Review Article

Dentistry Section

A Review of Laser Doppler Flowmetry and Pulse Oximetry in Dental Pulp Vitality

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ABSTRACT

An early determination of pulp vitality is crucial with respect to the correct differential diagnosis of revascularization or necrosis and its treatment. The use of a sensibility test is no more a precise conclusion, for diagnosing the state of the pulp, as it is based on the neural response, which may not be reliable. The pulpal circulation is of utmost importance as it gives more value in diagnosing the state of the pulp, which aids the clinician to come to a decisive diagnosis and treatment plan. This article describes two non invasive methods for measuring vascular health by evaluating the blood flow in Laser Doppler Flowmetry (LDF) and by measuring the oxygen saturation in the circulation in Pulse Oxiometry.

Key Words: Vitality, Stimuli, Pulp, Laser Doppler Flowmetry, Pulse Oximetry, Sensibility

INTRODUCTION

The pulpal and periapical problems are often difficult to diagnose because of the seemingly conflicting or unclear symptoms. This difficulty increases when there is an emergency situation. An improper diagnosis can end up in a wrong treatment plan and procedures, thus causing the failure of treatment due to a poor diagnosis. Diagnosing the pulpal and periapical symptoms clinically is extremely difficult because the histopathological condition of the pulp cannot be determined by clinical means [1].

Successful endodontics begins with an accurate diagnosis. Thereby, the clinician should keep in mind that he/she has to go through various modalities and information before reaching a correct diagnosis and a treatment plan [2].

A pain response to hot cold or an electric pulp test does not give any idea regarding the status of the pulp. These tests are no more reliable, as they can give a false positive and false negative response depending on the conditions, which may end up in a wrong diagnosis and treatment plan. When we conduct these tests on patients actually, we are looking out for the nervous stimuli. Such tests stimulate the A delta fibers, thereby causing a distress sensitive response to the patient. The vascular supply is more important than the neural response. The pulp can heal only if there is a circulating blood flow [3].

Electric pulp testing is no more a reliable method, as it indicates the presence of vital sensory fibers within the pulp. Often, even though there is a cessation of blood circulation, electric pulp testing gives a positive response in an irreversibly inflamed pulp because it contains vital nerve fibers. Most importantly, it fails to provide valuable information regarding the blood supply [4].

Newer testing modalities have been developed to determine the vascular supply of the pulp, thus giving a more accurate and clear diagnosis about the status of the pulp,it thereby helps in deciding a precise treatment plan.

OBJECTIVES OF PULP TESTING

1. Assessment based on its qualitative sensory response [5].

The sensory response of the pulp is usually assessed before restorative, endodontic and orthodontic procedures. This response is also assessed as a follow up of a pulpal trauma and alsoin differential diagnoses such as excluding periapical pathosis of pulpal origin. The most accurate way of evaluating the pulp status is by the examination of histological sections. Unfortunately, in the clinical scenario, these are impractical and not feasible. Hence, the clinicians must use investigations such as the pulp test to provide additional information.

2. Pulp vitality testing, assessment of the pulp's blood supply, the pulp tissue may have adequate vascular supply, but it may not be necessarily innervated [6]. Hence, most of the current pulp testing modalities do not directly assess pulp vascularity and this is exemplified by the clinical observation [7], that the traumatized teeth can have no response to a stimulus such as cold for a period of time following an injury.

3. Pulp sensibility testing; assessment of the pulp's sensory response. 'Sensibility' is defined as the ability to respond to a stimulus (8). This is an accurate term for the common pulp tests such as the thermal test, electrical test, etc. They do not detect or measure the blood supply to the pulp.

4. Pulp sensitivity; the condition of the pulp being very responsive to a stimulus. Thermal and electric pulp tests are not sensitive tests, although they can be used as sensitivity tests, when attempting to diagnose a tooth with pulpitis, since such teeth are more responsive than the normal teeth. Clinicianswho perform pulp sensibility tests, use such results to estimate the "vitality" and the state of the pulp health [5]. If the pulp responds to a stimulus, then the clinician can generally assume whether the pulp has a viable blood supply and whether it is either healthy or inflamed, depending on the nature of the response, such as duration and the nature of the pain, its

history and other findings. The three types of responses can be summarized as follows:

A. When the response of the pulp to the stimulus which is provided by the sensibility test is not pronounced or exaggerated, the pulp is considered as normal.

B. When the exaggerated response produces pain to the stimuli applied, it shows pulpitis. Pulpitis can be reversible or irreversible, depending on the severity of the pain and whether the pain subsides or not when the stimuli are removed [9,10].

C. The absence of the response to the sensibility tests usually denotes pulpal necrosis. The replication of the symptoms and triggers for pain diagnostic purposes [11,12] are commonly done.

a) to localize the source of pain
b) as an aid in excluding non odontogenic orofacial pain.

In cases where an inflamed pulp is suspected to be the source of the pain, with the patients complaining of onset and aggravation by specific thermal triggers, pulp testing agents are useful in identifying the offending (9,13). When the presentation of the pain is inconsistent and atypical with the possibility of referred or nonodontogenic pain, pulp testing can assist in the correct diagnosis by the process of confirmation or elimination.

LASER DOPPLER FLOWMETRY

This is a non invasive, objective, painless, semi-quantitative method, which is more reliable in measuring the blood flow to the pulp. As it doesn't cause any noxious stimuli, apprehensive or distressed patients accept it more readily than the current methods to assess the pulp vitality. Laser light is transmitted to the pulp by means of a fiber optic probe [14]. Laser Doppler flowmetry uses Helium Neon (HeNe) and Gallium Aluminum (Ga AlAs) as semiconductor diode lasers at a power of 1 to 2 mW. The wave length of the HeNe laser is 632.8nm and that of the semiconductor diode laser is 780 to 820nm [15]. The scattered light from the moving red blood cells in the circulation will be frequency-shifted, while those from the static tissues remain unshifted. The reflected light composed of Doppler shifted and unshifted light is returned by the afferent fibers and a signal is produced. This technique can be successfully employed for estimating the vitality of the pulp in both adults and children. The tooth to be checked should be isolated. The closer the probe is positioned to the gingival margins, the higher the signal output because of the greater volume of the pulp tissue [16]. At the same time, the potential gingival contamination is also higher [17]. The ideal position to place the probe is 2 to 3 mm from the gingival margin [18]. Different ranges of band width can be set to filter the reflected signal, with a wider frequency being more sensitive to the moving red blood cells with a wider range of velocity [19]. Theoretically, a wider bandwidth such as 15kHz is preferred, but in case of pulp vitality testing, a much narrower 3 kHz bandwidth may be ideal [20,21]. The end of the LDF which contacts the tooth contains both sending and receiving optic fibers, with one of the configuration being one source and two detectors in a triangular arrangement at the probe end [22]. Calibration of the probes is important to ensure accurate readings [23]. The larger the optical fiber separation distance on the probe, the higher the signal output as a larger surface area is covered, and also there is potentially a higher chance of blood flow signal contamination of the non pulp sources [24]. To date, the 0.5mm or 0.25mm separation distances seem to be preferred in experiments [22,21]. Due to the pulsatile nature of the blood flow, many studies [22,25,26,27] have observed that the LDF recordings in the teeth with an intact pulp blood flow have rhythmic fluctuations or oscillations. Synchronization was found with both heart beat and electrocardiogram readings, when they were taken simultaneously. In teeth without pulp blood flow, however, usually only irregular fluctuations can be observed in contrast to the concurrent ECG readings. The disadvantages of LDFs are that they detect only the coronal blood flow of the pulp, which may not relate to the actual blood flow on the linear scale. The assessment may be highly susceptible to environmental and technique related factors. Hypersensitive drugs, as well as , nicotine usage may give inaccurate results. It is also more convenient for use in the anteriors than in the posteriors and the thickness of the enamel also can give invariable results. It is impossible to completely eliminate the contamination of the scattered light from the periodontal issues [28,29], which can give wrong results even if the light is controlled by using a covering such as PVS splints [21]. Laser Doppler flowmetry is not useful in teeth with crowns and large restorations.

PULSE OXIMETRY

The term 'oximetry' is defined as the determination of the percentage of oxygen saturation of the circulating arterial blood [30]. Pulse oximetry is a relatively inexpensive procedure [31, 32] which is commonly used in anaesthetic procedures. Pulse oximetry readily differentiates between vital and non vital teeth. Studies have shown that vital teeth constantly provided oxygen saturation values that were lower than the values recorded on the patients' fingers(assessment of the efficacy of an indigenously developed pulse oximeter). Oxygenated haemoglobin and deoxygenated haemoglobin are different in colour and therefore absorb different amounts of red and infrared light. The pulse oximeter therefore utilizes probes which emit red and infrared light to transilluminate the targeted vascular area, which allows the photo detectors to identify the absorbance peak due to a pulsatile blood circulation, and thereby calculate the pulse rate and oxygen saturation levels [32, 30]. A pulse oximeter works on the principle that uses a photo electric diode that transmits light in two wave lengths (red -660nm, infrared-850nm).

An in vitro study by Noblett et.al [32] compared pulse oximetry with blood gas saturation in a simulated pulp blood flow model and showed promising results. The initial in vivo trials of pulse oximetry on ten adults by Khan et al. [31] found poor results, with the prototype oximeter being unable to obtain correct readings for clinically healthy pulp. However, a pilot study by Goho [33] found that 48 permanent and deciduous teeth had SaO2 on an average, in the range of 93-94% in comparison to the SaO2 which was taken from the index finger, which was approximately 97%. Radha Krishnan etal [30] reported registering the SaO2 of 100 permanent teeth of children in the region of 80%. It was interesting to know that both studies had ten root filled teeth as the controls, all of which recorded 0% SaO2. The lower SaO2 and the discrepancies in values obtained in the two studies were attributed to the differing optical properties of the teeth, because infrared light undergoes diffraction when it passes through the teeth [34] and because of the scattering of the light rays as they pass through the gingiva [35].

CONCLUSION

The pulp with its limitations, has been, and will still remain a very helpful aid in endodontic diagnosis. Attempts at measuring the true blood flow clinically have met with mixed success, with Laser Doppler flowmetry being one of the popular techniques which is

applied in dental traumatology. .Currently, no vitality test has been proven to be superior in all aspects. Further research is needed to improve the reliability and the accuracy of the diagnostic dental pulp testing.

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