Upper Cervical Specific Chiropractic Management of a Patient with Hypertension: A Case Report and Selective Review of the Literature

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ABSTRACT

Objective: To examine the effects of Knee Chest upper cervical adjustments on a single patient already being treated with Hydrochlorothiazide for hypertension and to review the literature on hypertension and chiropractic.

Clinical Features: The patient was a 25-year-old woman with medically diagnosed hypertension. She also had symptoms of migraine headaches occurring two times per week. A thorough history and examination were performed. Her blood pressure was 134/98 mmHg at initial examination. Diagnosis of an upper cervical subluxation was made and cervical radiographs supported upper cervical misalignments. Paraspinal thermography, supine leg length assessment, postural assessment, and blood pressure were monitored every visit.

Intervention and Outcome: The patient received Knee Chest upper cervical care for twelve weeks. By the end of care the patient experienced a significant decrease in blood pressure to 114/80 mmHg. She also experienced a significant decrease in both frequency and severity of migraine headache symptoms.

Conclusions: Definite conclusions cannot be drawn from a single case study, but this case does show a decrease in overall blood pressure in a patient diagnosed with, and pharmaceutically managed for, hypertension. This study warrants larger studies with control groups to further understand the benefits of upper cervical specific chiropractic care for the reduction of vertebral subluxation to those suffering from hypertension.

Keywords: Knee Chest Technique, upper cervical, hypertension, subluxation, chiropractic, blood pressure

INTRODUCTION

The burden of disease has shifted from infectious to chronic diseases based on lifestyle and chronic disease has become a significant cause of morbidity and mortality in the United States. According to the American Society for Hypertension, there has been a specific increase in the prevalence of hypertension in the United States and it can no longer be considered a single disease entity. Mangum et al state that hypertension related diseases are the leading cause of morbidity and mortality in industrially developed countries.
2008, high blood pressure mortality rates were 43.9% of male deaths and 56.1% of female deaths.⁴

Increased life expectancy corresponds with a rise in chronic degenerative diseases like heart disease, stroke, diabetes, arthritis and cancer.⁵ According to the American Heart and Stroke Associations, 76.4 million people over age 20 have high blood pressure, one in three Americans have high blood pressure, and projections show that by 2030 approximately 27 million people could have high blood pressure.⁶ The direct costs of hypertension in the United States were $185 billion or 12.6% of health care costs in 1998.⁷

The detection and pharmaceutical management of cardiovascular disease has improved and become a common practice in medicine.⁸⁹ Driscoll⁸ suggests that chiropractic adjustments might be an alternative to controlling high blood pressure. Plaugher et al⁹ believe that multidisciplinary cooperation between chiropractors and medical doctors is a necessity in the treatment of hypertensive patients. Close monitoring of a patient’s blood pressure is required for optimum management of a hypertensive patient.⁷

There is a good amount of literature on chiropractic care in regards to managing low back pain, neck pain, and headaches. For this reason chiropractors are stuck with the stigma of treating back pain and other pain syndromes. However, the use of manipulation for episodic symptoms is not chiropractic.⁸

The International Federation of Chiropractors and Organizations defines chiropractic as a philosophy, science, and art for the sole purpose of non-therapeutic objective of locating, analyzing, and correcting vertebral subluxation.⁹ Sweat & Pottenger¹⁰ define subluxation as a misalignment within the spine causing nerve interference. Chiropractors believe that removal of subluxation causes improvement to certain physiological functions.¹¹ The primary focus of traditional chiropractic is to return the body to its natural homeostasis via the nervous system.¹²

**Review of the Literature**

A review of the literature was performed searching for published peer-reviewed studies on chiropractic in relation to hypertension. The computerized databases used included the Index to Chiropractic Literature, Pubmed, Galileo, and Mantis.

The keywords used were blood pressure AND chiropractic on the Index to Chiropractic Literature with 141 results and on Pubmed with ten hits. Keywords chiropractic AND hypertension OR blood pressure revealed 228 articles on Galileo’s Alt-Health Watch search engine. Mantis was searched with keywords knee chest AND blood pressure supplying seven resulting articles. Twenty-one of these articles were selected as relevant for this review by the author.

Mangum et al³ performed a review of the literature looking at articles pertaining to chiropractic and hypertension. This review was looking at the level of bias in studies done on spinal manipulative therapy for the treatment of hypertension. The authors stated that two main issues with most of the studies reviewed was a lack of reporting the position of the patient while blood pressure was taken and not addressing the type of sphygmomanometer used in the study.³

Magnum et al³ concluded that only two studies showed low bias; these two studies showed no clinically relevant decrease in blood pressure. Spinal manipulative therapy needs to influence one or more physiological processes that cause hypertension to be effective.³

Hannah¹¹ wrote about orthogonal alignment of the atlas influencing neurovascular mechanisms that regulate blood pressure. Dysfunctional alignment of the atlas vertebrae can inhibit proper function of the vagus nerve and/or the carotid artery.¹² He proposed that stasis of cerebrospinal fluid may disrupt sympathetic and/or parasympathetic integration at the medulla oblongata, thalamus, and hypothalamus.¹³ He also discusses the cervicosympathetic, vestibulosympathetic, and pressor reflexes in relation to toxicity of the suboccipital muscles and how this may affect blood pressure.¹³

Yates et al¹⁴ used an Activator device to study the effects of spinal manipulative therapy and blood pressure and anxiety. Twenty-one patients were diagnosed with upper thoracic subluxation and elevated blood pressure. They were then assigned to one of three groups: active treatment, inactive treatment, and no treatment control. Systolic blood pressure significantly decreased in the treatment group supporting their hypothesis that chiropractic manipulation to the thoracic spine can reduce blood pressure.¹⁴

McKnight & DeBoer utilized healthy subjects with normal blood pressure to study how physiological changes to the cardiovascular system related to cervical spine adjustments.¹⁵ They found a substantial change in blood pressure following cervical adjustments in subjects with a pre-treatment blood pressure above 130/90 mmHg.¹⁵ They concluded that chiropractic adjustments might have a beneficial therapeutic effect for borderline hypertension and may be a potential method to control mild-to-moderate hypertension.¹¹

Another study investigated the difference in blood pressure between arms and the effect that manipulation has on the difference. Dimmick et al¹⁶ found that manipulation had a significant effect on the difference in systolic blood pressure between arms in normotensive subjects. They concluded that the subjects under treatment had vertebral subluxation that could have been responsible for the difference between right and left systolic blood pressures.¹⁶

Wells & Williams described a patient with ankylosing spondylitis who was put under Knee Chest upper cervical chiropractic care and a beneficial decrease in blood pressure was noted as a secondary result of upper cervical subluxation reduction.¹⁶ They noted that the patient’s thermal pattern was reduced and he was no longer physiologically compromised leading to a reduction in blood pressure from 133/76 mmHg to 123/75 mmHg.¹⁶

Zhang¹⁷ looked at how custom-made orthotics could affect blood pressure and heart rate variability. His study demonstrated a significant decrease in blood pressure and increased heart rate variability for thirteen subjects wearing orthotics while under an exercise program.¹⁷ This randomized controlled study showed a significant decrease in blood
pressure over a five-month period. He concluded that there is a potential benefit in combining exercise and foot orthotics to improve cardiovascular health.

A second study by Zhang et al looked at the effects of a fruit and vegetable powder mix on hypertensive subject; this was a second study done on hypertensive patients as a follow-up to a similar study done on normotensive subjects. It is clearly stated in the article that nutritional supplements are not meant to be direct treatments for hypertension. The authors noted a significant decrease in systolic and diastolic blood pressure in their experimental group.

Another study looked at the effects of deep tissue massage therapy on blood pressure. Kaye et al found an average decrease in systolic pressure of 10.4 mmHg, diastolic pressure decrease of 5.3 mmHg, and a mean arterial pressure decrease of 7 mmHg. The authors concluded that the efficacy and safety of deep tissue massage for hypertensive patients is a complementary therapy to antihypertensive medications.

Holt et al studied the effects a chiropractic adjustment to any region of the spine has on blood pressure. The study used seventy subjects and the average change in systolic pressure was 3.9 mmHg after a single chiropractic adjustment. The authors concluded that the direction of blood pressure changes did not depend on the area of the spine adjusted.

Knutson performed a controlled clinical trial with two different tests. His first test was done on forty patients with upper cervical subluxation and forty patients without subluxation; the second test was done with thirty patients with signs of upper cervical subluxation. Knutson found that palpation and vectored atlas adjustment of joint dysfunction in the upper cervical spine significantly lowered systolic blood pressure in comparison to control groups. He adds that elimination of joint dysfunction can positively affect and normalize organ physiology and hormonal systems.

Two studies used arterial tonometry to measure autonomic nervous system changes following chiropractic adjustments. It was found that autonomic changes could be measured by tonometry and other conclusions drawn about body physiology following chiropractic manipulative treatments. Driscoll says that arterial tonometry is beneficial in measuring cardiovascular function and blood pressure to determine the effects of spinal manipulative treatment on the cardiovascular system.

McCoy presents a protocol of dietary modification, aerobic and strength training, vitamin supplementation, and one-on-one coaching to improve health risk factors such as heart disease and metabolic syndrome. He states that in the case of blood pressure, health-related lifestyle modifications are the standard of care. A noninvasive protocol may be effective in reducing risk factors associated with cardiovascular disease, diabetes, and cancer.

A randomized controlled-comparison clinical trial was performed on twenty-three patients by Plaugher et al to study what effects chiropractic adjustments and brief massage would have on essential hypertension. Alternative treatments for hypertension include weight loss, stress management, nutritional supplementation, and exercise programs. The study had twenty-three patients divided into a chiropractic group, massage group, and control group. Plaugher et al concluded that the potential benefits of chiropractic treatment for hypertensive patients are reduced costs, decreased drug side effects, improved quality of life, and more effective healthcare.

Torns studied how atlas vertebral realignment affects arterial blood pressure regulation. This was a cohort study consisting of forty-two subjects assigned to three separate groups depending on their blood pressure. Atlas Orthogonal technique was utilized and results showed the ability to lower high blood pressure and raise low blood pressure. The author concluded that a regulation of blood pressure was demonstrated.

Bakris utilized National Upper Cervical Chiropractic (NUCCA) procedure for a randomized, double-blinded placebo controlled trial to determine the effects of atlas realignment on blood pressure. This was an eight-week study done with fifty participants divided into treatment and control groups. The study revealed a sustained reduction of blood pressure after correction of atlas misalignment.

A case study presented by Qualls & Lester report the results of a sixty-eight year old female with hypertension, atrial fibrillation and other related symptoms under Knee Chest upper cervical chiropractic care. The authors noted that her blood pressure returned to normal and her other symptoms reduced.

Plaugher & Bachman also wrote a case report on a thirty-eight year old male with hypertension. This patient was taking various medications to control his blood pressure throughout his chiropractic treatment. The patient experienced a decrease in systolic and diastolic pressure following chiropractic adjustment and a sustained reduction by the end of care.

Lynch & Boone studied chiropractic adjustments and the mechanisms behind how physiology is controlled. They concluded that spinal adjustments might influence various physiological parameters including heart rate variability, blood flow and blood pressure.

The following case study was done to examine the effects of chiropractic management on blood pressure. This paper examines a twenty-four year female patient with medically diagnosed and pharmaceutically managed hypertension. This case details the progression of her blood pressure while under Knee Chest upper cervical specific chiropractic care for the removal of vertebral subluxation.

Case Report

History

A twenty-four year old female presented for chiropractic care. The patient had a history of migraine and tension headaches, and was diagnosed with hypertension one year prior to seeking chiropractic care. Family history revealed that her father had a myocardial infarction and suffers from high blood pressure. The patient was taking supplements and medication to control
her blood pressure. Supplements included 1200 mg of Fish Oil, Co-Q10, and Vitamin D. Her obstetrician prescribed 24 mg Hydrochlorothiazide to control her high blood pressure.

This drug is a diuretic used to treat high blood pressure by decreasing fluid retention and preventing potassium loss with one side effect being headaches. Diuretics are used in the treatment of patients with hypertension to reduce blood volume. The medication blocks exchange of certain chemicals in the kidneys so that sodium and water are excreted and potassium is conserved.

Examination

The physical examination included measurement of auscultatory blood pressure in the right and left arms and additional use of an Omron 10 series automatic blood pressure monitor Model BP785 (Omron healthcare, Inc., Bannockburn, Illinois; accuracy for pressure ±3 mmHg or 2% of reading). The monitor was operated following the guidelines set by the company as per the instruction manual. Auscultatory blood pressure was monitored simultaneously with a stethoscope to assure proper calibration of the monitor during every assessment.

The patient’s blood pressure was 134/98 mmHg on the left and 130/94 on the right at initial examination. Blood pressure measurements were taken every visit (Graph 1) and if an adjustment was rendered, a post blood pressure reading was taken. The methods for monitoring patient blood pressure were similar to those presented in the literature. It is specifically recommended by Plaugher & Bachman that the chiropractor closely monitor patient blood pressure from visit to visit if the patient is also taking medication for hypertension.

Paraspinal thermal analysis was performed to determine pattern using a Tytron C-3000. The protocol that has been presented in the research was used to establish a thermal pattern. This diagnostic tool is specifically recommended by Plaugher & Bachman that the chiropractor closely monitor patient blood pressure from visit to visit if the patient is also taking medication for hypertension.

Muscle and motion palpation were performed. Muscle palpation revealed muscle spasm of the right levator scapulae with pain at fifth and sixth vertebral levels. Motion restrictions were noted with right rotation between first and second cervical vertebra and left rotation restriction at second and third cervical vertebra. A motion restriction was also noted at the second lumbar with a malposition of posterior and vertebral body left.

A supine Grostic leg check was performed following the protocol established in the literature. Leg length inequalities are described as a test for neurological interference from upper cervical misalignment. The Dentate ligament theory states that mechanical stress to the spinal cord creates neurological insult from torsion of the dentate ligaments. Schwartzbauer & Hart assessed the interexaminer reliability of leg length assessments and noted that supine leg length inequality has been shown in the past to have high reliability. Supine leg length inequality assessment was shown to have a 43.3% interexaminer reliability in this study.

The patient had a 0.5 inch short leg on the left.

Cervical radiographs were also taken (see Figures 3-6). Radiographic views included the neutral lateral cervical, anterior to posterior open mouth (APOM), anterior to posterior lower cervical, and vertex views. Radiographs were acquired for the analysis of occipital-atlanto-axial misalignment similar to upper cervical management found in the literature.

Radiographs were analyzed for Knee Chest upper cervical technique. The radiographs were analyzed using specific angular line drawing analysis with the foramen magnum used as the central point for analysis of atlas laterality and axis rotation on the APOM, the anterior tubercle of atlas as the central point on the neutral lateral cervical, and the neural canal as the central point on the vertex view.

The neutral lateral cervical and APOM views revealed that atlas was misaligned anterior, superior to the right and axis was misaligned posterior and the spinous shifted to the right. The vertex view revealed that atlas was rotated anteriorly on the right. Specific radiographic line analysis revealed that the atlas had moved anterior and superior on the right with anterior rotation (ASRA) and axis was misaligned posterior with the spinous shifted to the right (PR).

Diagnosis and Impressions

The examination revealed that there was neurological compromise stemming from an upper cervical subluxation. This diagnosis is supported by Wells & Williams who used radiographs, supine leg checks, and thermographic pattern analysis as indicators for vertebral subluxation in the upper cervical spine. Subluxation based chiropractors use thermal scanning to characterize vascular and neurological components of subluxation.
Radiographs measure and help to visualize the three-dimensional atlas misalignment. The atlas relies on soft tissue structures to maintain alignment making it uniquely vulnerable to displacement. Research done by McKnight & DeBoer points out that physiological change in the cardiovascular system can occur from cervical spine adjustments. For this reason it was critical to monitor the patient’s blood pressure from visit to visit.

**Technique and Intervention**

The patient was placed under Knee Chest upper cervical chiropractic care. Knee Chest was researched and developed by BJ Palmer in 1931. The patient is in the kneeling position with the head turned on a solid headpiece table. Adjustments were given on a Kale Knee Chest table. The patient’s sternal notch is placed on the rounded off portion of the lower headpiece with the knees on the floor and femurs at ninety degrees in a flexed position.

The doctor is on one side of the table with the cranial knee in the patient’s axillary fossa, the doctor’s legs shoulder width apart, hips and shoulders squared up to the table. The doctor’s elbows are bent to approximately 150 degrees to form the toggle mechanism. The contact was a clockwise tissue pull, the doctor rolls in the right pisiform onto the axis posterior arch and a set down occurs.

The doctor applies a body drop force in a superior direction. This specific atlas adjustment allows atlas to recoil into normalized alignment. There is a very high degree of satisfaction associated with upper cervical chiropractic care presented in the literature.

The first three adjustments were administered to the axis vertebrae addressing the posterior right (PR) misalignment. For this adjustment the patient was placed in the knee chest posture with her head turned to the right. The doctor took a clockwise tissue pull onto the spinous process of axis and placed the right pisiform onto the spinous contact point. Set down occurred by placing the left hand onto the contact hand and the toggle mechanism was formed with the elbows bent.

A body drop force was applied simultaneously with a quick contraction and relaxation of the triceps muscle. The patient was then rested for ten minutes and reassessed for thermographic pattern, leg length inequality, posture, and blood pressure. After each of these three adjustments the legs balanced, posture leveled out, and pattern was reduced but still revealed a significant thermal reading different from the established pattern (see Figure 1). The patient had three visits during this period of care with no adjustment administered because thermal scans did not produce her established pattern and supine leg length was within normal limits (See Table 1).

The patient still had significant thermal readings outside the normal limits established by Qualls & Lester but they were not indicative of the original established pattern (See Figure 2). Therefore, three consecutive scans were performed and confirmed a different thermal pattern. The decision was made to adjust the atlas anterior, superior on the right with anterior rotation (ASRA). The first two adjustments to the atlas were administered using a light force Toggle-Recoil adjustment with the patient in a side-posture position, head resting on a drop mechanism headpiece, and the doctor’s pisiform contacting the right transverse process of atlas. This was done to monitor how the patient responded to a lighter force adjustment of the atlas before administering a heavier body drop force.

The second two adjustments were delivered using the Knee Chest adjustment in the same manner used for axis but instead of an axis spinous contact, the posterior arch of atlas was the segmental contact point. After each adjustment the patient was rested for ten minutes and post assessment revealed balanced legs, level posture, and a reduced thermal scan (See Figure 2) confirming that the patient was no longer physiologically compromised. This was the course of care for the next seven weeks (See Table 1).

The patient remained on her medication through the course of care. Appointments were scheduled at the same time each day to minimize diurnal variations as suggested by Driscoll & Hall. It was also recommended that the patient continue her supplementation regimen, reduced sodium diet, and three times per week exercise regimen she had already established for herself which corresponds with the article by McCoy regarding health-related lifestyle modifications to reduce health risk factors. A low tyramine diet was also recommended to the patient as is suggested by the National Headache Foundation to manage her headaches.

**Outcomes**

The patient returned for an adjustment one month after the initial examination was performed. Blood pressure at this time was 126/90 mmHg; supine leg length showed a half-inch short left leg. Postural assessment revealed right head rotation and left high shoulder, and thermal pattern was present for confirmation of the presence of vertebral subluxation.

At her two-month reassessment her blood pressure was 125/94 mmHg, and no other indicators for vertebral subluxation were present. The patient remained compliant with visits two times per week for the remainder of the care period. At the three-month reassessment, her blood pressure was 114/83 mmHg, supine leg length was balanced, thermal scan was clear of pattern, postural assessment was normal, and muscle palpation revealed normal muscle tonicity. Overall, a decrease in blood pressure was recorded (See Graph 1) and the patient also noticed a reduction in the frequency and severity of her headache symptoms.

**Discussion**

Many mechanisms have been suggested in the literature that were reviewed for this study. Mangum et al discuss the various etiologies of hypertension that include increased sympathetic nervous system activity, long-term high sodium intake, inadequate potassium and calcium intake, and/or an increased production of aldosterone.

Hannah talks about disruption to autonomic nervous system integration at the medulla oblongata, thalamus, and/or hypothalamus. He believes that hypertonicity of the suboccipital muscles can cause aberrant neurological
coordination of the cervicosympathetic, vestibulosympathetic, and/or pressor reflexes.\textsuperscript{13}

Knutson\textsuperscript{21} also refers to these reflexes as a possible mechanism but also discusses the effect of stimulating or normalizing the upper cervical muscle spindles via Golgi tendon organ output. Kaye et al\textsuperscript{19} suggest that an increase to oxygen saturation can lead to a decrease in activity of the renin-angiotensin pathway, which will reduce aldosterone production and serum sodium levels. Another proposal includes the axis (C2) dorsal root ganglion and its vulnerability to compression and subsequent vascular insufficiency to the cranium causing neurological symptoms.\textsuperscript{10}

Plaugher et al\textsuperscript{8} entertain a few different mechanisms including aldosterone levels, and the autonomic nervous systems role in hypertension. This article makes a specific statement about the role that the sympathetic nervous system mainly seen in younger patients with borderline hypertension\textsuperscript{6} that might specifically apply to this case. Torns\textsuperscript{8} notes that it has been demonstrated that neurological elements of the cervical dorsal root ganglion travel to the intermediate nucleus of the medulla noted as an indirect cardiorespiratory regulator.

Qualls & Lester\textsuperscript{24} support the medulla oblongata mechanism and note that the upper cervical region misaligns in a three-dimensional torque that can put pressure on the medulla and affect vital functions of the cardiovascular system. The Lynch & Boone\textsuperscript{25} study focuses on the autonomic nervous system and how it is controlled. They suggest that anti-gravity muscle input to the cerebellum is a requirement for the coordination of autonomic nervous activity, and that mechanoreception is responsible for the inhibition of sympathetic neurons through the activation of supraspinal structures.\textsuperscript{26}

Kent\textsuperscript{8} states that the use of manipulation for the alleviation of episodic symptoms is not chiropractic. He presents many different models of subluxation in this article. Various aspects of many of these models that Kent provides apply to this case. The nine component model\textsuperscript{8} can be applied to this case; the patient presented with aberrant kinesiology in the upper cervical spine, with altered neurology confirmed by thermal pattern scans, myopathology confirmed by muscle palpation, issues with anatomy confirmed by postural analysis, and physiological and biochemical alterations confirmed by initial increased blood pressure and simultaneous medical management.

The dysafferentation model\textsuperscript{28} applies to this case as well and is also supported by Bennett & Tedder,\textsuperscript{30} where we see biomechanical dysfunction leading to alterations in mechanoreception that lead to abnormal postural tone\textsuperscript{8} in this case study. The neurodystrophic model\textsuperscript{8} also applies to this case; we see the stressful effects of neural dysfunction leading to immune responses and increased impulse traffic to the visceral structures, and pharmacological manipulation of neurotransmitters\textsuperscript{8} altered the functioning of the body's normal homeostatic processes.

This case fits into many of these mechanisms and models. It is suggested that the most prominent mechanism in this case is regarding the autonomic nervous system, including the cervicosympathetic, vestibulosympathetic, and pressor reflexes.\textsuperscript{3,6,13,22} Due to the age and presentation of the patient, her high blood pressure is likely due to over activity of the sympathetic nervous system that has led to subsequent postural distortions.

The noted postural distortions are likely caused by dysafferention\textsuperscript{8,30} and have caused spinal cord distortion from an atlas misalignment greater than 0.75 degrees leading to multiple neurological manifestations.\textsuperscript{32} It is also noted that one of the neurological manifestations may be in the form of increased aldosterone secretions and abnormal sodium retention\textsuperscript{6,7,19} that have been controlled by pharmacological management with diuretics.

Limitations

Although a positive reduction in blood pressure is seen in this case it must be taken into consideration that the patient was simultaneously on medication to lower her blood pressure. This is a single case study with management performed by the author, which opens up debate as to examiner bias.

Conclusion

This case study describes in detail the history, and management of a female patient with medically diagnosed hypertension. The patient showed improvement in blood pressure readings from initial examination to three-month follow-up assessment. Her blood pressure decreased from 134/98 mmHg at initial examination to 114/83 mmHg over the course of care (see Graph 1).

It is also noted that the patient experienced a significant reduction in headache symptom severity and frequency. There is a potential benefit in regards to upper cervical specific chiropractic management for the patient with hypertension. This form of intervention may help reduce costs to the patient, third party payers, and now the American taxpayer with the new healthcare mandates put into place.

There is a growing amount of literature regarding the effects of upper cervical specific chiropractic adjustments for the reduction of vertebral subluxation on blood pressure. It is therefore recommended that further research be done on this topic to expand the literature and further validate the use of chiropractic management for the reduction of upper cervical subluxations and subsequent reduction of blood pressure.

References


Graph 1.

Change in Arterial Blood Pressure Measurements Over the Course of Chiropractic Care

- Systolic
- Diastolic

Date of Blood Pressure Reading

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(N/A = no adjustment administered)
Figure 1. Axis (PR) Pre-Adjustment Established Thermal Pattern

Post Axis Adjustment Thermal Scan
Figure 2. Atlas (ASRA) Pre-Adjustment Established Thermal Pattern

Post Atlas Adjustment Thermal Scan