



Thermal Imaging Guided Laser Therapy – Part 1

An innovative method for determining optimal treatment location and effectiveness of laser therapy.

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Infrared thermography or infrared imaging is an exciting and valuable tool that has many applications in healthcare. In part 1 of this series, I will review some of the basic principles and history of thermal imaging. In part 2, I will discuss and illustrate its use in guiding laser therapy.

History

A Canadian physician, Dr. Ray Lawson, established the first known medical application for modern thermography with extensive research regarding breast patterns. He published his first paper in 1956, titled “Implications of surface temperature in the diagnosis of breast cancer.”¹ Thirty years of clinical use and more than 8,000 peer-reviewed studies in the medical literature have established thermography as a safe and effective means to examine the human body. It is completely non-invasive

and, as such, does not require the use of radiation or other potentially harmful elements. Medical research has shown thermography to be a useful tool in research as well as being helpful in the diagnosis of breast cancer, nervous system disorders, metabolic disorders, neck and back problems, pain syndromes, arthritis, vascular disorders, and soft tissue injuries among others.²

Every object at temperatures above Absolute Zero (0 degrees Kelvin or -273.15 degrees Celsius) emits thermal radiation, much of it in the infrared portion of the electromagnetic (EM) spectrum. Objects that are very hot emit thermal radiation that is in the visible and even the ultraviolet portion of the EM spectrum as well as the infrared—such as an incandescent light bulb or our local star that we call the sun.

The IR or infrared portion of the EM spectrum occupies

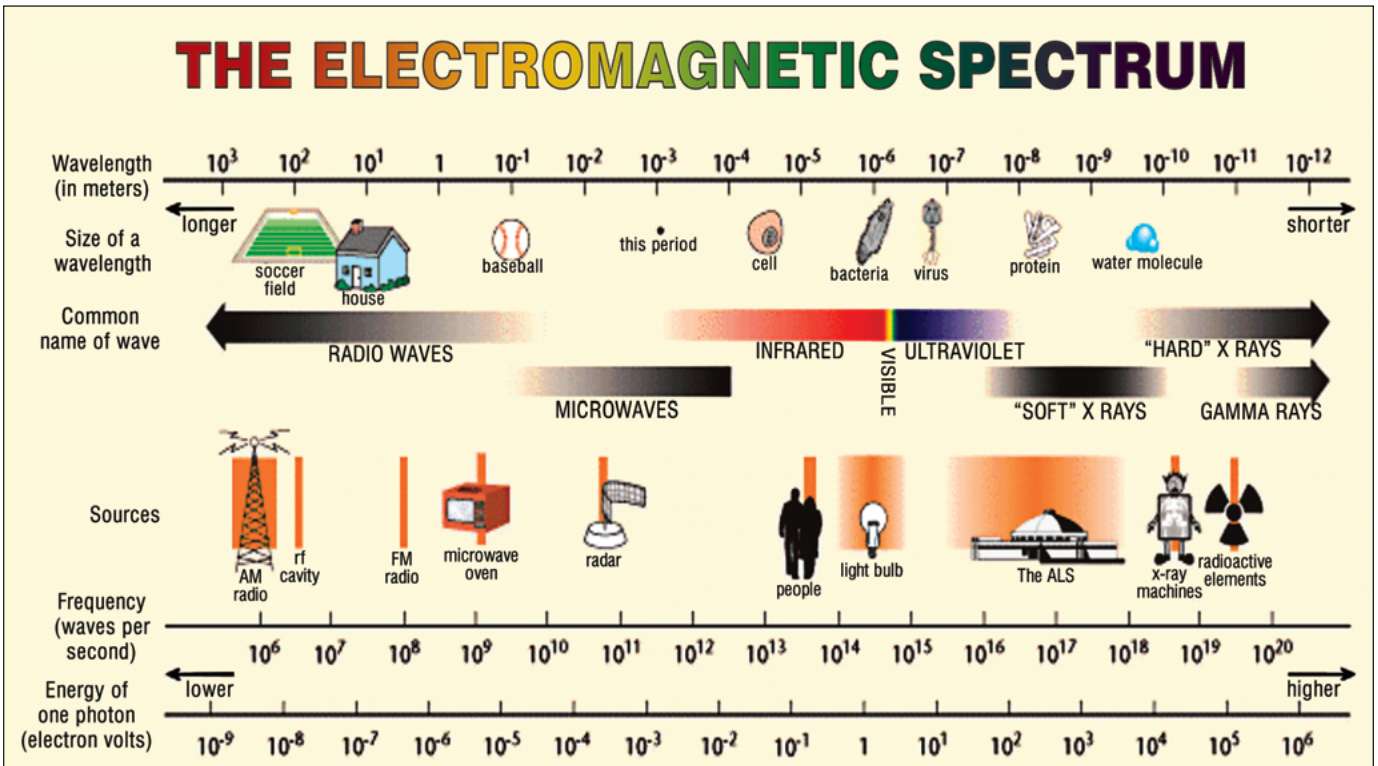


FIGURE 1. Electromagnetic spectrum summary.

roughly the wavelength region between 10^{-4} to 10^{-3} centimeters, or from about 1 micron to about 100 microns (see Figure 1).

Thermography and the Human Body

The skin temperature distribution of a healthy human body exhibits a contralateral symmetry.¹ Temperature distribution that shows asymmetrical patterns is usually a strong indicator of abnormality,²⁻⁴ but the converse is not always true since some pathological conditions may exhibit bilateral thermal dysfunction. In such cases, other signs of abnormalities in the temperature distribution need to be identified.^{5,6} Some nociceptive and most neuropathic pain pathologies are associated with an alteration of the thermal distribution of the human body in the form of hyperthermic or hypothermic regions.⁵ Since the dissipation of heat through the skin occurs for the most part in the form of infrared radiation, infrared thermography is the method of choice to study the physiology of thermoregulation and the thermal dysfunction associated with pain. The early literature on medical thermography focused on qualitative interpretation of thermograms. This involved determining abnormal thermal variations of the skin by means of a visual assessment of pseudo colored or grey-level thermograms with the help of isothermal displays, visual localisation of hot or cold spots, and visual detection of symmetry.⁷⁻¹²

Commercial Thermography Equipment

Most commercial thermography equipment is designed to operate in only specific ranges for a number of reasons—such as lower atmospheric absorption of IR radiation or IR “atmospheric windows,” and detector availability at reasonable cost.

Commercial IR thermography equipment comes in the following wavelength bands and their filtered sub-bands:

- near IR region and band is from about 0.7 to 1.7 microns,
- short wave or SW band is from about 1.8 to 2.4 microns,
- medium wave or MW band is from about 2.4 to 5 microns,
- long wave or LW band is from about 8 to 14 microns.

Thermal imaging devices provide the observer with instruments that can collect and convert the thermal infrared radiation emitted and/or reflected by objects into images that can be seen on a viewing screen or computer display analogous to a video or still camera.

What is invisible to humans, particularly when only thermal infrared is present, can be “seen” by a thermal imager or, more precisely, a thermal imaging camera—especially at night. It works in daylight too and one can easily see the surprising differences in appearance of any object from emitted thermal “light” versus reflected visible light. The shape will be the same but the brightness distribution and shadows look very different even in black and white and are especially pronounced when viewed in false colors.

The CCD and CMOS sensors used for visible light cameras are sensitive only to the part of the infrared spectrum referred to as near-infrared, but not to the part of infrared spectrum useful for thermal imaging (mid- and long-wavelength infrared). Therefore, most thermal imaging cameras use specialized focal plane arrays (FPAs) that respond to longer wavelengths. The most common types are InSb, InGaAs, HgCdTe and QWIP FPA. The newest technologies incorporate low-cost and uncooled microbolometers FPA sensors. Their resolution is considerably lower than of optical cameras: typically 160x120 or 320x240 pixels



FIGURE 2. Example of latest handheld thermal imaging camera.

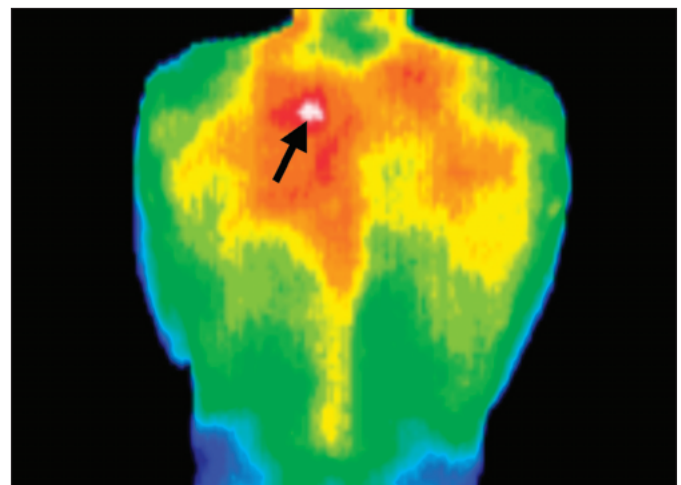


FIGURE 3. Blush hyperthermia of the right posterior cervical muscles is suggestive of a muscle trigger point.

and up to 640x512 for the most expensive models. Thermographic cameras are much more expensive than their visible-spectrum counterparts and higher-end models are often export-restricted. Older bolometers or more sensitive models such as InSb require cryogenic cooling, usually by a miniature Stirling cycle refrigerator or liquid nitrogen (see Figure 2).³

Clinical Applications

Thermal Imaging has been shown to be an effective tool for assessing the functional status of the back—from the cervical to lumbar regions.^{4,5}

Typically, muscle spasm and myofascial trigger points are seen as hyperthermic^{6,7}:

- trigger points are seen as focal hyperthermias,
- myofascial referral patterns are seen as hyperthermic,
- muscle spasm is seen as bands of hyperthermia along the muscle’s distribution.

Myofascial referral patterns usually display pain not only in the area of the trigger point but distal as well. They can mimic a radicular pattern, but are usually hyperthermic. Travell did much work with myofascial-referred pain as documented in *The*

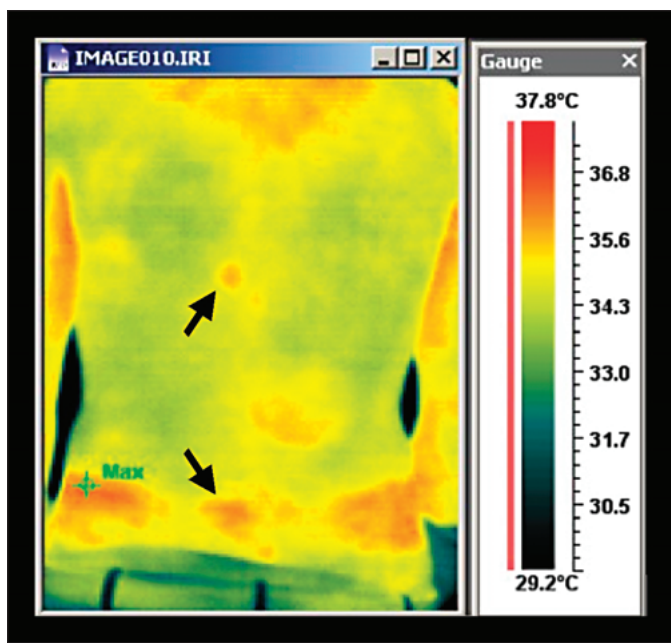


FIGURE 4. Left paraspinal focal hyperthermia indicating a probable left T8 and left L5 facet involvement.

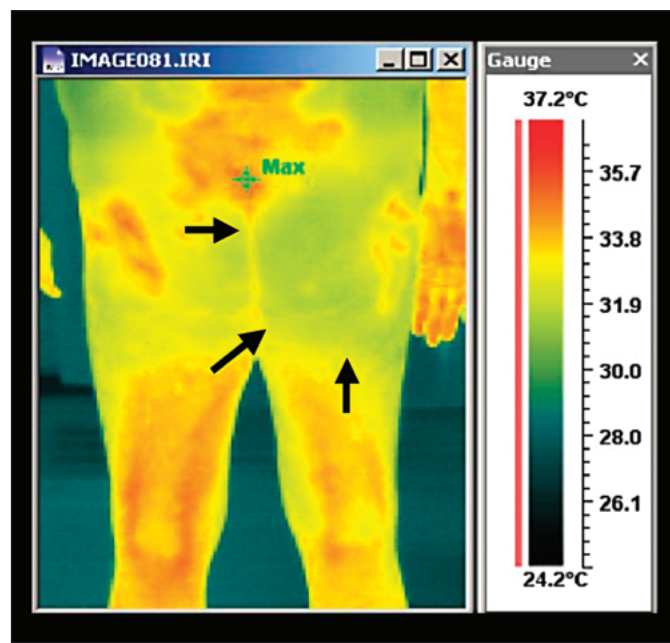


FIGURE 5. Hypothermia of the right posterior buttock and posterior-lateral thigh indicating possible L5 dermatome involvement.

Trigger Point Manual. Fischer likewise did much study with trigger points and thermography and found it to be a valuable tool in diagnosis (see Figure 3).⁸

Sclerotomal patterns are seen in thermography as hyperthermia due to somatocutaneous reflex. Facet joints are imaged as focal hyperthermia over, or adjacent to, the spine of the level involved (usually over the TP). Wexler has published much work on lumbar facet joints L4, L5, S1 and their pattern on thermography scans. They usually appear as focal hyperthermia. Chapman has also done much work documenting various sclerotomal patterns from facet joints, fractures, spondylolisthesis, degenerative disc disease and shin splints (see Figure 4).⁹

Dermatomal patterns are usually seen as hypothermic in the extremities. This is due to sympathetic autonomic fibers causing a vasospasm. The vasospasm occurs segmentally in the dermatomal territory. The vasospasm will cause vaso-constriction of the precapillary sphincters and peripheral arterioles thus causing hypothermia. Dermatomal maps vary but the most commonly used are those of Keegan and Keegan.¹⁰

Summary

Thermography is well-suited to help in the differential diagnosis. Dermatomal patterns are typically hypothermic in the extremities. Myotomal and sclerotomal patterns are hyperthermic. Each has its own unique map of referral patterns and can be referred to when interpreting a thermography evaluation.

Observation and recognition of these patterns can assist the clinician in locating the optimal treatment areas. Thermal pattern changes during a laser treatment session can guide emitter placement and duration of irradiation in each area.

In part 2 of this series, I will discuss my observations in utilizing thermal imaging guided laser therapy (TIGLT) over the past two years and will present a number of pre- and post-thermal images following TIGLT. ■

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