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Original Article

Newly Designed Non-Contact Probe for Tooth Surface Temperature Measurement-An In-Vitro Study

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ABSTRACT

Diagnosing teeth with vital pulp by temperature measurement may provide valuable information and integrity of pulp. Some authors found that non vital pulp has lower temperature than the vital pulp. Infrared technology is not a new phenomenon. It has been utilized successfully in industrial and research settings for decades. New innovations have resulted in noncontact infrared sensors offering smaller units of measurements led infrared technology to become an area of interest for new kinds of applications and users. The optimum resolution is the relationship between the distance of the measuring device from the target and the diameter of the spot (D: S), greater the value, better the optical resolution of the measuring device and smaller the target can be at given distance. The measurements of temperature in dentistry are important because of the fact that dental procedures can bring on uncontrolled increasing in temperature inside the oral cavity. It is known that temperature increase inside the pulp of about 5°C can lead to irreversible changes in the pulp. Attempt was made to bring the sensor much closer to the tooth surface and evaluated surface temperature rise of extracted teeth following exposure to composite light curing halogen – quartz halogen lamp. Results shows temperature changes of tooth can be recorded before and after light exposure by using newly designed probe.

Keywords: Application, Dental, Infrared, New Design Probe, Temperature.

1. INTRODUCTION

Pulp vitality testing is more important aid in the diagnosis of pulp disease and treatment planning. Pulp vitality test is indicated prior to dental restorative procedure. Sometimes in clinical situations in clinical situations the diagnosis is inconclusive because of

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absence of pulpal and periapical signs and symptoms because degeneration of pulp tissue without clinical evidence. Non odontogenic lesions situated at the apical region mimics of dental origin such instances determination of pulp vitality is important to eliminate pathology of dental origin.

The measurements of temperature in dentistry are done both in vivo and invitro because of the fact that dental procedures can bring on uncontrolled increasing in temperature inside the oral cavity. It is known that temperature increase inside the pulp of about 5°C can lead to irreversible changes in the pulp [1].

In assessment of tooth vitality in recently traumatized tooth is difficult to assess because of paraesthesia of nerve fibres. Assessment of anaesthetic test cannot be done as routine procedure. Most of pulp vitality test depends on stimulation of nerve fibre. Several studies show lack of correlation between pulp vitality testing method with actual histological condition of the pulp tissue. And there is poor correlation between the symptom and pulp histopathology. Intake of sedation drugs, analgesics increase the threshold of stimulation of pulpal nerve fibre. Teeth vitality depends on with vascular supply not nerve stimulation. Several methods been used to measure the blood flow to tooth, Doppler Flowmetry, Pulse Oxymeter, Photoplythesmography, dual wave length spectrometry [2].

Temperature measurement as a diagnostic aid in diagnosis of pulp status has been described with the use of thermocouples, infrared thermometers, miniature thermometer, infra red thermography and cholesteric crystals. However, some of these devices, Including thermocouples and cholestric liquid crystals are no longer advocated.

There are several studies conducted in vitro to measure the in surface temperature if the tooth pulp chamber changes by using thermocouple devices. M.Sulieman et al measured pulpal temperature rise during tooth bleaching [3]. The accuracy of infra red temperature can be quite accurate but it also affected by several factor. One such factor is distance to spot ratio. This indicates the size of the area measured relative to the distance away from the object being measured. This study focus on development of probe using MLX 90614 sensor designed especially to measure the tooth surface temperature in future can be used for determination of pulp vitality and can be used for experimental in vitro studies.

2. MATERIALS AND METHODOLOGY

Ten freshly extracted non carious maxillary central incisor teeth were selected and stored in distilled water with 0.2% thymol until start of procedure and attached to 1cm x 1cm acrylic resin block up to cement enamel junction. Mid labial surface is used to measure temperature changes by exposing high intensity visible blue light of wave length 400- 500 nm wavelength (3M. ESPE) which is used for curing dental composites in dental restoration, Temperature tooth surface on the labial surface was calibrated using the new probe setting the room temperature at 20 degree with room air conditioner and post exposure temperature was measured e palatal surface of tooth after exposing tooth surface with blue light for 40 seconds.

3. RESULTS

Surface temperature raise in before and after exposure of visible light cure is significant. Mean average temperature before exposure of light 20.25.Mean average temperature measured after exposure of light 24.27. All specimens' shows mean average temperature difference 4.03.

Table 1: Surface temperature raise in before and after exposure of visible light

Sl No	Before Exposure Of Light	After Exposure Of Light	Temperature Difference
1.	20.5	24.1	3.6
2.	20.4	25.1	4.7
3.	20	24	4
4.	20.5	24	3.5

5.	20.4	24	3.6
6.	20	25	5
7.	20.3	24	3.7
8.	20.2	24.5	4.3
9.	20	24	4
10.	20.2	24	3.9

Fig 1: MLX 90614 (MELEXIS)

4. DISCUSSION

Infrared technology is not a new phenomenon. It has been utilized successfully in industrial and research settings for decades. New innovations have reduced costs, increased reliability and resulted in noncontact infrared sensors offering smaller units of measurement. All of these factors have led infrared technology to become an area of interest for new kinds of applications and users.

Each object with temperature above zero (-275.15 deg c= zero –kelvin) emits electromagnetic radiation from its surface which is proportional to its intrinsic temperature. A part of this is so called intrinsic temperature, which can be used to measure. The cause of this is the internal mechanical movement of molecules. The intensity of this movement depends on the temperature of the object. Since the molecule movement represents charge displacement, Electromagnetic radiation (photon particles) is emitted. These photons move at the speed of light and behave according to the known optical principles. They can be deflected, focused with a lens, or reflected from reflective surfaces. The spectrum of this radiation ranges from 0.7 to 1000 µm wavelength.

Sir William Herschel is credited with the discovery of infrared radiation, but proof of its existence is ascribed to his son, Sir J.F.W.Herschel, who succeeded in recording these wavelengths on paper, thereby introducing the term thermograph. Hardy showed that it was practical to make thermograms of human skin [4]. Lawson et al credited the American missile program with introducing of infrared scanning techniques, which could be adapted to medical use [5]. Crandell and Hill in 1966, attempted to use thermography in dental patients [6].

Assessment of tooth surface temperature is one such method for evaluation of pulp vitality. Temperature of the tooth surface is determined by balance between case with which the heat is brought to the surface and case with which it is dissipated to the environment. The source of heat of normal tooth are conducted from the periodontal tissues and tooth root through the dentin and enamel up to the surfaces, heat carried by the circulation in to the pulp and heat produced by metabolic activity of the pulp.

Pogrel et al by use of an infrared thermographic camera he recorded temperature patterns over the crowns of teeth. He established that the temperature of upper incisor teeth decreased from gingival margin to incisal edge by approximately 2.5 degrees C. Vital and nonvital teeth were the same temperature at rest, but after cooling with cold air, nonvital teeth were slower to rewarm than vital teeth. The infrared thermographic camera could provide a method of testing tooth vitality based on blood supply rather than nerve supply [7].

Mc Cullagh JJ et al use infra red thermography and thermocouple devices to measure temperature changes of root surface. His study was designed to use two methods of temperature measurement to analyse and quantify the in vitro root surface temperature. His study concluded that infrared thermography is useful device than thermocouple [8].

Fanibunda found that pulpal circulation is more efficient than supplying the temperature of the crown with respect to the local atmosphere[9]. Fanibunda

studied the feasibility of temperature measurement as a diagnostic procedure in human teeth after mouth opening; it was found that the temperature dropped rapidly over a period of time over of period one minute. In teeth with vital pulp the end of cooling period a rise in temperature observed after the steady state was reached. However nonvital pulp after the cooling period temperature remained at a steady state. His study indicated that is possible to indicate that it is possible to differentiate the pulp vitality by means of crown temperature measurement using time – temperature relationship although Saliva evaporation will cool moist teeth and the heat gained from the adjacent tissue will raise tooth temperature there change will be equal for symmetrically placed tooth. The surface temperature of tooth suspected of being pulp less can be compared with the contra lateral homolog tooth. Most of the studies were done using contact thermocouple devices in measuring tooth surface temperature which is not possible in clinical applications.

They made a scan of a patient with a known periapical abscess and then compared the results from infrared thermography with the results obtained from the use of electric pulp test. No correlation was found between electric pulp test results and infrared temperatures or between decayed and filled surfaces and infrared temperatures. Measurement of tooth temperature using various systems may provide valuable information on integrity of underlying pulp. However, others found that teeth with nonvital pulp have lower temperatures than teeth with vital pulp. This test is very technique sensitive and should be performed in completely controlled conditions. For creating controlled conditions, each patient should be examined in a thermologic environment. The room should be insulated and draft free and the temperature should be maintained at 20°C [10].

The accuracy of infra red temperature can be quite accurate but it also affect by several factor. Distance to spot ratio. This indicates the size of the area measured relative to the distance away from the object being measured. Infrared thermometer does not emit any infrared radiation. It only measures it. However laser guided models should not used for medical application. Lowest level radiation may affect eyes.

The optic system of infra red thermometer pick up infra red energy emitted from circular measurement spot and focuses it on detector. The target should completely fill the spot.

The optimum resolution is defined as relationship between the distance of the measuring device from the target and the diameter of the spot. (D: S) greater the value, better the optical resolution of the measuring device and smaller the target can be at given distance.

MLX 90614 (MELEXIS) infrared sensor used in thermometer. It is non contact thermal measurement sensor. It has low noise amplifier.17 bit ADC and powerful DSP unit thus achieving high accuracy and resolution of thermometer. The thermometer using MLX 90614 is calibrated with a digital system management Bus (SMBus) which is two wire interface through which simple power related chips can communicate with rest of the system output signal, giving full access to measured temperature in complete temperature range with the resolution of 0.02^{o}C. as a standard, the 10 bit pulse-width modulation (PWM) used to encode sensed infrared rays into pulsing signal, is to configure continuously transmit the measured temperature in range of -20 to 120 deg c with an output resolution of 0.14^{o}C .

The accuracy of the non contact infrared thermometer is primarily determined by the distance-to-spot ratio (D/S Ratio). This ratio is the size of the area being evaluated by the infrared thermometer as it relates to distance. In other words, the area being measured

becomes larger as the distance increases. This ratio will have a significant impact on the accuracy or precision of the reading. Evaluation of tooth surface temperature changes on exposure to composite curing light cure by using newly designed probe. This new design is to bring the sensor as close as possible to D: S ratio greater. Idea of this new design is to bring the sensor close to the tooth structure to prevent any particular interference from the environment.

Probe tip was confined enough to fit on to the labial surface of incisor tooth, so that the environmental interference can be avoided while measuring the temperature. Digital infrared thermometer is easy. Maxillary central incisor teeth were selected to get broader surface for placement probe. Mid labial surface is used to measure temperature changes by exposing high intensity visible blue light of wave length 400-500 nm wavelength (3M.ESPE), which is widely used for curing dental composite in dental restoration. Temperature tooth surface on the labial surface was calibrated using the new probe setting the room temperature at 20 degree with room air conditioner in order to standardise the room temperature and post exposure temperature was measured on palatal surface of tooth after exposing tooth surface with blue light for 40 seconds. Palatal surface temperature was recorded so that the amount of heat generated and entire tooth surface change in temperature can be measured. Since 40 seconds light exposure was done in curing of dental composite 40 seconds exposure time was used in this study [11]. Results shows mean temperature changes of 4^{o}C which is not high enough to cause pulpal damage. However the heat produced by dental composite resin on polymerization is not taken into account in this study.

5. CONCLUSION

This study is done to measure temperature change occurs during light cure application on tooth surface with the newly designed infra red thermometer using MLX 90614 sensor in order to get precise reading and to bring the sensor closer to the tooth surface. There was lot of difficulty is registering precise temperature of tooth surface. This device need improvement and further studies needed to compare with the thermocouple and thermographic methods to establish its reliability in determining tooth surface temperature in future

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