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Review Article

Recent Diagnostic Aids in Endodontics- A Review

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ABSTRACT

In the modern world, there are so many recent advances in diagnosis in Endodontics. It is enhanced by newer technologies. The style of this improvement is targeted towards increasing the objectivity sensitivity and reproducibility of the pulp tests while decreasing the patient's discomfort. Methods like Pulse Oximetry, Laser Doppler Flowmetry, Ultrasound Doppler, Dual Wavelength Spectroscopy, Photoplethysmography are being developed and evolved to get adapted to the current clinical setting which may be of great use to the modern endodontist. These new methods fulfill the necessity of choosing the best tools for a good diagnosis. The aim of this review therefore was to assess the utility of some devices and techniques utilized in endodontic therapy to make the correct diagnosis.

Keywords: endodontic diagnosis, photoplethysmography, pulp vitality, recent advances.

INTRODUCTION

The principle behind diagnosis is the determination of what kind of complication the patient has and why does he have that complication. In due course of time, this will lead to what treatment, the patient requires and if it's necessary. Providing the wrong treatment intensifies the patient's symptoms thereby increasing the difficulty of arriving at a correct diagnosis[1]. To put it in simple terms, diagnosis is the process by which the dentist collects the information obtained from questioning, examining and test in gthepatient to identify the anomalies[2,3].

Pulse Oximetry

This technique is most commonly utilised for the measurement of oxygen concentration because of its ease and availabilty[4]. Squire, in 1940, perceived that the changes of red and infrared light transmission caused by pneumatic tissue compression permitted saturation to be computed[5]. In 1950, Wood[6] used this principle to compute absolute saturation continuously from the ratios of optical density differences with the ear oximeter's pressure. Takuo Aoyagi, an electrical engineer in Tokyo, realized that, to compute saturation from the ratio of ratios of pulsating changes in the red and infrared light, the pulsating variations of oxygen saturation could be used[7,8]. Schnettler and Wallace[9] in 1991 have reported a correlation between pulp and systemic oxygen saturation readings using a modified pulse oximeter ear probe on a tooth. Gopikrishna. *et al*,[10-12] developed a custom-made Pulse Oximeter sensor holder for an existing Nellcor OxiMax Dura- Y D- YS. Pulse Oximetry also utilises the haemoglobin aspects in the red and infrared light. Oxy-haemoglobin absorbs more light in the red range than deoxy-haemoglobin and vice versa in the infrared range. The devices may further be 'reflectance' type or 'transmission' type. The difference is in the type of light incident on the detector. This sensitivity test can be an ideal chair-side screening test[13-15].

Laser Doppler Flowmetry

This is another non-invasive method for the measurement of the blood flow of the pulp. For monitoring tissue blood flow, an apparatus based on Laser Doppler principle was developed in 1970. At the beginning, it was used for the measurement of blood flow in the retina, skin and renal cortex[16]. Gazelius *et al*.[17] used it first for measuring pulpal blood flow in 1986. Helium-neon (He-Ne) laser light was used to measure the pulp blood flow[17-19]. Pettersson and Oberg[20] in 1991 used Laser Doppler flowmetry to check the activity of pulp in intact and traumatized teeth. An infrared laser diode with a long wavelength was used. A transmitted laser-light flow meter that used high-powered laser light was developed by Sasano *et al*.[21]. Konno *et al.*[22] in 2007, modified this instrument and indicated that a high powered (5 MW vs 2 MW) transmitted light flow meter apparatus is a better tool than the back scattered light flow meter apparatus in assessing changes in pulpal blood flow in molar intrusion. During testing, the laser beam was allowed to hit the tissue and the reflected light that was scattered by the moving blood cells, was observed. Since this reflected light undergoes Doppler Frequency shift, it varies from the incident light. It was revealed that the laser can penetrate densely upto 4 mm depth and less densely for upto 13 mm length.

Ultrasound In Endodontic Diagnosis

It is of great convenience in conventional radiography as an imaging technique in clinical dentistry. Due to it's high resolution, 3-D images of the innermost structure of the tooth can be viewed. Cotti[23] reported the differential diagnosis of periapical inflammations and cystic lesions using UltraSound imaging and they were confirmed by histopathological examinations. Rajendran and Sundaresan[24] in 2007, have determined the efficiency of

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this tool for monitoring the reparation of periapical lesions treated by nonsurgical endodontics. UltraSound instrument has the aspect of penetrating hard tissues and can also identify anomalies and the disease condition even under existing radio-opaque restorations[25]. Different biological tissues in our body possess different mechanical and acoustic properties. Henceforth, the UltraSound waves, at the interface between two tissues with different acoustic impedance, undergo the phenomena of reflection and refraction.

Ultrasound Doppler Or Color Power Doppler

Color Power Doppler flowmetry detects as well as elicits the direction of the blood flow within the tissue to be observed. Power Doppler in accordance with the color Doppler enhances it's sensitivity to low flow rates. It is based on the principle of integrated power spectrum and can disclose the smaller vessels. In a recent assessment of the device, the origin of the signals could also be detected with the aid of different Doppler graphic waveforms and sounds in vital teeth as well as the nonvital teeth. In vital teeth, UltraSound Doppler reveals a 'pulsating' waveform and sound attribute whereas, root canal filled teeth shows linear non-pulsed waveform without pulsating sound[10]. The intravenous injection of contrast media is said to further increase the echogenicity of the area of interest[26-28].

Dual Wavelength Spectrophotometry

It is a class of studies in the field of dynamic light scattering related to the investigation of the dynamics of particles within very short time intervals. Diffusion wave spectroscopy was introduced by W.L. Butler in 1962 for the measurement of small absorption changes of highly dense biological materials *in vivo*[29]. This method is independent of a pulsatile circulation because of the measurement of oxygenation variations in the capillary bed rather than in the supply vessels. Moreover, the presence of arterioles rather than arteries in the pulp and its hard covering by surrounding dentine and enamel make it difficult to detect a pulse in the pulp space. An *in vitro* study was done by Nissan *et al.*[30] for determining the utility of Dual Wavelength Spectrophotometry to identify teeth with pulpal chambers that are either hollow, filled with pulpal tissue or filled with oxygenated blood. Their studies suggested that continuous-wave spectrophotometry may be a better method for testing pulp vitality.

Photoplethyesmography

It is an optical measurement technique that is used for the detection of blood volume anomalies in the micro-vascular bed of tissue. Only a few opto-electronic components are required: a light source to illuminate the tissue (e.g., skin or tooth) and a photo-detector to measure the small changes in light intensity in relation with the changes in perfusion. This technique is also used to detect the circulatory anomalies in the human dental pulp. The specific wavelengths of light alone are absorbed by haemoglobin, while the remaining light passes through the tooth and is detected by a receptor.

Cholesteric Liquid Crystals

These crystals have a helical structure, arranged in order along the long axis known as chiral- nematic liquid crystals. Due to their fluidity, these crystals are easily affected by temperature or pressure. Henceforth, they are thermochromic. These were studied by Howell *et al*.[31] in Lexington 1970. They found that non-vital teeth have lower temperature than vital teeth. They analysed a variety of liquid crystals until they arrived at a combination that would indicate temperatures in 30° to 40°C range. They used cholesteric compounds that were in a 10% solution in a chlorinated hydrocarbon solvent. When applied to the tooth surface, the crystals went through colour changes. Detecting pulp vitality is based on the principle that the teeth in intact pulp blood supply would have a higher tooth-surface temperature compared with teeth that had no blood supply.

Computed Tomography

The principle behind this is the usage of a narrow fan shaped beam and multiple exposures around an object to reveal its internal structures which aids the clinician to view morphologic features and pathology in three dimensions[32]. It determines the mesio-distal as well as the bucco-lingual extent of the pathology. There are four generations of CTs. The Hounsfield's unit belonged to the first generation of CT scanners which utilized a single detector element to capture the beam of Xrays. The second generation of CT systems introduced in 1975 used more than one detector and used small fan-beam. The first and second generations of CT scanners used a translate-rotate design and were used to scan only the head. Third generation CT scanners introduced in 1976 use a large, arc-shaped detector that acquires an entire projection without the need for translation. Third generation scanners are most commonly used today. Fourth generation scanners made a replacement of the arc-shaped detectors with an entire circle of detectors. The development of the power slip ring facilitated the development of spiral (or helical or volumetric) CT in the late 1980s. Current CT scanners, also known as multi-slice CT scanners have a linear array of multiple detectors (up to 64 rows) that simultaneously acquire tomographic data at different slice locations. However, they are expensive and may have limited usages in maxillofacial diagnosis. CT was the first technology to allow visualization of both hard and soft tissues of the facial bones by image processing enhancement and the ability to acquire multiple, non- superimposed cross-sectional images. CT images have the ability to show slices of a given tissue, with each slice thickness (1-2 mm) and location chosen by the operator[32]. Trope et al[33] in 1989 used CT scans to differentiate radicular cysts from granulomas based on the difference in density between the content of the cyst cavity and granulomatous tissue. Markowitz et al[34] discovered that coronal CT is the most accurate method in the diagnosis of mandibular fractures. CT exhibits perfect visualization of impacted teeth and their relationship to the nearby anatomical structures which is essential during surgical removal of impacted teeth. Aggarwal et al[35] concluded that both, the CT scans as well as the ultrasound with power Doppler flowmetry can offer an accurate diagnosis of periapical lesions equivalent to histo-pathological diagnosis[35]. CT helps to prevent endodontic treatment failure by detecting multiple extra root canals. Velvart et al[36] in 2001 compared CT scans with periapical radiographs of 50 mandibular posterior teeth scheduled for periapical surgery and found that CT detected the presence of an apical lesion and the location of the inferior alveolar nerve in all cases. Robinson et al[37] assessed mandibular first premolars on 120 routine dental. They found that CT images identified a greater number of morphologic changes than a panoramic radiograph[37]. CT has been used as a research tool for the comparison of the volume of root canals before and after instrumentation with different rotary nickel-titanium systems[38] and for volumetric analysis of root filling using various obturation systems[39].

Tuned Aperture Computed Tomography

A faster method by which tomographic images can be re-established is through tuned aperture computed tomography, which was developed by Webber and colleagues[40]. Its principle is based on tomo-synthesis and optical-aperture theory[41,42]. Its overall radiation is not higher than 1 to 2 times that of a conventional periapical X-ray film. The resolution is similar to 2-D radiographs. In 1998, Nair et al[43] demonstrated that this type of computed tomography had more effective imaging modality than film or individual digital images for the detection of recurrent caries. Webber et al[44] in 1999 also found it to be more diagnostically informative. This type computed tomography has proved to be effective in the determination of root fractures, especially vertical fractures. Nair et al[45] discovered that TACT had accurate imaging modality for non- destructive quantification of osseous changes within the reparative bony discrepancies. TACT appears to be an accurate imaging modality in the future, although it lies at the trial stage in dental applications.

Cone Beam Computed Tomography

A cone-shaped X-ray beam centred on a 2-D detector is the principle behind this imaging technique. A single rotation is performed by the beam around the object and produces a series of 2-D images which are re-organized in 3-D using a modified version of the original cone-beam algorithm developed by Aboudara et al[46] in 1984. When compared to helical computed tomography, its subjective image quality is high. Cone Beam Computed Tomography elicits a high spatial resolution of bone and teeth which makes it better, to understand about the relationship of adjacent structures. It's high resolution helps in identifying variety of cysts, cancerous lesions, infections, developmental discrepancies and traumatic injuries involving the maxillo-facial structures. It depends on various aspects such as the size and shape of the detector, beam projection, geometry and the ability to assemble the beam. Large field of view units ranges from 15-23 cm. These units have many utilities such as the evaluation of maxillofacial trauma, orthodontic diagnosis and treatment planning, temporo-mandibular joint (TMJ) analysis and pathologies of the jaws and are most advantageous for endodontic applications[47].

CONCLUSION

Newer advancements in imaging technologies have enhanced the dental diagnostics and treatment planning. These could be helpful in providing diagnosis accurately. Correct usage of appropriate imaging technology, cost-effectiveness, novel radiographic strategies can aid in the detection of pathologies in very early stages, ultimately helping in the reduction of morbidity, mortality and in improving the life expectancy of the patients.

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