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Review Article

The hunt for the hidden – Methods of locating root canals

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ABSTRACT

Predictable endodontic therapy begins with good access preparation, which allows for the accurate location of any given orifice, facilitating the negotiating, securing, and shaping of the canal, as well as 3D disinfection and filling of the root canal system. Missed, unfilled, and untreated root canals have been identified as one of the leading causes of endodontic therapy failure in several investigations. With the advent of CBCT, magnification, ultrasonics and other diagnostic and treatment adjuvants, searching for and treating root canals has become easier and more predictable.

1. Introduction

“Well begun is half done” quoted Aristotle, Greek philosopher, nearly 2000 years ago. This statement holds true even today- in modern day Endodontics. The importance of a well-executed access cavity preparation cannot be overemphasized. The ideal access cavity creates a smooth, straight-line path to the canal system and ultimately to the apex. When prepared correctly, the access cavity allows complete irrigation, shaping, cleaning, and quality obturation. Locating canal orifices is a crucial and critical step during access preparation.

Over the past decades, many technologies have evolved to enhance the clinical performance of dentists for start-to-finish endodontics. Many of these technological breakthroughs, however, are meaningless if a practitioner is unable to identify a specific orifice, underlying canal, or root canal system. Missed canals include pulp tissue, bacteria, and other irritants, all of which contribute to clinical complaints and endodontic lesions, ultimately leading to endodontic treatment failure.[1]

According to an in vivo cross sectional study by Dr.Azhar Iqbal in 2014, the factors which were most responsible for endodontic failures were underfilled canals (33.3%), unfilled and missed canals (17.7%) and untreated root canals (12.2%).[2]

In a study published in 2018-19 by Mustafa et al, inadequate root canal filling (36.8%), missed canals (14.4), over-extension root canal fillings (12.8%), perforations (9.6%), instrumentation-related (8.8%), and endodontic access preparation-related (2.4%) were found to be the most common causes of endodontic treatment failure in decreasing order of frequency.[3]

Hence it is of paramount importance that we hunt for those hidden canals, and clean, shape and fill them for positive treatment outcomes.

2. Strategies for Locating Canals

The following represent, in no particular order, the important strategies for locating any given orifice, canal, and its related root canal system,

1. Knowledge of tooth anatomy
2. Radiographic diagnosis

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3. Cone-beam computed tomography
4. Vision (Magnification + Illumination)
5. Access cavity modification
6. Ultrasonics
7. Tests used in canal location

3. Knowledge of Tooth Anatomy

The clinician should be well versed with the normal as well as aberrant anatomy of individual tooth in the oral cavity, as well as racial and demographic predilection of any unique anatomical features in teeth. This basic awareness goes a long way in tracing hidden canals. The elusive root canals are easier to locate if the clinician knows what to look for and where.

As the external morphology of the tooth varies from person to person, so does the internal morphology of the crown and root. Changes in pulp cavity anatomy result from age, disease, and trauma. Although morphologic variations occur, clinical experience indicates that these changes usually follow a general pattern, and thus the study of pulp cavity morphology is a feasible undertaking.[4]

4. Radiographic Diagnosis

Radiographic diagnosis has been the conventional and gold standard technique for initial diagnosis and treatment planning before starting an endodontic therapy. The most commonly used radiograph is the Intraoral Periapical Radiograph (IOPA), RVG (Radiovisiography) and the Orthopantomogram (OPG) to a lesser extent.

IOPAs and RVGs are still routinely used as one of the important investigative tools during endodontic examination and the diagnosis stage. Even though it has a few limitations, an appropriately taken and processed periapical radiograph can still provide enough information and evidence to aid in diagnosis.

A sudden shift in the radiographic density of the pulp space usually suggests the presence of an extra canal, whereas a sudden constriction or disappearance of the root canal space indicates a bi- or tri-furcation. Post-operative radiography can also reveal the presence and location of an additional root or canal. There may be a missing canal if the root filling material is not centered within the root.[5]

5. Cone-Beam Computed Tomography (CBCT)

CBCT is one of the most significant advances, which has caused a radical change in diagnosis and treatment of endodontic cases in the last decade.

CBCT images always resulted in the detection of a greater number of root canals than digital radiography images, according to Matherne et al.[6] An operating microscope and CBCT scanning were shown to be helpful for locating and identifying root canals by Baratto Filho et al, and also that CBCT scanning can be utilized for initial identification of the internal morphology of teeth and missed canals.[7]

In general, the use of CBCT in endodontics for root canal location should be limited to certain specific situations like-

1. Identification of root canal system anomalies and determination of root curvature.[8]
2. During endodontic re-treatments to locate missed or extra canals for example the MB2 and the Middle Mesial.
3. Verifying patency of calcified canals.

6. Vision (Magnification + Illumination)

In the last 15 years, the introduction of Dental Operating Microscopes (DOM) into dentistry, notably in endodontics, has transformed how endodontics is practised around the world.[9] The DOM has established the gold standard for exceptional lighting and magnification, making it easier to spot orifices. Because the light from a microscope is parallel to the line of sight, it provides two to three times the amount of light that a surgical headlamp does. Magnification can be achieved by two ways,

1. Dental Loupes
2. Dental Operating Microscope

Loupes are classified by the optical method by which they produce magnification. There are 3 types of binocular magnifying loupes:

1. a diopter, flat-plane, single lens loupe
2. a surgical telescope with a Galilean system configuration (2-lens system)
3. a surgical telescope equipped with a Keplerian system (prismroof design that folds the path of light).

Loupes have the disadvantage of having a practical maximum magnification of just around 4.5. Higher magnification loupes are available, but they are cumbersome and bulky, with a narrow field of view.

Apotheker introduced the DOM in 1981. The initial OM was poorly designed and difficult to use ergonomically. Gary Carr introduced an OM with Galilean optics and ergonomically designed for dentistry in 1999.[9] It used a confocal illumination module to keep the light route in the same optical path as the visual path, which provided significantly better illumination than the prior scope's tilted light path. Many endodontic procedures require magnifications of x10 to x15, and some even require magnifications of x30.

The most obvious purpose of magnification in endodontics is to locate canals. Magnification can effectively help in managing calcified canals, missing canals, aberrant canals, dilacerated canals, and canals occluded by restorative materials.

7. Access Cavity Modification

The pulpal morphology of the tooth being treated, as well as the position of the canal orifices, are now mostly dictated by the Minimally Invasive Endodontics approach, which indicates that an access cavity is mostly dictated by the individual pulpal anatomy of the tooth being treated.

During root canal preparation, enough tooth structure should be removed to enable instruments to be placed freely into the orifice of every canal without interfering with overhanging walls. The access cavity outline form should be altered if additional roots and/or canals are suspected during the diagnosis stage. There are four stages to access cavity preparation.[10]

1. Pre-treatment assessment and Isolation
2. Armamentarium and Preparation of the tooth for endodontic treatment
3. Removal of the roof of the pulp chamber and coronal pulp tissue
4. Creating straight line access

7.1. Pre-treatment assessment and isolation

Fortunately, the vast majority of teeth may be isolated easily and rapidly for endodontic treatment in a single step. Once accessibility has been established, it is vital to mentally map out the pulp chamber's location. The angulation and any rotation of the teeth or coronal restorations in relation to the roots must be evaluated because it will affect the access cavity design. The cemento-enamel junction and furcation should be observed as well, as these features can help determine the level of the pulp floor and the likely placement of canal openings.

7.2. Armamentarium and preparation of the tooth for endodontic treatment

Endodontic treatment requires front surface mirror, DG16 endodontic probe, long shank small excavator, other instruments along with magnification, and excellent illumination. Prior to preparing the access cavity, all caries and failed restorations must be entirely removed. In some cases it may be necessary to do a pre-endodontic build-up to firstly aid rubber dam placement, and secondly create a reservoir for irrigants in the access cavity.

7.3. Removal of the roof of the pulp chamber and coronal pulp tissue

At a point where the roof and floor of the pulp chamber are at their widest, the roof of the pulp chamber should be penetrated through the central portion of the crown; this often occurs where the pulp horn relating to the widest canal is located (for example, palatal canal in maxillary molars and distal canal of mandibular molars). The bur will suddenly drop into the pulp chamber space once the pulp chamber's roof has been breached. To avoid damaging the pulp chamber's floor, a non-end-cutting bur (such as the Endo-Z bur [Dentsply Maillefer Instruments, Ballaigues, Switzerland]) is used to completely de-roof the pulp chamber.

Damage to the pulpal floor also may obliterate the dentinal map, thus making canal location difficult. The walls of the access cavity should be probed to ensure that the roof of the pulp chamber has been completely removed, that is, no dentine ledges/lips are present. A close examination of the pulpal floor of a molar tooth will reveal slight changes in the colour of the dentine, allowing the canal openings to be identified. Dark developmental lines can be seen connecting canal openings, and tracing along the developmental line can reveal the location of an undetected canal entrance. On a background of yellow/grey secondary dentine, the canal opening will appear as a small region of white opaque dentine. When using a DG16 endodontic probe to probe the narrow canal entry, it will feel sticky.

7.4. Creating straight line access

Once the canal entrances have been discovered, the shape of the access cavity may need to be refined or modified to provide endodontic files unrestricted (straight line) access into the coronal-third of the root canal.

7.5. Dynamic and static image guided access

The Dynamic guided system in endodontics, first introduced by Dr. Charles M, uses information from the patient's CBCT volume to design an access cavity. Virtual planning of an optimum access cavity is possible with the use of sophisticated software and alignment with a CBCT and surface scan. After that, a 3D printer can be used to create a template. A minimally invasive drill is guided to the calcified root canal using this template.[11] Dynamic guided access cavities can help in accurately locating highly difficult calcified canals through minimally invasive access cavities.

In order to increase the accuracy of dental implant placement, computer-aided static navigation procedures using surgical templates were created. In endodontic treatment, this approach has been used to improve the conservative access cavities. To give direct access to individual root canals in posterior teeth, static guiding necessitates the creation of many surgical templates. During surgery, a computer-aided static navigation technique using surgical templates eliminates the requirement for drilling guiding. As a result, endodontic cavity access accuracy is directly dependent on the surgical template's design and manufacturing process, and any inaccuracy during the fabrication process could result in intra-operative difficulties like perforations, gouging, and so on.[12]

8. Ultrasonics

Ultrasonics (US) were first used in dentistry for cavity preparations with an abrasive slurry.[13] Richman was the first to propose the use of ultrasonics in endodontics in 1957. Martin and Cunningham coined the term endosonics, which they defined as an ultrasonic and synergistic root canal instrumentation and disinfection system.[13]

Locating canals is one of the most difficult tasks in endodontics, especially when the orifice has become obstructed by secondary dentin or calcified dentin as a result of the placement of restorative materials or pulpotomies.

Ultrasonic cutting tips are a very useful tool for treating problematic molars because they allow visual access and greater control during access procedures. Access modification, identification of MB2 canals in upper molars and accessory canals in other teeth, location of calcified canals in any tooth, and elimination of pulp stones are all possible with ultrasonic tips.[14–16] It is important to remember that secondary dentin is generally whitish or opaque, whereas the floor of the pulp chamber is darker and gray in appearance while troughing the floor for canal orifices.

During the initial phase of eliminating calcification, interferences, materials, and secondary dentin, larger tips with less diamond coated extension should be utilised since they offer the best cutting efficiency and control when operating in the pulp chamber. The next phase of locating canal orifices should be done with thinner, longer tips that allows us to operate in deeper locations while keeping the vision clear.[17,18]

9. Tests used in Locating Canals

Not all dental clinics have access to newer technologies or armamentarium. In such scenarios, chair-side tests and clinical tips can be of immense help in locating canal orifices. Some of them are-

9.1. Champagne bubble test

After debridement of pulp chamber and located canals, flooding of NaOCl in the pulp chamber will cause bubbling, where it comes in contact with tissue. NaOCl, in this case dissociates into Na^+ and OCl^- ions and liberates free oxygen. The hypochlorite ion has a superior tissue-dissolving capacity. A positive "bubble" or "champagne" test indicates a response between OCl^- and pulpal tissue within a canal, or bubbles indicate a reaction between NaOCl and a residual viscous chelator used in canals when manually performing glide path procedures. This aids in the cleansing of the pulp chamber as well as the visibility of concealed orifices and overlooked canals.[19]

9.2. Use of dyes

Various dyes, such as, iodine in potassium iodide, ophthalmic dye (e.g. 1% fluorescein sodium (rose bengal) or 1% methylene blue can be irrigated into the pulp chambers of the teeth, rinsed thoroughly with water, dried, and viewed. The pigment will be absorbed into the orifices, fins, and isthmus regions, and will act as a 'roadmap' for identifying overlooked canals and fractures.[19,20]

9.3. Transillumination

Fiber optics have been used in dentistry for adjunctive illumination of other devices such as handpieces and ultrasonic scalers, as well as attached to magnifying loupes. Transillumination is a low-cost, simple-to-use, and effective diagnostic method. A powerful transilluminated light passing through the tooth can reveal dental caries, show evidence of dental trauma such as coronal fractures, and help locate calcified canals. A fibre optic wand can be positioned cervically to direct light perpendicular to a tooth's long axis. Turning off any overhead light source during transillumination might sometimes help in identifying an orifice.[21]

9.4. Red line test

Blood frequently oozes from an orifice, fin, or isthmus area in vital teeth. Blood, like a dye, maps and aids in the visual identification of the underlying anatomy.[1] A red dot on the lateral aspect of a paper point is occasionally seen, which is thought to be an offshoot or accessory canal within a canal.

9.5. White line test

Dentinal dust collects into any accessible anatomical area when doing ultrasonic procedures in necrotic teeth without using water. This dust can appear as a white dot or a white line inside a hidden orifice or an anatomical fin, groove, or isthmus.[1] On the pulpal floor, this observation can give a clear anatomical roadmap. Magnification is required while performing the red and white line tests, as they can be deceiving at times.

9.6. Perio-probing

Another approach for finding canals is circumferential probing of the sulcus of a tooth. Intersulcular probing with a periodontal probe reveals the clinical crown's emerging profile as well as the underlying root's orientational alignment.[1] It can also aid in identifying root fractures.

10. Conclusion

The elusive root canal, entrenched within the confines of the pulp chamber challenges the expertise of even the best of the endodontists. Not detecting it can lead to failure of the treatment. The "pathways of the pulp" are varied; the responsibility falls on the clinician to locate them, so that they can be cleaned, shaped and filled. A combination of preoperative diagnostic tools, clinical tips and methods can aid the endodontist in the "Hunt for the hidden" root canals.

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12. Conflict of Interest

The authors declare no conflict of interest

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