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CASE STUDY

REVASCULARIZATION OF IMMATURE PERMANENT TEETH WITH PERIAPICAL LESION: TWO CASE REPORTS

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ABSTRACT

Pulpal necrosis of an immature tooth caused by caries or trauma may lead to potential complications. Regenerative endodontic procedures are biologically based procedures which deals with the regeneration of pulp like tissue, more idealistically the pulp-dentin complex. These case reports describe the treatment of immature permanent teeth with periapical lesion which were treated with regenerative approach. The root canal was gently debrided of necrotic tissue and irrigated with 2.5% NaOCl, and then medicated with triple antibiotic paste. When the tooth was asymptomatic, bleeding was induced into the canal; blood clot was allowed to form and mineral trioxide aggregate (MTA) was placed over the clot. After 3, 6, 9 and 12 months, radiographical examination revealed resolution of the radiolucency and progressive thickening of the root wall and apical closure. Proper disinfection and use of a suitable scaffold and proper coronal seal led to successful outcome of revascularization in the patients.

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INTRODUCTION

Regenerative endodontic procedures are biologically based procedures which deal with the regeneration of pulp like tissue, more idealistically the pulp-dentin complex (Murray *et al.,* 2007). Though the tooth is necrotic, some pulp tissue can survive apically which can proliferate to aid in the process of regeneration under favorable conditions (Banchs and Trope 2004, Ritter *et al*., 2004, Trope 2010). Thus, uninfected necrotic pulp may serve as a scaffold for in growth of new tissue (Kakehashi *et al.,* 1965). Pulpal necrosis of an immature tooth caused by caries or trauma may lead to potential complications. Instrumentation of immature canal spaces with conventional endodontic techniques poses difficulty (Thibodeau and Trope, 2007).The traditional treatment of immature teeth with necrotic pulps and apical periodontitis involves $Ca(OH)_2$ (calcium hydroxide) induced apexification with long-term application of $Ca(OH)_2$. But long-term $Ca(OH)_2$ treatment may weaken the tooth making it more susceptible to fracture, emphasizing the need for an improved treatment modality (Andreasen *et al.,* 2002). Windley *et al*. (2005) stated that revascularization of immature teeth with apical periodontitis depends mainly on:

(a) disinfection of the canal; (b) placement of a matrix in the canal for tissue in-growth; and (c) a bacterial tight seal of the access opening. Since infection of the root canal system is considered to be polymicrobial, a combination of metronidazole, ciprofloxacin and minocycline is recommended by Hoshino *et al*. for disinfection of the canal (Hoshino *et al.,* 1996, Reynolds *et al.,* 2009). Use of this antibiotic combination has been supported by Banchs and Trope (2004). Sato *et al*. (1993) found that a combination of ciprofloxacin, metronidazole, and cefaclor was equally effective. Iwaya *et al*. (2001) used combination of two antibiotics metronidazole and ciprofloxacin. Several studies have identified the Hoshino combination of antibiotics as biocompatible (Gomes-Filho *et al.,* 2012), effective and widely used (Hoshino *et al.,* 1996, Banchs and Trope 2004, Reynolds *et al.,* 2009, Nosrat *et al.,* 2011).

Though a disinfected canal is a prerequisite for tissue regeneration, tissue will not grow into an empty space (Torneck, 1966, Torneck, 1967). Rather, a scaffold is essential to aid the in growth of new tissue into the canal space. Induction of a blood clot from the periapical tissues may serve as a scaffold. The blood clot consists of cross-linked fibrin. It serves as a pathway for the migration of cells including macrophages and fibroblasts from the periapical area. The cells of blood clot contain many growth and differentiation factors

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which are important in the wound healing process (Freymiller and Aghaloo, 2004, Harrison and Jurosky 2001a, Harrison and Jurosky 2001b, Maeda *et al.,* 2004, Marx, 2004). According to previous literature (Ostby, 1961, Iwaya *et al*., 2001, Banchs and Trope, 2004, Ritter *et al*., 2004, Murray *et al*., 2007, Trope 2010), number of cases have been reported which were treated with revascularization procedure. This indicates that revascularization therapy has been a well-established treatment modality for treatment of immature permanent teeth with necrotic pulp but still it is not used widely and readily by Pedodontists. The present cases are reported to highlight and emphasize a novel regenerative endodontic therapy of immature teeth with necrotic pulp.

Case Report 1

A 13-year-old girl reported to the Department of Pedodontics and Preventive Dentistry, AME's Dental College and Hospital, Raichur for restoration of a fractured maxillary right central incisor (Figure 1). The dental history disclosed that the patient had suffered dental trauma nearly 4 years back, sustaining a complicated crown fracture of her permanent maxillary right central incisor. Medical history was noncontributory. On thorough clinical examination, the tooth did not respond to palpation and percussion. Further investigations for pulp vitality, the tooth did not respond to cold testing with CO_2 ice and electric pulp testing versus adjacent and contra lateral teeth whereas probing pocket depths were within normal limits. An intraoral periapical radiograph showed open apex of right maxillary central incisor and a diffuse apical radiolucency. Correlating the history, clinical and radiographic findings, the tooth was diagnosed with chronic periapical abscess. (Figure 2)

Figure 1. Preoperative clinical photograph

Keeping in mind the developing state of tooth (apical diameter=1.15mm i.e. 1mm), it was planned to be treated with revascularization therapy. Patient and parents were informed regarding treatment procedure in detail and informed consent was gained. Patient's bleeding and clotting time was evaluated and found within normal limits. On the day of treatment, access was made to the pulp chamber under local anesthesia and rubber dam isolation where a necrotic pulp was confirmed clinically also. The canal was not instrumented in the normal manner, but instead was irrigated copiously with 2.5% sodium hypochlorite (NaOCl) and dried with sterile paper points. A creamy paste of equal proportions of ciprofloxacin (Ciprodac, Cadila), metronidazole (Flagyl, Abott HC) and minocycline (Minolox, Micro Labs, Gratia) mixed with propylene glycol was delivered into the canal using the blunt ends of sterile paper points till cement enamel junction (CEJ) which was verified clinically.

Figure 2. Preoperative radiograph showing periapical lesion irt 11

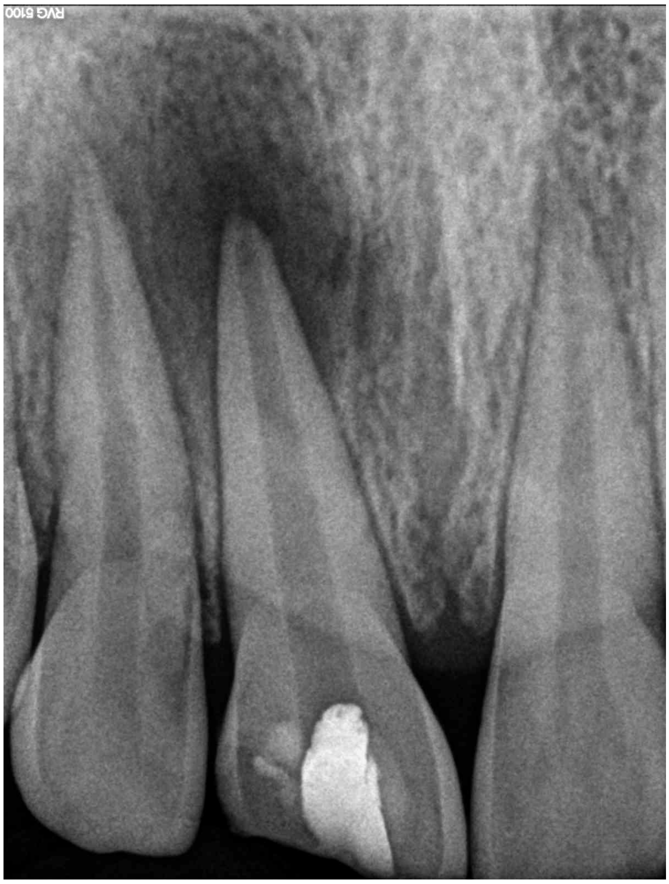

Figure 3. MTA placed over blood clot

Access cavity was closed with temporary restorative material (Zinc oxide eugenol cement). No oral medications were given. Instructions were given for maintenance of oral hygiene and patient was recalled after 4 weeks. After 4 weeks, on evaluation, patient was asymptomatic with no fresh complaints. The tooth was assessed clinically which showed no signs of pathology and showed radiographic evidence of healing of periapical lesion with considerable decrease in size of periapical radiolucency. Under local anesthesia (without adrenaline) and rubber dam isolation, access to the pulp chamber was regained. The antibiotic paste was irrigated away with copious and gentle saline irrigation. Bleeding into the canal space was induced by over-instrumenting beyond the apex with sterile endodontic#15 K-file. Approximately 15 minutes were allowed for the blood clot to reach a level that approximated the cementoenameljunction. The clot was verified clinically. Mineral trioxide aggregate, MTA (MTA Angelus) was mixed with sterile water and applied over the blood clot (Figure 3). The access was sealed with Glass Ionomer Cement followed by composite restoration. Patient was periodically recalled at 3rd, 6th, 9th, 12th months for clinical and radiographic evaluation. At the 3rdmonth follow-up evaluation, the patient was asymptomatic. Maxillary right central incisor was within normal limits regarding percussion, palpation and pocket probing depths when compared with adjacent and contralateral teeth. Radiographic examination indicated healing of periapical lesion with decrease in size of radiolucency and continued increase in root length (Figure 4).The tooth remained nonresponsive to CO_2 ice. At subsequent recall appointments at 6th and 9th month, patient showed no sign of clinical or radiographic pathology. At 12th month recall, tooth responded positively to CO_2 ice though it was nonresponsive to heat and electric pulp tests. Radiographic evaluation disclosed significant reduction in size of periapical radiolucency and fully developed root of maxillary right central incisor. (Figure 5)

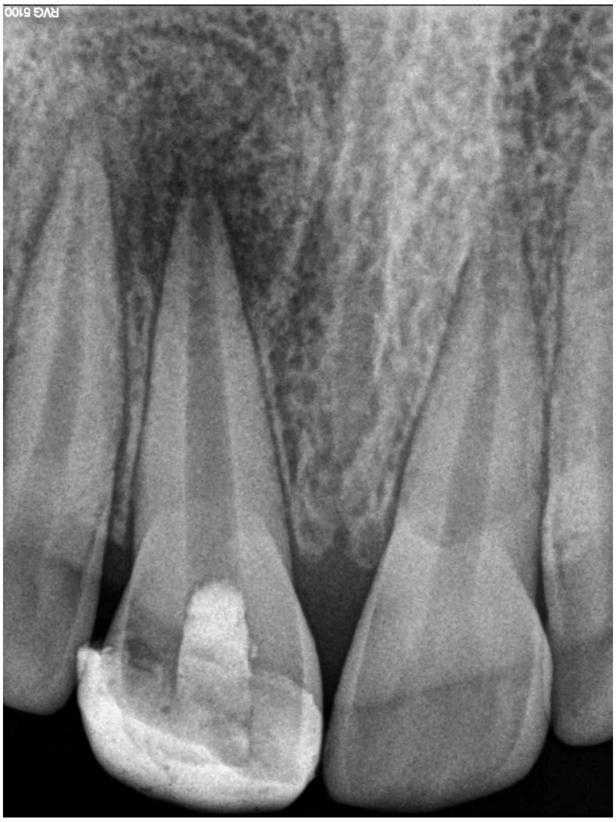

Figure 4. Follow up at 3rd month

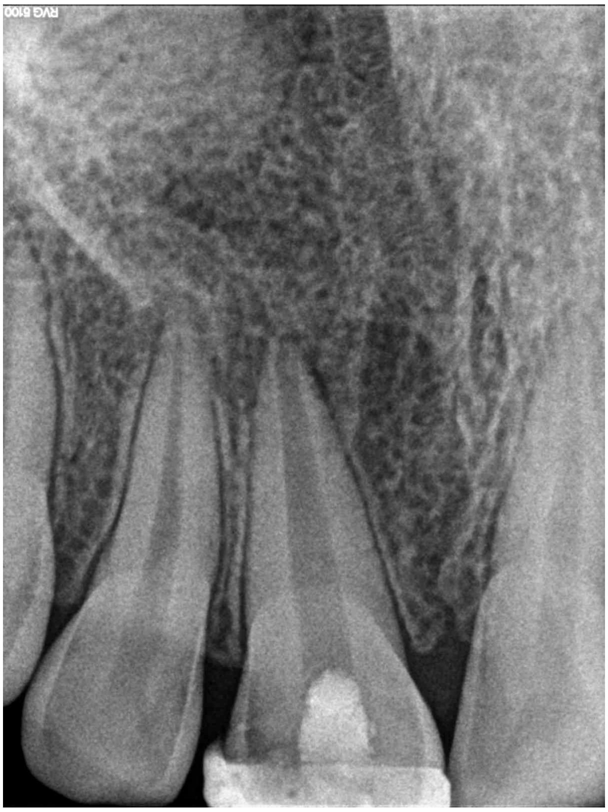

Figure 5. Follow up at 12th month shoeing significant reduction in size of periapical lesion and apical closure

Case Report 2

A 10‑year‑old boy reported to the Department of Pedodontics and Preventive Dentistry, AME's Dental College and Hospital, Raichur with a complaint of fractured maxillary central incisors. The patient's mother gave the history of accidental fall while playing 1 month ago. The medical history was non‑contributory. Clinical examination of teeth revealed Ellis class III fracture and slight brownish discoloration of right maxillary central incisor and class II fracture of left maxillary central incisor (Figure 6). Left maxillary central incisor responded within normal limits to palpation, percussion and pulp vitality tests whereas right maxillary central incisor did not respond to any of pulp vitality tests including thermal and electric test but was sensitive to percussion. The periodontal examination of all teeth showed probing depths within normal limits. An intraoral radiograph was taken which showed an immature root with widened periodontal ligament space and open apex in relation to right maxillary central incisor (Figure 7). Patient's bleeding and clotting time was evaluated to be within normal range.

Figure 6. Preoperative clinical photograph

Figure 7. Preoperative radiograph showing periapical lesion irt 11

Correlating clinical and radiographic findings, it was diagnosed as Ellis class 3 fracture in relation to right maxillary central incisor with apical periodontitis and Ellis class 2 fracture in relation to left maxillary central incisor. Decision was made to carry out revascularization among various treatment options in right maxillary central incisor considering developmental status of tooth and adhesive composite restoration in left maxillary central incisor. Treatment was explained to parents and informed consent was obtained. Same treatment protocol was followed as above case. On second visit, after 4 weeks, both teeth were asymptomatic with no clinical complaints and showed no sensitivity to percussion and palpation. Access was regained after isolation and the triple antibiotic mixture was washed out with copious and gentle saline irrigation. Canal was dried with paper points and bleeding was induced by over instrumentation of the canal beyond the apex with sterile #15 K-file allowing clot to form till the level of cement-enamel junction and assessed clinically. MTA (MTA Angelus) was placed directly over the clot and tooth was temporarily restored (Figure 8). After 72 hours, permanent restoration of both teeth right and left maxillary central incisors was done with composite. The patient was followed‑up at 3rd and 6th months for clinical and radiographic re‑evaluation. At 3rd and 6th months recall, teeth were asymptomatic with no clinical complaints and were not sensitive to percussion or palpation tests. Pulp tests with cold and Electric Pulp Tester elicited a negative response in tooth whereas left maxillary central incisor responded within normal limits. Radiographic examination showed resolution of the periapical lesion and further root development in right maxillary central incisor. Complete apical closure was evident radiographically at 12th month recall with no radiographic signs of pathology (Figure 9). The tooth remained asymptomatic with normal responses to percussion, palpation and CO_2 but no response to electric pulp test. Periodontal probing depths and mobility were within normal limits.

Figure 8. MTA placed over blood clot

Figure 9. Follow up at 12th month shoeing significant reduction in size of periapical lesion and apical closure

DISCUSSION

Nygard Ostby (1961), a pioneer of regenerative endodontic procedures in the early 1960s, showed that new vascularized tissue could be induced in the apical third of the root canal of endodontically treated mature teeth with necrotic pulps and apical lesions. In 2001, Iwaya *et al*. described a procedure, which they termed revascularization, which was undertaken on a necrotic immature mandibular second premolar with a chronic apical abscess. Subsequent to this case report, Banchs and Trope (2004) described a revascularization procedure for the treatment of a necrotic immature mandibular second premolar with an open apex and a large apical lesion. This procedure was supported by Murray *et al*. (2007), who also added that the procedure was technically simple, inexpensive, and adapted to currently available instruments and medicaments. Furthermore, if the revascularization fails, other more traditional treatment options remain available (Thibodeau and Trope, 2007). Other modalities for treatment of immature permanent nonvital tooth include MTA apexification and $Ca(OH)_2$ apexification. Jeeruphan *et al*. (2012) found that the percentage changes in root width and length were significantly greater in the revascularization group when compared with the MTA apexification group and $Ca(OH)_2$ apexification group. Moreover, the survival rate of teeth in the revascularization group was also greater.

When an apexification procedure is attempted, the root canal is filled with a non-setting formulation of calcium hydroxide and the material is changed every 3–6 months until a hard tissue barrier forms at the apex. There is no room for vital tissue to proliferate as the pulp canal space is physically occupied by the material; in addition, $Ca(OH)_2$might not provide a favorable environment for proliferation of cells. Hence, apexification would not lead to continued root formation or thickening of the root canal wall, leading to the risk of an undesirable side effect of a short and weakened root that is susceptible to fracture (Cvek, 1992). An alternative treatment regime of revascularization is preferred to overcome these problems. According to Kling, an apical opening greater than 1 mm mesiodistally resulted in successful revascularization of avulsed permanent teeth, while teeth with a smaller apical opening showed no evidence of revascularization (Kling *et al.,* 1986). Therefore revascularization was opted for present cases as treatment of choice. Calcium hydroxide has been traditionally used as anintracanal dressing in the treatment of immature teeth but its role in revascularization is being debated (Hargreaves *et al*., 2013). Its high pH is believed to reduce the viability and regenerative capacity of the apical vital cells (Spångberg, 1968).

Use of triple antibiotic paste consisting of ciprofloxacin, metronidazole, and minocycline was proposed by Hoshino *et al*. (1996) for improved disinfection in cases of revascularization. An empty canal space would not support the in growth of new tissue from the periapical area (Petrino *et al*., 2010, Nosrat *et al*., 2011). Cell growth, differentiation, migration and adhesion need a matrix to provide a physiochemical and biological microenvironment. A successful revascularization procedure is associated with an intracanal sterile tissue matrix in which undifferentiated mesenchymal cells can proliferate and differentiate under the organizing influence of Hertwig's epithelial root sheath to ultimately reestablish the pulp vitality. The apical pulp tissue remnants (Heithersay, 1970, Cvek *et al*., 1990), the periodontal ligament (Nevins *et al*., 1977, Lieberman, 1983), the apical papilla, or bone marrow (Krebsbach, 1997, Gronthos *et al*., 2000) can provide these cells. One of the recommended protocols for revascularization includes induction of blood clot as a scaffold in the canal space. Several studies have reported on revascularization using blood clot as a matrix (Petrino *et al*., 2010, Nosrat *et al*., 2011). Considering these points in mind triple antibiotic paste was used for disinfection and revascularization was done by providing blood clot as matrix in present cases. MTA was preferred in most of the studies in which revascularization procedures were attempted due to its sealing ability and biocompatibility (Banchs and Trope, 2004, Rudagi and Rudagi, 2012). In the present cases, MTA was placed into the root canal above the clot to obtain tight coronal seal as it is hydrophilic and needs moisture to set. In addition, MTA provides signaling molecules for the growth of the stem cells (Rudagi and Rudagi, 2012). Lastly, the coronal seal consisted of a glass-ionomer base followed by a bonded resin material, which apparently provided a bacteria-tight seal.

Conclusion

In the present cases, proper disinfection, induction of intentional tissue inflammation and use of a suitable scaffold (blood clot) and proper coronal seal led to successful outcome. Revascularization protocols offered a favorable result for resolving the infection and promoting root development in the management of infected immature permanent teeth. Particularly in children this procedure proves to be promising in terms of time, patient compliance, materials required and ultimately overall cost of the treatment.

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