Endodontic management of nonvital permanent teeth having immature roots with one step apexification, using mineral trioxide aggregate apical plug and autogenous platelet-rich fibrin membrane as an internal matrix: Case series

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Abstract

A tooth with blunderbuss canal and open apex can be an endodontic challenge because of difficulty in obtaining an apical seal, and existing thin radicular walls which are susceptible to fracture. To overcome the limitations of traditional long-term calcium hydroxide apexification procedures, nonsurgical one step apexification using an array of materials such as mineral trioxide aggregate (MTA) has been suggested. However, adequate compaction of MTA in teeth with wide open apices can be an arduous task, and an internal matrix is required for controlled placement of MTA against which obturating material can be condensed. Platelet-rich fibrin (PRF), a second generation platelet concentrate containing several growth factors that promotes hard and soft-tissue healing, has been used as an internal matrix to create an apical plug of MTA and hence prevent extrusion of filling materials. This case series presents the endodontic management of immature permanent teeth with open apices using internal matrix of autologous PRF membrane and one step apical barrier placement of MTA.

Keywords: Apexification, blunderbuss canal, immature pulpless tooth, matrix, mineral trioxide aggregate, open apex, platelet-rich fibrin

Introduction

An immature permanent tooth having blunderbuss canal and open apex can be an endodontic challenge because of difficulty in obtaining an apical seal, and existing thin radicular walls which are susceptible to fracture.[1] Long-term application of calcium hydroxide ($Ca(OH)_2$) has traditionally been used for inducing apexification in immature permanent teeth with open apices, pulpal necrosis, and periradicular diseases. Unfortunately, use of $Ca(OH)_2$ for apexification procedures has several shortcomings such as prolonged treatment time spanning over several months, lack of patient motivation, risk of reinfection due to loss of intermediate coronal restoration, "Swiss cheese" porous callus bridge formation, aesthetic problems, inability to promote continued root development and thickness of lateral dentinal walls, and a high pH which promotes necrotic and degenerative changes in the apical tissue in contact.[2,3] To overcome all such shortcomings, the concept of "one step apexification" with materials such as mineral trioxide aggregate (MTA) was introduced.

One step apexification is defined as nonsurgical compaction of a biocompatible material into the apical end of the root canal to establish an apical stop that would enable the root canal to be immediately filled.[4] MTA has a remarkable capacity to induce hard-tissue formation and periradicular healing; however, the material may still get extruded into periapex in teeth with wide apices preventing its adequate compaction. Hence, an apical matrix is needed for controlled compaction of MTA similar to the "modified matrix concept" where perforation repair was performed using resorbable collagen as a matrix before placement of MTA.[5] Several biocompatible materials such as dentin chips, bovine true ceramics, tricalcium phosphate, collagen-calcium phosphate, bone growth factors, and oxidized cellulose have been used to create an apical matrix. Platelet-rich fibrin (PRF), a second generation platelet concentrate, first described by Choukran and associates in France has shown to have

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several benefits when used to form an apical matrix. With this material, the quest for an ideal template, which is autogenous, resorbable, promotes healing, has lesser allergic potential and provides a stable matrix against which an apical barrier is formed can be met. The authors are presenting a series of teeth with immature roots having necrosed pulp and apical pathosis which were successfully managed using one step apexification procedure utilizing MTA and PRF for apical barrier formation.

Case Reports

Case 1

A 26-year-old male reported to the Department of Conservative Dentistry and Endodontics with the complaint of discolored upper front teeth. The patient reported that his upper front teeth were traumatized when he suffered a fall at the age of 8 years. Clinical examination revealed discoloration in maxillary right and left central incisors. Radiographic examination showed immature right and left maxillary central incisors with open apices and periapical radiolucency [Figure 1a]. Upon clinical testing, the upper central and lateral incisors were nontender on percussion and nonresponsive to pulp vitality tests. Rubber dam was applied, and endodontic access cavities were prepared in the teeth. Working length was determined using both radiographs and electronic apex locator (Root ZX, J Morita MFQ Corp., Kyoto, Japan). The debridement of canals was done by light instrumentation with K-files (Mani, Japan) followed by copious irrigation with 1.25% sodium hypochlorite (Septodont Healthcare India Pvt., Ltd., Mumbai) and normal saline to flush out the necrotic pulp tissue. Sterile paper points were used to dry the canals, and $Ca(OH)_2$ paste was applied as an intracanal medicament. The access cavities were temporized with provisional restorative material IRM (Caulk Dentsply, Milford, DE, USA). The patient was recalled after 2 weeks.

After a 2-week period of disinfection, the patient was asymptomatic. The teeth were reaccessed, and the canals flushed off of $Ca(OH)_2$ paste by irrigation with 1.25% sodium hypochlorite and 17% liquid EDTA Smear Clear (SybronEndo, CA, USA). The canals were then dried with sterile paper points. It was decided to perform single step apexification with MTA in both central incisors with open apices. To facilitate accurate placement of MTA as an apical barrier, it was decided to use PRF membrane as an internal matrix.

PRF membrane was prepared following the procedure as described by Dohan *et al.* 30 min before the clinical procedure.[6] A volume of 8.5 ml of whole blood was drawn by venipuncture of the antecubital vein. Blood was collected in a 10 ml sterile glass tube without anticoagulant and immediately centrifuged at 3000 revolutions/min (rpm) for 10 min. The final product consisted of three layers (from top to bottom): acellular platelet poor plasma at the top, PRF clot in the middle, and red blood cells at the bottom. The PRF clot was retrieved, and fluids were squeezed out to obtain a PRF membrane [Figure 1b].

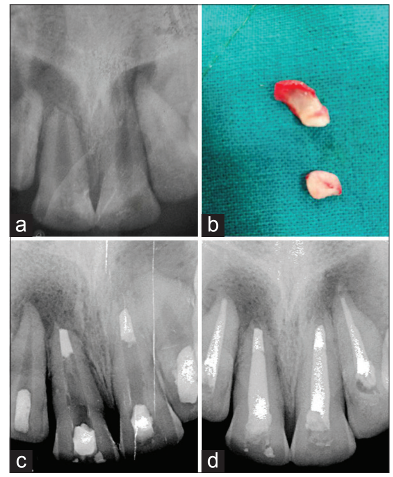

Figure 1: (a) Preoperative radiograph showing periapical radiolucency and immature roots in teeth number 11, 21. (b) Platelet-rich fibrin membrane. (c) Mineral trioxide aggregate apical stops formed against a barrier of platelet-rich fibrin membrane and (d) Postoperative intraoral periapical radiograph showing healing

The PRF membrane was gently packed using hand pluggers to produce an internal matrix at the level of the apex. White ProRoot MTA (Maillefer, Dentsply, Switzerland) was then mixed with normal saline according to the manufacturer's instructions and compacted using MAP system intro kit NiTi (Dentsply Maillefer, Switzerland) and Schilders pluggers (Dentsply Caulk, Milford, DE, USA) against the PRF membrane.

Apical stops of approximately 3–4 mm thickness of MTA were formed and confirmed radiographically [Figure 1c]. A large paper point was moistened with water and left in the canal to promote setting. A moistened cotton pellet was then placed in the chamber, and the access cavity was sealed with provisional restorative IRM (Caulk Dentsply, Milford, DE, USA).

After 1 week, the patient remained asymptomatic, and teeth were isolated and reaccessed as before. The hardened set of MTA plugs was confirmed by gentle tapping of a hand plugger. Central incisors were obturated using injectable thermoplasticized Gutta-percha (Calamus Dual, Dentsply Maillefer, Ballaigues, USA) whereas lateral incisors were obturated using lateral condensation technique. Postendodontic restorations were done with resin composite. Follow-up radiograph at 6 months interval showed good healing at the apex [Figure 1d].

Case 2

A 16-year-old male patient reported with the complaint of pain in upper front teeth. The patient reported that he had suffered a fall 6 years previously resulting in trauma to maxillary anterior teeth. Clinical examination revealed Ellis class II fracture in teeth number 11 and 22, as well as discoloration with respect to tooth number 21. Both 21 and 22 were tender on percussion. Radiographic examination showed inadequately obturated tooth number 21 and open apex with enlarged canal space and reduced dentinal wall thickness in tooth number 22. A periapical radiolucency of about 1.5 cm × 1.5 cm was also seen in relation to this tooth [Figure 2a]. Pulp vitality tests revealed that tooth number 22 was nonvital. Endodontic treatment was initiated in tooth number 22 under local anesthesia and rubber dam isolation. Working length was determined using both radiographs and electronic apex locator.

$Ca(OH)_2$ disinfection, irrigation protocol, formation of MTA apical plug with PRF as an internal matrix and obturation with injectable thermoplasticized Gutta-percha were similar to as described in case 1. Retreatment was performed in tooth number 21 whereas tooth number 11 was restored with resin composite. Periapical radiograph at 12 months revealed reduction in radiolucent area at the apical region [Figure 2b].

Case 3

A 29-year-old male patient reported with pain and recurrent pus discharge in the upper front teeth region. Maxillary left central incisor was tender on percussion and nonresponsive to pulp vitality tests. Intraoral periapical radiographic examination showed periapical radiolucency measuring approximately 10 mm × 8 mm and an open apex in tooth number 21 [Figure 3a]. Root canal treatment was initiated under local anesthesia and rubber dam isolation. Working length was determined using both radiographs and electronic apex locator. Further treatment instituted was similar to as described in case 1 except that the entire canal was filled with MTA.

Figure 2: (a) Preoperative radiograph showing inadequately obturated tooth number 21, and open apex with enlarged canal space and reduced dentinal wall thickness in tooth number 22 and (b) Postoperative radiograph at 12 months showing complete healing

1-year follow-up showed no recurrence of symptoms, formation of calcific apical barrier and healing of periapical radiolucency [Figure 3b].

Discussion

$Ca(OH)_2$ has been the material of choice for apexification procedures for many years and has shown success rates of up to 90%. However, achievement of complete apical seal in teeth with open apices with its use is still debatable due to the formation of porous callus bridge with "Swiss cheese" appearance. The apical barrier formation can take long time and is dependent on the size of the lesion and patient's age.[7] Long-term $Ca(OH)_2$ application may also alter the mechanical properties of dentin leading to increased risk of root fracture after treatment. Conversely, short-term use of $Ca(OH)_2$ followed by MTA apical plug formation may improve long-term prognosis in apexification procedures.

MTA was developed by Torabinejad *et al*. and introduced to the dental field in 1993.[8] When compared to $Ca(OH)_2$, MTA offers lesser leakage, better marginal adaptation and has antibacterial action with a shorter setting time. Being a bioactive material, it has the ability to promote hard tissue formation increasing thickness of the lateral dentinal walls and thus increasing fracture resistance of fragile roots. One of the major problems associated with teeth with open apices is the possible extrusion of the obturating material into the periapex initiating an inflammatory response which prevents healing and leads to possible failure of therapy. Therefore, for successful treatment, extrusion of MTA into periradicular space must be avoided.

A variety of synthetic and autogenous materials such as calcium sulfate, resorbable collagen, hydroxyapatite, dentin chips and collagen membranes have been tried as an internal matrix.[6] Autogenous materials are usually preferred over synthetic materials as there is minimal possibility of allergic

Figure 3: (a) Preoperative radiograph of tooth number 21 showing periapical radiolucency and immature apex in tooth number 21 and (b) postoperative radiograph at 1-year showing formation of calcific apical barrier and resolution of radiolucency

reactions with them, and they aid in wound healing, unlike their synthetic counterparts.

PRF is an autologous, biocompatible, immune fibrin biomaterial which has all the properties required for optimal wound healing.[9] It permits rapid angiogenesis, quicker remodeling of fibrin network, stimulates osteoblasts, fibroblasts, periodontal ligament cells and also activates stem cells from the dental pulp and periodontal ligament.[10] All this owes to the release of several growth factors such as platelet-derived growth factor, transforming growth factor-beta, vascular endothelial growth factor, and platelet-derived growth factor from PRF for up to several weeks that assists in wound healing. It also offers no pressure – resistant support which is necessary for the application of freshly mixed MTA.

It can be concluded that combination of PRF as a matrix and MTA as an apical barrier is a good option for creating artificial root-end barrier. However, controlled clinical trials are necessary to investigate the predictability of the outcome of this technique.

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Conflicts of interest

There are no conflicts of interest.

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