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 pathophysio-logical 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.

KeyWords: Chiropractic, Thermography and Thermo-regulation.

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°ree 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°reeC (98.6°ree 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°ree 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 color-graphic 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°reeC 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°ree 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 Videocons51 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°ree 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]
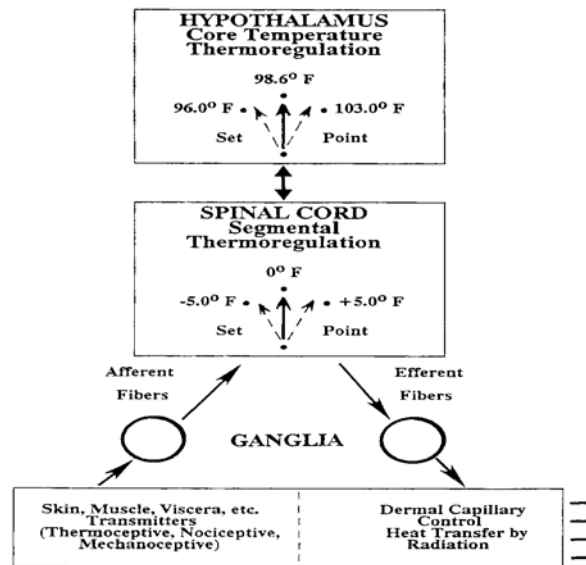

Figure 1. Simplified Representation of Thermoregulation

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°reeC 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 Physiology 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"
•Decreased sympathetic-fiber function •Neurochemical alpha-receptor blockade
2.Thermographically "Cold"
•Increased sympathetic-fiber function •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
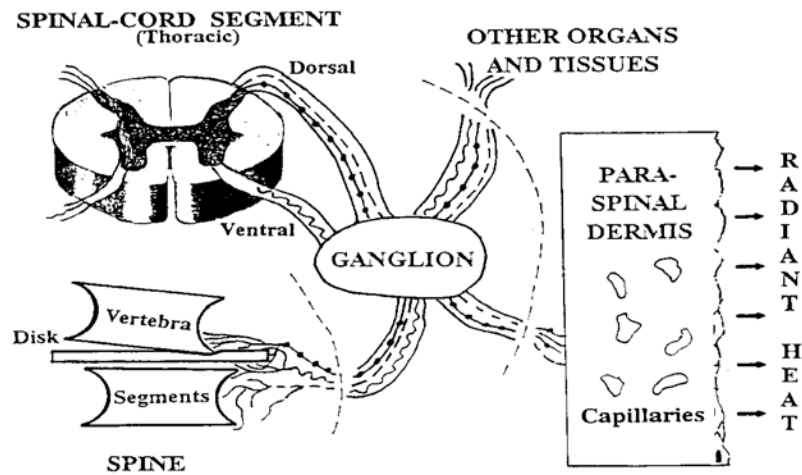
Figure 2. Representation of Sympathetic Function

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°ree 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°reeF) 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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