ISSN No:-2456-2165

Recent Advances in Endodontics Exploring the Trends in Diagnosis

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Abstract:- The incorporation of technology into dentistry has seen a multitude of changes in the diagnosing of a disease. Most of the problems associated with dentition are, in recent times, diagnosed with much more accuracy. The advantage with the use of technology is the precision with which the clinician can decide on the treatment planning. Most of the time in decision making is saved, as the diagnosis is made at a faster rate. Chairside advancements have also helped in reducing the patient discomfort and also relief to the presenting complaint of the patient. An attempt is made to present the recent technique in diagnosis that have been in use for the better understanding of the clinician.

Keywords:- *Cholesterol Liquid Crystals, Doppler Flowmetry, Laser, Recent Advances, Thermocouple.*

I. INTRODUCTION

An accurate diagnosis is the corner stone in developing a proper treatment plan. Inaccurate diagnosis can lead to an improper treatment plan.[1] A thorough clinical knowledge and using the latest diagnostic aids is of utmost importance in case of arriving at a diagnosis.[2] Proper diagnosis can be obtained by a systemic and methodical collection of data. [3]The diagnosis cannot be made just by clinical examination and using conventional diagnostic aids.[4]Lasers, temperature, microbiology, infrared beams, illumination, ultrasonic, radiography, fluorescence can be used as a modality for diagnostic purpose.

II. APPLICATION OF LASER IN DIAGNOSIS - LASER DOPPLER FLOWMETRY

Adequate blood supply in an area is essential for the viability of any tissue. Blood supply provide sufficient oxygen to the cells. The routine thermal tests assess the sensory response. Innervations in the pulp does not always ensure vitality. Adequate blood flow, pulsations and oxygen saturation in the pulp is an indication of a healthy vital pulp. The LDF is based on the Doppler effect. The laser beams emitted from the source is scattered and there is a change in frequency when it gets hit by moving objects. The red blood cells in the pulpal tissue represent the moving bodies.

The LDF device has a fiber optic probe which is placed on the surface of the tooth through which the laser beam is radiated. The laser beams are scattered and reflected on contact with red blood cells. The beams undergo for a frequency shift if it is hit by a moving red blood cell. No difference in the frequency is seen if laser beams is hit by a stationary cell. A photodetector receives the scattered beams back and convert to signal which calculate the magnitude of pulpal flow called as Flux. Helium Neon laser beams are mainly used at a range of 632.8nm, 780nm.

It can be used for estimation of pulpal vitality, pulp testing in children, to detect non endodontic causes in periapical pathosis, understanding the age related changes, helps in comparing the reactions of thermal and electric signals, understanding the pulpal reactions during orthodontic treatment, orthognathic surgery, monitoring the revascularization of implanted tooth.

The angulation of the LDF probe did not have an impact on the results. The surface area in the gingival or the cervical area is comparatively less and hence there is higher rate of flux at these areas. The probe should be held stationary at the contact point to get a more accurate result. Probe holders, rubber dam clamps, specialized stents can be used for this purpose. The laser technology is expensive, technique sensitive and can vary because of extraneous noise.[5]

III. LEVEL OF BLOOD OXYGEN SATURATION - PULSE OXIMETRY

Pulse oximetry can detect the vitality of the tooth by measuring the changes in light absorption as it passes through the tooth, thereby measuring the blood oxygen saturation of pulp. Pulse oximetry was developed by a Japanese bioengineer, Takuo Aoyagi. It is based on Beer Lambert Law, which states that an unknown solute(hemoglobin) in a known solution(blood) can be assessed by the light absorption of the solute. The pulse oximeter emits light of red and infrared light. This is a noninvasive method to detect blood flow within the pulp. A light beam of known wavelength is passed through the tooth while continuously monitoring the intensity of the transmitted light.

ISSN No:-2456-2165

The pulpal oxygen saturation is reflected on the amount of light that is reflected back. The probe should be kept in a constant place while checking for vitality. Any interferences should be avoided. A stent, clamp camp can be used to stabilize the probe. It can be mainly used during maxillofacial surgery, during endodontic diagnosis, to assess the vitality of a recent traumatized tooth, during endodontic treatments under sedation, monitor patients under general anesthesia. Increased acidity, increased carbon dioxide in blood stream, blood disorders, venous pulsations contribute to wrong reading.[6]

IV. DUAL WAVELENGTH SPECTROPHOTOMETRY (DWLS)

Dual wavelength spectrophotometry (DWLS) is a method independent of a pulsatile circulation. The presence of arterioles rather than arteries in the pulp and its rigid encapsulation by surrounding dentine and enamel make it difficult to detect a pulse in the pulp space. This method measures oxygenation changes in the capillary bed rather than in the supply vessels and hence does not depend on a pulsatile blood flow. DWLS detects the oxygenated and deoxygenated blood at 760 nm and 850nm. Studies have shown that DWLS differentiated the pulp chambers that were empty, filled with oxygenated blood or fixed pulp tissue.

DWLS was able to differentiate with reproducible readings between a pulp chamber of a vital and non-vital tooth in vivo. DWLS is of a great use in the replantation cases where the healing period can be monitored more accurately. DWLS use the visible light thus minimizing the hazards caused by other mode like the laser beam. It is an inexpensive, accurate device which is portable and can be used like a pulp tester.[7]

V. APPLICATION OF TEMPERATURE IN DIAGNOSIS – THERMISTOR, THERMOCOUPLE, INFRARED THERMOGRAPHY

A vital tooth has its heat source both from the periodontium through the root as well as from the pulpal blood circulation. A nonvital tooth has its heat source is only from the periodontium. As a note of this mechanism, heat source or the temperature of the tooth surface can be taken as a parameter to check vitality.

- *Thermistor*

Thermistor is a small thermometer which can detect minute temperature difference having a high sensitivity. A drop of saliva present on the tooth surface can lead to a change in the readings obtained. Researchers have stated that a vital tooth and a nonvital teeth if cooled below room temperature its seen that vital teeth rewarm back to the room temperature faster than the nonvital tooth. Thermistor measure the temperature for the same. It has two thermistor – a measuring and a reference thermistor. Measuring thermistor is kept in contact with the surface enamel and reference thermistor measures the change in atmospheric temperature.

- *Cholesteric Liquid Crystals*

The term “liquid crystal” was first used by Baltzer to describe a group of crystalline cholesteric esters that behave peculiarly when subjected to temperature changes. The term “mesophase” evolving thereof describes the state of the ester in which they are neither crystals nor liquid. The basic principle of evaluating pulp vitality using cholesteric liquid crystals lies on the fact that crystals of these esters exhibit different colors at different mesophases that could then be calibrated according to the temperature that produces the colors. The liquid crystals have a property of exhibiting various colours on heating through their mesophase. Cooling of the crystals back reverses the colour. A colour of blue, green or a combination of blue green signifies that the tooth is vital. Red and yellow colour signifies that the tooth is nonvital. A nonvital tooth has a lower surface temperature than the vital tooth.

- *Thermocouple*

Thermocouples are used for measuring the tooth surface temperature. Brown and Goldberg et al using thermocouple found out that surface temperature decreased in an anterior direction. Labial surface had lesser temperature when compared to palatal surface. Periodontium is the heat source which is conducted through the pulpal tissues. A vital pulp is capable of circulation and thereby a source of temperature.

- *Infrared Thermography (Fig:1)*

Computer controlled infrared imaging system is a noninvasive sensitive method of measuring body temperature. It can be used as a research tool and is technique sensitive. It can respond to very small temperature changes. Sir William Herschel and his son Sir J. F. W. Herschel were pioneers in the field of infrared thermography. Crandell and Hill employed the technique for dental use. They compared the results obtained from thermal, electric tests with the infrared thermography and the results appeared to be more satisfactory. Using infrared thermography, it was found that temperature at the gingival third was greater than that at the incisal edges. Hughes probe eye thermal video system is based on this principle and it can detect changes as small as 0.1 degree Celsius.

Vital and nonvital teeth have same temperature at rest, but once a stream of cold air is passed through the teeth, nonvital teeth take longer time to rewarm than the vital teeth. It was also found that temperature at the gingival or cervical areas were a bit higher than that at the incisal edges. [8]

ISSN No:-2456-2165

VI. APPLICATION OF TRANSILLUMINATION IN DIAGNOSIS- FIBRE OPTIC TRANSILLUMINATION (FOTI) and DIGITAL IMAGING FIBRE OPTIC TRANSILLUMINATION (DIFOTI)

Transillumination has a wide range of applications in the clinical field. It can be used as an efficient diagnostic tool. It can be used as an efficient tool for caries detection, detection of calculus, evaluate stained margins of composite restoration, evaluation of fractures and cracks, improved evaluation of soft tissue lesions, illuminate the endodontic access, can be an adjunct to loupes and other magnification devices. It's a noninvasive, simple technique.

Fiber optics is based on Snell's law and Total internal reflection principle. Fiber optics (optical fiber) refers to flexible, thin cylindrical fibers of high-optical-quality glass or plastic. The theory of fiber optics is based on a single optical fiber that consists of glass or plastic material with an outer cladding of a lower index of refraction material.

Since the fiber core has a higher refractive index, light rays are reflected back. Individual fibers are grouped together to form a fiber optic bundle.[1] These fibers can be as small as 0.01 mm in diameter for glass and 0.1 mm for plastic. Curing lights or specialized light sources with small apertures of 3 mm or less can be used. Transillumination along with digital imaging is used in case of DIFOTI. [9]

- *Photoplethysmography (Fig: 2)*

Photoplethysmography is a way for depicting changes in tissue opacity. On contact with tooth, it facilitates the recording of pulsatile variations in the blood circulation of the dental pulp. The changes in blood flow and volume is the reason for the change of opacity. Since the pulp is an encapsulated organ the changes in the blood flow and volume cannot be recorded accurately.

The recordings read by the plethysmography in a tooth is mainly because of the light transmission and can be affected by level of blood oxygen. In the encapsulated dental pulp, the amount of blood passing from the tooth artery to the pulp capillaries would be determined by the arterial transmural pressure, which comprises the difference between arterial and interstitial pulp pressures.

Arterial vasoconstriction would result in an increase in arterial transmural pressure and a fall in interstitial pressure and would facilitate the filling of blood capillaries in the dental pulp. As a result of this, light transmission through the dental pulp will be reduced and, on the photoplethysmogram, an upward shift in base line and an increase in pulse wave amplitude would be recorded.[10]

- *Application of Ultrasound and Ultrasound Doppler Effect*

Due to the high resolution of ultrasound, the three-dimensional images of the inner macrostructure of the tooth can be seen in detail. The ultrasound apparatus incorporates a transducer, a coupling agent, and a software with electronic and digital signal processing units. When the ultrasound probe is moved, a 3D image is formed. Ultrasound has the ability to penetrate biological tissues and can detect the discontinuities and pathosis. Once the sound waves hits on the biological tissues it gets scattered and reflected back which is called the echo. The echo signals are transferred to electrical signals which are converted to a light image of various grey shades.

Ultrasound Doppler allows for the detection of the rate and direction of the blood flow. It is represented on a graph (Doppler) and as a grey scale image(colour). Positive Doppler shift is caused because of the movement of RBC towards the transducer and Negative Doppler shift is caused because of the movement in the opposite direction. In vital teeth a pulsating waveform is obtained and in nonvital or endodontically treated teeth a linear nonpulsative waveform is obtained.[11]

- *Presence Of Inflammatory Mediators As A Diagnostic Aid*

Molecules expressed in the cascade of tissue inflammation may serve as (diagnostic) biomarkers for the presence of inflammation. The dental pulp contains numerous inflammatory mediators, which can fight against irritating factors. Its mechanistic response begins with vascular changes mediated by Toll-like receptors -positive cells and includes release of measurable inflammatory mediators such as IL-8, IL-6, IL-1 and others biological molecules. The detection of these molecules can help in the diagnosis of periapical pathosis.[12]

- *Caries Activity Test*

Caries activity test helps in identifying the causative organisms for the pathosis. It helps in identifying the high-risk population for dental caries, helps in further researches, decreases the caries susceptibility at the individual level. Various tests include Lactobacillus colony count test, Streptococcus mutans test, S. mutans screening test, Alban test, Dewar test, Swab test, Salivary buffer test, Snyder colorimetric test, Enamel solubility test, Salivary reductase test, Fosdick calcium dissolution test.[13]

- *Quantitative Light Induced Flourescence*

Quantitative light-induced **fluorescence** (QLF) is an optical technique based on fluorescence. There is difference in the natural **fluorescence** of carious and decayed teeth. It measures the percentage of change in fluorescence of demineralized and mineralized enamel and dentine. It helps in measuring the development of caries and remineralization of lesions. The chromophore in enamel and dentine has the property of auto fluorescence which is reduced in demineralized tissues. The fluorescence loss in the demineralized areas can be quantified. Carious lesions appear dark when viewed with QLF, however, stains on the

tooth's surface exhibit the same phenomenon and appear dark, similar to caries, and the darkness increases as the intensity of the stain increases.[14]

VII. CONCLUSION

In this era when the science has an immense growth in all fields, the incorporation and utilization of the advanced technologies in the field of diagnosis has proved to be a great achievement in the field of medical and dental sciences. The enhanced diagnostic approach includes enhanced visualization tools to detecting the changes at cellular and molecular level. Ultimately the goal of all health care professional is to provide better treatment and improve the quality of life.

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