Dental Pulp Revascularization of Necrotic Permanent Teeth with Immature Apices

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Objectives: The treatment of immature necrotic teeth with apical periodontitis presents challenges in endodontic and pediatric dentistry. Revascularization is a recent treatment for such cases as an alternative to conventional apexification. The purpose is to examine the effect of a pulpal revascularization procedure on immature necrotic teeth with apical periodontitis. Study design: Twenty patients were enrolled for pulp revascularization procedure by root canal disinfection using a triple antibiotic mixture for 1–2 weeks, followed by creating a blood clot, sealing the root canal orifice using white mineral trioxide aggregate and a coronal seal of composite resin. Patients were recalled periodically for up to 24 months. Results: During follow-up, all patients were asymptomatic. Three cases of chronic apical periodontitis showed clinical disappearance of the sinus tract 2 weeks after treatment. Radiography revealed progressive periapical radiolucency resolution within the first 12 months. Within 12–24 months, the treated teeth showed progressive increases in dentinal wall thickness, root length and continued root development.

Conclusions: Clinical and radiographic evidence showed successful revascularization treatments of immature necrotic permanent teeth with apical periodontitis. More studies are necessary to understand the underlying mechanisms and to perform histopathology of the pulp space contents after revascularization procedures.

Key words: Immature, necrosis, permanent teeth, revascularization

INTRODUCTION

Treatment of a young necrotic permanent tooth with an immature open apex associated with apical periodontitis still presents multiple challenges in pediatric and endodontic dentistry. The traditional endodontic treatment using standard chemo-mechanical radicular instrumentation and sodium hypochlorite irrigant has been proven ineffective to achieve proper cleaning and disinfection of the overall dentin wall, particularly at the diverged apex.[1] Furthermore, an inadequate apical seal in such cases is a major problem during a conventional nonsurgical endodontic approach. The presence of thin apical root thickness creates a significant risk of root fracture.[2] The traditional management of such cases is an apexification technique using calcium hydroxide[3] or mineral trioxide aggregate (MTA).[4-7] This technique is successful in inducing apical closure; however, there is no expectation of root lengthening. An innovation in the endodontic field would be the generation of a functional pulp-dentin complex as an alternative technology to replace traditional apexification in an attempt to stimulate further root development and thickening of dentinal walls in a non-vital immature tooth.[8,9] Several studies have recently focused on the potential of revascularization for infected root canals if their environment has been improved with adequate disinfection. Windley et al [10] determined the effectiveness of antibiotic paste in the disinfection of immature dog teeth with apical periodontitis. They suggested that a predictable revascularization of necrotic immature teeth would be expected if 3 challenges can be are met: canal disinfection, placement of a scaffold matrix to permit tissue growth, and a tight coronal seal against bacteria.

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MATERIALS AND METHOD

Twenty patients were selected from among those attending the Pediatric Dentistry clinics of the Dental School at King Abdulaziz University, who had permanent incisor or premolars, according to following inclusion criteria: (1) a tooth associated with necrotic pulp as a result of trauma or carious pulp exposure, with or without signs and/or symptoms of periapical pathology; (2) the tooth has an immature apex, either tubular or blunderbuss; and (3) the crown of the tooth is restorable.

The teeth were evaluated clinically and radiographically to determine the preoperative status regarding the pulp sensitivity test, percussion and palpation sensitivity, tooth mobility, pocket depth, presence and absence of apical periodontitis, and the presence and absence of a sinus tract. An informed consent form was signed by the patients' parents or guardians.

Under local anesthesia, the tooth was isolated with a rubber dam and the access cavity was prepared. A K-file was introduced into the canal to establish a working length.[8, 11] Necrotic tissue was removed from the root canal by irrigating the root canal gently with a minimum of 10 mL 2.5% NaOCl dispensed through a syringe with a 27-gauge needle for 2 min.[2,8,12-15] The needle was introduced into the root canal to a point 2 mm short of the apical foramen[2,11,14,16] and NaOCl was slowly expressed from the syringe to prevent its introduction into the periapical tissues.[17]

The canal was carefully dried with large, sterile paper points. The root canal was then medicated with triple antibiotic dressing paste. The medicament was made by mixing equal doses of 3 antibiotics (250 mg each): metronidazole (Samil Pharm, Seoul, Korea), ciprofloxacin (Sinil Pharm, Seoul, Korea) and minocycline (Aurobindo Pharma USA Inc.), with sterile saline to a creamy paste. The dressing was applied using a lentulo-spiral and tapped down into the canal with the blunt ends of sterile paper points to a depth 2 mm short of the root apex.

The tooth was temporarily restored by placing a sterile cotton pellet over the root canal medicament and then covering the pellet with Cavit cement (3M ESPE, St. Paul, MN,USA). The Cavit was in turn covered with glass ionomer cement that affords the seal greater resistance to occlusal forces and wear during the long intervals that can occur between appointments. The patient was instructed to come for a follow-up visit 2 weeks later.

After 2 weeks, and if the tooth was free of symptoms, under rubber dam isolation and local anesthesia without a vasoconstrictor,[18] the Cavit was removed. The mixture of antibiotics was completely removed with 2.5% NaOCl and sterile saline. The apical tissue was stimulated with a No. 20 K-file to induce bleeding into the pulp canal. Bleeding control was performed at a level 3mm below the cementoenamel junction. A blood clot formed in the canal about 15 min after simulation. Inducing bleeding and establishing a blood clot in the root canal system via over- instrumentation was supplemented by a good coronal seal. MTA (Dentsply Tulsa Dental, Johnson City, TN, USA) was applied over the blood clot, followed by a moist cotton pellet. Cavit was placed temporarily over the cotton pellet. One week later, the Cavit and cotton pellets were removed and the coronal accesses were finally sealed with composite resin (Z250; 3M ESPE, St. Paul, MN, USA).[19]

The patient was instructed to visit at 2 weeks, then at 6, 12, and 24 months for postoperative follow-up.

At each follow-up visit, the patient was assessed clinically as well as radiographically, except at the 6-month visit, where the patient was assessed clinically only, since major radiographic changes were not expected to be seen in such a short period.

The treatment was considered successful according to the following criteria:

Clinical criteria were a lack of signs or symptoms.

Radiographic criteria included evidence of periapical healing (if a periapical lesion was present), increased root length, and increased root canal wall thickness.

RESULTS

This study included 20 patients. Two patients withdrew from the study because of pain experienced after the repeated placement of the antibiotic mixture because of persistent infection and continuous exudation from inflamed periapical tissues. In another patient, no bleeding was observed after the over-instrumentation procedure. These three patients received apexification therapy instead. Another patient dropped out during the follow-up period after receiving a complete course of revascularization treatment.

During the follow-up evaluations, the patients were asymptomatic. At the 6-month follow-up, the teeth were functional, without sensitivity or tenderness to percussion or palpation, and the periodontal examination revealed no pocket depths over 3mm and normal physiological mobility. At the 24 month follow-up, the patients continued to be asymptomatic.

Three of the 16 completely treated cases that were initially presented with chronic apical periodontitis showed clinical disappearance of a sinus tract 2 weeks after starting treatment. Radiographic follow-up revealed a progressive resolution of the periapical radiolucency within 6–12 months. Within 12–24 months, the treated cases showed a progressive increase in dentinal wall thickness with increased root length and continued root development (Figures 1, 2, and 3).

DISCUSSION

Pulp necrosis of an immature tooth resulting from caries or trauma could result in a discontinuation of root development, leading to roots with thin canal walls and open apices.[20] Management of immature necrotic teeth is considered a great challenge to the clinician. Endodontic treatment of thin, fragile blunderbuss canals in non-vital teeth is difficult, as they do not allow for much mechanical instrumentation, and the open apex is difficult or impossible to seal with the conventional methods of lateral condensation or thermo plasticized techniques.[21,22] The traditional treatment for these teeth is apexification using a long-term calcium hydroxide application, which should be changed every 3–6 months until a hard tissue barrier forms at the apex. More recent treatments have used an artificial barrier of MTA. Both of these techniques are followed by a traditional root filling, but do not increase the fracture resistance of the walls, as strengthening or reinforcing of the thin, fragile blunderbuss canals is not achieved.[23-25] Root wall strengthening methods with composite resin have been advocated, but may limit the possibility of root canal retreatment if the need arises in the future.[26] The regeneration of tissues rather than their replacement with artificial substitutes is an emerging and exciting field in the health sciences.[27] A revascularization procedure is an alternative, biologically based treatment that has been introduced for immature teeth with necrotic

Figure 1: (A) Preoperative radiophotographs showed tooth #11 having open apex with periapical radiolucency. (B) Immediate postoperative radiophotograph. (C) 12 month postoperative radiophotograph showing disappearance of periapical radiolucency. (D) At 24 month follow-up, further narrowing of root canal in the apical third and thickening of the lateral walls are evident; normal bony architecture at the periradicular region could be seen.

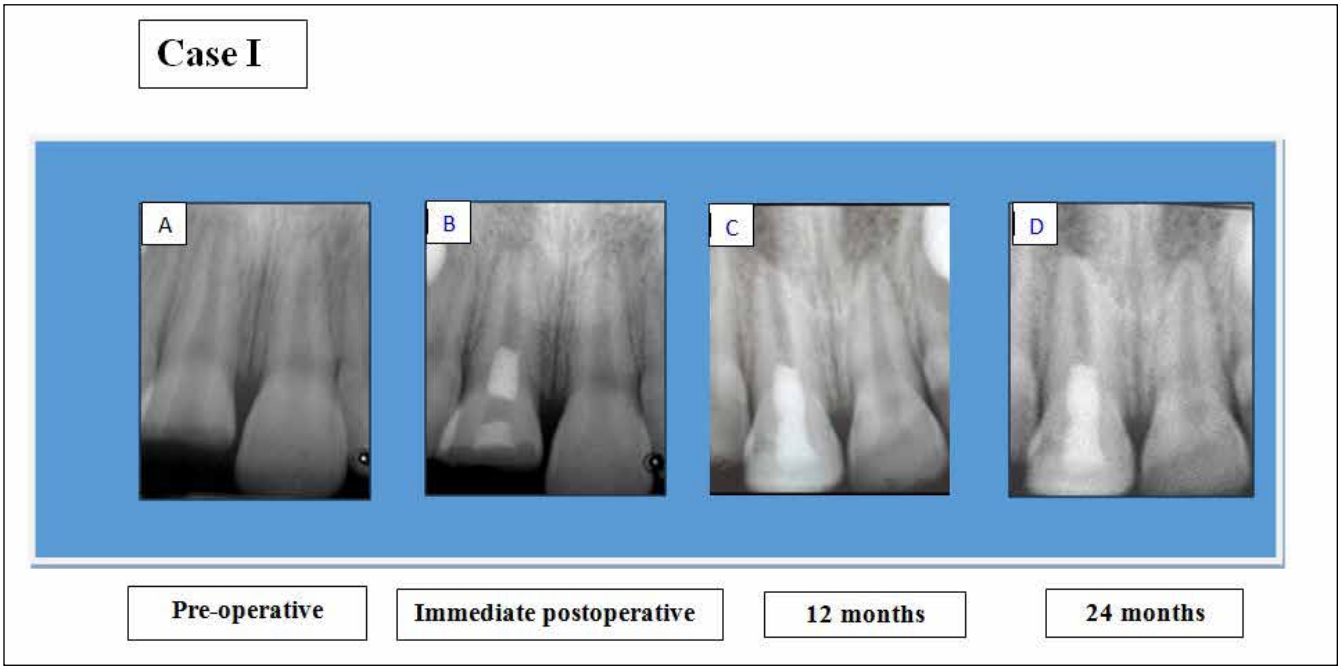


Figure 2: (A) Preoperative radiophotographs showed tooth # 11 having open apex with periapical radiolucency. (B) Immediate postoperative radiophotograph. (C) 12 month postoperative radiophotograph showing disappearance of periapical radiolucency. (D) 24 month follow-up radiophotograph revealing maturation of root with thickening and lengthening of the dentinal walls.

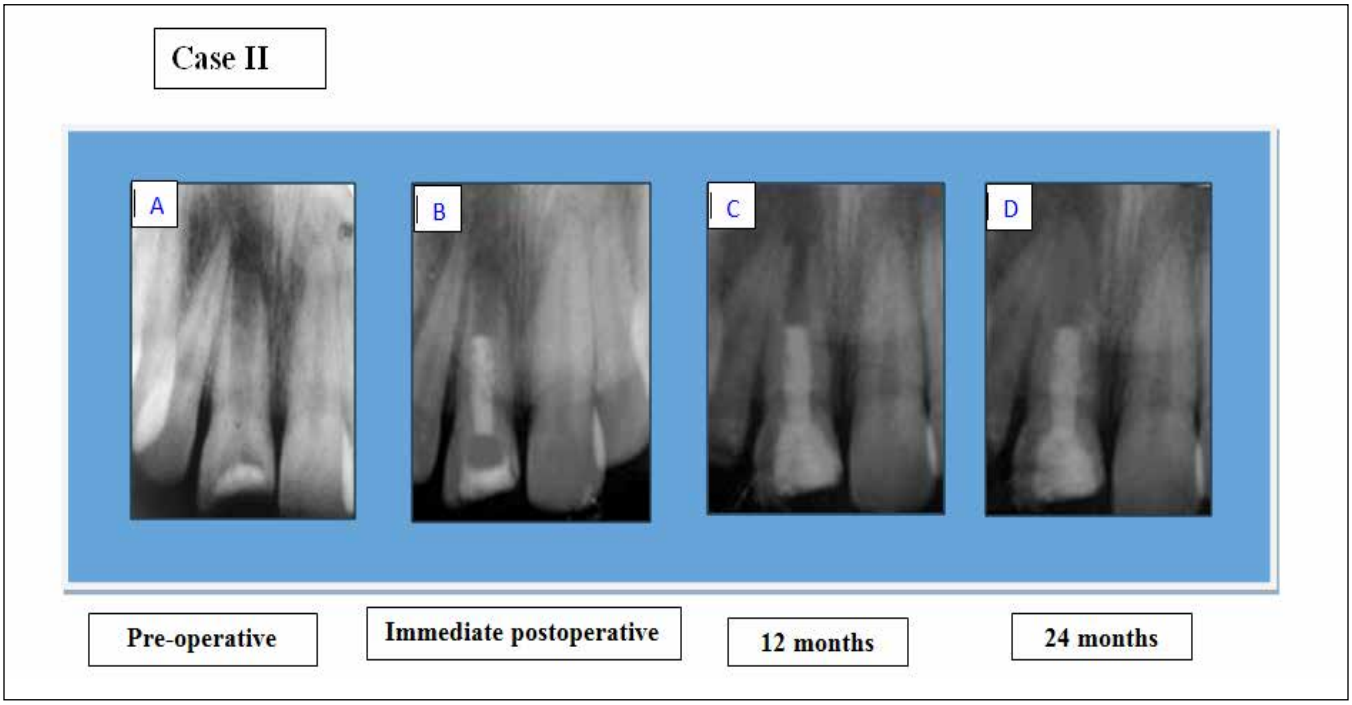
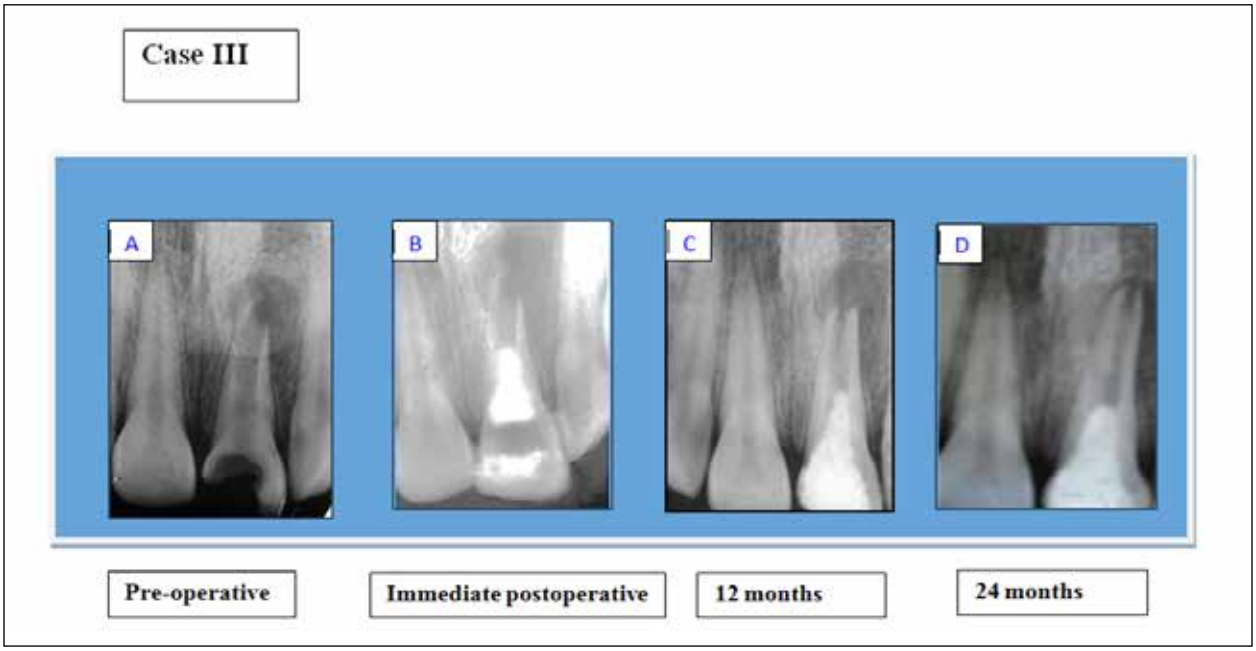


Figure 3: (A) Preoperative radiophotographs showed tooth # 21 having open apex with periapical radiolucency. (B) Immediate postoperative radiophotograph. (C) 12 month postoperative radiophotograph showing elongation of the root and reduction of periapical radiolucency. (D) At 24-month follow-up, further narrowing of root canal in the apical third and thickening of the lateral walls were evident with resolution of the periapical radiolucency



pulp.[28] Revascularization of infected, non-vital, immature teeth has been documented to stimulate regeneration of apical tissues to induce apexogenesis, and is emerging as a new treatment modality for such teeth.[23] The present study evaluated the prognosis of revascularization in necrotic immature teeth with aim of providing reliable evidence for the revascularization technique. This study is one of the few clinical trials applying a revascularization technique for immature necrotic permanent teeth in a large number of patients. A combination of topical antibiotics (metronidazole, ciprofloxacin, and minocycline) was used to disinfect necrotic, infected root canals. Eradication of bacteria from the pulp canal, especially in the deep layers of the root dentin, plays a key role in successful revascularization. This is in agreement with other researchers who stated that a critical step in regenerative therapy is complete disinfection of the root canal space using copious irrigation, minimal instrumentation, and the placement of antibiotic pastes effective in killing common endodontic pathogens in infected root canals, both in vitro and in vivo.[30,31,32]

After the disinfection step and under local anesthesia without a vasoconstrictor,[19] bleeding was induced into the root canals and a blood clot was allowed to form and act as a scaffold, as an an empty tube will not support the growth of tissues from the periapical region. This could be because the bleeding delivers stem cells from the periapical area to the root canal system, and the blood clot in the sterile root canal system creates a scaffold of fibrin that entraps stem cells capable of initiating new tissue development.[21, 33] Other studies state that a blood clot that acts as a scaffold might be a source of growth and differentiation factors that could be important for successful revascularization of the empty pulp canal.[2, 34, 35]

Given the importance of a bacteria-free environment, a coronal seal with MTA was used in this study because this material has been shown to possess excellent sealing ability. It has been shown to prevent coronal bacterial infiltration, is biocompatible with the adjacent pulp tissues, and allows for exceptional marginal adaptation.[12, 24]

All presented cases shown progressive thickening of the dentinal walls, increased root length, and narrowing of the canal space. This could be because the blood clot acts as a matrix onto which vital cells from the peri-apex can be seeded to reestablish pulp vascularity.

Several researchers have tried to explain the mechanism of revascularization. Some have stated that a small amount of vital pulp tissue containing dental pulp stem cells (DPSCs) remains at the apical end of the root canal. These DPSCs retain tissue regeneration potential and can proliferate into the newly formed blood clot matrix, differentiate into odontoblasts, and deposit tertiary or tubular dentin.[37]

Another explanation is the presence of stem cells in the periodontal ligament and bone marrow, when released by over-instrumentation that can proliferate and grow into the apical end and within the root canal, thus depositing hard tissue both at the apical end and on the lateral root walls.[38, 39]

The most plausible explanation for the revascularization mechanism is stem cells residing in the apical papilla of incompletely developed teeth (SCAP). Because of its apical location, the apical papilla has collateral circulation that enables it to survive during the process of pulp necrosis. The step of inducing a blood column triggers a significant accumulation of stem cells into the canal space. Moreover, it contributes to the regeneration of pulpal tissues, and under the influence of surviving epithelial cells from Hertwig's roots heath, can differentiate into primary odontoblasts to continue root formation.[27,40, 41]

The resultant increases in root length and thickness of the canal wall increase the resistance of the tooth against fracture. The

prognosis of a fully formed apex for any root canal treatment that might become necessary in the future as a result of necrosis of the new pulpal tissue would be much better than obturation of an open apex. This is in agreement with several studies concluding that pulp revascularization treatment of immature permanent teeth with apical periodontitis should be preferred to traditional apexification.[25, 42, 44, 45]

CONCLUSION

In the present study, clinical and radiographic evidence demonstrated the successful revascularization treatment of immature necrotic permanent teeth with apical periodontitis. More studies are necessary to understand the underlying mechanisms. A detailed histopathological study is necessary to demonstrate the actual contents of the pulp space after revascularization procedures.

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