



## **INFRARED THERMOGRAPHY- A NEW TOOL IN OROFACIAL DIAGNOSIS**

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### **ABSTRACT**

Thermography is based on the ability to image the heat emission of the human body. Most biochemical processes generate heat which must be dissipated. Skin is the major route for heat dissipation using blood as the heat exchange fluid. Skin temperature is an indicator of aberrations in metabolism, hemodynamics or in neuronal thermoregulatory processes. Since most of the heat dissipation of skin is by infrared blackbody emission, skin temperature should be measured without contact by monitoring the emitted infrared radiation. This has been the basis of infrared thermography. Infrared thermography is technique for sensing and recording on film, hot and cold areas of the body by means of infrared detectors that reacts to blood flow. This paper deals with infrared thermography technique and its applications in orofacial diagnosis.

**Key words:** thermography, infrared, blackbody emission.

### **INTRODUCTION**

Heat has a profound cognitive impact on humans. Even the most primitive humans knew that the body of a dead person is always cold. There are strong associations of life with warmth, of moderate body temperature with health, and of high body temperature with disease.<sup>1</sup> Body heat is generated by metabolism and by muscular activity, and keeps the core body temperature at a defined slightly oscillating level (about 37°C). The organisms' heat loss depends on ambient factors and results of conduction, convection IR radiation, and of evaporation (sweating) from the surface of the skin despite of breathing and other mechanisms. Inside

the organism, heat is transported by convection (blood flow) and by conduction.<sup>2</sup> Thermography is a noncontact, nondestructive, and noninvasive investigative method that utilizes the heat from an object to detect, display and record thermal patterns and temperatures across the surface of the object.<sup>3</sup>

### **HISTORY**

Ancient medicine perceived good health as a state of balance between the elements. The assessment of body temperature was an integral part of Greek pre-Hippocratic medicine (600-400 BC),<sup>4</sup> and as early as 400 BC, human body temperature was used as a medical diagnostic sign. Hippocrates used his right hand to judge the skin temperature of his sick patients.<sup>5</sup>

About 600 years later, Galen (130-210 AD) advanced the notion that body heat is produced by the biocombustion of food. Galen also discussed a theory on the feedback between sensory and motor nerves,<sup>6</sup> which, as we know today, is the primary mechanism of thermoregulation. About 1400 years later, in 1592, Galileo Galilei is credited with inventing the semiquantitative air thermometer (Galileo's 'thermoscope'). In 1611, Santorio Sanctorius, developed the first thermometer. It took, however, another 300 years before Wunderlich introduced fever measurements as a routine clinical diagnostic procedure (Germany in 1872).<sup>7</sup>

Czerny documented the first infrared image of a human subject in Frankfurt in 1928. The medical use of infrared thermography started in 1952 in Germany. The physician Schwamm, together with the physicist Reeh developed a single detector infrared bolometer for sequential thermal measurement of defined regions of the human body

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surface for diagnostic purposes. They founded the first medical association of thermography in 1954, today still active as German Society for Thermography and Regulation Medicine (Deutsche Gesellschaft für Thermographie und Regulationsmedizin eV).<sup>2</sup>

### INFRARED TELETHERMOGRAPHY

Thermal or infrared energy is not visible because its wavelength is too long for the sensors in our eyes to detect. It is the part of the electromagnetic spectrum that we perceive as heat. Unlike visible light, in the infrared spectrum everything with a temperature above absolute zero emits infrared electromagnetic energy. Even cold objects, such as ice cubes, emit infrared radiations. The higher the temperature of the object the greater the infrared radiations emitted.<sup>3</sup>

In 1899, Max Planck suggested that the energy emitted by any object is quantized. Planck formulated a theoretical function to quantitatively describe the spectrum of black body radiation. Planck's basic assumption was, that the energy ( $\epsilon$ ) of each emitted quantum is a product of some universal constant ( $h$ ) and the frequency ( $\nu$ ) associated with it ( $\epsilon = h \times \nu$ ). The frequency is equal to the speed of light ( $c$ ) divided by the wavelength ( $\lambda$ ) ( $\nu = c/\lambda$ ). The value of that universal constant,  $h$ , could be derived from the experimental data.<sup>8,9</sup>

Thermography is a noncontact, nondestructive test method that utilizes a thermal imager to detect, display, and record thermal patterns and temperatures across the surface of an object. Since infrared radiation is emitted by all objects based on their temperatures, according to the black body radiation law, thermography makes it possible to "see" one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature; therefore thermography allows one to see variations in temperature.<sup>3,7</sup> Planck's quantitative treatment has permitted us to calculate the black body photon fluxes of any energy for any temperature, or to determine temperature by measuring the black body radiation. Since the maximum flux of black body radiation at human skin temperature (30-36°C) is in the infrared part of the spectrum (about 9-10  $\mu\text{m}$ ), clinical black body radiative thermometry, or telethermometry, must preferably use detection systems, sensitive in that region of the infrared spectrum.<sup>10</sup> An additional important reason for using 8 to 12  $\mu\text{m}$  detectors is the fact that, unlike in other

regions of the infrared spectrum, skin is > 98% emissive in that region. When skin is partly reflective, as it is below 8  $\mu\text{m}$ , the detected infrared emission may represent artifacts due to reflected infrared radiation that originated from some environmental source.<sup>9</sup>

Noncontact clinical thermometry did not become a reality with the advent of quantum physics. Because of the low energy and low intensity of the radiation emitted by the body at skin temperature, biological telethermometry was not practical until the development of sensitive and precise detectors of infrared radiation.<sup>11</sup>

### FACIAL TELETHERMOGRAPHY

The pattern of radiative heat dissipation over the human body is normally symmetrical. It has been shown that, in normal subjects, differences in skin temperature on selected points from side-to-side are small (about 0.2°C).<sup>12</sup> The significant difference between the absolute facial temperature of men vs women has also been observed. Men were found to have higher temperatures over the 25 anatomic zones measured on the face (e.g. orbit, upper lip, lower lip, chin, cheek, etc.) than women.<sup>13</sup> Whereas the right versus left-side temperature differences (termed static area DT values) between many specific facial regions in asymptomatic individual subjects were shown to be low (< 0.3°C). The area DT values were found to be > 0.5°C in a wide variety of chronic facial pain disorders.<sup>14</sup>

There are certain guidelines to be followed while taking a facial telethermography as advised by Japanese Society of Thermology:

1. Keep the testing room free of wind. Turn off air conditioners.
2. Keep sources emitting high-temperature infrared away from the subject. Place a screen between any heater and the subject.
3. Keep control room temperature at over 25°C. Record room temperature and humidity when taking each thermal image.
4. Stabilize the environment for at least 20 minutes before examination in the winter.
5. Instruct the subject to refrain from smoking for at least 4 hours before thermographic examination.
6. Note the following items as subject-related information in the medical record including name, sex, age, chief complaint, history of tobacco use, history of alcohol consumption,

handedness, painful position, abnormal position, region of cold sensitivity, past medical history, present clinical history, presence of medical treatment and detail of medical treatment, diagnostic entity, body temperature, time when the thermal image is taken, room temperature, room humidity, and wall temperature.

7. Check the first thermal image again at the end of the sequence to confirm the reproducibility of images and changes over time.
8. Judge the intraoral condition and perform periodontal inspection.
9. Hold the frontal region and chin of the subject and set a thermo camera at a consistent distance from the subject.
10. Instruct the subject to remain seated during image acquisition.
11. Inform the subject to keep water in mouth for 5 seconds before image acquisition.
12. Instruct the subject on edge-to-edge occlusion and on the prohibition of mouth respiration during image acquisition.<sup>15</sup>

### **Applications of Thermography in orofacial region:**

#### ***TMJ Disorders***

TMJ pain patients were found to have asymmetrical thermal patterns with increased temperatures over the affected TMJ region of their face and mean area DT values of + 0.4°C ( $\pm$  0.2°C SD).<sup>16</sup> Specifically, painful TMJ patients with internal derangement and painful TMJ osteoarthritis were both found to have asymmetrical thermal patterns and increased area temperatures over the affected TMJ region of their faces, with mean area TMJ DT of + 0.4°C ( $\pm$  0.2°C SD). In addition, a study of mild-to-moderate TMD patients indicated that area DT values correlated with the level of the patient's pain symptoms.<sup>17</sup>

#### ***Detection of Infra-alveolar Nerve Deficit***

The thermal imaging of the chin has been shown to be an effective method to assess inferior alveolar nerve deficit.<sup>18</sup> Subjects with no inferior alveolar nerve deficit show a symmetrical thermal pattern, with an area DT of + 0.1°C ( $\pm$  0.1°C SD) w ( $\mu$ ), while patients with inferior alveolar nerve deficit had an area DT of + 0.5°C ( $\pm$  0.2°C SD) on the affected side.<sup>18</sup> The observed vasodilatation seems to be due to blockage of the vascular neuronal vasoconstrictive messages, since the same effect on the

thermological pattern could be invoked in normal subjects by temporary blockage of the inferior alveolar nerve, using a 2% lidocaine nerve block injection.<sup>19</sup>

#### ***Chronic Orofacial Pain Patients***

A new classification system of facial area DT measurements was introduced.<sup>14</sup> This system classifies telethermographs as 'normal' when selected anatomic area DT values range from 0.0 to  $\pm$  0.25°C, 'hot' when area DT is  $>$  - 0.35°C, and 'cold' when area DT is  $<$  + 0.35°C. When a selected anatomic area DT value is  $\pm$  (0.26-0.35°C), the finding is classified as 'equivocal'.<sup>20</sup>

#### ***Detection of Herpes Labialis in Prodromal Phase***

During the prodromal phase, all patients showed an increase in temperature with the mean localized change in temperature (Dt°C) being 1.1°C  $\pm$  0.3°C, over a mean thermographically positive area of 126 mm<sup>2</sup>  $\pm$  34 mm<sup>2</sup> even when the patient was asymptomatic. After 72 hours of treatment with acyclovir cream, majority of the patients returned to normal with no clinical or thermographical evidence of infection.<sup>21</sup>

#### **Other uses in Dentistry:**

A thermogram can offer precise images for:

- Diagnosis of bone and nerve disorders
- Articular pain in arthritis, osteoarthritis, rheumatoid arthritis
- Muscular pain, hyper- or hypotonic reactions
- Monitoring endodontic treatments
- Tissues reactions to new dental materials
- Diagnosis of any kind of maxillofacial inflammation
- Chronic and acute periodontitis
- Sinus disease
- Cancers in maxillofacial territory
- Myofascial pain syndrome
- Neuralgia.<sup>20</sup>

#### **ADVANTAGES OF THERMOGRAPHY**

The various advantages of thermography are:

- Noninvasive technique
- Easy seating examination
- Minimal examination time (2-3 minutes)
- Obvious differences in color changes (gradient - 0.05°C).<sup>8</sup>

#### **CONCLUSION**

The application of temperature measurement and thermal imaging to assess health and disease has continued to advance since antiquity up to the present day. Thermography is of importance due to accurate measurement of regional temperature (0.05°C differences). Thermography may be useful in elaborating of a right diagnosis on an inflammatory reaction from maxillofacial territory. Thermograms can be saved in a database, on compact disc or printed on a special or regular paper.

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