Review Article

Recent Trends in Pulp Vitality Test – A Review

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Abstract

Endodontic diagnosis plays an important role in the assessment of the health status of the dental pulp, which allows the clinician to initiate the most conservative and appropriate treatment and to prevent complications due to untreated diseases over a longer period of time. Various diagnostic tests have been employed to assess the pulp vitality. Pulp sensitivity test which assesses the nerve supply of pulp and the pulp vitality test which assesses the blood supply of pulp are discussed in detail. This article provides an elaborate view of all available diagnostic test to check pulp vitality.

Keywords: Laser Doppler flowmetry, Pulp sensitivity test, Pulp vitality test.

Introduction

Diagnosis is the art and science of detecting and distinguishing deviations from health and their cause.[1] Endodontic diagnosis plays an important role in the assessment of the health status of the dental pulp, through clinical, radiographic examinations, and special diagnostic tests, that allow the clinician to initiate the most conservative and appropriate treatment and to prevent complications due to untreated diseases over longer periods of time.[2]

Several endodontic tests have been employed to determine the status of pulp accurately; however, no single test can be employed in all clinical scenarios. This facilitates the use of multiple diagnostic tests in arriving at a diagnosis. The article gives an insight into the recent modalities of tests that can be employed.

Tests to assess pulp vitality

1. Tests that assess nerve supply-pulp sensitivity test[3]
2. Tests that assess blood supply-pulp vitality test[1]

Pulp sensitivity test

1. Thermal test
2. Electric pulp tester
3. Local anesthetic test
4. Test cavity.

Thermal Test

To measure sensitivity, these procedures involve applying cold and heat stimuli to a tooth. Despite the fact that they are both sensitivity tests, they are used for different diagnostic purposes. Sensitivity to cold usually suggests the presence of vital pulp, whether normal or pathological. Increased sensitivity to heat, on the other hand, may indicate pulpal or periapical pathology requiring endodontic treatment.[4]

Cold Test

Cold thermal testing causes dentinal fluid within the tubules to contract, causing a rapid outward flow of fluid within the patent tubules leading to a sharp sensation.

Materials used:

- Ice
- Carbondioxide snow
- Refrigerant spray.

Cold testing should ideally be done in conjunction with an electric pulp tester so that the findings of one test are confirmed by the findings of the other. If a mature, non-traumatized tooth does not respond to Electric pulp testing (EPT) or cold, the tooth may be classified as non-vital. When testing multi-rooted teeth, however, caution should be exercised because they may respond to cold even when only one root has vital pulp tissue.[5]

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Heat Test

Heat testing can be undertaken using a stick of heated gutta-percha, compound material, or ball-ended instrument. A guttapercha stick, preferably base-plate gutta-percha, is heated with a naked flame or an electric heater until it becomes soft and glistens. This technology is said to be capable of achieving a tooth surface temperature of up to 150° C. Gutta-percha softens at 65° C and can be heated to 200° C in delivery systems. Because of the restricted access, this test has restricted use on the posterior teeth. Another problem is that excessive heating can harm the pulp. Long-term heat exposure causes bi-phasic stimulation of the A-delta fibers first, then the pulpal C fibers. The C fibers might cause persistent pain; hence, heat tests should be limited to 5 s.[6]

Electric Pulp Tester

EPT is based on the idea that electrical stimuli create an ionic shift across the neural membrane, resulting in a rapid hopping action potential at the nodes of Ranvier's unmyelinated nerves. The electric current is considered to go from the test device's probe tip to the tooth, following the enamel prisms and dentine tubules, and then through the pulp tissue. The "circuit" is completed by the patient wearing a lip clip or contacting the probe handle with his or her hand; alternatively, the operator can touch the patient's skin with one "gloveless" hand.[7]

Test Cavity

In a tooth when no other method can determine the pulp condition, the preparation of a test cavity has been advised as a last resort. Cutting through dentine with a high or low-speed bur without local anesthesia can reveal whether the pulp's sensory element is still functional. Although the tooth defect can be fixed with restorative dental materials, this procedure is still considered invasive and irreversible.[6]

Local Anesthetic Test

Patients may be unable to differentiate between symptoms caused by the maxillary or mandibular arch. An anesthetic test may be useful in such circumstances, especially if pulp testing has been unsatisfactory. The procedure is as follows: The most posterior tooth in the area suspected of producing the discomfort is anesthetized using either infiltration or an intraligamentary injection. If pain remains after the tooth has been thoroughly anesthetized, the tooth next to it is anesthetized, and so on, until the discomfort is gone. An inferior alveolar nerve block injection is given if the cause of the pain cannot be pinpointed to the upper or lower jaw.[8]

The pulp sensibility test is a diagnostic procedure to determine pulpal status; which is performed with electrical, mechanical, or thermal methodologies to assess the pulp's response to the stimulus.[1] These methods of pulp testing fall short of ideal pulp testing methods because these may aggravate the existing pain of the patient.[3] Another problem is that they only monitoring neural response of the pulp. However, the vitality of the pulp relies on the vasculature of the pulpal tissue. For a tooth with intact vasculature may test non-vital due to damaged nerve fibers (e.g. traumatized tooth).[9]

Due to these limitations, the pulp vitality test is a real test to assess the pulpal health status. Pulp vitality test – A diagnostic procedure to determine pulpal status by the assessment of blood supply to the tooth.[1] This review will discuss in detail on various technologies used in pulp vitality testing.

In this review, various pulp vitality tests will be discussed:

1. Laser Doppler Flowmetry
2. Pulse Oximetry
3. Liquid Crystals
4. Dual Wavelength Spectrophotometry
5. Transmitted Light Photoplethesmography (TLP)
6. Ultraviolet Light Photography
7. Transmitted Laser Light
8. ^{133}xenon Radioisotope
9. Ultrasound Doppler Flowmetry
10. Detection Of Interleukins
11. Dental Pulp Hemogram.

LASER DOPPLER FLOWMETRY

The aim of this LDF is to objectively measure the "true" vitality of the pulp (i.e., the pulp blood flow rather than its sensory function without invasive procedures.[6] Gazelius *et al*. (1986) first described the laser Doppler flowmetry in dental literature.[10]

Polyvinylsiloxane or acrylic is used to stabilize the LDF probe. The probe is aimed at the pulp and laser light passes through dentinal tubules and backscattered from blood cells in the pulp. This backscattered reflected light is processed to produce an output signal. A perfusion unit (PU) is used to record the signal. (2.5 v of blood flow= 250 PU).[11-13]

Several research have been conducted to determine the best testing parameters for Doppler flowmetry. The laser beam produced is a low-power laser beam: 1–2 mW power beam with a variety of wavelengths. Different sources can generate lasers: 633 nm helium-neon or semiconductors with wavelengths of 780–810 nm. Gazelius *et al*. conducted the first investigation discovered that a 750 nm laser penetrated deeper but was less effective. Signal contamination from non-pulp sources from the tissues that surround it. Longer wavelength light sources were more sensitive due to deeper penetration into red blood cells.[14]

The limitation of LDF is contamination "noise" due to backscattered light from periodontal tissues. Using the polyvinylsiloxane splint and placing the LDF probe, 2–3 mm from the gingival margin will overcome the contamination "noise".[15]

Pulse Oximetry

Pulse oximetry is a non-invasive technique used to assess pulp vitality. The principle of pulse oximetry is based on a

modification of beer's law.[12] It consists of two light-emitting diodes, (red and infrared) and a photodetector on another side of the vascular bed. Red and infrared lights are transmitted through the blood cells (transmissible pulse oximetry). Oxygenated hemoglobin and deoxygenated hemoglobin absorb different amounts 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 photodetector. The relationship between the pulsatile changes in the absorption of red light and infrared light is analyzed by the pulse oximeter to determine the saturation of arterial blood.[16]

The infrared light emitted by the reflectance pulse oximetry probe is reflected by bone after transmitting through tissues. This technology has been used in fetal oximetry and is also well developed in veterinary science. Its application in dentistry needs to be studied to overcome the unadaptability of the transmissible pulse oximetry probe.[17]

Liquid Crystals

In 1922, Friedal proposed that when crystalline cholesteric esters, "liquid crystals," were heated to their melting points, they became cloudy liquid, not become clear until heated to a much higher temperature. This cloudy liquid is known as " mesophase." In 1964, Ferguson reported that when heated through their mesophases, liquid crystals exhibited various colors and when heated beyond the mesophase, they became colorless. Based on this research, liquid crystals were used in pulp vitality testing. A non-vital tooth containing necrotic pulp tissue has a lower surface temperature than a normal tooth. The surface temperature of the non-vital tooth is not altered by surrounding tissues. The presence of vital tissues in the apical third of the root can maintain the temperature of the tooth. More extensive trials are needed to make liquid crystals as a usual diagnostic procedure.[18]

Dual-Wavelength Spectrophotometry

Unlike pulse oximetry, DWLS does not depend on pulsatile circulation. The pulsation can be recorded easily in arteries, but pulp consists of smaller blood vessels such as arterioles, capillaries, and venules. Moreover, also pulp is present inside a rigid chamber surrounded by dentin and enamel. Hence, it is difficult to detect a pulse in the pulp.

DWLS detects the presence or absence of oxygenated blood in the capillary bed at 760 nm–850 nm. It uses visible light that is filtered and guided to the tooth by fiber optics. The blood concentration channel is arranged to respond linearly to the increase in light absorption. The oxygenation channel senses the oxygenated blood because of the greater absorption at 850 nm when compared to 760 nm. DWLS can also be used in regenerative and replantation procedures. Mass of pulp tissue needed for accurate readings and the influence of gingival tissue must be determined in future studies.[19]

TLP

TLP is a non-invasive optical measurement to detect pulp vitality. Based on the concept, hemoglobin absorbs a certain wavelength of light and the remaining light detected by the receptor, TLP assesses the blood volume changes in the microvascular bed of tissue in the pulp. A photodetector to measure the small variations in light intensity. It was compared with LDF and found to be of similar value. Signal contamination from periodontal tissue is less when compared to LDF. Various applications of PPG are clinical physiological monitoring, vascular assessment, and autonomic function.[20]

Ultraviolet Light Photography

When light falls on an opaque object, it is partly absorbed and partly reflected. The absorbed light imparts energy to emit light of higher wavelength than irradiating light. This phenomenon of light emission is called fluorescence. Benedict in 1928 observed that dentine fluoresced more brilliantly than enamel. There may be a loss of fluorescence due to "quenching agents," which absorb either irradiating or fluorescent light. In 1981, the foreman stated that the iron-containing pigments from the breakdown of hemoglobin are quenching agents. Based on these concepts, UV light was used to test the pulp vitality. Pulpless teeth do not fluoresce under ultraviolet light. However, there are other quenching agents such as caries, and filling material may hinder the result. Hence, the UV light photography needs further investigation and also it can be used as an adjunct in pulp vitality testing methods.[21]

Transmitted Laser Light

In LDF, the main limitation is contamination "noise," which is due to signals from periodontal tissues (non-pulpal origin). To overcome this, transmitted laser light technology has been explored. Instead of reflected laser light in LDF, TLL utilizes transmitted laser light technology. TLL consists of separate sending and receiving probes. Thus, the laser beam is passed through from the labial/buccal side of the tooth to the receiver probes on the palatal/lingual side. TLL is an experimental variant of LDF. At an incisal third of tooth, TLL showed zero, but LDF showed small reading. In the middle third, TLL output signals were twice that of LDF. At the cervical third, TLL showed zero, because of the increase in thickness of the tooth. Based on these data, TLL has proved to give more accurate results than LDF. However, further development is needed to increase the path length, thereby TLL can be used to assess pulp vitality in the posterior tooth.[22]

^{133}Xenon Radioisotope

The radioisotope ^{133}xenon in saline was injected into the periodontium which enters the pulpal blood flow and is picked up by a radiation probe placed on the crown. For the non-vital teeth, relatively constant counts for the duration of the experiment (200–300). For the vital teeth, the initial counts were much higher (718–981). After 6 min, it equals non-vital

tooth. Based on this, it is possible to assess the vitality of the tooth. The use of radioactive materials is expensive, restricted on humans, and requires special licensing requirements.[23]

Ultrasound Doppler Flowmetry

UDF is a non-invasive and radiation-free method of assessing blood flow by transmitting ultrasonic waves into the tissues. UDF was also successful in identifying changes in pulpal blood flow before and after anesthetic injection.[24] When comparing blood flow velocity in normal teeth to that in root canal-treated teeth, normal teeth had a faster blood flow velocity and a pulsed waveform, whereas root canal-filled teeth had a slower blood flow velocity and no pulsed waveform. Cho and Park investigated the pulpal blood flow rates of clinically normal and maxillary anterior teeth in healthy persons using UDF and reported that pulpal blood velocities were between 0.5 and 0.6 cm/s. Using a microfluidic-based pulpal arteriole blood flow phantom, UDF was recently proved to be an excellent technique for assessing pulpal blood flow velocity. Although UDF has the advantage of allowing for direct measurements of pulpal blood flow, it also has some drawbacks. First, nearby soft tissues may alter the UDF signal due to accidental contact with the UDF probe. Lips and tongue, in particular, could readily hinder the UDF probe's adaption to teeth.[25]

Detection Of Interleukins

The gold standard for pulpal diagnosis is now histological examination; however, this requires pulp removal. Clinical signs, symptoms, and radiologic appearance are insufficient for determining pulpal status, as they are frequently inconsistent with histology findings of pulpal inflammation. When the pulp is exposed, however, pulpal blood samples can be obtained, which may contain mediators reflecting the pulp's inflammatory state. The analysis of pulpal blood samples can provide useful information about pulpal health and can help with decision-making.[26] Guthrie *et al*. (1965) used pulpal blood at the exposure site to study dental pulp hemograms and observed higher neutrophil counts in pulpal blood obtained from teeth with severe inflammation. Cytokines are generally effective markers of inflammation.

Cytokines are polypeptides released by leukocytes and other cells that operate as modulators of immunological and inflammatory responses. They are classified as either pro-inflammatory or anti-inflammatory. Anti-inflammatory cytokines include interleukin (IL)-2, IL-6, IL-8, interferon (IFN)-c, and tumor necrosis factor (TNF)-a, whereas inflammatory cytokines include interleukin (IL)-2, IL-6, IL-8, interferon (IFN)-c, and tumor necrosis factor (TNF)-a.[27]

Nakanishi *et al*. (1995) assessed immunoglobulin levels in pulpal blood samples but were unable to detect cytokines, possibly due to the small volumes of blood obtained and minute concentrations of cytokines in the blood. Between normal and inflammatory dental pulps, they observed substantial changes in IgG, IgA, IgM, elastase, and prostaglandin E2.[28]

Because pulpal blood is easily acquired in the clinical setting, it may be a good sample for pulpal diagnosis in caries exposure situations. Because they provide information about the total cytokine balance in the pulp, IL-6/IL-10, and IL-8/IL-10, cytokine ratios may prove to be helpful markers of inflammation. The cytokine IL-8, as well as the IL-6/IL-10 and IL-8/IL-10 ratios, should be investigated further, help in the diagnosis of pulpal inflammation exposure to dental caries.[29]

Dental Pulp Hemogram

In 1949, Prader proposed that a white blood cell differential count (hemogram) from the first drop of blood from an exposed dental pulp could reveal the genuine pulpal status. He stated that the white blood cell hemogram of an intact healthy pulp that is free of inflammation is identical to the patient's circulating blood.[30]

The nerve block was used to anesthetize the affected tooth, which was then isolated with a rubber dam. The gross caries were then carefully removed with a spoon excavator, followed by the removal of peripheral caries with a large round bur. To reduce heat generation, a micromotor with water irrigation and high suction was utilized slowly for in-depth caries removal near the pulp. As soon as the first drop of blood came from the carious exposure, it was transferred to a sterilized and clean glass slide for the smear using a disposable syringe. A peripheral blood smear was also taken from the same patient's finger and cleaned with isopropyl alcohol to serve as a control for any divergence from peripheral blood. It was concluded that lymphocyte count was decreased in total pulpitis cases and also there was the increase in neutrophil count and degeneration, karyolysis was also found in neutrophils present in extensive inflammation cases.[31]

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