Timothy Conwell, DC, DABCO, RSD Multidisciplinary Clinic/Spalding Rehab Hospital, Colorado

Dr. Conwell presented a fabulous study on the utility of thermography in a multidisciplinary RSD/Pain Clinic. Their thermography criteria for probable RSD included three out of four of the following: 0.65 - 1.0oC delta T, clear demarcation in the extremities thermal pattern, abnormal gradient, abnormal autonomic challenge/stress testing. Thermographic criteria for possible RSD was 0.5oC - 0.65oC, clear thermal demarcation abnormal gradient and abnormal stress test. Dr. Conwell pointed out that RSD has a centralizing phenomena with crossover to the uninvolved side due to intermuncial-pool cross talk, abnormal longitudinal thermal gradients, and positive cold-stressor test (15.0oC) displaying paroxysmal vasomotor instability. Dr. Conwell found specificity/sensitivity/positive and negative predictive value to all be around 90 percent. Dr. Conwell also displayed his use of "Dynamic Subtraction Imaging" with Bates Thermographic Unit in the diagnosis of RSD. This was an excellent paper that we look forward to being published.

Matthew Lee, MD, DPM & R, director, Rusk Institute of Physical Medicine, NYU, Medical Center

Dr. Lee presented his work on the utility of thermography in the diagnosis of Raynaud's disease and chronic pain. He utilizes thermography to document the affects of acupuncture on such autonomic disorders as Raynaud's and RSD.

Dr. Purohit, DVM, director of Veterinary Medicine, University of Alabama

Dr. Purohit discussed the utility of thermography in veterinary medicine practice in the diagnosis of RSD, nerve injuries, and testicular function. Since animals cannot verbalize pain and dysfunction, thermography is a useful diagnostic tool. Dr. Purohit also discusses the unimpeded acceptance of thermography in his veterinary practice, since there are no third-party problems or bias.

William Hobbins, MD, director, Madison Pain Clinic

Dr. Hobbins, one of the present-day "patriarchs" in thermographic science, presented a basic study on an anatomical and neurophysiologic basis of infrared imaging. Dr. Hobbins who directs a pain clinic in Wisconsin also extensively taught thermology to many doctors in both the USA and internationally. Dr. Hobbins' dedication to the field of thermography is undying and like a "candle" has lit countless other "candles" without losing any of his bright light.

Harold Farris, DC

Dr. Farris presented a paper on the future of infrared thermal imaging in clinical chiropractic practice.

Tom Brozovich, DC

Dr. Brozovich presented a paper on the high correlation of patient pain diagrams and thermographic abnormalities.

James Christiansen, PhD, physiology professor at National College of Chiropractic

Dr. Christiansen presented a paper on the importance of quantitative data display on thermal images and the importance of investigating all presenting patterns (i.e., neurologic and myofascial).

Debbie Fraliker, DC

Dr. Fraliker presented a case report on the utility of thermography in imaging the sympathetic dysfunction associated with cervical facet dysfunction and the abolition of the aberrant thermal pattern postmanipulation.

David J. BenEliyahu, DC

I presented papers on the utility of thermography in cases of lumbar disc disease, cervical disc disease, and the utility of thermography as a treatment assessment/outcome tool. Thermography measures "autonomic" patterns of referred pain in the peripheral extremities due to sympathetic neural network which are not confluent with dermatomes. In patients with cervical and lumbar disc herniation (MRI documented) multiple areas of thermal asymmetry reverted to normal postchiropractic treatment.6,7,8

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Opposing Views On Thermography

Two strangely diametrical events concerning themography have recently occurred, attracting much attention among health care professionals in all specialties.

On one hand, the American Academy of Physical Medicine and Rehabilitation recently issued a favorable white paper on neuromusculoskeletal thermography1, confirming and amplifying what chiropractic physicians have known for nearly a century relative to the relationship of surface temperature to underlying biomechanical abnormalities.

Within this same time frame, the Health Care Financing Administration (HCFA) has announced a proposal to withdraw Medicare coverage for thermography2. Certainly, both of these events require further elucidation.

Medicare Coverage for Thermography

The Federal Register of October 9, 1990 contains a proposal by the Health Care Financing Administration (HCFA) to withdraw reimbursement for thermography under the Medicare program. This proposal is based upon a report released in August of 1989 by the Office of Health Technology Assessment (OHTA), which reviewed and quoted much literature on thermography, most of it favorable, but which chose to emphasize the minority of the available data which was negative. Anyone reading this 32-page document, titled "Thermography for Indications Other Than Breast Lesions,"3 can readily discern the negative bias because its conclusions, that "thermography lacks sensitivity, specificity, or predictive value," are unsupported by the actual text of the document itself. Another odd thing is that the author, an individual

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named Harry O. Handlesman, is a completely unknown osteopath who has never published on thermography and who no one in thermography has ever heard of.

HCFA is currently choosing to depend entirely on this seriously flawed OHTA document, and the proposal by HCFA in the Federal Register therefore lamely asserts that thermography "does not assist in accurately diagnosing an illness," that "there is no evidence to indicate that thermography provides a useful guide in monitoring the effect of treatment of any disease entity," and that "temperature differences in themselves add very little to a physician's assessment based on the patient's history, physical examination, and other studies." HCFA further asserts that "there have been no controlled clinical trials that provide conclusive evidence establishing the usefulness of thermography as a primary diagnostic guide," which is far from true.

The most serious flaw in the OHTA report, as noted above, is that its conclusions are not supported by the data referenced in the report itself; that is, the summary gives undue weight to negative biases against thermography, stressing the few negative papers and de-emphasizing the many positive papers which are listed in the OHTA report's own bibliography. Furthermore, most thinking persons would have difficulty trusting the reliability of a report written by a single individual who has no reputation for research or publication in thermography. It is even more curious that HCFA would rely entirely upon this one document, particularly in the face of literally thousands of scientific papers favorable to thermography, including the favorable AMA Council on Scientific Affairs4 and American Academy of Physical Medicine and Rehabilitation reports, which were compiled by knowledgeable panels and approved by committees and organization memberships.

Normally with federal proposals, there is a comment and evidence gathering period before any decision is published. This comment period concluded on December 10. It would normally be expected that a decision would be announced within a few months, but this varies greatly. At least until then, Medicare does make reimbursement for thermographic studies performed by eligible health care providers, as it has since 1985.

A class action suit has been filed on behalf of aggrieved patients against OHTA and HCFA in the United States District Court for the Eastern District of New York; and three major medical thermography organizations, the American Academy of Thermology, the Academy of Neuromuscular Thermography, and the American Herschel Society, have issued formal complaints to HCFA, as has the American Chiropractic College of Thermology (ACCT). The ACCT response discusses six major points:

1. Thermography is a window to the automatic nervous system. Spinal nerves have sensory, motor, and autonomic components. We routinely check the sensory and motor components, but without thermography we ignore the autonomic component.

2. Thermography is risk-free and painless.

3. Thermography is cost-effective.

4. Thermography is scientifically valid. The degree of sensitivity (99.2%), specifically (60%-98%), and predictive value for thermography compare extremely favorably to the other diagnostic procedures, these facts being proven in multiple studies, many of them excellent blinded and prospective studies.1,4

5. Thermography is a useful monitoring device for treatment efficacy.

6. Thermography is a test of physiology.

The ACCT response concludes with the statement:

Anatomic tests, such as CT, MRI, and myelography do not present the same information as, and cannot replace, the physiological data provided by thermography. Thermography is the somatotopic representation of the cutaneous vascular changes mediated by sympathetic nerve transmission and neurotransmitters, for which CT, MRI, myelography, radionuclide scans, and diagnostic ultrasound have zero sensitivity.

One may question the relevance of this whole matter to chiropractic practice, since Medicare does not pay for any diagnostic services ordered by or performed in chiropractic facilities. Like physical examinations and diagnostic x-rays, thermography has not been subject to Medicare reimbursement when the study is performed in the office of a chiropractor, whereas Medicare does make reimbursement for thermography when ordered and performed by medical and osteopathic physicians. The importance of the new HCFA proposal is that there is a concern that a negative decision on the part of HCFA, resulting in withdrawal of Medicare coverage for thermography, would cast an unfair shadow over the legitimacy of thermography and that it might also serve as a negative precedent to other third-party payers which, except for a few high-profile exceptions, have been routinely paying for justified thermographic studies. The full implication of this possible precedential effect remains to be seen. If a HCFA decision could be considered the ultimate federal edict as to the validity of a procedure, with inviolable trickle-down to other payers, chiropractic practice itself would obviously be in far greater jeopardy than we currently experience!

American Academy of Physical Medicine and Rehabilitation Report

The PM&R white paper titled "Neuromusculoskeletal Thermography," was submitted in June of 1990 and approved by PM&R membership in October 1990. This paper includes a discussion of the history and description of the technology, the physiological basis of the technology, imaging techniques, evidence from blinded and prospective studies, and a discussion on the usefulness of thermography for its most obvious indication, the reflex sympathetic dystrophy syndromes. The report lists 76 references, and its contents are summarized by the abstract, which states:

"Thermography is a safe, non-invasive test which does not involve the use of ionizing radiation. It is a test of physiological function that may aid in the interpretation of the significance of information obtained by other tests. Thermography can be useful in the diagnosis of selected neurological and musculoskeletal conditions. It may facilitate the determination of spinal nerve root, distal peripheral nerve, and soft tissue injuries. Thermography is useful in the diagnosis of reflex sympathetic dystrophy syndromes."

This report, in addition to the AMA Council on Scientific Affairs report, which lists 86 references, stands in sharp contrast to the single-author OHTA report on which HCFA is currently relying. The next few months should provide interesting chapters in the somewhat rocky, but continuing, integration of thermography into general acceptance within health care practice.

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