BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, April 2014. Vol. **11**(1), 211-218

Thermographic Analysis of Completely Edentulous Patients with and Without Complete Dentures - A Clinical Pilot Study

Sanjna Nayar, U. Aruna, S. Bhuminathan, J. Sri Nisha and Ragavendra Jayesh

Department of Prosthodontics, Sree Balaji Dental College and Hospital, Chennai, India.

dx.doi.org/10.13005/bbra/1257

(Received: 26 December 2013; accepted: 10 February 2014)

To assess the difference in oral temperature recorded through non- contact infra red thermography, in completely edentulous patients with and without complete denture wearing. To correlate the values obtained to assess the oral health with and without complete denture. A thermocam forward looking infrared camera was used to record the images of maxillary and mandibular arches in completely edentulous patients grouped into denture wearing and non- denture wearing sub groups at standardized conditions. The saved images were processed using the software given by the manufacturer to assess the oral temperatures in both the groups. The mean temperature in maxilla for non- denture wearing subjects was 35.77 degree Celsius and for denture wearing subjects was 37.23 degree Celsius. The mean temperature in mandible for non- denture wearing subjects was 35.83 degree Celsius and for denture wearing patients was 37.37 degree Celsius. The results were statistically analysed using Independent T- test. The overall values for edentulous maxilla and mandible for complete denture wearers were higher and statistically significant when compared to values for non-denture wearers. Within the limitation of the study, the clinical pilot study indicated that complete denture wearers recorded values closer to the normal oral temperatures whereas comparatively non-denture wearers recorded lower temperatures.

Key words: Edentulous patients, Clinical, Oral temperature.

The practice of rehabilitating edentulous patients with complete dentures has been followed for many years. After tooth extraction and placement of complete dentures there is continuous loss of bone tissue which varies from one patient to another. Residual ridge resorption is an inevitable, chronic, progressive, irreversible and cumulative reduction of residual ridge in edentulous individuals. Several attempts have been made to understand the etiology and still it seems to be one phenomenon which is discussed to be multifactorial and difficult to explain[1,2]. One factor of importance is the blood flow to the residual alveolar ridge. The changes with blood flow can be correlated with the bone changes and resorption of the bone. Studies correlating resorption and bone quality have also been reported[3-5]. As the amount of blood circulation varies, temperature also varies accordingly. One of the diagnostic techniques that is being researched in this context is thermography. Thermography interprets temperature changes through infrared images. Thermography has been used in several medical and dental applications. Recent reports have shown its trial in Prosthodontics in assessing temperature change during implant site preparation,

* To whom all correspondence should be addressed.
E-mail: Sanjna101@yahoo.com

to reveal the material behaviour of dentures made with polymethylmethacrylate, evaluating oral mucosa in dentate and denture stomatitis in edentulous patients[6-8]. In this pilot study an attempt has been made to evaluate thermography as a diagnostic aid to assess the prognosis of complete denture wearing.

The assessment of body temperature and its importance in the well being of an individual has been analysed and valued from the ancient times. Thermology is the study and application of biothermal processes to assess health or disease. Thermography is the procedure that employs imaging and visual evaluation of thermal changes[9-10].

The history of thermography dates back as early as 400 BC when the first thermogram was taken by Hippocrates, by applying wet mud over the patient's thorax and determined that the area to dry first is the problematic point[9] . The discovery of infrared radiation has been ascribed to William Herschel, who was an astronomer in the early 19th century. He detected infrared by using prisms to refract light from the sun, beyond the red part of the spectrum, through an increase in temperature recorded in the thermometer. He called them 'Calorific Rays' and the term 'infrared' did not appear until late in the 19th century[11]. The modern era of telethermometry was initiated in 1931 by Hardy, who described the physiological role of the infrared emission of human skin and its potential diagnostic importance[12]. The process of thermal imaging has become more precise with the availability of efficient, high resolution infrared cameras.

FLIR (Forward Looking Infra Red) systems are used for infrared thermographic imaging. Infrared thermography is the use of an infrared imaging and measurement camera to "see" and "measure" thermal energy emitted from an object. Thermal, or infrared energy, is light that is not visible because its wavelength is too long to be detected by the human eye; it's the part of the electromagnetic spectrum that we perceive as heat. Unlike visible light, in infrared, everything with a temperature above absolute zero emits heat. An infrared camera is a non-contact device that detects infrared energy (heat) and converts it into an electronic signal, which is then processed to produce a thermal image on a video monitor and perform temperature calculations. Heat sensed by an infrared camera can be very precisely quantified, or measured, allowing us to not only monitor thermal performance, but also identify and evaluate the relative severity of heat-related problems[13].

Telethermography can be Static Telethermography and Dynamic Telethermography. Temperatures measured at a single spot or several spots over an extended area can be displayed as a thermal image representing spatial distribution of temperature over an area. If the temperature is measured at a single instance it is termed Static TeleThermography and when the same is done in a series of instance it is termed as Dynamic Telethermography. The measurements made by Dynamic Thermography may be named dynamic spot thermometry and dynamic area thermometry based on whether a spot or area is imaged. Three methods used for obtaining thermograms or thermal images are 1. A semiquantitative contact method that uses liquid crystals and is called Liquid crystal thermography, whose disadvantages include poor sensitivity and low spatial resolution, 2. A quantitative non- contact infrared method called infrared telethermography. Infrared cameras with two- dimensional arrays are called as focal plane arrays which have an advantage of reliability and high speed allowing more than 100 images per second and 3. Dynamic area telethermometry (DAT), which also aims at quantitative measurement of the time dependence of temperature and assess modulation of temperature with Fast Fourier Transform Analysis (FFT)[9,10].

PRinciple of infrared thermography

Thermography is based on BLACK BODY RADIATION LAW which states that "black body is that which absorbs completely all the radiations falling on it" Max Planck's theory describes the spectrum of black body radiation. The amount of radiation emitted by an object increases with temperature; therefore thermography allows one to see variations in temperature. The higher the surface temperature is, the more infrared radiation is emitted in the form of black-body radiation. A special infrared camera can detect this radiation in a similar way an ordinary camera detects visible light[9-10].

Applications in dentistry

In dentistry thermography is being evaluated in various fields. It has been used

in evaluation in relation to craniomandibular disorders, assessment of neuropathic pain, assess postoperative inflammation, facial skin temperature, oro facial disorders, thermal imaging of ultrasonic scaler tips during tooth instrumentation, temperature change during implant drilling, to reveal the material behaviour of dentures made with polymethylmethacrylate, in assessing TMJ disorders, to evaluate oral mucosa in dentulous and edentulous patients[6,7,12,14–19].

AIM

To assess the changes in oral mucosal temperature and to identify the correlation between temperature and blood flow in completely edentulous patients in relation to anterior maxillary and mandibular arch between denture and non-denture wearers.

Methodology

A total of 10 subjects (6 males and 4 females) in the age group of 55 to 75 years were selected with no systemic illness. They were divided into two groups as group A who comprised of patients who were not wearing dentures and were edentulous for 2-6 months, and group B who were denture wearers for past 2-5 years. The camera used to record the images was THERMOCAM (IRIS ELITE), which is a FLIR (forward looking infra red) type. [Fig 1] The camera used infrared technology, making it possible to obtain a thermographic image without direct contact with the subject. Its technical characteristic can determine sensitivity value difference of 0.01 degree Celsius with a 16 bit digital resolution.

Description of the instrument and technique

A thermal imaging camera consists of five components: an optic system, detector, amplifier, signal processing, and display. The camera display shows infrared output differentials, so two objects with the same temperature will appear to be the same "color". Many thermal imaging cameras use grayscale to represent normal temperature objects, but highlight dangerously hot surfaces in different colors. With all thermography the color imaging is relative. The colors do not represent specific or absolute temperatures. To maintain optimum quality standard for images, it is important to adjust the image so that the area of interest is within the middle range of the color scale. This allows latitude on either side of the selected colors so that any 0.5°C variance will be visualized within the parameters of the color scale. This is referred to as "setting a technique" and is accomplished by adjusting the temperature base level. (adjusting the position of the allocated colors)

Positioning

For the best results with thermography the infrared scanner must be perpendicular (or as perpendicular as feasibly possible) to the area being thermographed. When obtaining right-to-left comparisons in separate frames (laterals and obliques), both sides should be the same distance and angle from the infrared scanner, and the temperature base and scale level must not be changed. Once the technique is set on one side, it must remain the same for the opposite side. This will provide a true comparison. Each individual image must be focused. The entire frame should be filled with the area of interest only. The patient should not be too far from, nor too close to the infrared scanner. Being too far may obliterate important information, and being too close may eliminate or cut off pertinent information.

Procedure

Thermography imaging procedure started 30 minutes after the presentation of subject in room. This time is required to thermally accommodate them to the ambient temperature. Sterile plastic oral spreaders were applied in the oral cavity and patient wearing dentures were asked to remove the dentures. The subject to the lens of the camera was fixed at 1 foot. When the camera was correctly positioned the lens was manipulated to bring the subject into focus and the images were taken. [Fig 2 (a,b), Fig 3 (a,b), Fig 4 (a,b), Fig 5 (a,b)]

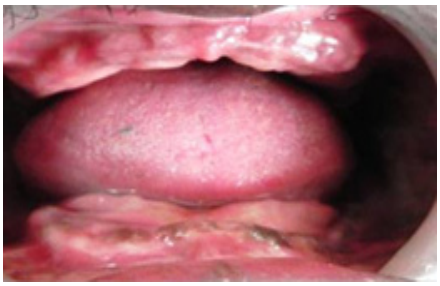
In each arch of anterior maxilla and mandible imaged, 5 regions were selected for imaging between the buccal frenum which included mid value at the labial frenum, two values just in front of the buccal frenum and two values inbetween labial and buccal frenum bilaterally. An average of these values was taken as the thermographic value of that arch. The approximate time taken for imaging was 1 minute for each arch. The images are accompanied with a scale and each colour represents a temperature presented in a scale. [Fig 6] All the images were saved with a resolution of 320 × 240 pixels and were processed using a software provided by the manufacture of the camera (Customised preloaded software meditherm).

RESULTS

Thermal images were taken and an average value was obtained from each group. [Table 1&2]. The mean temperature in anterior maxilla for group A subject was 35.77 degree Celsius and for group B subject was 37.23 degree Celsius. The mean temperature in anterior mandible for group A is 35.86 degree Celsius and for group B was 37.37 degree Celsius. Graphs 1 and 2 show comparative representation of values in Group A & Group B patients in maxilla and mandible respectively.

The values obtained were statistically analysed using independent sample t test. P value <0.05 shows highly significant difference between Group A (non-denture wearers) and Group B (denture wearers) in both maxilla and mandible.

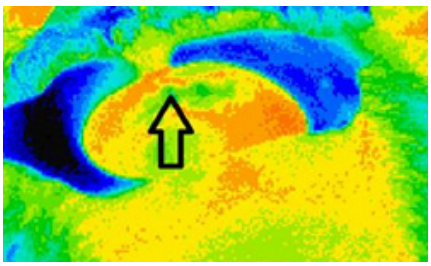
Fig. 1. Thermography System



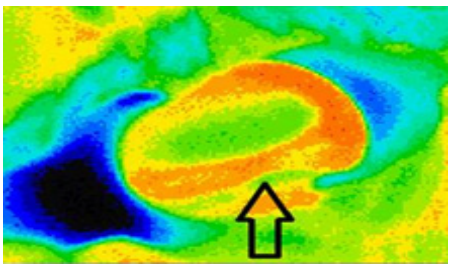
(a) Maxilla

(b) Mandible

Fig. 2. Intra oral images of a Group A patient

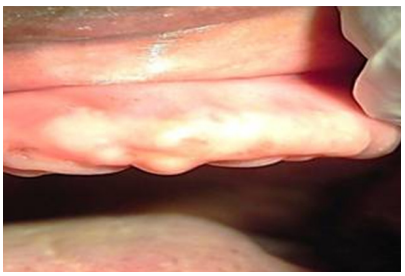


(a) Maxilla

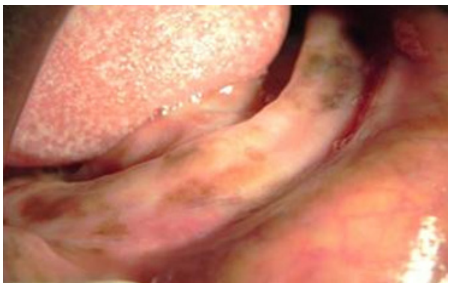


(b) Mandible

Fig. 3. Thermography pictures of a Group A patient

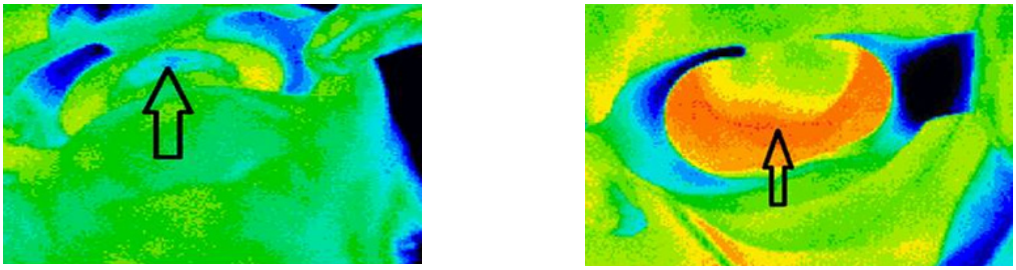


(a) Maxilla



(b) Mandible

Fig. 4. Intra oral images of a Group B patient



(a) Maxilla (b) Mandible

Fig. 5. Thermography pictures of a Group B patient

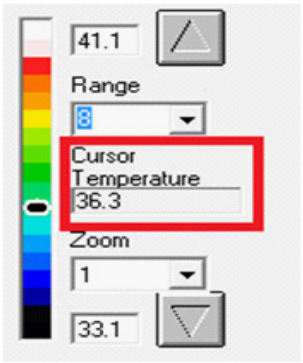
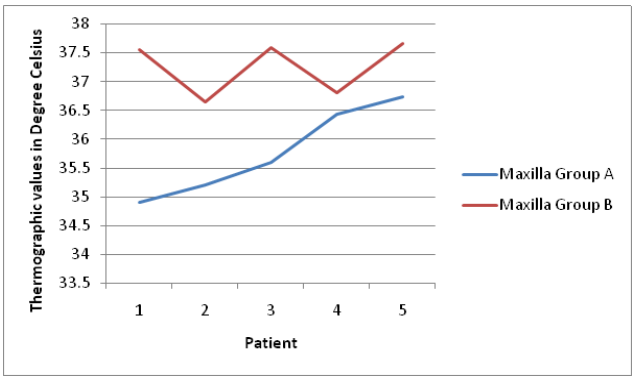
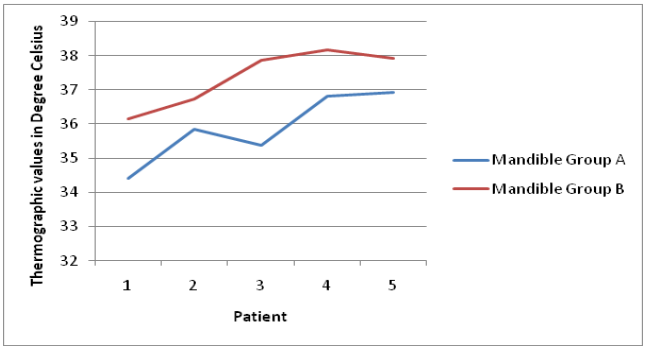


Fig. 6. Figure showing temperature scale



Graph 1. Showing comparison between Group A and Group B patients in Maxilla



Graph 2. Showing comparison between Group A and Group B patients in Mandible

Hence there is statistical difference between Group A and Group B values. Additionally there is no statistical difference between values obtained for Group A patients within maxilla and mandible and between values obtained for Group B patients within maxilla and mandible.

DISCUSSION

This pilot study was carried out to assess the oral temperature values of maxillary and mandibular arches for denture wearing and non-denture wearing patients who were completely edentulous using infrared thermographic method. The temperature change can be correlated with blood flow which in turn can be correlated to the bone resorption. This will help us understand the stimulation given by complete denture bases on the supporting tissue.

Thermography as a diagnostic aid has been experimented in Prosthodontics in assessment of temperature changes of oral mucosa and material behaviour of dentures for edentulous patients, during implant site preparation with respect to variation in drills used and different depths, to study temperature gradient in tooth crown[6-8,20-22].

In this study thermography has been used as a diagnostic aid to assess oral health of patients with and without complete dentures. The thermal images are obtained as visual display of the amount of infrared energy emitted, transmitted and reflected by an object. A thermal imaging camera can perform algorithm to interpret that data and build an image. The camera uses multiple sources of data based on the area of imaging and the temperature of the surrounding area. In order to differentially assess the temperature changes of anatomical areas characterized by localized blood supply or innervations, thermal imaging requires adequate spatial resolution to provide distinction between two points less than 1mm apart[9-10].

The results of this pilot study shows that the edentulous patients in the complete denture wearing group (Group B) have average temperature values of 37.66 in maxilla and 37.37 in mandible, which are closer to the normal oral temperature. The normal oral temperature ranges from 37°C (98.6°F) - <37.8°C (100°F)[23].

Efforts to study residual ridge resorption based on the estimation of bone resorption, ridge remodelling with respect to molecular, cellular and tissue levels and relation to blood supply of the denture bearing area have been attempted. The amount of bone loss after extraction has an influence on the amount of alteration on the blood supply. Pressure within limits of tolerance leads to bone apposition. Until the pressure does not interfere with the blood and nerve supply, pressure is resisted[24-25]. Mostly the first sign of destruction to residual ridge is the deformed and traumatized condition of the soft tissue; the osteoclastic deformation due to pressure primarily initiated by circulatory disturbance in the nutritive tissue of the bone[26]. Hence blood flow estimation will give us a reference to understand the bone changes in the residual ridge. As the amount of blood circulation varies, the mucosal temperature also varies. The abnormalities in temperature distribution can be correlated with the blood flow. This temperature variation caries a lot of diagnostic information and this can be measured using non- contact thermography[9-10].

The values obtained in this pilot study for denture wearers being closer to oral temperature can be explained based on positive stimulation by denture base. Denture base can have an effect to retard the process of bone resorption if properly constructed. This tolerance of tissue to the pressure from denture base depends on various factors like remaining functional stimuli, altered blood supply and body chemistry affected by nutritional, hormonal and emotional factors. The effect of denture base on resorption is limited to its local effects on the supporting tissue which is directed to the bone through the vascular tissue. If the mechanical factors acting through a denture base in terms of impression, jaw relation records and occlusion are controlled within the tolerance limit of the tissue, denture should not contribute to resorption[9-10].

CONCLUSION

The result of the study indicated that on an average, temperature values obtained for denture wearers was more than the average temperature values obtained for non denture wearers. Complete denture wearers recorded values closer to the normal oral temperatures whereas non-denture wearers recorded lower temperature. This could

be because of positive stimulation through denture on the oral mucosa. Similar studies in completely edentulous patients have been done reporting the usefulness of infrared thermography[9-10]. Further studies with larger samples and over a larger period of time need to be observed so that thermography could be used as a diagnostic tool to predict oral health and consequently residual ridge resorption

ACKNOWLEDGEMENTS

This study has been conducted with the support of Edentulism and Anodontia Research Center of Department of Prosthodontics, Sree Balaji Dental College & Hospital, Chennai, India
Conflict of Interest: Nil

REFERENCES

1. Zarb GA, Bolender CL, Eckert SE. Prosthodontic treatment for edentulous patients: complete dentures and implant-supported prostheses. St. Louis: Mosby; 2004.
2. Winkler S. Essentials of complete denture prosthodontics. Philadelphia: Saunders; 1979.
3. Klemetti E. A review of residual ridge resorption and bone density. *J Prosthet Dent.* 1996; **75**(5): 512-4.
4. Knezovic-Zlataric D, Celebic A. Resorptive changes of maxillary and mandibular bone structures in removable denture weavers. *Acta Stomatol Croat*. 2002; **36**: 261-5.
5. Schwartz-Dabney CL, Dechow PC. Edentulation alters material properties of cortical bone in the human mandible. *J Dent Res*. 2002; **81**(9): 613–7.
6. Kim S-J, Yoo J, Kim Y-S, Shin S-W. Temperature change in pig rib bone during implant site preparation by low-speed drilling. J Appl Oral Sci Rev FOB. 2010;18(5):522–7.
7. IOSIF L, AMZA OE, PREOTEASA E, AMZA G, PREOTEASA CT, DUMITRASCU C. Contributions Regarding the Assesment of Polymeric Materials used in complete Dentures by Thermographic analysis [Internet]. Mase Plastice; [cited 2013 Dec 20]. Available from: http://www.revmaterialeplastice.ro/pdf/IOSIF%20L.pdf%201%2011.pdf
8. Preoteasa E, Iosif L, Amza O, Preoteasa CT, Dumitrascu C. Thermography, an imagistic method in investigation of the oral mucosa status in complete denture wearers. *J Optoelectron Adv Mater*. **12**(11):2333–40.
9. Anbar M, Gratt BM, Hong D. Thermology and facial telethermography. Part I: History and technical review. *Dento Maxillo Facial Radiol.* 1998; **27**(2):61-7.
10. Sudhakar S BK. Thermography in dentistry-revisited [Internet]. 2011 [cited 2013 Dec 20]. Available from: http://www. biomedscidirect. com/121/thermography_in_dentistry_revisited/articlescategories
11. Infrared Thermography History - [Internet]. [cited 2013 Dec 20]. Available from: http://www.infraredtraininginstitute.com/history-of-infrared-thermography/
12. Gratt BM, Anbar M. Thermology and facial telethermography: Part II. Current and future clinical applications in dentistry. *Dento Maxillo Facial Radiol*. 1998; **27**(2):68–74.
13. Product Page [Internet]. [cited 2013 Dec 20]. Available from: http://www.flir.com/cs/emea/en/view/?id=41523
14. Biagioni PA, Longmore RB, McGimpsey JG, Lamey PJ. Infrared thermography. Its role in dental research with particular reference to craniomandibular disorders. *Dento Maxillo Facial Radiol*. 1996; **25**(3):119-24.
15. Graff-Radford SB, Ketelaer MC, Gratt BM, Solberg WK. Thermographic assessment of neuropathic facial pain. *J Orofac Pain.* 1995; **9**(2): 138-46.
16. Ventä I, Hyrkäs T, Paakkari I, Ylipaavalniemi P. Thermographic imaging of postoperative inflammation modified by anti-inflammatory pretreatment. *J Oral Maxillofac Surg off J Am Assoc Oral Maxillofac Surg*. 2001; **59**(2):145–148; discussion 149–150.
17. Lee J-G, Kim S-G, Lim K-J, Choi K-C. Thermographic assessment of inferior alveolar nerve injury in patients with dentofacial deformity. *J Oral Maxillofac Surg Off J Am Assoc Oral Maxillofac Surg*. 2007;**65**(1):74-8.
18. Christensen J, Vaeth M, Wenzel A. Thermographic imaging of facial skin-gender differences and temperature changes over time in healthy subjects. Dento Maxillo Facial Radiol. 2012; **41**(8): 662-7.
19. Lea SC, Landini G, Walmsley AD. Thermal imaging of ultrasonic scaler tips during tooth instrumentation. *J Clin Periodontol*. 2004; **31**(5): 370-5.
20. Scarano A, Piattelli A, Assenza B, Carinci F, Di Donato L, Romani GL, *et al.,* Infrared thermographic evaluation of temperature modifications induced during implant site preparation with cylindrical versus conical drills. *Clin Implant Dent Relat Res.* 2011; **13**(4):319–23.
21. Benington IC, Biagioni PA, Crossey PJ, Hussey

DL, Sheridan S, Lamey PJ. Temperature changes in bovine mandibular bone during implant site preparation: an assessment using infra-red thermography. *J Dent*. 1996; **24**(4): 263-7.

22. Pogrel MA, Yen CK, Taylor RC. Studies in tooth crown temperature gradients with the use of infrared thermography. *Oral Surg Oral Med Oral Pathol*. 1989; **67**(5): 583-7.
23. Burket LW. Burket's Oral Medicine: Diagnosis and Treatment. PMPH-USA; 2003. 680 p.
24. Jahangiri L, Devlin H, Ting K, Nishimura I. Current perspectives in residual ridge remodeling and its clinical implications: a review. *J Prosthet Dent*. 1998; **80**(2): 224-37.
25. Ortman HR. Factors of bone resorption of the residual ridge. *J Prosthet Dent*.1962; **12**(3): 429-40.
26. Lytle RB. Complete denture construction based on a study of the deformation of the underlying soft tissues. *J Prosthet Dent.* 1959; **9**(4): 539-51.