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Modification of pulse oximetry probe for evaluation of pulp vitality in anterior teeth – An in vivo evaluation

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ABSTRACT

Context: This study was done to modify the pulse oximetry probe for the evaluation of pulp vitality test in anterior teeth in humans

Aims: The objective of using the pulse oximeter is to assess the blood circulation of the pulp by:
1)Evaluation of the oxygen saturation of the pulp
2)Evaluation of the pulse rate readings from the pulp vasculature

Settings and Design: The conventional pulse oximetry probe was customized for the purpose of pulp vitality test and was used in this study and registered excellent readings.

Results: The result of the present study confirmed the efficacy of a customized pulse oximetry probe for the use of pulp vitality test for anterior teeth in human beings

Conclusions : Present study shows that pulseoximetry with probe modification can be successfully used for pulp vitality test.

KEYWORDS : Pulp vitality, pulse oximetry,

Introduction

The most commonly used test to check pulp vitality are thermal test and electric pulp test . Thermal test works on the principle of flow of dentinal fluid at temperature changes, which lead to the movement of the odontoblastic process and subsequent mechanical stimulation of the pulpal nerves. On the other hand, in electrical tests an electric current is conducted through the tooth giving an electrical stimulation to the pulpal nerves . These modalities fall short of the ideal pulp tests include on several criteria. All these tests are subjective tests that depend upon the patient's perceived response to a stimulus as well as the dentist's interpretation of that response. Moreover, these testing methods have the potential to produce an unpleasant and occasionally painful sensation. Inaccurate results may often result, for example, in thermal test when ice melts and drips o onto adjacent teeth or gingival tissues [1], or when electric current applied to the tooth surface is conducted to the periodontal ligament [2], thus stimulating periodontal nerve fibres. False negative responses may also occur in cases of calcific metamorphosis, in teeth with immature root formation, or subsequent to an impact injury. Patients' erratic response to avoid a painful stimulus has also been demonstrated in an analysis of electric pulp testers.

For electric and thermal testing to be effective, the pulp must have a sufficient number of mature neurons. However, both the primary and young permanent teeth are not fully innervated with alpha - myelinated neurons, the neural components that are responsible for the pulpal response .Permanent teeth may not exhibit full alpha - myelinated axon innervations until 4-5 y[3,4,5], ears after eruption. These reduced numbers of pain receptors in these teeth make them less responsive to stimuli and therefore more susceptible to give negative results with thermal and electrical testing [8].Considering all these limitations, present pulp testing with thermal and electrical methods cannot be cited as reliable pulp vitality tests. This emphasizes the need for a technique which directly assesses the pulpal circulation as a measure of pulp vitality Pulse oximetry is a completely objective test, requiring no subjective responses from the patients. It directly measures the blood oxygen saturation levels. It was proven effective and is routinely used in medical applications with finger, toe, foot and ear probes.

The present study was undertaken to detect the vascularity of the pulp as a measure of tooth vitality in normal and traumatized teeth.

Aim of the present study was

Modify the probe for dental use

The objective of using the pulse oximeter is to assess the blood circulation of the pulp by:

1) Evaluation of the oxygen saturation of the pulp
2)Evaluation of the pulse rate readings from the pulp vasculature

(1) PULSE OXIMETER MACHINE AND PROBE DESIGN

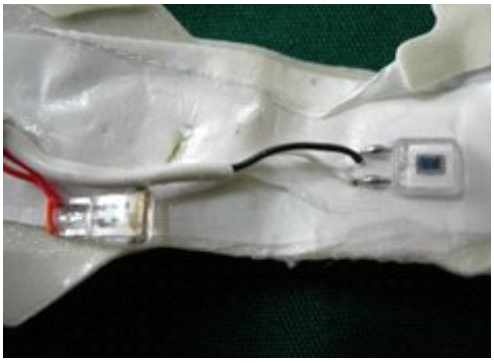
Aster 2 pulse oximeter instrument was used in this study (photograph 1).

Photograph I

Initially, a pulse oximeter with a pediatric probe (as used imedical & surgical specialty) was used which facilitated manual placement on the tooth surface.

It was found that the probe could not be held in close adaptation to the tooth surface and retained in that position without movement for sufficient length of time, so it became necessary to develop a customized probe to suit the nature of the study.

An extracted maxillary central incisor was taken to the lathe to provide a template for designing the probe. The probe was made of bakelite and the light source and sensor from the pediatric probe (Photograph II) was incorporated into this newly designed probe. This probe would closely adapt to the tooth surface. However, even this probe was unable to produce an acceptable reading.

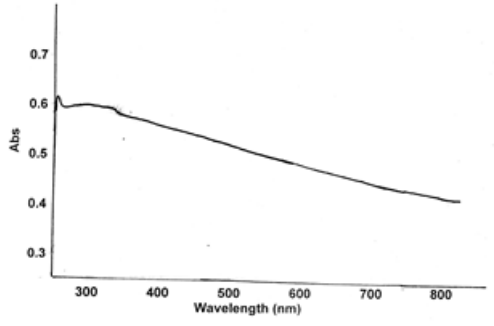


Photograph II

The probable causes of the failure at this step were assessed and could be due to

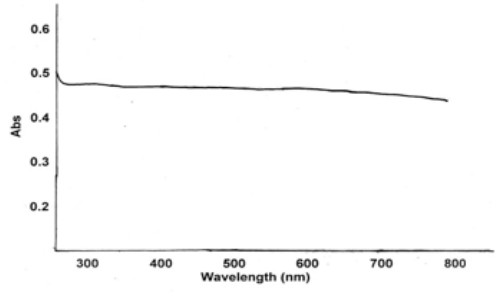
1) low intensity of the incident light to the tooth surface
2) low penetration of the light through calcified tissue of the tooth or due to high absorption of the light by calcified tissue of tooth
3) low intensity of the signals reaching in the sensor scattering of the incident light from the tooth surface(1) The intensity of the incident light was the property of the equipment used and hence could not be easily altered. Any attempt to alter the intensity of light or to change the source to laser light would require all the design and electronics of the equipment to be changed. Therefore, it was not practical.

(2) In order to know the transmission and absorption of light through the enamel, an absorption spectrometry of the enamel was carried out. It was studied by subjecting a layer of powdered enamel and a thin section of the tooth to absorption spectrometry. It was seen that the specimen exhibited a flat spectrometry between 200nm and 800nm (Fig 1 & Fig II). This means that light within this range of wavelength is transmitted entirely, without any absorption by the calcified tissue. The wavelength of light source used in pulse oximeter comes in this range and so it should pass through the tooth.



ABSORPTION SPERCTROMETRIC ANALYSIS REPORT OF ENAMEL POWDER

FIG 1

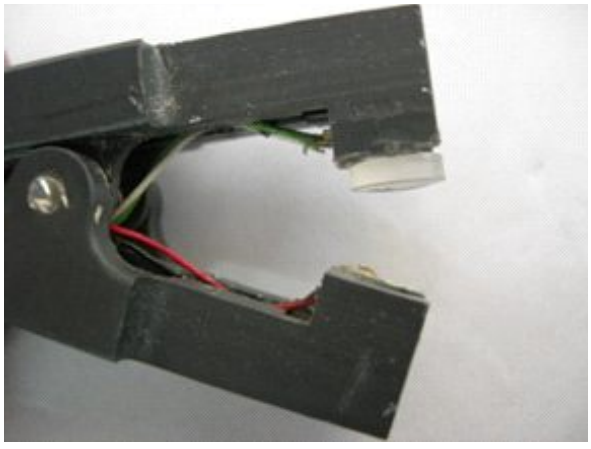


ABSORPTION SPERCTROMETRIC ANALYSIS REPORT OF ENAMEL POWDER

FIG 2

(3) Next attempt was made to prevent the scattering of the incident light. This was achieved by placing a Plano convex lens in the path of the incident light in order to converge the light beam. An 8mm diameter lens with a focal length of 10mm,was found to be satisfactory.

The probe thus customized (photograph III) was used in this study and registered excellent readings. (photograph IV)



PHOTOGRAPH III

PHOTOGRAPH IV

Discussion:

The vitality of the pulp-dentin complex is fundamental to the functional life of the tooth and is a priority for targeting clinical management strategies [9]. Pulp vitality test is crucial in monitoring the state of health of dental pulp, especially after traumatic injuries [10]. Pulp vitality is determined by blood circulation, i.e. the health of the vasculature of the dental pulp. Thus, vitality tests should determine whether the circulation is intact in the dental pulp.

Two wavelengths of light are used; 660 nanometers (red) and 940 nanometers (near infrared). At 660 nm, reduced hemoglobin absorbs about ten times as much light as oxyhemoglobin. At the infrared wavelength (940 nm), the absorption coefficient of oxyhemoglobin is greater than that of reduced hemoglobin. The pulse oximeter directly senses the absorption of red and infrared light; and the ratio of pulsatile to nonpulsatile light at the red and infrared wavelengths are translated through complex signal processing to a function of the arterial oxygen saturation [11].

Very few studies have. been reported in the literature regarding the application of pulse oximetry in the vitality assessment of the teeth. Earlier studies by Schnettler and Wallace [12] reported a correlation between pulp and systemic oxygen saturation readings using a modified ear pulse oximeter probe on a tooth.A K Munshi et al

(2002) conducted a study on pulse oximetry, to evaluate its reliability as a diagnostic instrument in pulpal vitality testing[8]. Siddeswaran et al (2011) conducted a study to evaluate the efficacy of pulse oximetry as pulp vitality test [13]. Gopikrishna et al. [14] developed a custom-made pulse oximeter sensor holder for an existing Nellcor OxiMax Dura-Y D-YS multisite oxygen sensor (Tyco Healthcare Group LP, Pleasanton, CA) and showed the utility of the pulse oximeter dental probe in assessment of human pulp vitality. V Gopikrishna et al evaluated the efficacy of pulse oximetry in pulp vitality in recently traumatized teeth [14][15][16] and later he patented the pulse oximetry probe for dental use.

Result

The result of the present study confirmed the efficacy of a customized pulse oximetry probe for the use of pulp vitality test.

Conclusion

Pulp vitality has been an elusive entity to the oral diagnostician and attempts at its accurate assessment have always fallen short of the goal. The current trend is towards mapping the blood flow of the pulp rather than depending on indirect measures of the integrity of neural elements. Pulse oximetry has been over looked in this regard and its potential as an adept diagnostic tool untapped to date .The present study was aimed at evaluating the reliability and accuracy of the pulse oximeter as a pulp vitality tester and assessing its superiority over conventional electrical and thermal methods by clinical trials.

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