

## Advances In Pulp Vitality Tests

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*Abstract: The endodontic diagnosis is made on the basis of patient history, clinical observation, radiological examination and diagnostic tests. The primary problem in pulp diagnosis appears to be identifying the symptomatic tooth when the pulp is in an irreversible state with the disease restricted to the pulp canal system. Ideally, any method used to assess the state of the dental pulp should be non-invasive, painless, reliable, reproducible, standardized, easily performed and inexpensive. A major and essential part in the diagnosis of pulpal disease is the use of pulp sensibility tests. The most popular clinical tests are thermal and electric tests. Recent advances in pulp vitality tests are Electric Pulp Tester, Laser Doppler flowmetry, Pulse Oximetry.*

*Keywords: Pulp Vitality, Electric Pulp Tester, Laser Doppler Flowmetry.*

### I. INTRODUCTION

The endodontic diagnosis is made on the basis of patient history, clinical observation, radiological examination and diagnostic tests. The primary problem in pulp diagnosis appears to be identifying the symptomatic tooth when the pulp is in an irreversible state with the disease restricted to the pulp canal system. Ideally, any method used to assess the state of the dental pulp should be non-invasive, painless, reliable, reproducible, standardized, easily performed and inexpensive. A major and essential part in the diagnosis of pulpal disease is the use of pulp sensibility tests. However, a major limitation of these tests is that they indirectly monitor pulp vitality by measuring pulp nerve responses not the vascular system, which is the reliable means of evaluating pulp vitality status.

### II. ELECTRIC PULP TESTER

No single element of the diagnostic process should be relied upon to make even what appear to be an uncomplicated diagnosis. Hence, two independent diagnostic test results that correlate should be used to indicate the disease process. Thermal and electrical pulp tester usually indicates whether there is a neural response from the pulp without indicating the state of health of the pulp. Some authors have reported inconsistencies between pulp symptoms and responses when compared with the histological findings. Thermal tests activate hydrodynamic movement of fluid within dentinal tubules, which excite A- $\delta$  fibers<sup>8</sup>. The non-myelinated C-fibers are not activated by these tests unless they produce injury to the pulp. Thus the pain sensation the patient experiences requires some vital pulp tissue, including odontoblasts for the function of hydrodynamic mechanism<sup>(1)</sup>.

### III. MECHANISM OF ACTION

There were two electric testing modes, bipolar and monopolar, which could be divided into two subclasses, those with mains connection and those using batteries (Ehrmann 1977, Na'rihi et al. 1979). However, the most common types are battery operated.(2)

Electric pulp tester delivers a current sufficient to overcome the resistance of enamel and dentin and stimulate the A- $\delta$  fibers. The C-fibers do not respond to the conventional EPTs because significantly more current is needed to stimulate those. A positive response to the EPT is the result of ionic shift in dentinal tubules causing local depolarization and subsequent generation of action potential from intact nerve.(2)

The concept of sensitivity, specificity, positive and negative predictive values have been developed to characterize test accuracy and to describe the benefit of test usage

As the calculations are based on comparison of the test results and the true disease status, identification of this true status become an important part of the evaluation of pulp status. The accuracy rate of any diagnostic test is usually determined by the availability of gold standard.(2) Limitations.

#### FALSE POSITIVE RESULTS

A false positive response is where a non-vital tooth appears to respond positively to testing. This may occur in anxious or young patients who may report a premature response because they are anticipating an unpleasant sensation. Necrotic breakdown products in one part of a root canal system can conduct electric currents to viable nerve tissue in adjacent areas, thereby resulting in a false positive result. Contact with metal restorations may also result in conduction of the current to the periodontium, giving a false vital response; the same may occur with inadequately dried teeth.(3)

#### FALSE NEGATIVE RESULTS

A false negative result means that a vital tooth has not responded positively to testing. This may be seen in teeth with incomplete root development, which have a higher threshold to testing, and require a stronger stimulation than normal to elicit a response. This is because teeth erupt and become functional before completion of neural development. In these conditions, cold testing has proved more reliable than EPT. Following injury, traumatized teeth may not respond to thermal or EPT due to nerve rupture. The pulps of these teeth, however, may still be vital as their blood vessels remain intact or have revascularized. Therefore, traumatized teeth should always be carefully monitored at periodic intervals as their nerve fibres may subsequently regain function. Interestingly, orthodontic tooth movement has been shown to produce changes in tissue respiration with a resultant reduction in blood flow and possible anoxia of A $\delta$  nerves. Cave and co-workers reported that orthodontic force increased the response threshold to EPT. The effect was almost instantaneous and could persist for up to 9 months following treatment. Patients

with psychotic disorders may not respond to pulp testing. It has also been reported that individuals who are under the influence of sedative drugs/alcohol may either not respond or respond to stronger stimulation due to their increased threshold to nerve excitation.(3)

### IV. PULSE OXIMETRY

Diagnosis is the art of identifying the problem and using scientific knowledge to determine the cause of the problem. The purpose of diagnosis in endodontics is to assess the condition of a tooth and to identify the cause of the discomfort. To determine the vitality of a pulp, the ideal tests used should be objective, painless, and reliable. Currently the most common tests for this purpose are sensibility tests (Kenneth et al, 2011). A major limitation of these tests is that they subjectively imply vitality through sensory responses. An alternative method would be to evaluate the vascularity of the pulp. This would be a more precise test, given the essential role of the pulp circulation in maintaining the tissue health. The evaluation of circulatory status of the pulp has been proposed to assess pulp vitality. Oximetry, the measurement of oxygen bound to hemoglobin is an advance in anesthesiology. Pulse Oximetry is a well established, noninvasive, direct, completely objective method for measuring vascular health by evaluating oxygen saturation levels (Noblett et al, 1996).(4)

#### PRINCIPLES OF OXIMETRY

In the 1930s Matthes used spectrophotometry to determine hemoglobin oxygen saturation. This method is based on the Beer-Lambert law, which relates the concentration of a solute to the intensity of light transmitted through a solution (Severinghaus & Astrup, 1987).(43)

#### MECHANISM OF ACTION

The pulse oximetry sensor consists of two light emitting diodes, one to transmit red light (640nm) and the other to transmit infrared light (940nm), and a photodetector on the opposite side of the vascular bed. The light emitting diode transmits light through a vascular bed such as finger, toes or ear. Oxygenated hemoglobin and deoxygenated hemoglobin absorb different amount of red /infrared light. The pulsatile change in the blood volume causes periodic changes in the amount of red/ infrared light absorbed by the vascular bed before reaching the photo detector. The relationship between the pulsatile change in the absorption of red light and the pulsatile change in the absorption of infrared light is analyzed by the pulse oximetry to determine the saturation of arterial blood. The information collected is converted into digital signals that are processed by the oximetry computer. A numerical estimation of the hemoglobin oxygen saturation is then produced and displayed. The machines can produce audible and visible signals to alert the doctor to change in the pulse rate and oxygen saturation. The machines safety mechanism includes low oxygen saturation and pulse rate range alarms. Displacement of finger probe also causes an

audible signal. The alarms can be set independently to desired range (Abd- Elmeguid& Yu, 2009).(4)

#### ADVANTAGES

Effective, objective, measures pulp vascularity, applicable to recently traumatized permanent teeth, non invasive, can be used in uncooperative, apprehensive patients, no unpleasant sensation, reproducible readings and data storage for further references (Radhakrishnan et al, 2002). (4)

#### LIMITATIONS

They may be classified as intrinsic and extrinsic (Jafarzadeh& Rosenberg, 2009).

#### INTRINSIC FACTORS

Increased acidity, increased carbon dioxide in the blood stream, increased metabolic rate arising from inflammation, intra venous dyes causing false low oxygen saturation level presence of other gases such as carbon dioxide. (4)

### V. LASER DOPPLER FLOWMETRY

LDF is another non-invasive method for assessing blood flow in microvascular systems. Its use in teeth was first described by Gazelius and co-workers in 1986. Since then, the technique has been widely used to monitor dynamic changes in pulpal blood flow in response to pressure changes and following administration of local anaesthesia. The technique utilizes a beam of infrared light produced by a laser that is directed into the tissue. As light enters the tissue, it is scattered and adsorbed by moving red blood cells and stationary tissue elements. Photons that interact with moving red blood cells are scattered and frequently shifted according to the Doppler principle. Photons that interact with stationary elements are scattered but are not Doppler shifted. A portion of the light is returned to the photon detector, and a signal is produced. Because red blood cells represent the vast majority of moving objects within the tooth pulp, measurement of Doppler-shifted backscattered light is interpreted as an index of pulpal blood flow. Gazelius and colleagues proved that LDF can reliably differentiate between healthy and non-vital teeth. Furthermore, LDF readings have proved extremely accurate in predicting revascularization in experimentally replanted dog teeth. Indeed, using this methodology, pulp revascularization has been shown to re-establish at around 4 weeks following tooth replantation, which is much earlier than would be expected from standard sensitivity tests. It is generally agreed that LDF assessment for human teeth should be performed at 4 weeks following the initial trauma, and repeated at regular intervals up until 3 months. The disadvantage of LDF relates to motion artefact due to uncontrolled movement of the probe when placed against the tooth. Thus, there may be a need for a modified mouthguard or splint to stabilize the measuring probe on the tooth surface in order to obtain more accurate and reproducible readings. Blood pigments within a discoloured tooth crown can also interfere with laser light transmission.

Care must also be taken to ensure that the false positive results are not obtained from the stimulation of supporting tissues.(5)

Laser Doppler Flowmetry (LDF) It is an accurate, non invasive, reproducible, reliable method of assessing blood flow in microvascular systems with a diode that projects an infra red light beam through the crown and pulp chamber. Unfortunately Laser Doppler Flowmetry takes about an hour to produce recordings, making it impractical for dental practices (Polat et al, 2005).(5)

#### CURRENT USES OF LDF IN ENDODONTIC TREATMENT

LDF is currently used in a number of dental specialties. Its most common use has been to determine the vitality of an injured tooth. Recent advances in endodontic treatment have improved the success rate and survival rate of injured teeth. Vascular supply and nerve innervation are currently considered the most accurate determinants of pulp vitality. Tests for assessing vascular supply that rely on the passage of light through a tooth have been used as methods for determining pulp vitality. Pulpal blood flow (PBF) measurement using LDF has been described as a more sensitive technique for evaluating tooth vitality compared with conventional methods, such as thermal and electrical pulp testing (EPT), especially in children. Indeed, in pediatric cases, electrical and thermal pulp testing can be painful and the responses can be subjective and unreliable. Following an injury (e.g. anaesthetized, traumatized, or impacted by orthognathic surgery), a period of denervation of the involved tooth results in the temporary or permanent loss of the tooth sensory function. This can cause the tooth to be nonresponsive to vitality tests, such as thermal or EPT tests. Up to 8 weeks may be required for a normal pulpal response to return (longer periods of time might be required in older patients because the repair mechanism of the nerve is slower).(5)

### VI. CONCLUSION

The unreliability of testing tooth pulp nerve response is well documented. When nervous sensations are inhibited or abolished in the tooth, for example following trauma, tooth transplantation procedures or during a general anaesthetic, conventional tests are of little value. However, a method based on the vascular response of the pulp need not be restricted under such conditions. Recording the pulpal blood flow would be an objective assessment of the status of the pulpal blood circulation, a true indicator of pulp vitality.

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