Review of Literature

Paraspinal Thermography in the Analysis and Management of Vertebral Subluxation: A Review of the Literature

Matthew McCoy D.C., MPH

Professor
Clinical Sciences
Life University
College of Chiropractic
Marietta, GA

Abstract

Objective: Paraspinal thermal scanning has been utilized by chiropractors to characterize vertebral subluxation and monitor the outcome of chiropractic intervention since the profession's inception. Thermal scanning has been shown to be a valid and reliable procedure for measuring paraspinal temperatures and clinical studies to explore the clinical meaningfulness of these measures have been conducted. The objective of this paper was to review the literature on paraspinal thermal scanning in chiropractic practice related to subluxation.

Methods: A search of the chiropractic literature was performed via the Index to Chiropractic Literature and PubMed along with hand and stack searches of relevant papers found through reference sections of already gathered papers. Only papers dealing with the utilization of thermography in relation to chiropractic and vertebral subluxation or related concepts were included.

Results: 72 papers were found to meet these guidelines and were made the subject of this review. The existing literature on reliability of paraspinal thermal scanning shows good to excellent reliability for the technique and issues related to interpreter reliability and computerized analysis are being addressed. While some authors have inappropriately interpreted the thermal literature, basic and advanced concepts related to its clinical meaningfulness such as pattern analysis, health perception and the use of thermal scanning as an outcome assessment tool in the management of vertebral subluxation, have a formidable evidence base from which to draw.

Conclusion: For those interested in the use of paraspinal thermal scanning as an outcome assessment tool for addressing vertebral subluxation the focus of research now needs to shift. There are several areas that need to be further explored including the issues related to reliability of interpretation, the clinical utility of pattern analysis, and the relationship between thermal readings and health outcomes.

Key Words: *Thermography, thermal scanning, chiropractic, skin temperature, vertebral subluxation, outcome assessment*

Introduction

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

The autonomic nervous system controls the organs, glands, and blood vessels and 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.[1-2]

The theory is that in a healthy patient, skin temperature patterns will change but remain symmetrical as the body adapts to the environment. Vertebral subluxations are contended to result in thermal asymmetries and/or fixed patterns and the levels of thermal asymmetry are not necessarily the levels of subluxation. The value of the thermal scan is thought to be in determining the overall degree of autonomic abnormality, and the response of the patient to the adjustment.[3-11]

Thermal readings have been used in chiropractic to detect differences in skin temperature from side to side since the 1920's.[12-14] 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.'"[4]

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 and 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.

In that regard, Uematsu et al determined normative values for paraspinal temperature based upon 90 asymptomatic "normal" individuals. The 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."[15]

Other more detailed papers have been published that review types of thermographic devices and the development, historical origins, and physiological rationales of thermography in chiropractic practice.[8,16]

Literature on Reliability

Several studies on intra- and inter-examiner reliability have been conducted on various thermal scanning instruments. Spector scanned twelve subjects at several spinal levels and measured the inter and intra-examiner reliability of an infrared instrument. The reliability ranged from .940 to .995. These patients were scanned in the prone, seated and standing positions.[17]

DeBoer and his team used three examiners and twenty four subjects to test the inter- and intra-examiner reliability of a handheld, infrared paraspinal instrument. The intra-class correlation coefficients for all three examiners was .657 with intra-examiner reliability ranging from 0.591 to 0.799 indicating moderate to good reliability.[18]

Keating's team found weak levels of inter-examiner agreement in their study of the lumbar spine in 25 pain-free and 21 symptomatic subjects.[19] However, his methodology was poor. Specifically, he used an arbitrary cutoff of 1.5 degrees F between adjacent segments, he used the Kappa statistic for analysis of his data which is considered an overly conservative measure of agreement and there was no continuous interval data.

Owens and his team studied the inter-examiner and intra-examiner reliability of 2 examiners utilizing the Tytron C-3000 handheld thermographic scanner. Using thirty subjects, each examiner scanned the subjects twice with the average time for completion of all four scans taking three minutes. They reported intra-class correlation coefficients between 0.91 and 0.98. In addition to the reliability issues they reported average temperatures from 35.4 degrees C to 30.0 degrees C with the average temperature changing little between scans suggesting that overall skin temperatures were stable during the procedures. The authors state that their results indicated that based upon their results, changes in thermal scans are actually due to physiological phenomena as opposed to equipment error. This becomes important from a clinical perspective in attempting to determine the clinical meaningfulness of thermal scan results.[20]

Perdew reviewed the reliability of test-retest data from several temperature reading instruments applying each to eight points on the backs of 46 subjects. The reliability was found to be generally high in this study.[21]

Plaugher and his investigators studied the intra and inter-examiner reliability of a thermocouple paraspinal skin temperature differential instrument using nineteen subjects and two examiners and found intra-class correlation coefficients of .27 to .85. Though in their study, they used the break system of analysis and had to rely on the examiner's interpretation of an abnormal temperature reading as opposed to a computerized reading of temperature differential. Nevertheless they found acceptable levels of reliability for all but one of the observations.[22]

Boone et al. utilized thermal scanning to describe a model for quality control in the chiropractic health care setting.[23] Their study presented one model for monitoring the reliability of reproducing thermal pattern scans using a

series of different instruments in different adjusting rooms.

The study was comprised of two separate trials (A), and (B). In each trial, one student served as the "subject" while a second student obtained thermographic scans. The subject then moved to the next room, and the second student again obtained a thermographic scan on the same subject. The scan from room 1 was then compared to determine percent agreement with the scan from room 2. This procedure was repeated in room 3, etc. Data was then analyzed and interpreted. Trial B also included a recording of the ambient temperature of each adjusting room immediately prior to the scan, and directly after each scan was taken. Comparisons of scans from 18 instruments fell within a range of 2 standard deviations (84.3 – 59.1 % similarity) around a mean of 71.7 + 6.3.

In the largest study of thermal scanning reliability conducted, the thermal functions of a commercially available infrared scanner (Insight Subluxation Station®) were evaluated for clinical reliability.[24] Two practicing chiropractors conducted the measures on 100 subjects and found intra class correlation coefficients (ICCs) for agreement and consistency ranging from 0.959 to 0.976. Concordance correlation coefficients (CCCs) ranged from 0.783 to 0.859 with tight confidence intervals indicating robust estimates of these quantities. This study revealed excellent intra-examiner and inter-examiner reproducibility of paraspinal thermography using a commercially available unit.[24]

It is clear that the existing literature on reliability of paraspinal thermal scanning shows good to excellent reliability for the technique.

Reliability of Analysis

Beyond the reliability of the testing procedure itself, there is the question of the reliability of the interpreter's analysis of the graphs and other data produced by the scans. In one of the first studies to address this issue, Stewart and his team conducted a study to attempt to establish a model for a reliable method of analysis of thermal data. Using a computer aided method of comparing graphs utilizing a moving Pearson Product Moment correlation and a moving *t*-test, the investigators found that thermal graphs can be compared over time for changes in temperature deviations at any given location.[7]

In a preliminary study, Owens had two experienced and blinded chiropractors judge the similarity of thermal graphs recorded on successive visits. Using 27 subjects and a total of 76 graphs the percent agreement was 38% with a kappa of .0008. Owens urges the development of a numerical computational method in order to garner increased objectivity of thermal pattern analysis.[25]

Using methods similar to Stewart and Boone, Owens reports on the development of specialized pattern analysis software that accepts data from thermographic instruments and provides tools for manipulation and visualization of two overlapping plots for comparison of thermographic scans taken on different occasions.

Owens states that further study is needed to determine what factors and range of values can be used to detect the presence of a pattern and neurological effects thought to be associated with vertebral subluxation.[26]

Hart and Boone provide a descriptive report of a method of determining patterns within paraspinal skin temperature readings whereby they used a modification of the evaluation described by Stewart. In their report they compared cervical and full spine graphs by creating a template and manually measuring and comparing one graph to another. They determined a total percentage of similarity between any two graphs and the number of areas where two graphs were deviating in the same direction. Using a total of 20 graphs they reported a range of 66.3% to 71% agreement for analysis of full spine graphs and a 67% to 83.6% agreement for analysis of cervical spine graphs.[3]

Computer-Aided Analysis

In a recent report by Hart and other investigators they looked at the reliability of three methods of computer aided thermal pattern analysis.[27] In their study, three examiners compared two sets of scans from 30 subjects using three methods. Two involved manually aligning the graphs prior to a computer software program calculating the percent similarity and the third was done without manual alignment prior to the calculation of similarity. The study demonstrated the inter and intra-examiner reliability for manually aligning the graphs to range from .791 to .987 and also showed that aligning the graphs plays a role in maximizing the percent similarity between graphs.[27]

Hart and others described above have done a good, initial job tackling the issue of interpreter reliability and computerized analysis. More work should be encouraged and supported in this fruitful area.

Pattern Analysis and Health Perception

As mentioned earlier, Uematsu et al determined normative values for the degree of acceptable thermal asymmetry in the cervical, thoracic and lumbar spine and even went so far as to state that deviations from these norms indicate pathology and can be used as an outcome assessment.[15] Nevertheless, there has been increasing interest in determining whether or not alterations of thermal patterns are indicative of ill health.

Using a thermal pattern calculator (TPC), Hart et al investigated the relationship between thermal pattern analysis and health perceptions using the SF-12 health survey in 68 subjects and found that right channel readings with TPC percents of 70.8 or higher were associated with lower mental health perception scores on the SF-12.[28]

In a similar study Hart compared thermal scans to health perception using the SF-12 in 51 subjects scanned twice on up to three separate occasions using a 5 minute acclimation period. Subjects having a left channel TPC of

79.5 percent or greater or a right channel TPC of 79.7 percent or greater experienced decreased physical health perception.[29]

In a follow-up study, Hart attempted to replicate his findings using 52 subjects, scanning them twice with a 5 minute acclimation period. In addition to analyzing the data from this study and the previous study he also did a combined analysis of data from both studies. The right channel showed significant correlations with health perception in two out of the three analyses while the left showed significant findings in all three.[30]

Hart also studied this phenomenon in 34 subjects using a 6 minute acclimation period with scans performed on three separate occasions. In this study those subjects exhibiting a right channel TPC percent of 72.2 percent or greater tended to report a perception of decreased mental health when compared to subjects with a right channel TPC percent of 71.7 or less.[31]

In another study involving 68 subjects, Hart used a Mastoid Fossa temperature differential (MFD) procedure to analyze the neurological interference component of vertebral subluxation.[32] This study compared MFD readings to the outcome of health perception using SF-12 data. No statistical difference was found in MFD readings in above average versus below average mental composite scores. Participants having above average physical composite scores tended to show larger MFD readings though actual differentials revealed the only statistically significant difference ($p = 0.0103$). Hart concluded that wider mastoid actual fossa differential readings were associated with better physical health perception.

Brown also studied mastoid fossa temperatures to determine how bilateral mastoid fossa asymmetry relates with other patterns of interference associated with vertebral subluxation analysis such as: spinal balance (Thompson-Derifield) leg length and cervical syndrome leg length tests.[33] In a retrospective analysis Brown extracted mastoid fossa data from 139 randomly selected patient visits from among those wherein the doctor had identified the presence of patterns of interference and who were receiving atlas adjustments; and 114 randomly selected patient visits without patterns of interference. He found that in the absence of patterns of interference, a tendency toward bilateral mastoid fossa temperature symmetry (55.26% of cases) was observed.

In the presence of patterns of interference there was less of a tendency for bilateral mastoid fossa temperature symmetry (32.0% of cases). When asymmetry was found the average difference in fossa temperatures exceeded those observed using conventional tools. In patients displaying the presence of patterns of interference the fossa temperature tended to be cooler on the side of atlas vertebra laterality (SOL). It was also observed that the pre-adjustment balanced temperatures were fewer than the number of post-adjustment balanced temperatures.[33]

In addition to chiropractors, it appears that osteopaths are also interested in the relationship between paraspinal temperature variation and health status.

In a study presented at the 2003 annual meeting of the American Academy of Osteopathy Richards and his team reported on the results of a study to explore the correlations between paraspinal temperature variation and health related quality of life. Using 79 subjects who completed the SF-36 short form health survey they found *r* values of -.23 to -.28 and stated that temperature imbalances in the spine were correlated with lower quality of life.[34]

Hart and other's work in this area of quality of life represents the nascent but progressive stages of the exploration of some deeply held beliefs that have survived since the beginning of the chiropractic profession. Others are encouraged to engage in researching and offering additional evidence in this area.

Clinical Meaningfulness

A number of chiropractic clinical studies have been reported where thermography has been utilized as an outcome assessment tool. Elster reports on single case studies as well as retrospective analyses of numerous cases involving symptomatology and disorders such as headaches, multiple sclerosis, Parkinson's, vertigo, attention deficit, infantile colic and Tourettes.[35-41]

In her reports, Elster identifies upper cervical vertebral subluxation through analysis of vertebral misalignment via x-ray and abnormal neurophysiology via thermal scanning. In all of her reports subjects demonstrated abnormal thermal scans upon presentation. Based on her review of the literature, Elster contends that upper cervical subluxations are a frequent result of head and neck trauma. She further contends that these injuries lead to long term neurological deterioration.[35-41]

In cases reported by Kessinger where vertigo, hearing loss, visual acuity, whiplash, pulmonary and cognitive function were studied - thermal scanning and the use of pattern analysis were the sole criteria used to determine the presence or absence of aberrant neurophysiology in the cervical spine. The timing of the adjustment in the upper cervical spine was also determined by reading the thermal scans.[42-46]

Two reports of successful pregnancy following a diagnosis of infertility included pre and post paraspinal thermal readings. The authors report on a demonstrated decrease in the number of abnormal readings following the introduction of chiropractic care directed at subluxation reduction.[47,48]

Goodsell reports on a case of resolution of secondary amenorrhea following reduction of vertebral subluxations.[49] Physical exam revealed indicators of vertebral subluxation including motion and static palpation abnormalities, postural alterations, as well as paraspinal thermography and surface electromyography asymmetries. Twelve weeks into care the patient reported having her first normal menstrual cycle in 5 years. Follow-up thermal scans revealed improvement in dysautonomia concomitant with the resolution of amenorrhea.

In a report of four cases of children with cerebral palsy

undergoing chiropractic care where thermal scanning was used as an outcome measure, clinicians reported improvement in thermal scans following the introduction of chiropractic care directed at subluxation reduction. The authors tied the improvements in neurological function to improvement in other parameters of function such as activities in daily living, locomotion, postural analysis and palpation findings.[50]

In another case report by Goodsell the author reports on improvement in sleep and quality of life in a child with cerebral palsy undergoing chiropractic care.[51] Thermal scanning indicated adaptive changes concomitant with the improvement in sleep and quality of life.

In a case study report, Pauli describes the use of various analyses employed to evaluate vertebral subluxations, including paraspinal surface electromyography and thermography, in a 36 year old male who presented with primary health concerns including stress, eye pain, left leg pain, gastritis, ulcers, nervousness, depression, lack of concentration and general loss of interest in daily life. Following the introduction of chiropractic care the patient experienced improvement in quality of life with associated improvements in objective outcome assessments such as paraspinal thermography.[52]

In a study of 18 subjects who were evaluated with Moire contourography and infrared thermography prior to and after receiving a single chiropractic adjustment, investigators reported that mean thermographic measurement was lower following the adjustment.[53]

In a review of 10 cases of Menieres Disease that responded to specific upper cervical adjustment to reduce vertebral subluxation, Burcon utilized thermal scanning in order to determine the presence or absence of subluxation.[54]

In a single case report by Burcon on resolution of Trigeminal Neuralgia following specific upper cervical adjustments to reduce vertebral subluxation, he similarly utilized thermographs of the cervical spine to develop a pattern of subluxation in order to determine when to adjust.[55]

Hoffman and Russell in a single case report describe objective changes of a 3½ year old autistic girl following chiropractic adjustments over a 10 week period.[56] The 3½ year old child had reduced social interaction and language skills and learning difficulties and received full spine adjustments where indicated to reduce vertebral subluxation. After 5 visits there were improvements in social interactions, language skills and increased symmetry in surface EMG and thermal scanning.

In three separate case studies, Stone-McCoy reports on successful resolution of a child with otitis media, a woman with verbal and motor tics, and a child with ADHD.[57-59] In all three cases thermal scanning was used as part of the clinical work-up and showed improvements following intervention.

While not addressing paraspinal thermal scanning, Knutson reports on a single case of improved temperature differential in the hands following chiropractic adjustment to the upper cervical spine to reduce subluxation.[60]

Activator Effects

In a series of studies by Roy et al., they explored paraspinal cutaneous temperature including: comparison in the standing versus prone position, temperature changes after manipulative therapy directed at L5, temperature changes after the application of an Activator Instrument, and an acclimation study. [61-64]

They found that there was a positive Pearson correlation (0.802-0.803; P <.000) between the standing and prone positions for both left and right sides and concluded that there were no differences between the prone or standing paraspinal cutaneous temperature measures in symptom-free subjects who acclimate for 8 minutes before recording.[61]

In their study of cutaneous temperature changes following spinal manipulation at L5, Roy et al. found that the effects of a lumbar spine manipulation appear noticeable as measured by temperature changes.[62]

In their study of temperature changes with the use of an Activator Instrument, Roy and his team found that contacting the skin with the instrument and with *or* without a thrust with a sustained pressure stronger than the loading principle taught in the Activator Methods Chiropractic Technique protocol or a thrust respecting the standard loading principle of the instrument produced a cooling immediately after the adjustment.

They also observed that contacting the skin with the instrument and *with* a thrust respecting the standard loading principle of the instrument produced a secondary cooling at T5 followed by a re-warming at T10. Further, they found that contacting the skin with the instrument *without* a thrust and respecting the standard loading principle of the instrument did not produce a temperature change.[63]

Following their study on acclimation relative to thermal scanning, Roy et al recommended acclimatization in a temperature and humidity controlled environment for a minimum of 8 minutes followed by an 8 minute maximum recording period with the patient in a prone position to obtain accurate temperature readings.[64]

The above studies and case reports represent a foundational stage upon which much larger studies can be conducted.

Misappropriation of the Literature

There are few peer reviewed sources that objectively discuss it, however some within and outside the profession suggest that the use of thermography is controversial. Typically this occurs when the nuance of measuring

vasomotor function as apart from detecting a specific clinical entity is not considered. One such source is a report of the American Academy of Neurology, Therapeutics and Technology Assessment Subcommittee (AANTTAS).[65]

The Committee points out appealing features of thermography such as being painless, non invasive, objective, inexpensive, permanent and safe. They report that thermography has been shown to be sensitive in regards to radiculopathy and specific compared to CT, myelography, EMG and surgical exploration.

However, they feel that the inability to determine precise localization or pathology hamper its clinical usefulness. It is important to point out that this report does not address the use of thermal scanning in the context of this present study. The Technology Subcommittee addresses the use of thermography primarily relative to radiculopathy, neck, back and head pain.

Thermography Favorably Compared to Myelography

Another older paper is a review of similar applications of neuromusculoskeletal thermography by Meeker and Gahlinger who found a number of areas wanting relative to thermography including observer and interpretive reliability, lack of prospective controls and incomplete follow-up.[66]

Their review of the thermographic literature focused on the sensitivity, specificity and predictive value of thermography and its relationship to pain syndromes. As such they relied on comparisons to diagnostic procedures typically utilized to assess pain and related diagnoses similar to the AANTTAS report. In this regard they conclude that the use of thermography for such complaints was promising and compared favorably with myelography, EMG's and CAT scans in sensitivity and predictive value.

They found that specificity and positive predictive value compared well but was not as supported. Comparing it to surgical results and clinical impressions they suggested it appears as valid as more commonly used tests.

Despite discussion of some of this positive data in their review of the literature they concluded that there was little to suggest thermography could replace established tests and that there was little in the way of cost benefits.

There is no data on how widespread the varying applications of thermography are within the profession. The only data on this topic is from a survey of North American Chiropractors completed by the Institute for Social Research at Ohio Northern University and published in 2003.[67] Their research found that 88.6% of the chiropractors surveyed stated thermography was appropriate for use in practice.

While the question does not address utilization we are unaware of any other data on this issue. Without such data it is impossible to state with any authority how extensive thermography utilization is within the profession for any application.

At a minimum there are two broad uses, at least within the chiropractic community. One is the application for neuromusculoskeletal pain syndromes such as was reviewed by Meeker and Gahlinger[66] and the other is in line with the focus of the instrumentation and protocols utilized by subluxation based practitioners. This involves the use of thermal scanning to characterize vascular and neurological components of subluxation and/or joint dysfunction. This may involve simple side to side comparison to normative data or may involve the concept of pattern work.

While others such as Hart[29-31] and Boone[28] have begun preliminary work in this area these attributes will need to be much more fully addressed in future studies.

Standards of Care & Practice Guidelines

In perhaps one of the most bizarre examples of misappropriation (or in this case *denial*) of the literature, the managed care company American Specialty Health (ASH) makes the following statement in their Clinical Practice Guideline on Upper Cervical Adjusting:[68]

> Leg checks or thermography used to confirm the subluxation removal or to assess outcomes of care have not been shown to be either effective or scientifically plausible.

ASH lists no evidence on thermography in their reference section to substantiate their position, so one is left to assume that they did not review any thermography literature or they decided that the existing literature (such as that reviewed here) was not worthy of their consideration.

And while one can at least debate the merits of the evidence if it is at least presented, ASH's contention that thermal scanning is "not scientifically plausible" removes all notion of credibility to their guideline. They define scientific plausibility as follows: [68]

> A belief, theory, or mechanism of health and disease is said to be implausible if it requires the existence of forces, mechanisms, or biological processes that are not known to exist within the existing framework of scientific knowledge.

Making matters worse ASH takes one step further and suggests that doctors utilizing such outcomes assessment tools are indirectly harming patients which they define as: [68]

> *Indirect harm (substitution).* Harm caused to a patient by substituting a specific diagnostic or therapeutic procedure whose safety, therapeutic effectiveness, or diagnostic utility is either unknown or is known to be unsafe, ineffective, or no diagnostic utility, for a diagnostic or therapeutic procedure of known safety, effectiveness, or diagnostic utility.

Despite ASH's efforts as a for profit company to portray the use of objective assessment of vertebral subluxation as unscientific or scientifically implausible, two major standards of care and practice guideline documents consider there to be sufficient evidence that thermal scanning is a valid and reliable procedure for its use in assessing components of the vertebral subluxation.

The Council on Chiropractic Practice's Clinical Guideline Number One: Vertebral Subluxation in Chiropractic Practice[69] has rated thermal scanning as an "Established" procedure stating:

> Temperature reading devices employing thermocouples, infrared thermometry, or thermography (liquid crystal, telethermography, multiple IR detectors etc.) may be used to detect temperature changes in spinal and paraspinal tissues related to vertebral subluxation.

The International Chiropractors Association's Practice Guidelines also give thermal scanning an established rating.[70]

Both the Council on Chiropractic Practice and the International Chiropractors Association's documents are accepted by the National Guideline Clearinghouse of the United States Federal Government.[71,72]

Conclusion

The existing literature on reliability of paraspinal thermal scanning shows good to excellent reliability for the technique and issues related to interpreter reliability and computerized analysis are being addressed. While some authors and managed care companies have inappropriately interpreted or even ignored the thermal literature, basic and advanced concepts related to its clinical meaningfulness such as pattern analysis, health perception and the use of thermal scanning as an outcome assessment tool in the management of vertebral subluxation, have a formidable evidence base from which to draw.

It is suggested that anyone contending that thermal scanning in relation to analysis and management of vertebral subluxation is not evidenced based is at best wholly ignorant of the literature or at worst purposely misinterpreting or ignoring it.[68]

Those issues aside there are several areas that could be explored relative to a research agenda involving thermal scanning. The issues related to reliability of interpretation, composite scoring, the clinical utility of pattern analysis, and the relationship between thermal readings and health outcomes are fruitful areas for exploration.

Moving beyond the relationship between components of vertebral subluxation and thermal values it would be helpful to thoroughly investigate the relationship between thermal changes, subluxation and their relationship to health outcomes. Similarly, if not more importantly, the relationship between paraspinal thermal changes to other components of vertebral Subluxation would be a worthy area of study.

References

1. Segmental Neuropathy." Canadian Memorial Chiropractic College. Toronto. No date
2. Wallace H,Wallace J, Resh R. Advances in paraspinal thermographic analysis. Chiropractic Research Journal 2(3):39, 1993. See also ref for 5 degree variation in Kessinger JMPT Vertigo page 359
3. Hart,J.F.,Boone,W.R. Pattern Analysis of Paraspinal Temperatures: A Descriptive Report. Journal of Vertebral Subluxation Research,Vol. 3,No. 4, 2000.
4. Miller JL. Skin temperature instrumentation. International Review of Chiropractic.April 1967, pp. 39-41.
5. Schram SB, Hosek RS, Owens ES. Computerized paraspinal skin surface temperature scanning:A technical report. J Manipulative Physiol Ther 1982; 5(3): 117-122.
6. Ebrall PS, Iggo A, Hobson P, Farrant G. Preliminary report: The thermal characteristics of spinal levels identified as having differential temperature by contact thermocouple measurement (Nervo Scope). Chiropr J of Australia 1994; 24(4):139-143.
7. Stewart MS, Riffle DW, Boone WR. Computer-aided pattern analysis of temperature differentials. J Manip Physiol Ther 1989;12(5):345-352.
8. Plaugher G. Skin temperature assessment for neuromusculoskeletal abnormalities of the spinal column. J Manip Physiol Ther 1992;15(6):368.
9. Senzon, S.A. The Theory of Chiropractic Pattern Analysis Based on the New Biology. Abstracts of the Eighth Annual Vertebral Subluxation Research Conference Sponsored by Sherman College of Straight Chiropractic. Journal of Vertebral Subluxation Research, Vol 4, No. 1, 2000
10. Hart, J.F. Analyzing the neurological interference component of the vertebral subluxation with the use of pattern analysis:A Case Report. Abstracts of Association of Chiropractic Colleges Eighth Annual Conference.The Journal of Chiropractic Education,Vol. 15, No. 1, 2001.
11. Brand N, Gizoni C. Moiré contourography and infrared thermography: Changes resulting from chiropractic adjustments. J Manipulative Physiol Ther 1982; 5:113-116.

12. Rademacher WJ. A premise for instrumentation. Chiropr Tech 1994;6:84-94.
13. Palmer BJ. Chiropractic clinical controlled research. Vol. XXV. Hammond (IN): W.B. Conkey Co; 1951. p. 587.
14. Duff SA. Chiropractic clinical research, interpretation of spinal bilateral skin temperature differentials. San Francisco: Paragon Printing; 1976. p. vi-vii.
15. Uematsu, E, et al. Quantification of thermal asymmetry, part 1: normal values and reproducibility. J Neurosurg 1988; 69: 552-555.
16. Spector B, Fukuda F, Kanner L, Thorschmidt E, Dynamic thermography: a reliability study. J Manipulative Physiol Ther 1981;4 (See Kyneur & Bolton
17. Kyneur JS, Bolton SP. Chiropractic instrumentation: an update for the 90's. Chiropr J. Aust;21:3 82-94 Sept 1991
18. DeBoer KF, Harmon RO, Chambers R, Swank L. Inter- and intra-examiner reliability study of paraspinal infrared temperature measurements in normal students. Res Forum 1985;2:4-12.
19. Keating JC, Bergmann TF, Jacobs GE, Finer BA, Larson K. Interexminer reliability of eight evaluative dimensions of lumbar segmental abnormality. J Manipulative Physiol Ther 1990;13:463-70.
20. Owens EF, Hart JF, Donofrio JJ, Haralambous J, Mierzejewski E. Paraspinal skin temperature patterns: An interexaminer and intraexaminer reliability study. J. Manipulative and Physiol. Ther. March/April 2004.
21. Perdew W, Jenness ME, Daniels JS et al. A determination of the reliability and concurrent validity of certain body surface temperature measuring instruments. Dig Chiro Econ May/June:60-5.
22. Plaugher G, Lopes MA, Melch PE, Cremate EE. The inter and intra-examiner reliability of a paraspinal skin temperature differential instrument. J Manipulative Physiol Ther 1991;14:361-7.
23. Boone WR, Strange M, Trimpi J, Wills J, Hawkins C, Brickey P. Quality Control in the Chiropractic Clinical Setting Utilizing Thermography Instrumentation as a Model. Annals Vertebral Subluxation Res. Vol. 2007. October 12, 2007, pp 1-6.
24. McCoy M, Campbell I, Stone P, Fedorchuk C, Wijayawardana S, Easley K. Intra-examiner and Inter-examiner Reproducibility of Paraspinal Thermography. February 2011. Public Library of Science (PLoS)
25. Owens E. Thermographic pattern analysis using objective numeric methods. The Journal of Chiropractic Education. Vol. 14, No. 1, 2000.
26. Owens E, Stein T,. Computer aided analysis of paraspinal thermographic patetrns: A technical report. Chiropractic Research journal Vol. 7 No. 2 Fall 2000.
27. Hart J, Omolo B, Boone WR, Brown C, Ashton A. Reliability of three methods of computer-aided thermal pattern analysis. J Can Chiropr Assoc 2007; 51(3)
28. Hart JF, Omolo B, Boone WR, Thermal patterns and health perceptions. J Can Chiropr Assoc 2007; 51(2)
29. Hart, J. Five minute thermal pattern analysis and health perception. J. Vertebral Subluxation Res. May 3, 2007.
30. Hart, J. Five-Minute Thermal Pattern Analysis and Health Perception: A Follow-up Study. J. Vertebral Subluxation Res. September 26, 2007.
31. Hart, J. Six minute acclimated thermal scans and health perception. J. Vertebral Subluxation Res. July 30, 2007.
32. Hart J. Mastoid Fossa Temperature Differentials & Health Perception. Annals Vertebral Subluxation Res. Vol. 2010. September 28, 2010, pp 1-6.
33. Brown M, Coe A, DeBoard TD. Mastoid Fossa Temperature Imbalances in the Presence of Interference Patterns: A Retrospective Analysis of 253 Cases. Annals Vertebral Subluxation Res. Vol. 2010. July 15, 2010 pp 1-13.
34. Richards DG, McMillin MA, Mein EA, Nelson CD. Correlations between paraspinal temperature variation and health status: From manual therapeutic art to objective measurement. American Academy of Osteopathy Annual Meeting March 2002.
35. Elster E. Sixty Patients With Chronic Vertigo Undergoing Upper Cervical Chiropractic Care to Correct Vertebral Subluxation: A Retrospective Analysis. J. Vertebral Subluxation Res. Nov. 8, 2006, pp 1-9
36. Elster E. Eighty-One Patients with Multiple Sclerosis and Parkinson's Disease Undergoing Upper Cervical Chiropractic Care to Correct Vertebral Subluxation: A Retrospective Analysis J. Vertebral Subluxation Res. August 2, 2004, pp 1-9
37. Elster E. Upper Cervical Chiropractic Care for a Patient with Chronic Migraine Headaches with an Appendix Summarizing an Additional 100 Headache Cases J. Vertebral Subluxation Res. August 3, 2003, pp. 1-10
38. Elster E. 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 J. Vertebral Subluxation Res. July 12, 2003, pp. 1-11
39. Elster E. Upper Cervical Chiropractic Management of a Multiple Sclerosis Patient: A Case Report J. Vertebral Subluxation Res. May 2001, Vol 4, No.2
40. Elster E. Treatment of Bipolar, Seizure, and Sleep Disorders and Migraine Headaches Utilizing a Chiropractic Technique Journal of Manipulative and Physiological Therapeutics March 2004 Volume 27 Number 3.

41. Elster E. Sixteen Infants with Acid Reflux and Colic Undergoing Upper Cervical Chiropractic Care to Correct Vertebral Subluxation: A Retrospective Analysis of Outcome. J. Pediatric, Maternal & Family Health – Chiropractic. Vol. 2009 No. 2
42. Kessinger RC, Boneva DV. Vertigo, tinnitus, and hearing loss in the geriatric patient Journal of Manipulative and Physiological Therapeutics June 2000 Volume 23 Number 5 pp 352-362 .
43. Kessinger RC, Boneva DV Case study: Acceleration/deceleration injury with angular kyphosis. Journal of Manipulative and Physiological Therapeutics May 2000 Volume 23 Number 4 pp 279-287.
44. Kessinger RC, Boneva DV Changes in Visual Acuity in Patients Receiving Upper Cervical Specific Chiropractic Care J. Vertebral Subluxation Res. Vol 2, No. 1, p 1-7
45. Kessinger RC Changes in Pulmonary Function Associated with Upper Cervical Specific Chiropractic Care J. Vertebral Subluxation Res. Vol 1, No. 3. p 1-7
46. Kessinger R, Boneva D. Neurocognitive Function and the Upper Cervical Spine. Chiropractic Research Journal 1999; 6(2): 88-89.
47. Kaminski TM Female Infertility and Chiropractic Wellness Care: A Case Study on the Autonomic Nervous System Response while Under Subluxation Based Chiropractic Care and Subsequent Fertility. J. Vertebral Subluxation Res November 2, 2003, pp. 1-10
48. Lyons DD. Response to Gonstead Chiropractic Care in a 27 year old Athletic Female with a 5 year history of Infertility J. Vertebral Subluxation Res November 9, 2003, pp 1-3
49. Goodsell L, Shtulman I. Resolution of secondary amenorrhea following reduction of vertebral subluxations: A Case Report. J. Pediatric, Maternal & Family Health – Chiropractic. Vol. 2011 No. 2.
50. McCoy M, Malakhova E, Safronov Y, Kent C, Scire P. Improvement in paraspinal muscle tone, autonomic function and quality of life in four children with cerebral palsy undergoing subluxation based chiropractic care: Four retrospective case studies and review of the literature. J. Vertebral Subluxation Res June 21, 2006, pp 1-15
51. Goodsell L, Schneider J. Improvement in Sleep and Quality of Life in a Child with Cerebral Palsy Undergoing Chiropractic Care. J. Pediatric, Maternal & Family Health – Chiropractic. Vol. 2010. No. 3.
52. Pauli Y. Quality of Life Improvements and Spontaneous Lifestyle Changes in a Patient Undergoing Subluxation-Centered Chiropractic Care: A Case Study. J. Vertebral Subluxation Res October 11, 2006, pg 1-15
53. Brand N, Gizoni CM. Moire contourography and infrared thermography: Changes resulting from chiropractic adjustments. J. Manipulative Physiol. Therapeutics. Vol. 5 No. 3. September 1982.
54. Burcon M. Upper Cervical Protocol to Reduce Vertebral Subluxation in Ten Subjects with Menieres: A Case Series. Annals Vertebral Subluxation Res. Vol. 2008. June 2, 2008, pp 1-8.
55. Burcon M. Resolution of Trigeminal Neuralgia Following Chiropractic Care to Reduce Cervical Spine Vertebral Subluxations: A Case Study. Annals Vertebral Subluxation Res. Vol 2009. October 26, 2009, pp 1-7.
56. Hoffman N, Russell D. Improvement in a 3½-year-old Autistic Child Following Chiropractic Intervention to Reduce Vertebral Subluxation. Annals Vertebral Subluxation Res. Vol. 2008. March 24, 2008, pp 1-4.
57. Stone-McCoy P, Boutilier A, Black P. Resolution of Otitis Media in a Nine Month Old Undergoing Chiropractic Care: A Case Study and Selective Review of the Literature. J. Pediatric, Maternal & Family Health – Chiropractic. Vol. 2010, No. 3.
58. Stone-McCoy P, Muhlenkamp K. Reduction in Motor and Vocal Tics in a Female Undergoing Chiropractic Care to Reduce Vertebral Subluxation. J. Pediatric, Maternal & Family Health – Chiropractic. Vol. 2009, No. 3.
59. Stone-McCoy P, Przybysz L. Chiropractic Management of a Child with Attention Deficit Hyperactivity Disorder & Vertebral Subluxation. J. Pediatric, Maternal & Family Health – Chiropractic. Vol 2009, No 1.
60. Knutson GA. Thermal asymmetry of the upper extremity in scalenus anticus syndrome, leg length inequality and response to chiropractic adjustment. J. Manipulative Physiol. Therapuetics. Vol. 20. No. 7. September 1997.
61. Roy RA, Boucher JP, Comtois AS. Consistency of cutaneous thermal scanning measures using prone and standing protocols: A Pilot Study. J Manipulative Physiol Ther 2010;33:238-240
62. Roy RA, Boucher JP, Comtois AS. Paraspinal cutaneous temperature modification after spinal manipulation at L5. J Manipulative Physiol Ther 2010;33:308-314
63. Roy RA, Boucher JP, Comtois AS. Effects of a manually assisted mechanical force on cutaneous temperature. J Manipulative Physiol Ther 2008;31:230-236
64. Roy RA, Boucher JP, Comtois AS. Digitized infrared segmental thermometry: Time requirements for stable recordings. J Manipulative Physiol Ther 2006;29:468.e1-468.e10
65. Thermography in neurologic practice. Report of the American Academy of Neurology, Therapeutics and Technology Assessment Subcommittee. Neurology 1990;40:523-525
66. Meeker WC, Gahlinger PM. Neuromusculoskeletal Thermography: A Valuable Diagnostic Tool? J. Manipulative Physiol Ther. 1986; 9:4 257-266.
67. McDonald W, Durkin K, Iseman S, Pfefer M, Randall B, Smoke L, Wilson K. How Chiropractors Think and Practice: The Survey of North American Chiropractors, Institute for Social Res, Ohio Northern Univ, Ada, Ohio, 2003.

68. American Specialty Health Clinical Practice Guideline: Upper Cervical Adjusting Techniques. July 13, 2006. American Specialty Health. San Diego, California.
69. Council on Chiropractic Practice Clinical Guideline Number One: Vertebral Subluxation in Chiropractic Practice. Council on Chiropractic Practice, Chandler, AZ Update and Revision. 2008.
70. Recommended Clinical Protocols and Guidelines for the Practice of Chiropractic. International Chiropractor's Association. Arlington, VA 2000.
71. United States Department of Health & Human Services. Agency for Healthcare Research & Quality: National Guideline Clearinghouse. Vertebral subluxation in chiropractic practice. http://www.guideline.gov/content.aspx?id=13617.
72. United States Department of Health & Human Services. Agency for Healthcare Research & Quality: National Guideline Clearinghouse. Best practices & practice guidelines. http://www.guideline.gov/content.aspx?id=14231