Preservation of a Non-Vital Immature Maxillary Central Incisor Using MTA Apexification: Case Report with Long-Term Follow-Up

Case Report

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Abstract: ***Traumatic dental injuries in children commonly involve maxillary central incisors and may lead to pulpal necrosis in immature permanent teeth with open apices. Management of such teeth is challenging due to thin dentinal walls and the lack of an apical constriction. Apexification aims to create an apical barrier to enable proper obturation. Although calcium hydroxide has been traditionally used, it requires prolonged treatment and may increase the risk of root fracture. Mineral trioxide aggregate (MTA) offers a predictable alternative, allowing single-visit apexification with superior sealing ability. This case report presents the management of a 10-year-old girl with a chronic periapical abscess associated with an immature maxillary central incisor. After infection control, canal debridement, and interim calcium hydroxide dressing, an MTA apical barrier was placed, followed by obturation with gutta-percha and bioceramic sealer and composite restoration. At The two-year follow-up, periapical healing was observed. This case supports the clinical effectiveness of MTA apexification for long-term preservation of non-vital immature teeth.***

Keywords: Apexification; Mineral trioxide aggregate; Pulp necrosis; Immature permanent tooth; Chronic periapical abscess

1. Introduction

Traumatic dental injuries frequently occur during childhood and adolescence and predominantly affect the maxillary central incisors (1). Such injuries often lead to pulpal necrosis, resulting in the cessation of root development and the formation of teeth with open apices, commonly referred to as immature teeth (2). The management of non-vital immature permanent teeth presents a significant clinical challenge due to their unfavourable crown–root ratio, thin dentinal walls, and the lack of an apical constriction against which root filling materials can be condensed (3, 4). Consequently, these teeth are highly susceptible to fracture, and conventional root canal instrumentation and obturation are technically demanding. Historically, treatment strategies have focused on the creation of an apical barrier to facilitate root canal obturation and prevent extrusion of filling materials into periapical tissues. Apexification, defined as "a method to induce a calcified barrier in a root with an open apex or the continued apical development of an incomplete root in teeth with necrotic pulp" (5), has been the most widely adopted approach. Calcium hydroxide ($Ca(OH)_2$) has long been used for this purpose because of its high pH and antimicrobial properties (9, 10). Although $Ca(OH)_2$ apexification has demonstrated predictable and reliable clinical outcomes, it is associated with several disadvantages, including prolonged and unpredictable treatment duration, the need for multiple visits, challenges with patient compliance, risk of reinfection due to temporary restoration failure, and an increased susceptibility of the tooth to cervical root fracture (6, 7, 11, 12). The frequency of such fractures has been shown to correlate with the stage of root development (4), and this weakening effect has been attributed to the hygroscopic and proteolytic properties of $Ca(OH)_2$, which may alter the organic matrix of dentin and reduce the modulus of elasticity of the root dentinal walls (4, 6, 12, 13).

The introduction of mineral trioxide aggregate (MTA) over the past decade has provided an alternative approach by enabling the placement of an artificial apical plug, allowing immediate obturation of the root canal system (6). Single-visit apexification using MTA offers several advantages over $Ca(OH)_2$, including reduced treatment time and improved apical sealing ability (14–16). Owing to its favourable physical, chemical, and biological properties, MTA has been widely recommended as an alternative material for apexification of immature teeth (17). Bonte et al. (17) reported that MTA apexification was superior to $Ca(OH)_2$ in achieving earlier coronoradicular filling and in limiting the risk of root fracture. Nevertheless, MTA remains relatively expensive and does not promote further root lengthening or thickening of dentinal walls. Moreover, in vitro studies have demonstrated that MTA may exert a weakening effect on dentin comparable to that of calcium hydroxide (18).

More recently, a paradigm shift has occurred with the emergence of regenerative endodontic therapy (RET) as a treatment option for immature teeth with necrotic pulps. Evidence from uncontrolled longitudinal studies and randomised controlled trials (RCTs) suggests that RET can support continued root development by harnessing stem cells from the apical tissues, allowing repopulation of the root canal space with vital tissue and ongoing deposition of hard tissue (19). Despite promising outcomes, regenerative procedures may not always be feasible or successful, and in such cases apexification remains a necessary alternative (8).

Various materials and techniques have been proposed for apical barrier formation; however, MTA has gained widespread acceptance for one-visit apexification because of its biocompatibility, antibacterial properties, regenerative potential, and superior sealing ability (20-24). Although numerous studies have evaluated the clinical success of MTA in the treatment of immature teeth, the optimal thickness of an MTA apical plug remains controversial. Therefore, further investigation is required to determine the effect of different

MTA plug thicknesses on the fracture resistance of immature teeth (20, 22, 23).

The aim of this case report is to demonstrate the clinical management of a non-vital immature maxillary central incisor using a structured apexification protocol with mineral trioxide aggregate (MTA), highlighting infection control, apical barrier formation, and long-term preservation of tooth function and aesthetics in a growing patient.

2. Clinical case

A 10-year-old girl was referred by her general dentist for evaluation due to the presence of a sinus tract associated with the apical region of the maxillary right central incisor. At presentation, her height and weight fell within the normal range for her age, and she was otherwise healthy, with no reported systemic conditions. Three years earlier, her dentist had recommended an orthodontic consultation to assess the need for treatment. During the clinical examination, tooth 11 was in the process of eruption. The more prominent cingulum was identified as a persistent root of a deciduous incisor, and extraction was initiated. During luxation, a fragment of the tooth fractured, and the extraction procedure was discontinued. The patient exhibited additional occlusal trauma due to a deep bite and a pronounced contact at the prominent cingulum. About three years post-trauma, the patient began experiencing intraoral and extraoral swelling, persistent sharp pain, and difficulty in eating. Following consultation with her general dentist, a 10-day course of systemic antibiotic therapy with amoxicillin/clavulanic acid (Augmentin, Bulgaria) was prescribed; no intervention was performed on the affected tooth. The symptoms resolved after completion of the antibiotic regimen. Subsequent paraclinical investigations included panoramic radiography and three-dimensional computed tomography (CBCT) (Fig. 1).

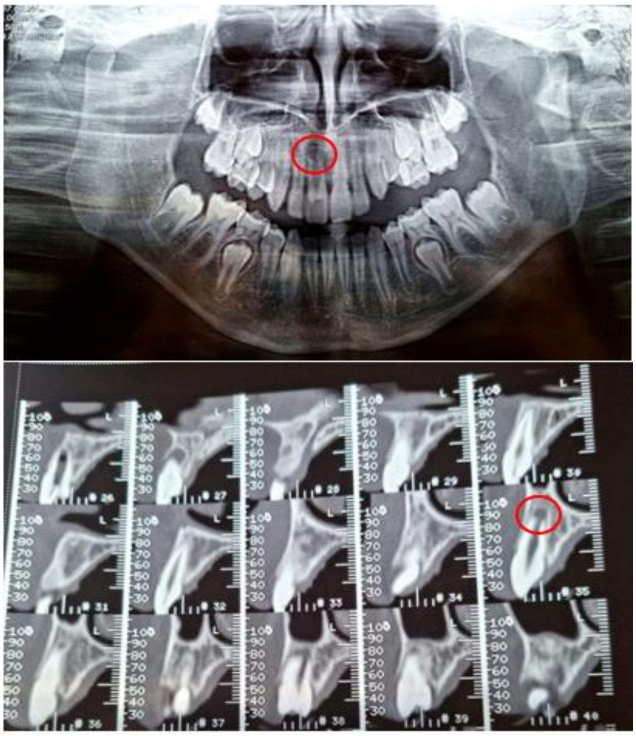

Figure 1: Panoramic radiograph and three-dimensional computed tomography (CBCT).

Paraclinical examination revealed an enlarged periapical space associated with tooth 11, which was notably different from the contralateral tooth 21. The tooth demonstrated incomplete root development, lacking apical constriction, and exhibited an open apex. One month following the completion of systemic therapy, the patient reported the appearance of a small vesicle in the apical region of tooth 11.

On clinical examination, tooth 11 appeared discolored and elicited mild pain upon vertical percussion. A sinus tract was observed in the apical projection area, maxillary, to the right of the labial frenulum (Fig. 2). Electric pulp testing (EPT) revealed no response. Based on these findings, a diagnosis of chronic periapical abscess (Abscessus periapicalis chronica) was established, and apexification was chosen as the treatment approach.

Figure 2: Intraoral clinical status.

The tooth was isolated using a rubber dam, and an endodontic cavity was prepared. Necrotic tissue, a small amount of exudate, and a fetid odor were observed. The canal was mechanically instrumented with a K-file #40 and irrigated to remove necrotic tissue using 2.5% NaOCl, 17% EDTA, and saline solution. An Indextol dressing was placed to manage the infection, followed by a sterile cotton pellet and temporary restoration. The fistulous tract was irrigated with hydrogen peroxide, saline solution, and iodine.

After seven days, the same mechanical and chemical preparation of the canal was performed. No exudate was observed, although an unpleasant odor remained. The fistulous tract in the apical region was no longer present, and the patient reported a reduced response to vertical percussion. A non-setting calcium hydroxide paste (Calcipaste, Cerkamed, Poland) was applied. A follow-up radiograph was scheduled for six weeks (Fig. 3).

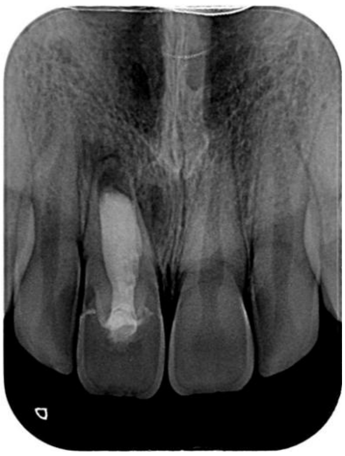

Figure 3: Follow-up radiograph

Follow-up imaging revealed the formation of an apical constriction at the level of the newly developed thin root walls, with evidence of resolution of periapical inflammation and initial regeneration of periapical structures.

Twelve weeks later, the patient returned for review, reporting no subjective complaints. After isolation with a rubber dam and provision of endodontic access, no exudate or odor was observed. Hard tissue formation at the apex was confirmed with a K-file #40. Mechanical instrumentation of the root canal was intentionally minimized to preserve the remaining tooth structure. Irrigation was performed following the established protocol using 2.5% NaOCl, 17% EDTA, and saline solution. Ultrasonic activation of the irrigants was employed to enhance biofilm disruption without excessive dentin removal.

A mineral trioxide aggregate (MTA) apical barrier (ProRoot™, Dentsply Maillefer) was placed using an MTA placement gun (Dentsply Maillefer), followed by a moist cotton pellet and temporary restoration. After formation of the MTA apical barrier, the root canal was obturated with gutta-percha and a bioceramic sealer (AH Plus Bioceramic Sealer; Dentsply Sirona, Germany) in accordance with the manufacturer's instructions. The tooth was then restored with a composite restoration (GC Essentia; GC Europe, Europe). Periodic follow-up examinations demonstrated resolution of the apical lesion, closure of the apical foramen at the level of the newly formed root walls, and normal periodontal tissue formation (Fig. 4).

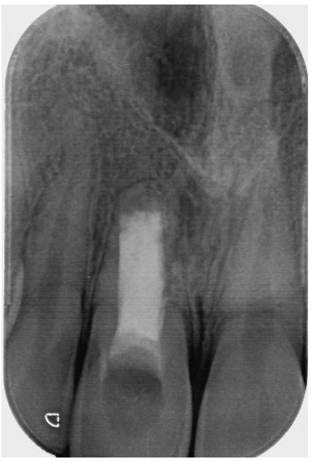

Figure 4: Follow-up radiograph two years after completion of treatment

Informed consent was obtained from the patient's legal guardian for all clinical procedures and for the publication of this case report.

3. Discussion

The management of traumatised immature teeth remains clinically demanding, even in cases initially presenting with apparently minor hard tissue injuries. The primary therapeutic objective in such situations is the preservation of pulp vitality in order to allow continued root development and maturation (25). The long-term prognosis of these teeth is closely related to biological events occurring within the pulp tissue, including the potential development of pulp necrosis, calcific changes caused by tertiary dentin deposition, or resorptive processes. The choice of treatment therefore depends largely on the extent of damage to the pulpo-dentinal complex and the pulp's ability to respond to injury.

In cases of uncomplicated crown fractures involving dentin exposure, immediate sealing of the dentinal wound is considered the treatment of choice to prevent bacterial ingress through open dentinal tubules. This may be achieved by direct dentin bonding and restoration or by the application of hard-setting calcium hydroxide followed by definitive restoration to protect the pulp tissue. Despite these preventive measures, pulp necrosis may still develop following trauma. Ravn et al. (26) reported an incidence of pulp necrosis of 8% when calcium hydroxide was placed over dentin close to the pulp chamber, compared with 54% when no protective base was used. Similar studies demonstrated pulp necrosis rates of approximately 7% following uncomplicated crown fractures with dentin exposure, with immature teeth exhibiting a more favourable prognosis due to superior pulpal vascularisation compared with teeth with complete root development (16).

The development of pulp necrosis may be attributed to bacterial invasion or diffusion of bacterial toxins through exposed dentinal tubules, either prior to placement of the composite restoration or as a consequence of microleakage (26). Alternatively, a pulp exposure caused directly by the traumatic event may have remained undetected during the emergency visit. In situations where pulp exposure is evident, hard-setting calcium hydroxide or mineral trioxide aggregate (MTA) are recommended for direct pulp capping or partial and full pulpotomies. Recent evidence supports the use of MTA because of its biocompatibility, superior sealing ability, and capacity to set in a moist environment (28). Direct pulp capping is generally limited to small exposures of less than 24 hours' duration in teeth with healthy, non-inflamed pulp tissue (29). When bleeding control cannot be achieved, partial pulpotomy is indicated, with the extent of tissue removal depending on exposure size and duration. Reported success rates for direct pulp capping, partial pulpotomy, and total pulpotomy range from 72% to 96% (29). In addition to bacterial factors, disruption of the neurovascular supply following a concussion or concomitant luxation injury may compromise pulpal immune response and healing capacity. Robertson et al. (27) identified impaired pulpal blood circulation after crown fractures associated with luxation as a major determinant of pulpal healing. Immature teeth that initially show a negative responses to vitality testing may recover after at least 36 days. The subsequent development of tooth discoloration, persistent negative cold response, and the presence of a fistula tract after three months were considered definitive signs of pulp necrosis (30). Tooth discoloration following trauma is a well-documented phenomenon (31, 32). Grey discoloration is typically associated with pulp necrosis (33, 34) and is attributed to the formation of black ferric sulphide following the reaction of iron released during haemolysis with bacterially produced hydrogen sulphide (35). If a dislocation injury had damaged the root cementum, the combination of infection and compromised root surface integrity could have predisposed the tooth to external root resorption, which is frequently reported in immature teeth with thin root canal walls (36).

Once pulp necrosis has occurred, conventional root canal treatment is indicated to eliminate infection and prevent apical periodontitis. As apexogenesis is no longer possible in necrotic immature teeth, treatment options include calcium hydroxide apexification (37), single-visit apexification using an MTA apical plug, or regenerative procedures such as pulp revascularisation (19, 38). Long-term calcium hydroxide therapy can induce the formation of an apical hard tissue barrier (40), with reported success rates between 90% and 95% (41, 42). However, the prolonged treatment duration, requirement for multiple visits, and increased risk of root fracture associated with thin dentinal walls represent significant disadvantages (4, 6).

MTA is preferred over gutta-percha and sealer-based or resin-based filling materials to minimise the risk of irritation to periapical tissues, particularly in the presence of porosities within the newly formed mineralized barrier. In addition to excellent biocompatibility, MTA exhibits osteoinductive properties and promotes the formation of cementum-like hard tissue (43). In vitro studies have demonstrated that MTA induces cytokine release from osteoblasts, supporting its role in hard tissue formation (44). Although long-term clinical data remain limited, several studies support the use of MTA for the management of immature roots (45, 46). The nature of the hard tissue formed remains speculative without histological analysis; however, a composite mineralized tissue comprising osteocementum, osteodentin, cementum, atubular dentin, or bone is plausible. The involvement of pluripotent mesenchymal stem cells or progenitor cells originating from Hertwig's epithelial root sheath or residual apical pulp tissue may explain both hard tissue barrier formation and continued root development (47).

4. Conclusion

This case highlights the complexity of trauma-related endodontic treatment and underscores the critical role of timely intervention, continuous monitoring, and patient compliance. Early recognition of changes in pulp vitality and periapical status is essential to enable effective treatment. When appropriate protocols are applied, the high regenerative potential of pulpal and periapical tissues in growing patients, combined with contemporary materials such as MTA, allows for the preservation of teeth that might otherwise be considered hopeless. Periodic follow-up confirmed periapical healing and functional stability, maintaining natural occlusion, aesthetics, and phonetics at an age when implant therapy is contraindicated due to ongoing craniofacial growth.

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