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Apexification Using MTA in Immature Permanent Anterior Teeth- A New Era in Pediatric Dentistry- Case Series

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Abstract

Apexification is a biologically guided technique aimed at forming mineralized tissue at the apex of an immature, non-vital permanent tooth, overcoming the challenge posed by its open apex. Historically, calcium hydroxide was the material of choice, but its prolonged treatment time—often requiring 6 to 24 months or more—and its association with increased risk of cervical root fracture led clinicians to seek better alternatives. Mineral Trioxide Aggregate (MTA) emerged as a superior option due to its biocompatibility, excellent sealing properties, and capacity to stimulate periapical healing and hard-tissue formation. Numerous clinical studies and systematic reviews have confirmed MTA’s efficacy and predictability, noting significantly faster apical barrier formation and lower fracture risk compared to calcium hydroxide. In this case series, adolescent patients with necrotic immature anterior teeth underwent apexification following a comprehensive disinfection protocol using triple antibiotic paste and sequential irrigation with sodium hypochlorite, chlorhexidine, and saline. A 4 mm MTA apical plug was placed—one case included a resorbable collagen barrier and use of the MAP system to maintain moisture control before MTA placement. Subsequent canal obturation was performed with bioceramic sealers to ensure a hermetic seal. Over follow-up, all cases showed complete resolution of periapical pathology, absence of clinical symptoms, and

successful apical closure radiographically. These outcomes reaffirm MTA's clear advantages over calcium hydroxide—namely, reduced treatment duration, superior sealing, and enhanced structural integrity of the root. Thus, MTA apexification represents a predictable, efficient, and biologically favorable treatment for managing immature necrotic permanent teeth in pediatric dentistry, fully aligned with evidence-based practice.

Keywords: Apexification, Immature permanent tooth, Mineral Trioxide Aggregate, MAP system

Introduction

Apexification is a way to treat young permanent teeth whose roots have stopped growing and developing because the pulp has died. Its goal is to make the root end close without the canal wall getting thicker or the root getting longer. The completion of root development and closure of the apex occurs up to 3 years after eruption of the tooth[5]. The primary focus of apexification procedures is mineralised tissue formation, the continued elongation of the unformed root apex remains a potential benefit.[7]

According to the American Association of Endodontics (2012), apexification is defined as "a method that induces calcified barrier formation at the root tip of a permanent tooth with an open apex and necrotic pulp".[6]

Historically, techniques for management of the open apex in non-vital teeth were confined to custom fitting the filling material, paste fills and apical surgery. The limited success enjoyed by these procedures resulted in significant interest in the phenomenon of continued apical development or establishment of an apical barrier, first proposed in the 1960s.[5]

Dental trauma is common in young children and is the most frequent cause of pulpal non-vitality in immature permanent incisors. Treating teeth compromised by infection or trauma prior to full root development presents significant challenges.[2]The etiology of the open apex are as follows: Pulp necrosis can occur due to caries or trauma, orthodontic teeth have caused extensive apical resorption, periapical pathosis or trauma, over instrumentation (iatrogenic), thermal injuries, chemical injuries, and others such as dens in dente and dentin dysplasia, exhibit similar symptom.[1]

Most common tooth involved is maxillary central incisor accounting for 78% traumatic dental injuries in children with mean age of 8 years.[16] The highest levels of treatment were carried out at age 15 years, of which only 27% had their damaged incisors treated.[8] Injuries to the anterior teeth, particularly the upper central or lateral incisors, are quite common, affecting almost 16%-17% of the population.[1]

Mineral Trioxide Aggregate (MTA) has emerged as the material of choice for apexification. Mineral trioxide aggregate (MTA) first received Food and Drug Administration of the USA (FDA) approval in 1998. It was later used in achieving an apical barrier in non-vital immature teeth.[8] MTA is a powder that consists of fine hydrophilic particles that set in the presence of moisture. Hydration of the powder results in a colloidal gel with a pH of 12.5 that solidifies to a hard structure. MTA is available as grey or white and is made mainly of tricalcium silicate, dicalcium silicate, tricalcium aluminate, calcium sulphate dehydrate and bismuth oxide. It possesses several advantageous properties including biocompatibility, antibacterial activity and the prevention of bacterial leakage, the absence of cytotoxicity and the ability to trigger the release of cytokines from bone cells in order to promote the formation of hard tissues. Additionally, it offers a more predictable time for apical closure and a shorter treatment period than calcium hydroxide.[8]

Hence, this case series includes application of MTA for apexification in immature permanent anterior teeth using various methods and assessing its positive outcomes clinically and radiographically.

Case Series

Case 1

A 14-year-old male patient reported to the Department of Pediatric and Preventive Dentistry with the chief complaint of pain and swelling in relation to the maxillary right central incisor (11) for the past 2 days. The dental history revealed a traumatic injury to the same tooth one year back. Patient was diagnosed with Ellis class IV fracture in relation to 11. Radiographic examination revealed pulp necrosis and apical pathology in the apical third of the canal in relation to 11. In the first visit, endodontic access cavity was prepared and working length was determined using a no. 15 K-file under rubber dam isolation. The root canal system was cleaned using irrigation with 1.5% sodium hypochlorite (20 mL) and saline irrigation (40 mL) with 27 G double-sided vented needles 3 mm above the working length. Final irrigation was performed using 2% chlorhexidine gluconate (5 mL). The canal was subsequently dried with F2 paper points and triple antibiotic paste was placed as intracanal medicament for 2 weeks.

In the second visit, clinical and radiographic evaluation was done. Intracanal medicament was cleaned using normal saline. Copious irrigation was done using 1.5% sodium hypochlorite to ensure removal of all the debris from the canal, followed by final irrigation of 17% EDTA (20 mL, 5 min), after which the canals were dried using paper points. An apical plug of 3 mm was established using Mineral Trioxide Aggregate (MTA) and obturation was carried out using a bioceramic root canal sealer (SAFE ENDO) and gutta percha. Post-endodontic restoration was done using composite. The patient is advised for follow up every 1, 3 and 6 months.

Figure 1: Pre-clinical picture

Figure 2: Pre-Clinical

Figure 3: Irrigation done

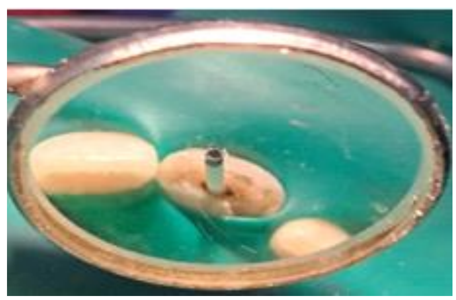

Figure 4: Drying with Paper point

Figure 5: Hand plugger inserted

Figure 6: MTA plug inserted (4mm)

Figure 7: Obturation done

Figure 8: One month follow

Case 2

A 16-year-old male patient reported to the Department of Pediatric and Preventive Dentistry with a chief complaint of pain and discomfort in relation to the maxillary left lateral incisor (22). The dental history revealed a traumatic incident involving the same tooth approximately 1.5 years ago. An initial attempt of regenerative endodontic therapy (revascularization) was undertaken one year prior at private practice. Radiographic examination showed a previously initiated endodontic treatment in tooth 22. Re-entry into the pulp chamber was performed and the previously placed Biodentine was removed using a No. 1 Gates-Glidden drill and stainless-steel H-file up to size 50K. Canal disinfection was carried out using a triple antibiotic paste placed for two weeks, following copious irrigation with 2% chlorhexidine gluconate and normal saline. The root canal system was then dried with sterile absorbent paper points. To manage the apical third, a resorbable collagen plug was introduced using a plugger to absorb residual moisture and provide a scaffold. An apical barrier of approximately 4 mm in thickness was created using Mineral Trioxide Aggregate (MTA), which was precisely delivered with the MAP (Micro-Apical Placement) system. Final obturation was completed using a calcium silicate-based Bioceramic sealer (SAFE ENDO) to ensure effective sealing of the canal. Post-endodontic restoration was done using composite. The patient is advised for follow up every 1, 3 and 6 months.

Figure 1: Pre-operative radiograph

Figure 2: Biodentine removed using no. 1 GG drill and 50 H-file

Figure 3: Working length determined,

Figure 4: MAP system,

Figure 5: Collagen plug is placed,

Figure 6: MTA plug upto 4mm placed using MAP system,

Figure 7: Apical plug upto 4mm,

Figure 8: Obturation done,

Figure 9: Follow up of 2 weeks.

Case 3

A 16-year-old patient reported to the Department of Pediatric and Preventive Dentistry with a chief complaint of pain and discomfort in maxillary left central incisor (21) persisting for the past 6–7 days. The dental history revealed a traumatic injury to the same tooth approximately four years ago. At that time, endodontic treatment was initiated but remained incomplete due to the patient's failure to return for further treatment. Patient reported after four years with complaint of pain and discomfort. Upon re-evaluation, clinical and radiographic assessment revealed signs of pulpal necrosis and apical pathosis, along with hard tissue calcification in the apical third of the canal. Endodontic access cavity was re-established and working length was determined using a size 35 Hedstrom file. Radiographic examination confirmed apical calcification. To achieve canal disinfection, a triple antibiotic paste (TAP) was placed as an intracanal medicament for two weeks. Irrigation was performed using 2% chlorhexidine gluconate and normal saline, followed by 17% liquid ethylenediaminetetraacetic acid (EDTA) to remove the smear layer. The canal was subsequently dried with F2 paper points and Obturation was completed with a bioceramic root canal sealer, ensuring a proper seal and closure of the canal system. Post-endodontic restoration was done using composite. The patient is advised for follow up every 1, 3 and 6 months.

Figure 1: Pre-operative radiograph

Figure 2: Working length determined,

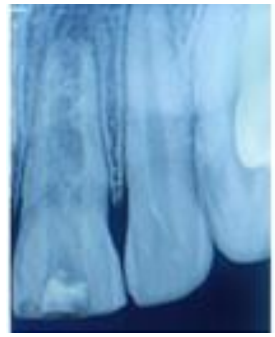

Figure 3: TAP placed,

Figure 4: Obturation done,

Figure 5: One week follow up,

Figure 6: One month follow up

Case 4

A 12-year-old male patient reported to department of Pediatric and Preventive Dentistry with chief complaint of pain in upper front tooth region since two days. The dental history reveled traumatic injury while playing six months back. Clinical examination showed Ellis class IV fracture irt 21 and radiographic examination showed immature apex with apical diameter >1mm (CVEK stage IV). Treatment planned for this case was MTA apexification followed by disinfection using intracanal medicament.

In the first visit, endodontic access cavity was prepared and working length was determined using a no. 15 K-file under rubber dam isolation (29mm). The root canal system was cleaned using irrigation with 1.5% sodium hypochlorite (20 mL) and saline irrigation (40 mL) with 27 G double-sided vented needles 3 mm above the working length. Final irrigation was performed using 2% chlorhexidine gluconate (5 mL). The canal was subsequently dried with F2 paper points and triple antibiotic paste (TAP) was placed as intracanal medicament for 4 weeks until apical barrier is formed.

Every four weeks intracanal medicament was cleaned using normal saline and final irrigation was done using 2% chlorhexidine gluconate (5 mL). The canal was dried using paper points and TAP is placed using lentulospiral, to ensure even placement of medicament and sealed with temporary restorative material (CAVIT).

After the interval of 7 months, calcified apical barrier was formed which was confirmed clinically and radiographically. Following cleaning of root canal system using normal saline and 17% EDTA (20ml for 5 mins), 3mm of MTA apical plug was created using hand plugger. Obturation was done using bioceramic root canal sealer (SAFE ENDO) and gutta percha. Post-endodontic restoration was done using composite. The patient is advised for follow up every 1, 3 and 6 months.

Figure 1: Pre-operative clinical photograph

Figure 2: Pre-operative radiograph

Figure 3: Irrigation

Figure 4: canal dried with paper point

Figure 5: TAP placed using lentulospiral

Figure 6: Access cavity sealed using cavit

Figure 7: 7 months follow up radiograph,

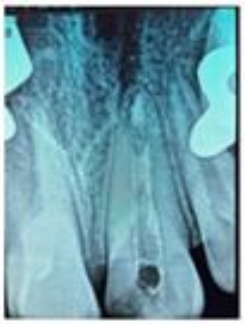

Figure 8: MTA apical plug created (3mm),

Figure 9: Obturation using Bioceramic sealer,

Figure 10: Post- operative photograph.

Discussion

This case series aims to provide evidence supporting the efficacy of MTA-based apexification in the management of traumatic immature permanent anterior teeth.

The primary objective of apexification is to ensure the formation of a hard-calcific barrier that can assist in obturation. Other objectives include thickening of root dentin and increase in the root length. The material of choice should fulfil the above requirements and also maintain an antibacterial environment for faster healing.[5]

The 3 important criteria for the success of apexification are:

1. Irrigation
2. Disinfection of canal
3. 3D apical seal

Irrigation Protocol for Apexification

In our case report, 3% NaOCl, 2% Chlorhexidiene gluconate, 17% EDTA and Normal saline is used.

5.25% sodium hypochlorite for 1 min is been suggested by recent guidelines according to American Academy of Endodontics (2025). In contrast, a study by Mohmmed et al revealed that the Enterococcus faecalis biofilm could not be effectively removed by irrigation with 5.25% sodium hypochlorite for 1 min. But, the investigation conducted by Martin et al revealed that the dentinal walls were less affected by 1.5% sodium hypochlorite irrigation than by 6% sodium hypochlorite irrigation.[1]

Three-dimensional canal cleaning has been demonstrated to be possible through the application of a 17% EDTA solution and internal heating of 5.25% sodium hypochlorite with ultrasonic activation. Hence, The sequence of irrigation to be followed in apexification procedure is use of 5.25% NaOCl, Normal Saline and 17% EDTA as a last irrigant.[1]

Use of Intracanal Medicament

In all the three cases discussed here, we have used TAP (Triple Antibiotic Paste) in ratio 1:1:1(ciprofloxacin, metronidazole, and minocycline) to achieve the disinfection which is similarly seen in the case report published by Sachin Chauhan et al (2025). The reason to use TAP instead of calcium hydroxide is that it uses a mix of several antibacterial medications to disinfect oral infectious lesions, such as dentinal, pulpal, and peri radicular lesions. Since most of the bacteria in the infected root canal dentin are obligate anaerobes, metronidazole was initially prescribed as an antibacterial medication of choice. TAP has demonstrated significant success in reducing the number of bacteria in the infected root canal system and is effective in eliminating Enterococcus faecalis colonies even at low concentrations (e.g., 1 mg/mL, 0.1 mg/mL, and 0.01 mg/mL) with minimal impact on stem cell viability.[1]Additionally, TAP has shown effective result in increase in root length and achieving apical barrier in our cases.

However, TAP also posseses disadvantage of tooth discoloration along with its prolonged use, as shown in case 4. The reason of tooth discoloration is presence of minocycline in triple antibiotic paste, that leaches out into the dentinal tubules and imparts blackish discoloration to the crown.[1]

Previously, Calcium hydroxide was used as intracanal medicament due to its highly alkaline pH, but it can cause desiccation of dentinal proteins thereby leading to the weakening of the tooth structure (Tunnelling effect) and predisposing teeth with immature apex to fracture. Hence now-a-days, CaOH2 is not been used as intracanal medicament.[8]

MAP System – A precision tool in apexification

One of the case in our case series demonstrate the use of MAP system for better placement of MTA. In teeth with open apices, achieving and apical stop is challenging. The use of Micro Apical Placement (MAP) System in the process of MTA apexification facilitates precise and controlled intracanal placement of MTA into the canal and ensures that it stays within the apical region. It delivers MTA incrementally and directly to the apex without contamination or material displacement.[3]

The MAP System offers accurate, reproducible, and non-traumatic placement of the apical plug (usually 4-5 mm thick). The advantages of MAP are precision, efficiency, conservation, versatility and improves seal.[16]

Various other techniques used for apical placement of MTA includes manual compaction with paper points, Buchanan hand pluggers, amalgam carrier, MTA carrier, modified cannula, etc with the thickness ranging from 3 to 4 mm.[3, 18]

Use of Resorbable Collagen Matrix

One of our cases, also favours the use of resorbable collagen matrix prior to the placement of MTA plug. In accordance to this, Songtrakul et al. (2020) proposed a modified apexification procedure, in which a 3 mm-thick MTA/Biodentine barrier is placed inside the canal over a collagen matrix, which will be eventually resorbed and leave an apical canal space unfilled for continued root development. The use of a resorbable collagen matrix also helps to hold the material during its application inside the root canal space, which allows for apical deposition of mineralized tissue and consequent biological barrier formation, usually with cellular cement following apical healing events.[3]

MTA vs Other Materials for Apexification

Our case series shows that MTA putty is a material of choice as it gives favourable results clinically and radiographically. Similar results were demonstrated in a meta-analysis carried out by Shaik et al., (2021), comparing Bioceramic root repair material (BCRRM), mineral trioxide aggregate (MTA), and calcium hydroxide, among which bioceramic and MTA success rates, were 93.3% and 90%, respectively. The better sealing ability, biocompatibility and the handling properties of MTA could be the possible results for it being the material of choice in apexification procedure.[2]

Currently, a wide range of bioactive materials have been used, including mineral trioxide aggregate (MTA) putty, EndoCem, Biodentine, EndoSequence, OrthoMTA, MTA Plus, and mineral tricalcium phosphate (MTA)[1]

In the contrary, systematic review (2022) by Vignesh Ravindran et al assessed efficacy for the management of open apex case scenarios which showed that biodentine performed better. The reason explained was that the silicate ingredients in the powder content sets faster with the liquid content containing calcium chloride thereby setting in 10 minutes. Change in opacifier, that is, zirconium oxide reduces discoloration and improves handling properties.[5]

The extra coronal restoration is recommended following apexification procedure that includes composite build up, post and core followed by esthetic crown or temporary acrylic crown in case of fixed orthodontic appliance therapy.

Limitations

The limitations of this case series include the requirement for an extended clinical and radiographic follow-up period, which is currently in progress to evaluate the long-term success and stability of the treatment. Additionally, the use of CBCT and magnification could have provided more precise diagnostic and procedural accuracy, enhancing the overall assessment and management.

Conclusion

Root development continues for about three years after eruption, but trauma or disease can interrupt this, leaving an open apex. Traditional calcium hydroxide apexification requires multiple visits, often reducing patient compliance. One-visit apexification with MTA and bioceramic sealer offers a faster, more reliable alternative by forming an immediate apical barrier. In this report, all cases were treated with MTA putty, which provided excellent sealing and ease of handling, making it especially beneficial in pediatric cases requiring apical barrier formation.

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