Thermographic Investigation of Ergonomic Medical Posture in Dentistry

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Our current work is aimed at using a physical technique such as thermographic imaging in new approach to monitor the working posture of clinicians during live procedures. Thermograms are the representations of heat distribution in the area investigated and allow for the formation of heat maps concerning the objects or areas of interest. Although there are many applications for this technique presently we believe its use for correct posture management in the dental practice could be very useful for clinicians raising understanding on importance of ergonomics in daily practice.

Keywords : Thermography, clinician posture, thermogram, emissivity, heat areas

Infrared thermographic imaging is part of infrared imaging science [1]. The direct results of this application are the thermograms obtained by thermographic cameras [2]. These devices detect radiation in the infrared range of the electromagnetic spectra emitted by various physical bodies. Thermograms are the representations of heat distribution in the area investigated and allow for the formation of heat maps concerning the objects or areas investigated [3]. Thermal images are practically representations of infrared energy emitted, transmitted and reflected by a physical body. Infrared energy when incident on a physical body be it matter liquid or gas will yield properties of absorption, reflection and transmission to various degrees. Emissivity is the ability of a body to emit energy as thermal radiation. It can be measured by comparing the sample with an ideal black sample. The black sample has a very high emissivity close to 1[4].

There are many applications regarding thermal imaging mainly in the defense programs of the army [5], security on international airports[6] and firefighter aid[7]. Other applications are in the medical field to diagnose different degrees of illness or simple screening applications. In the dental field thermography has been used to observe ailments of the temporal-mandibular joint (TMJ) [8,9] and even follow-up of endodontic treatments [10] following heat centers determined by recurrent or chronic infectious conditions in regard to the dental apex.

This current study offers a novel approach of thermal imaging proposing the monitoring of correct posture of the medical staff during everyday practice

Experimental part

This current study was conducted using two clinical subjects both medical dental doctors that were required to conduct similar interventions on patients for an identical timeframe of 90 min. The two doctors were ages 60 and respectively 30 years old, furthermore we will refer to the older subject as clinician A and the second clinician B. They were required not to change their posture and to reduce auxiliary movement to a minimum in order to preserve the purpose of the investigation.

In order to study the modifications that occur during dental treatment on the clinician's body we used thermography-imaging technique correlated with classical photography.

The protocol was to record IR and normal photos every ten min during the first hour and after the first hour every 15 min of the remaining time in total 8 acquiring sessions for 90 min. At the end of the experimental time a comparative set of photos, both infrared and visible spectra, were obtained for comparison between the two clinicians in regard to affected muscle groups and body areas.

During our experiment in order to gain accurate data both doctors did not wear any upper protective gowns [11].

The thermographic device used for infrared photography was FLIR model I60 by FLIR Systems AB, Sweden with a resolution of 180x180 pixels.

The device used for photography was a Canon 5D mark II camera.

In order to facilitate data analysis we use the rainbow spectra with the temperature scale between 20-36°C. Furthermore temperatures described on the IR image represent the highest in the region.

For objective quantification of temperature variation certain temperature points were marked and lines down strategic muscle groups were considered on IR photos as follows:

- first line situated on the right side parallel to the spine composed of four points:
  - P1 – situated under the hair insertion
  - P2 – situated at the intersection of a parallel line to the spine and a horizontal shoulder line
  - P3 – situated at half distance between P2 and P4
  - P4 – situated above the pelvis
- second line situated on the posterior of the arm going down on the forearm:
  - U1 – identical to P2
  - U2 – situated at 1/2 distance between the base of the neck and external shoulder line
  - U3- situated on the external part of the shoulder on the posterior side
  - BP1 – forth point situated on the posterior arm half the distance between elbow and shoulder
- Anterior line of arm and forearm

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- B1 - situated on the anterior side of the shoulder
- B2 – situated on the anterior side half the distance between elbow and shoulder
- AB1 – situated on the anterior side of the forearm and half the distance between elbow and wrist
- AB2 – situated on the anteriror side on the wrist just above the protective globe that invalidates the thermographic measurements
- One leg line composed of:
- C1 situated on the thigh under the inferior margin of the clothing
- G1 situated on the lateral knee side
- G2 situated on the lateral side of the calf muscle half way between the knee and ankle

In order to identify which point corresponds to which doctor we will add, after the point indicative, number 1 for the clinician A respectively 2 for clinician B.

During our experimental steps we have adhered closely to the working conditions described by Ring and Ammer. [12,13].

Posture of medical practitioners is sitting, with all horizontal axes parallel to the ground, the spine straight, unforced, to allow normal curvature with a 110 degrees angle between the lower and upper leg [14]. The foot positioned on the floor on its entire surface. Arms closely along the upper torso to offer stable and secure support for the forearm positioned at approx. 90-120 degrees with an accepted deviation of around 10 degrees. The hand must be positioned in a straight line with the forearm in a neutral position. Extreme flexion or extension of this segment must be avoided together with excessive force during procedures [15].

Recommended posture for the patient during dental treatment is a horizontal position roughly with the knees at the same level as the nose.

Results and discussions

Infrared imaging offers valuable data in two major regards. The first is that it presents the possibility to precisely measure temperature variation on the skin which is subsequently influenced by muscular activity offering insight on the correct ergonomic posture or in contrast a less harmonious one. The second point is that this technique shows the evolution of the temperature in direct connection to clinical real time procedures being an indicator of muscle group activity.

Infrared photograph analysis for clinician A

Dorsal line

Diferentiated evolution of temperature points with delayed temperature spiking of inferior points P3 and P4. P2 and P3 showed a marked increase in temperature after 30 min (fig.1).

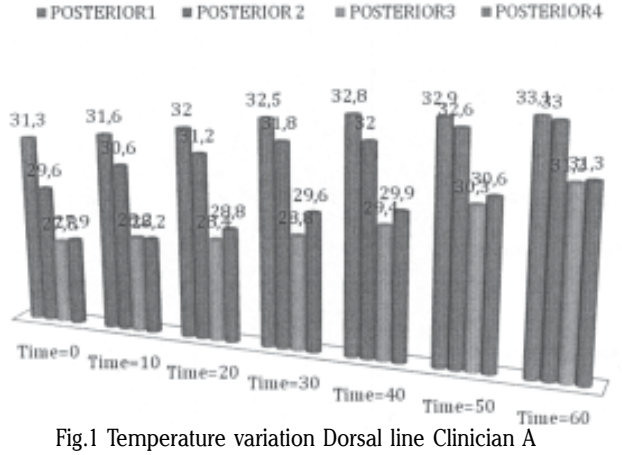

Fig.1 Temperature variation Dorsal line Clinician A

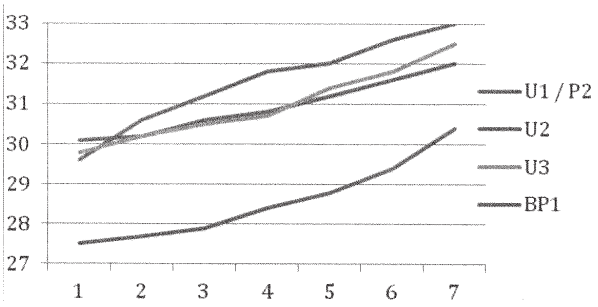

Fig.2 Temperature variation for posterior line clinician A

Posterior line

Rapid increase during the initial 10 min in point U1 which then remains constant. The increase of U2 is linear and U3 and BP1 increase after 40 min (fig.2).

Anterior line of arm and forearm

Important initial increase of point B2 after which a normalization of its value followed by a new increase every 40 min. In this moment we have a decrease of temperature growth in the forearm (AB1). B1 and AB2 evolve normally (fig.3).

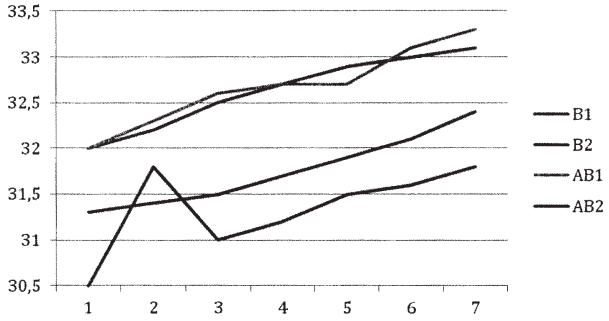

Fig.3 Anterior line temperature variation clinician A

Lateral leg line

A delayed increase in temperature in the thigh (after 20 min). The knee presents a rapid temperature spike starting from the first ten minutes and the calf has a low increase of temperature.

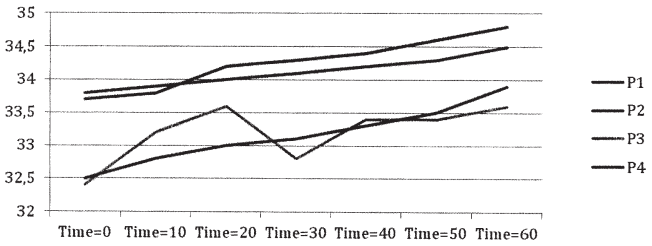

Fig. 4 Temperature variation dorsal line clinician B

Infrared photograph analysis for clinician B

Dorsal line

Points P1 and P4 have a constant temperature evolution while P2 indicates a slow increase of temperature after the first 10 min then normalize. P3 indicates a rapid increase of temperature during the first 20 min then evolves erratically (fig.4).

Posterior line

Rapid growth during the initial 20 mins of temperature in point U3 followed by a decrease and inconstant evolution. Temperature increase of U1 is linear with a decrease in temperature growth after 10 mins. U2 and BP1 similarly increase with a slight decrease of temperature growth after 40 min (fig.5).

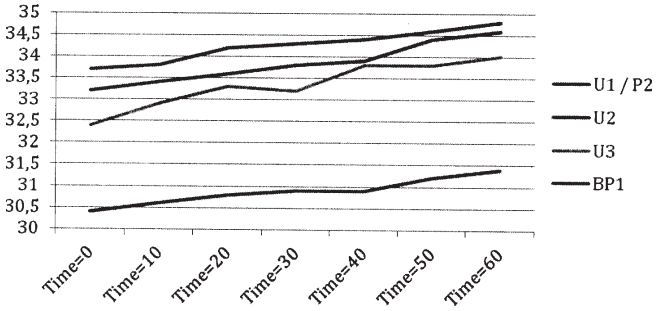

Fig. 5 Temperature variation posterior line clinician B

Anterior line of arm and forearm

B1 has a rapid increase of the initial temperature followed by a growth plateau and then a subsequent increase. The highest temperature increase is located in the forearm (fig.6).

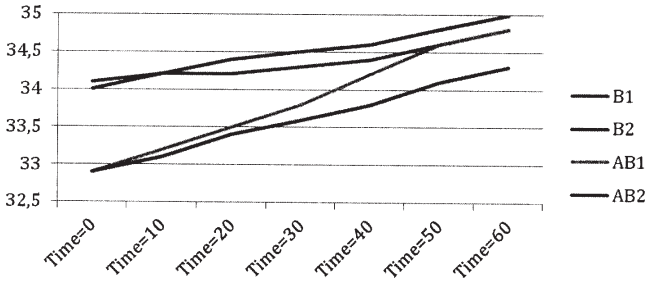

Fig. 6 Temperature variation anterior arm and foreream clinician B

Lateral leg line

The temperature variation displays a slow increase at knee level which recovers after 20 min and then evolves erratically. The calf has a constant temperature growth starting from the first 10 min. The thigh has a slow increase in temperature with a plateau forming just before the second half hour.

Comparative analysis of temperature variation bodily areas

Infrared photographs yielded important data. An increase in investigated temperature areas in direct link to muscles used during treatment. This growth proportional to :

- intensity of muscle use
- time of muscle use

In case of prolonged muscle use the said group will reach muscle contracture.

Temperature variation between areas intensively used and less used ones is perfectly delineated in infrared photographs, being easily identifiable for each area of interest.

Temperature variation in key areas of investigation for both clinicians

Muscular contracture with stasis is indicated on the thermograph by areas heated over the average of the neighboring ones. The first area of increase is the subscapulary muscle zone, which further progresses down the back and laterally toward the shoulder. The second area that heats up is the right hand shoulder side the clinicians are both right hand users. The anterior side of the arm shows rapid heating progressing to the posterior and anterior side of the arm. The anterior arm also shows rapid heat increase but is quickly surpassed by the posterior side. The third area that shows heating is the forearm followed by the anterior thigh. Furthermore the final area that heats up is the posterior and anterior calf. By this time the back is fully heated (fig.7,8).

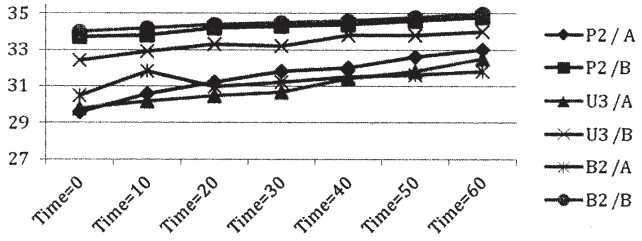

Fig.7 Temperature variation on body surface between clinicians

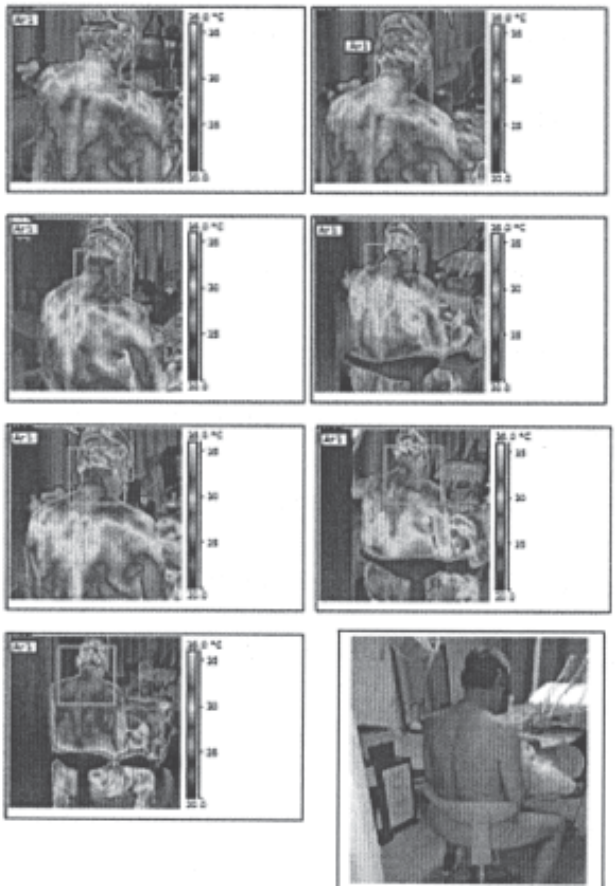

Fig.8 Heat area generation with time

Comparative study of temperature variation on the body surface between the two subjects shows interesting data in regard to non-ergonomically posture management with consequences in regard to muscle fail and adaptive processes to compensate for incorrect body posture.

Clinican A has presents a rapid increase in point P2 because of incorrect posture with accentuated curvature of the back thus imposing unnecessary pressure on the spine to compensate the anterior inclination correlating with a decrease in effort resistance of course correlated with age. P3 evolves normally for the first ten minutes and then spikes around 30 min. P4 evolves normally and spikes similarly after 30 min.

In case of clinician B points P2 and P4 start from a high value and continue to heat constantly while P3 has a rapid growth spiking after 20mins because of incorrect working posture visible on the photograph (fig.9).

Increase for the two subjects is:

- higher for B2/1,U3/1 and BP1
- lower for P2/2 and B2/2

We can evidentiate temperature growth points of about one degree between two consequent measurements. If we analyze the temperature point variation in direct link to temperature mean values we obtain the figure 10.

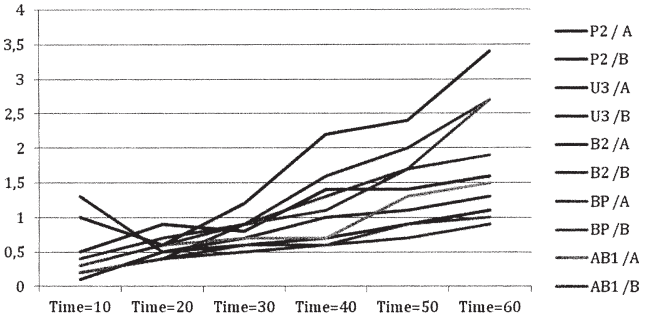

Fig.9 Increase of temperature of measured points over time

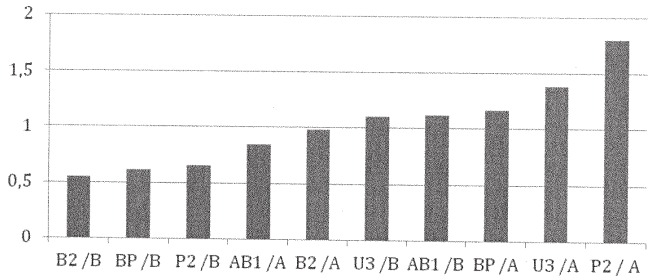

Fig.10 Medium temperature increase of main measured points

Comparative analysis of areas in regard to temperature variation

It showed modest variation between the two clinicians that are mainly determined by momentary deficiencies in posture, summing up in corresponding time frames.

Conclusions

Thermographic investigations applied in the medical field can yield very useful data offering a new perspective to understanding clinical implications of ergonomics. Only by interdisciplinary together with the core sciences of physics and chemistry can the medical field evolve to offer better and more predictable results for its patients. In order to offer the highest degree of quality during the clinical procedures it is important that the clinicians understand the basics of posture mechanics and their short and long therm effects. Termographic investigation in ergonomics is very useful because it offers results in real time, so immediate measurements can be applied

Furthermore it is a reliable method, offering objective data being a repeatable method and noninvasive. From our current study we can conclude:

- areas of muscle contracture appear after an isometric contracture of more than 20min;
- in regard to posture technique is more important than fitness during the medical act;
- continuing a clinical procedure beyond the timeframe of 30 min surely leads to the extension of muscular contracture areas.

The sequence of muscular contracture seems to form a pattern as follows:

- suprascapular area and neck muscles
- shoulder muscles on working side area
- anterior arm side area
- dosterior arm side area
- porearm working side area
- lateral arm side area
- posterior of calf muscle area
- anterior of calf muscle area

As a general conclusion working posture determines the speed and area size affected by muscle contracture. Furthermore the use of physico-chemical techniques in the dental field offer a new perspectives and understanding regarding classical clinical procedures, helping clinicians better themselves and increase the general quality of the medical act by true interdisciplinarity.

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