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Review Article

Negotiating Calcific Canal Obliteration with Predictability: A Literature Review

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ABSTRACT

Injuries to permanent teeth can result in clinical complications, presenting significant challenges for dental practitioners. Studies indicate that approximately 4 to 24 percent of cases experience pulp canal obliteration post-trauma. The process of locating canals after calcific metamorphosis and ensuring successful negotiation to their full length can potentially result in iatrogenic issues like fractured instruments and perforation. This review article offers insights into the management of obliterated root canals.
KEYWORDS: Calcified Canal, Calcific Metamorphosis, Pulp Canal Obliteration

Dental trauma stands out as the primary cause of injury in the head and neck area. According to research, the global prevalence of traumatic dental injuries ranges from 13 to 17.5%, with a pooled prevalence of 13% in India.[1] These injuries can give rise to various clinical complications, among which one is Calcific Metamorphosis (CM). CM is described by the American Association of Endodontists as a pulpal response to trauma characterized by the rapid deposition of hard tissue within the canal space.[2] Typically viewed as a defensive reaction of the body to trauma, calcification can also stem from factors such as deep decay, excessive force on teeth, nearby restorations, aging, or specific dental conditions. Additionally, teeth that have undergone rigid splinting, often following concussion or subluxation injuries, are prone to calcification. The process of locating canals post-calcific metamorphosis and ensuring their complete negotiation carries the risk of iatrogenic complications like fractured instruments or perforations.

DIAGNOSIS OF CALCIFIC METAMORPHOSIS

Identifying the calcified canals can be challenging for a clinician. The diagnosis of pulp canal obliteration can be established based on- clinical features like presence of localised pain or discomfort, which may or may not be associated with sensitivity to heat and cold and pain on biting or discoloration of the affected tooth. There might also be history of trauma, teeth with caries, fractures or restorations. In some cases, pulp stones are also associated with systemic diseases. These teeth are frequently discovered unintentionally during clinical or radiographic examinations. With significant pulp calcification, there's a gradual reduction in responsiveness to sensibility tests. When pulp obliteration occurs, it's commonly acknowledged that sensitivity tests become less dependable. The conventional radiographs used for detecting pulp canal calcification are periapical and bitewing radiographs. Typically, an X-ray shows complete obliteration of the pulp space with no visible pulp chamber. Unless there are signs of periapical radiolucency, the lamina dura remains intact, and there is no widening of the periodontal membrane space. In such cases CBCT can provide assistance in evaluating the extent and depth of calcification and aid in determining corrected location, angle and depth required to navigate the patent portion of the canals, ensuring proper treatment. Tooth segmentation is also a critical step in the diagnosing and planning the treatment of calcified canals. Segmenting the tooth from dental radiographic images or 3D scans allows for better visualization and analysis of the root canal system. Automated segmentation methods, particularly those based on deep learning, have the potential to streamline and improve the accuracy of this process.

MANAGEMENT OF CALCIFIED CANAL

Forming a treatment plan for a tooth with calcific metamorphosis is a difficult assignment. The prognosis of treatment in these cases depends on the patient's aesthetic requirements, presence of signs and symptoms and continued health of the pulp or periapical area on the apical side of the blockage. The literature mentions various treatment options to manage pulp canal obliteration (Figure1):

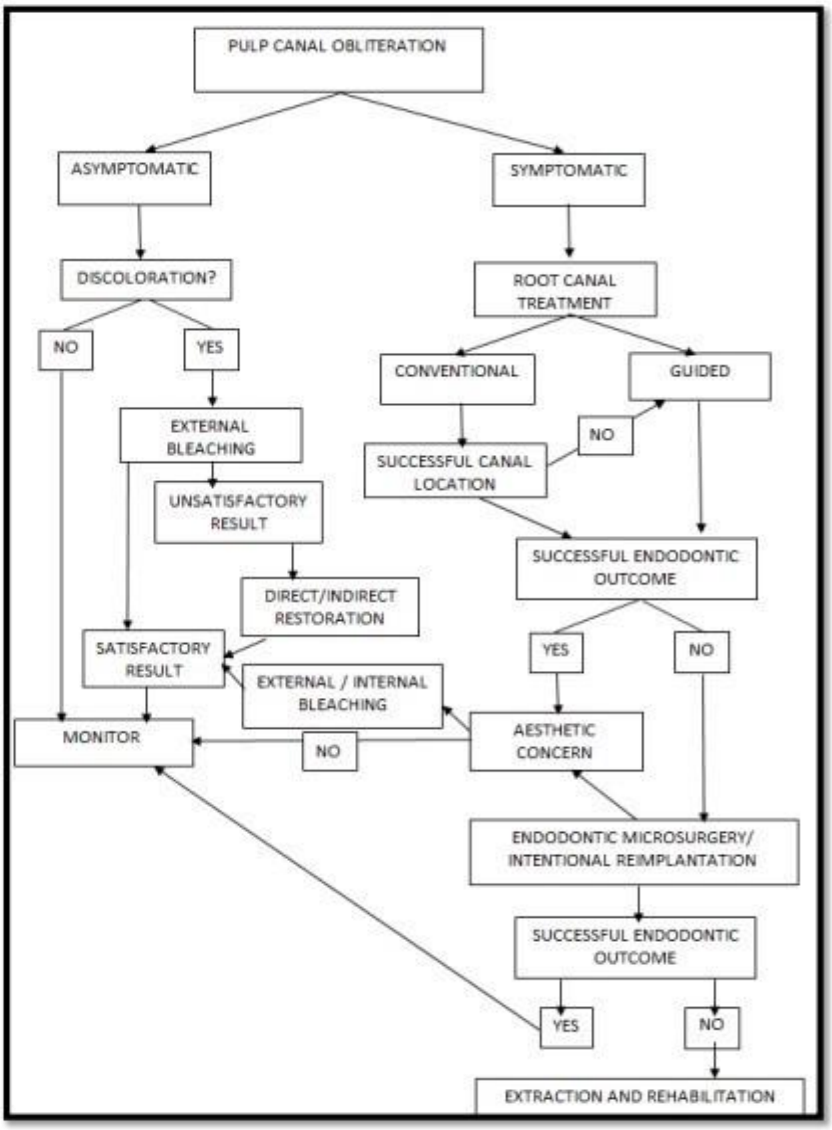

Figure 1- management of calcified canals

MANAGEMENT OF ASYMPTOMATIC PULP CANAL OBLITERATION

Various approaches are available to tackle the cosmetic worries of patients linked with pulp chamber calcification, including:

1. Vital Bleaching
   Vital tooth bleaching involves applying a chemical solution to a tooth's surface clinically to lighten it. Several authors suggest that vital bleaching should be considered as the initial treatment option because of its conservative nature.[3]
2. Bleaching (Internal-External) Without Root Canal Treatment
   Pedorella, Meyer, and Woollard [4] have formulated a technique wherein the sclerotic dentin in the coronal portion of the affected tooth is removed to prepare an access cavity. Followed by placing a suitable base/liner on the cavity floor. This approach addresses cosmetic concerns associated to both internal and external bleaching, eliminating the need for a root canal procedure.
3. Veneers And Crowns
   Veneers entail applying a tooth-coloured layer to rectify confined or widespread flaws and internal discolorations. Typically, veneers can be fabricated from direct composite, indirect composite or all ceramic materials (lithium disilicate or zirconia). Teeth with facial surfaces exhibiting malformations, discolorations, abrasions, erosion, or faulty restorations are among some of the indications for veneers. Crowns serve as synthetic replacements that reinstate missing tooth structure by enveloping the remaining structure with materials such as cast metal, porcelain, acrylic, composite, or a combination thereof (e.g., ceramo-metal, metal and acrylic).[5]

MANAGEMENT OF SYMPTOMATIC PULP CANAL OBLITERATION

Symptomatic teeth, characterized by tenderness upon percussion or accompanied by a periapical lesion, demand proactive therapeutic measures. Conventional non-surgical endodontic treatment is preferred as it effectively removes infection from the root canal space. However, if infection persists despite non-surgical intervention, a surgical approach becomes necessary.

NON-SURGICAL APPROACH

Accessing The Calcified Pulp Chamber

Managing calcified canals initiates with gaining access to the pulp chamber and removing any present pulp stones. Pulp stones, also known as denticles, may be embedded, adherent, or free, depending on their location.[6] Adherent and embedded pulp stones can impede instrumentation by obstructing canal orifices or being situated at curvature levels. Their attachment hampers the smooth movement of explorers or other dental instruments within the canal.[7]

Removal Of Pulp Stones

To remove denticles, dentists commonly use standard round burs for slow-speed handpieces. However, utilizing Munce Discovery Burs and/or an ultrasonic scaler with recommended tips offers easier workflow and enhances visibility at the operating site. When working under dry conditions, it's advisable to take intermittent breaks for irrigating the pulp cavity with a solution of sodium hypochlorite (NaOCl) or ethylenediaminetetraacetic acid (EDTA). In narrow canals, combining ultrasonics with sodium hypochlorite is recommended, as it dissolves collagen-based tissues within the canal, producing a synergistic effect. Additionally, a new solution known as "Physiological Simulated Decalcifying Agent (PSDA)" with a pH of 2.5 has been developed for pulp stone dissolution. PSDA effectively decalcifies pulp stones within 24 hours without significantly compromising the structural integrity or hardness of dentin.[8]

Radicular Access And Canal Preparation

Following the initial access and canal identification, the process proceeds to radicular access and canal preparations. Currently, primary methods for addressing root canal calcification involve appropriate pre-operative dental radiography, optimal magnification (using a dental operating microscope), and instruments such as small K files or C files, along with ultrasonic equipment featuring endodontic tips.

Glide Path

The fundamental step in non-surgical endodontic treatment is establishing and securing a smooth radicular pathway from the canal orifice to the physiological terminus.[9] K-files or rotary instruments are commonly employed to create this glide path. Utilizing K-files offers advantages such as enhanced tactile sensation, reduced fracture risk, and greater maneuverability in tortuous canal trajectories. Engine-driven glide path files offer benefits including shorter instrumentation time, reduced risk of canal irregularities such as ledges or transportation, better preservation of anatomy of the canal, decreased fatigue of operator, and minimized apical debris extrusion. It's recommended that no engine-driven instrument should be used without first employing a hand instrument during the mechanical preparation of constricted canals.[10]

Securing a challenging glide path can be addressed by:

- For calcified or fibrotic canals, employing stiffer files capable of withstanding increased pressure is advisable. Additionally, abundant irrigation using sodium hypochlorite (NaOCl) solutions alternatively with ethylenediaminetetraacetic acid (EDTA) at 17% concentration may help soften calcified tissues, facilitating further file advancement.[11],[12]
- In cases where file advancement is restricted, frequent irrigation with a chelating agent and sodium hypochlorite is necessary.

Studies have shown that establishing a glide path before shaping with engine-driven instruments leads to superior outcomes in terms of mechanical integrity, shaping and cleaning, reduced apical debris extrusion, and decreased formation of dentinal defects compared to not using a glide path.[13],[14]

Engine-Driven Instruments

Engine-driven instruments are developed to address root canal constrictions, which can induce increased torsional stress and cyclic fatigue on stainless-steel files, leading to undesirable transportation of the canal and instrument separation. NiTi alloys introduction has facilitated the production of tapered files that can be employed with rotational or reciprocating movements.[15],[16]

Disinfection-Related Factors

In calcified canals, even the smallest needles fail to reach the apical third entirely.[17] Hence, employing enhanced irrigation techniques is recommended to optimize the disinfection process. Over time, various strategies have been formulated to enhance the chemical process. These include sonic or ultrasonic activation of irrigants, utilizing negative pressure irrigation techniques, employing laser activation at low power levels, and utilizing the Sonendo multisonic system.[18]-[20] Additionally, fine irrigation needles (31–32 G) may penetrate closer to the apex in such scenarios. Moreover, primary alternatives for activation of irrigants in calcified canals include manual dynamic activation with gutta-percha points[21] or a multisonic activation system.[22] Furthermore, heating sodium hypochlorite might reduce its viscosity, enhancing the flow and activity of the irrigant in calcified and constricted canals.[22]

Guided Endodontics

As per the AAE case difficulty assessment guidelines, cases where canals are not visible on radiographs due to calcification are categorized as high-difficulty cases. Consequently, practitioners should anticipate significant challenges when dealing with an obliterated canal.

Static Navigation System

To mitigate procedural challenges, Krastl *et al* [23] have proposed a modern approach called guided endodontics for early detection and negotiation of teeth with Calcific Metamorphosis (CM). Guided endodontics involves a combination of CBCT and intra-oral surface scanning using virtual planning software. The steps of guided endodontic therapy post-CBCT include assessment of root canal curvature, evaluation of the degree of calcification and instrumentation required, identification of the location of the calcified root canal orifices and calculation of the instrumentation angle for calcified canals. Identification of position of the root canal on the CBCT is followed by creation of a virtual guide by merging the three-dimensional (3D) and CBCT images. This guide is then fabricated using a 3D printer. The guide is positioned on the teeth clinically, and penetration of the obliterated portion of the root canal is done with a specific drill. A #10 K-file combined with an apex locator is used to test canal permeability and determine the working length after accessing the canal, which is confirmed with an X-ray. Subsequently, standard endodontic treatment resumes with canal shaping and cleaning.[23]

Dynamic Navigation System

Dynamic navigation allows for tracking of the position of both the patient and dental handpiece throughout the procedure via motion tracking. The CBCT dataset uploaded into the planning software is used to determine the ideal drill position virtually. Both the surgical handpiece and the patient's head or teeth transmit three-dimensional spatial data to a stereo-tracker through sensors.[24]

SURGICAL APPROACH

1. **Micro-Endodontic Surgery**

   Endodontic microsurgery entails addressing the root apex of an infected tooth that remained unhealed through non-surgical root canal therapy.[25] This technique employs high magnification, ultrasonic root-end preparation, and root-end filling. With precise visualization, root canals can be precisely obturated, resulting in high-quality sealing and enhanced survival rates. Endodontic microsurgery serves as a well-established option for managing calcified canals in cases where traditional root canal treatment proves ineffective, offering a direct course to the root apex.[26]

2. **Root End Preparation Without Root Canal Treatment**

   According to Schindler & Gullickson,[27] when it's impossible to locate a canal and perform endodontic treatment satisfactorily, periapical surgery or root-end resection with retrograde filling becomes essential. The steps involved in managing the root end are as follows: assessing the need for resection and filling, performing resection, preparing the root-end surface, conditioning the root-end and filling the root end. In modern endodontic surgery, typically 3 mm of the root end is resected, and the resection is positioned at 90 degrees to the tooth's long axis. This method aims to improve disinfection, decrease exposure of dentinal tubules, reduce the potential for micro-leakage, and preserve the surrounding tooth structure. Achieving precise root-tip resection can be challenging due to factors such as a restricted field of view, awkward perspective and interfering hemorrhage. However, with the introduction of CBCT and static and dynamic navigation, the success rate of surgical endodontics has increased significantly from 44.2-53.5% to 90.5–31.1%.[28] Nowadays, MTA is commonly employed as a root-end filling material during IR procedures and in apical surgery. Research has shown that compared to IRM, Super-EBA, or MTA, amalgam has a lower success rate. Conversely, a prospective clinical study revealed a high success rate for periapical surgery when MTA was used as the root-end filling material.[27]

3. **Intentional Replantation**

   Intentional replantation (IR) involves the controlled extraction of a tooth, followed by extracorporeal endodontic treatment and re-implantation into its original alveolar socket. Majid *et al* [29] suggested that intentional replantation may be contemplated as an alternative to tooth extraction, particularly for single-rooted teeth, when nonsurgical and surgical endodontic treatments are considered impractical.

4. **Guided Endodontic Surgery**
Guided endodontic surgery has shown promising results, with successful utilization of guide templates in resection of root end resulting in better accuracy, increased comfort of the patient, and reduction in surgery time by upto 30%. Endodontic microsurgery employing a guide template has demonstrated enhanced precision compared to freehand procedures. Utilizing the guide template offers several advantages, including precise location of the root apex through predefined drilling holes, minimally invasive preparation, reduced surgical time and bone preparation volume, improved post-operative healing, reduced risk of infection, more predictable results regardless of clinician experience, and potential educational benefits.[30]

CONCLUSION

There is an ongoing debate regarding the optimal timing for endodontic treatment in cases of progressive calcification within the pulp space. Performing a root canal procedure in such circumstances can be challenging for practitioners due to calcific changes, and early detection of canal obliteration through radiographs can help avoid considerable frustration. However, because the occurrence of periapical pathology in these cases is rare, the rationale for early prophylactic intervention may not be compelling. Therefore, if prophylactic intervention is considered, it must be justified. Surgical intervention may become an option if other treatments prove ineffective. Given the complexities involved in managing such cases, teeth exhibiting signs of calcification should be referred to an Endodontist.

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