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Advances in Endodontics: A Brief Review

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Abstract

With continuous evolution of science, there are many innovative instruments and materials introduced for the benefit of the dentist and dental profession. Gone are the time when endodontics was followed with using conventional equipment and instruments such as files, reamers etc., along with patient being uncomfortable by spending excessive time on dental chair leading to discomfort both to dentist and the patient. Over the past few decades' development in endodontics and restorative dentistry took a leap with the advent in which dentistry was practiced earlier. The present article is aimed to briefly review a number of these advances pertinent to endodontic pulp vitality testing, working length determination, instrumentation and irrigating needle, root canal disinfection, and sealer used in endodontic procedures.

Keyword: *pulp vitality testing, root canal disinfection, Plethysmography.*

Introduction

Endodontics is a branch of dentistry that deals to treat root canal infections. The most important steps involved within this treatment is diagnosis of the case, access opening, working length determination, biomechanical preparation and obturation. From the time, path of endodontics had witnessed a load of changes considered as advances so as to enhance treatment outcome and for the better diagnosis. In past few decades there has been a very rapid and extensive development in the field of endodontics and these advancements are included in each and every step of the endodontic procedure.

Advances in pulp vitality testing

The assessment of pulp vitality is a very important diagnostic procedure within the endodontics and is broadly classified into

- diagnostic methods that access nerve supply (Senstivity tests)
- diagnostic methods to access the blood supply and
- non-invasive experimental tests.

Chambers suggested that the technique for evaluation of dental pulp status must be simple, objective, standardized, reproducible, non-painful, non-injurious, accurate and inexpensive way of assessing the exact condition of the pulp tissues at any given time. Unfortunately, the traditional methods such as cold test, electric pulp test, percussion test, heat test, test cavity preparation and local anaesthetic test fall short of nearly all the above criteria.[1]

The limitations of traditional methods are as follows:

- Inaccurate results (a false positive result or a false negative result)
- Lack of objectivity
- Lack of reproducibility.
- The potential to produce an unpleasant and infrequently painful sensation.

To overcome these, the advent of newer tests to access the pulp vascularity that apply newer technology are discussed in detail such as laser Doppler flowmetry (LDF), dual wave spectrometry,pulse oximetry. Other than the methods used to access the pulp vascularity, methods such as other non-invasive experimental tests are also reviewed briefly. E.g transmitted light Photoplethsmography, transmitted laser light, transillumination and uv light photography.

1.Methods determining the blood flow.

The Laser Doppler Flowmetry (LDF)

Laser Doppler flowmetry (LDF) is a noninvasive, painless, electro optical technique, which allows the semi-quantitative recording of pulpal blood flow. It measures blood flow even in the very small blood vessels of the microvasculature.

Principle and Working

It consists of a fibreoptic source, laser light and a photodetector. It is based on the Doppler principle within which the light that contacts a moving object is doppler shifted and some of that light is going to be back scattered out of a tooth into a photodetector.. Since RBCs represents most of a moving object at intervals the tooth, absorb some of light and scattered some light back that could be measured as associate index of pulpal blood flow[2].

Laser Doppler flowmetry uses semiconductor diode lasers such as Helium Neon and Gallium Aluminum with a power of 1 to 2 mW. The wavelength of the laser Helium Neon is 632.8nm and of the semiconductor diode laser is 780 to 820nm. The ideal position to place the probe should be 2 to 3 mm away from the gingival margin[3].The distal part of the laser doppler flowmetry which contacts the surface of the tooth contains each sending and receiving optic fibers. It has a configuration of a triangular arrangement containing one supply and two detectors at another end also known as probe end[4]. The larger the optical fiber separation distance on the probe, the higher will be the signal output, and hence, a higher chance of blood flow signal contamination from the non-pulp sources[5,6].

Advantages

- Accurate
- Reliable
- Reproducible
- Nonpainful
- Luxation injuries

Limitations

- Too expensive
- Motion artifact due to uncontrolled movement therefore the sensor should be still and in constant contact with the tooth for accurate readings.
- The laser beam must interact with the moving cells within the pulpal vasculature.
- It should be performed at 4 weeks following the initial
- In trauma it is repeated at regular intervals until 3 months
- Blood pigments within a discolored tooth crown can also interfere with laser light transmission.

- The false positive results rarely obtained from the stimulation of supporting tissues.

a) Dual Wavelength Spectrophotometry (DWLS)

Principle and Working

Dual wavelength spectrophotometry (DWLS) is an independent method based on the principal of pulsatile circulation. The presence of capillaries particularly arteries within the pulp, forms a rigid encapsulation by close dentine and enamel creating it troublesome to notice a pulse within the pulp space. This method thus, measures change in the oxygen level within the capillary bed instead of measuring the change in the oxygen level within the supply vessels and hence, does not rely on a pulsatile blood flow.

DWLS detects the presence or absence of oxygenated or arterial blood at 760 nm and 850nm. The blood volume and its concentrated channel is arranged to respond parallel to the increase in light absorption. The oxygenation channel senses the arterial blood attributable to the larger absorption at 850 nm as compared to 760 nm[7,8,9].

Advantanges[8]

- Easy to use as it uses visible light that is filtered and guided to the tooth by fibreoptics.
- No need for added eye protection for the patient and the operator.
- Non-invasive and yields objective results.
- Small, portable and relatively inexpensive.

Limitations

- A major advantage is that it uses visible light that is filtered and guided to the tooth by fibreoptics[6]

b) Pulse Oximetry

Principle and Working

This technology is based on a modification of Beer's law: namely, the absorption of light by a solute is related to its concentration at a given wavelength.[10,11]

A pulse oximeter works on the principle that uses a photo electric diode that transmits light in two wave lengths. The probe is placed on the labial surface of the tooth crown and the sensor on the palatal surface. Ideal placement of the probe is in the middle third of the crown. If placed in the gingival third, disturbances from gingival circulation or any gingival trauma or bleeding will interfere with the readings. Useful in cases of impact injuries where blood supply remains intact but the nerve supply is damaged. Pulpal circulation can be detected independent of gingival circulation.[12,13,14]

Advantages

- Patient co-operation and acceptance therefore indicated mostly in young children.
- Non invasive and atraumatic.

Limitations

- Too expensive
- Readings affected by motion of patient or mobile teeth.
- Time consuming
- False positive results when used for endodontically treated teeth.
- Sometimes detecting pulpal inflammation in the teeth that are still vital.

1. Other Non- invasive Methods

A. **Transmitted-light photoplethysmography (TLP)**

Transmitted-light photoplethysmography (TLP) is a non-invasive technique used to measure the flow of blood within the pulp. TLP has the greater advantage of less signal contamination derived from periodontal or jaw blood flow. It was developed for pulp testing to improve pulse oximetry, by adding a light of shorter wavelength. It helps to detect pulpal blood flow in young permanent teeth. This technique is considered to be applicable to the assessment of pulp vitality[15].

B. Transmitted Laser Light (TLL)

It is an experimental variation to LDF, aimed at eliminating the non-pulp signals. TLL uses similar sending/receiving probes as conventional LDF, but the probes are separate. Thus the laser beam is passed through from the labial or buccal side of the tooth to the receiver probe which is situated on the palatal or lingual side of the tooth. The limitations with TLL are the same as with any laser technology where obstruction and/or interference from within the tooth structure will affect the results.[15]

C. Transillumination

It utilizes a strong light source which identifies colour changes that may indicate pulp pathosis. This technique may not be useful in large posterior teeth and especially in teeth with large restorations. However, it is a helpful adjunct to conventional pulp tests and it can help to identify cracks in teeth.[16]

D. Ultraviolet Light Photography

It examines different fluorescence patterns that may allow additional contrast of otherwise more difficult to observe visible changes. It has similar limitations as transillumination, and it is only an adjunct to conventional pulp tests, at best.

Advancement in working length determination

Electronic apex locators play an important role in establishing working length[17]. Innovations in apex locator's also results in greater accuracy when determining working length when combined with radiographs. This approach will also provide essential information about tooth anatomy, canal morphology, additional canals, missed canals or procedural errors[17].

1. Fifth Generation Apex Locator/Dual Frequency Ratio Type:

It uses multiple frequencies rather than the dual frequency as used in the third and fourth generation of apex locator, so it works effectively in both dry as well as wet canals without any requirement of calibration. It measures the capacitance and resistance of the circuit separately[17,18]. It is supplied by diagnostic table that includes statistic of the file. Example: RAYPEX

2. Sixth Generation Apex locator/ Adaptive Apex Locator:

Adaptive apex locators continuously define humidity of the canal and immediately adapts to dry or wet canal. It is based on the principle of impedance rather than the conventional gradient method. It is an effective diagnostic tool for detecting root perforation[18,19]. Example: ProPex Pixi. A major advantage of adaptive apex locator is eliminating necessity of drying and moistening of the canal.

3. Triauto ZX

It is a cordless electric endodontic handpiece with inbuild root apex locator. The handpiece uses Ni-Ti rotary instruments that rotate 280+/- 50 rpm. The handpiece is not capable of detecting the diameter of 0.5mm from the foramen position and thus, should only be used to detect the major diameter[20].

Advancement in instrumentation

1. Self-adjusting file (SAF)

The Self-Adjusting File (SAF) System was designed to overcome many of the current drawbacks of rotary file systems. The SAF technology allows for effective cleaning of all root canals including oval canals, thus allowing for the effective disinfection and obturation of all canal morphologies. This technology uses a new concept of cleaning and shaping in which a uniform layer of dentin is removed from around the entire perimeter of the root canal, thus avoiding unnecessary excessive removal of sound dentin.

Principle and Working

It is based on a hollow, highly compressible file that adapts itself three-dimensionally to the shape of a given root canal, including its cross section. The file is operated with vibratory in-and-out motion, with continuous irrigation delivered by a peristaltic pump through the hollow file.[21,22]

They are based on the mechanism of action of scrubbing, sand paper like effect on the wall of the canal. The 3D scrubbing effect of the file, combined with the always fresh irrigant, result in unprecedentedly

clean canals which facilitate in turn better obturation[21,22]. In the literature, it was found that upon using these files, the root canal walls were made free of debris and smear layer to a larger extent than with the use of normal k-file[21].

Advantages

- uses a new concept of no-pressure irrigation
- does not cause micro-cracks in the remaining root dentin.
- high mechanical stability
- Minimally Invasive 3D Endodontics.

2. Apexum device

It is based on the concept of a minimally invasive removal of inflamed periapical tissue which is chronic in nature. It consists of 2 instruments such as an Apexum Ni-Ti ablator and an Apexum polyglycolic acid ablator (PGA).

Procedure

A #20 K-file is passed through the apical foramen and beyond the apex to verify patency. It is followed by a rotary #30 file that is passed 1 mm beyond the apical foramen, creating a passage with a 330µm diameter. The Apexum NiTi Ablator is then inserted, while encased in its sheath, to the working length as established at the cleaning and shaping stage[23,24]. The sheath is stabilized to the occlusal surface of the tooth using glassionomer cement. The Nitinol filament is then pushed manually through the enlarged apical foramen and into the periapical tissues. The NiTi Ablator is then rotated in the periapical tissues for 30seconds at 200 to 250 rpm to initially mince the tissue[23,24,25].

The stabilizing glass-ionomer cement is then removed and the NiTi Ablator withdrawn from the root canal with its sheath to examine it for any mechanical damage or missing parts. The root canal is then rinsed with sterile saline, and the Apexum PGA Ablator is manually inserted through the root canal and into the periapical tissues. It is then connected to a low-speed contra-angle hand piece and rotated for 30 second sat 5,000 to 7,000 rpm to turn the minced tissues into a thin suspension. Next, it is withdrawn from the root and examined for any mechanical damage or missing parts. The tissue suspension is now washed out with sterile saline solution. The cross-sectional area between the enlarged apical foramen and the outer surface of the needle is 3.4 times larger than that of the needle's lumen. This facilitated an unobstructed backflow and prevented pressure buildup in the periapical crypt[23,24,25].

Advantages

- Minimal invasive technique
- Removes chronically inflamed periapical lesions through root canal access.

- Removal and debulking of periapical lesions without using scalpels, periosteal elevators or sutures.
- Overcome the drawbacks of the conventional surgical procedure.
- Enhanced healing kinetics of periapical tissues
- No events of severe postoperative pain or swelling
- Not technique sensitive.
- Eliminate or disrupt bacterial biofilm.

Disadvantages

- Chances of causing a flare-up sometimes.
- Widening of the apical foramen to form a passage of 330µm diameter may lead to softened guttapercha extruding beyond the apex.
- Management of procedural errors is also a matter of concern.

Advanced Irrigating Needle

The anatomy of a root canal is complex and accessory features such as fins, intercanal communications. The goal of every endodontic procedure is to clean the canal both mechanically as well as chemically to remove all the necrotic tissue, microorganisms, webs, fins, and anatomises to prevent any further progress of disease or pathology. Sometimes, root canal spaces cannot be cleaned mechanically due to complex anatomy of the canal. The only way is through the effective use of irrigation solution. Hence, various new irrigating needles have been introduced to improve work efficiencies.[26,27]

1. Max1 Probe needle/ Pro rinse

It is a closed ended side vented needle that prevents extrusion of irrigating solution in the peri-apical tissue. The technique involves dispersion of the irrigant into the root canal with the help of needles that work either passively or with agitation[27].

Advantages:

It gives an easy control of the depth of the needle penetration of the canal.

Disadvantages:

• Weak mechanical flushing action.

• Removal of smear layer in apical one-third is not effective.

• Periapical extrusion of irrigation.

• Irrigating solution is delivered only 1mm deeper than the tip of the needle.

Brushes

Brushes are used as an associate adjunct for debridement the walls of the canal or agitation of the root canal irrigant.

A 30-gauge irrigation needle lined with brush was introduced commercially. (Navitip FX Needle with brush). Moreover, the endobrush used includes the nylon bristles set in twisted wires with an associated handle and encompasses a constant diameter on its entire length[27].

Disadvantage:

It could not be used to full working length because of its size, which lead to packing of the debris into the apical section of the canal after brushing.

Manual dynamic irrigation

It is a straightforward and cost-effectiveness technique. However, the hard nature of this hand-activated procedures still hinders its application in routine clinical routine. A gently moving well-fitting gutta percha master cone associated with up and down in short 2-3mm strokes, within an instrumented canal that activates to provide result of an effective hydrodynamic effect and improve the displacement of any given chemical reagent[7,28,29,30].

Advances for disinfection of Root Canal

Sodium hypochlorite is most commonly used endodontic disinfection. The main aim of using this disinfection is to provide a dynamic fluid environment during root canal irrigation by improving bubble dynamics and activating intensified cavitational bubbles[31,32]. Some of the recently introduced disinfection are:

1. Antibacterial nanoparticles:

Nanoparticles (NPs) are microscopic particles with one or more dimensions in the range of 1-100nm. Antibacterial NP has been found to own a broad spectrum of antimicrobial activity and much lower propensity to induce microorganism resistance. The electrostatic interaction between the positively charged NPs and negatively charged bacterial cells, and also the accumulation of enormous variety of NPs on the microorganism cell membrane are related to the resulting in the loss of membrane permeability and speed loss of membrane function[7,31,32]

2. Photon-induced photoacoustic streaming

The laser system is provided with a fibreoptic delivery tip and subablative parameters to supply the specified result. It is based on the direct shock wave generated by an erbium:YAG (Er:YAG) laser in a liquid irrigant. The laser system is equipped with a fiberoptic delivery tip and subablative parameters to produce the desired effect[28,29].

3. Gentlewave irrigation

It has been developed and successfully tested for root canal irrigation[33]. The GentleWave System utilizes advanced fluid dynamics, acoustics, and tissue dissolution chemistry to more thoroughly debride and disinfect the entire root canal system. Reaching areas of the root canal system often untouched or undetected by standard root canal therapy has been an essential challenge in endodontics to this day[34,35].

The GentleWave Procedure presents as a minimally invasive endodontic therapy to more effectively debride and disinfect the entire root canal system. Moreover, it has the technological capabilities to debride and disinfect these integral complex anatomies which are often inaccessible through standard endodontic therapies[34,35].

It delivers sodium hypochlorite into the root canal under pressure through a specialized handpiece, that is activated by a broad spectrum of acoustic waves. At the constant time, suction removes the effluent fluid through the handpiece. A silicon ring surrounding the extremity of the handpiece establishes a vented and closed-loop fluid flow within the root canal[33,34,35].

Advantages

- Meant to detect, debride, and disinfect complex anatomies.
- minimally invasive
- safe and reliable.

Advances in Sealers

1. Resilon

The Resilon core material a thermoplastic synthetic polymer-based root canal core material containing bismuth oxychloride, barium filler and bioactive glass. It basically formed a monobloc consisting of filling material which is a resin sealer. The monobloc concept suggest that the creation of a solid, bonded, continuous material from one dentine wall of the canal to the other[36,37].

Conclusion:

New endodontic technologies have emerged in the last few decades, which aimed at addressing current limitations. The success of endodontic treatment depends upon the elimination of microorganisms and removal of the smear layer during cleaning and shaping. Vital advances in regenerative endodontics enables a better understanding of many factors that govern stem cell-mediated regeneration and repair of the damaged pulp–dentin complex. Translational research is proving to be crucial in creating these

procedures additional predictable whereas pushing the boundaries of future procedures that are likely to involve the direct clinical manipulation of scaffolds, growth factors, and stem cells.

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