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Pulp Revascularization in Three Immature Permanent Mandibular Molars with Necrotic Pulps: A Case Series

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ABSTRACT

The management of necrotic immature permanent teeth, with blunderbuss root anatomy, is a treatment challenge. Treatment protocols include root canal apexification, creation of an apical plug and recently, regeneration and revascularization protocol (RRP). The latter may have the advantage of continued root development. The main purpose of this case series was to describe the RRP of three necrotic immature permanent mandibular molars with open apices. RRP involved accessing the pulp chamber, disinfecting the root canal system with copious irrigation using 2.5% sodium hypochlorite, applying triple antibiotic paste/calcium hydroxide as an intracanal medicament and sealing the access cavity. After three weeks, the medicament was removed and the apex was irritated with a K-file to induce blood-clot formation inside the pulp canal space; which would provide a suitable matrix for new tissue in-growth. Mineral trioxide aggregate was employed to seal the canal orifices before final restoration. During follow-up sessions, patients were asymptomatic and root development seemed to be in progress. Therefore, it seems that with proper case selection, regeneration and revascularization can be considered as a suitable alternative for the apexification of necrotic immature teeth.

Keywords: Dental Pulp Necrosis; Mineral Trioxide Aggregate; Revascularization

Introduction

Endodontic treatment of immature permanent teeth with necrotic pulp, is a challenge for dentists because of the thin, fragile dentinal walls and short roots with the blunderbuss anatomy. The treatment choice includes *a)* apexification; which consists of inducing apical closure through using calcium hydroxide (multiple-session apexification) or *b)* induction of artificial barriers using biomaterials such as mineral trioxide aggregate (MTA) (one-step apixification) [1, 2]. However, while apexification resolves the problem of apical periodontitis and induces apical closure, both techniques have a major limitation; they stop the process of root development, and as a result a thin, fragile root will remain [3]. In recent years, previous thought about regeneration of necrotic pulp in immature permanent tooth are changing; nowadays we know this can be achieved by using a technique known as revascularization [4, 5] or revitalization [6].

Revascularization treatment includes *a)* disinfection of the root canal system and *b)* application of triple antibiotic paste (TAP), which is a mixture of ciprofloxacin, metronidazole, and minocycline, or calcium hydroxide (CH) as an intracanal medicament. The treatment proceeds with the removal of intracanal dressing and the induction of bleeding from periapical tissues into the root canal space; thus, providing a suitable matrix for new tissue in-growth. Unlike the apexification with an artificial barrier, revascularization may lead to root maturation. Stem cells, in the tissues around the root, may have a role in this procedure [5, 7, 8].

Figure 1. *A)* Initial periapical radiograph: occlusal caries can be observed extending into the pulp chamber and radiolucency on the root apices can be seen; *B)* Completion of revascularization was done; *C)* Follow-up periapical radiograph, 12 months after the completion of revascularization. The root development and apical closure had taken place. This phenomenon is expected to improve in the following check-ups

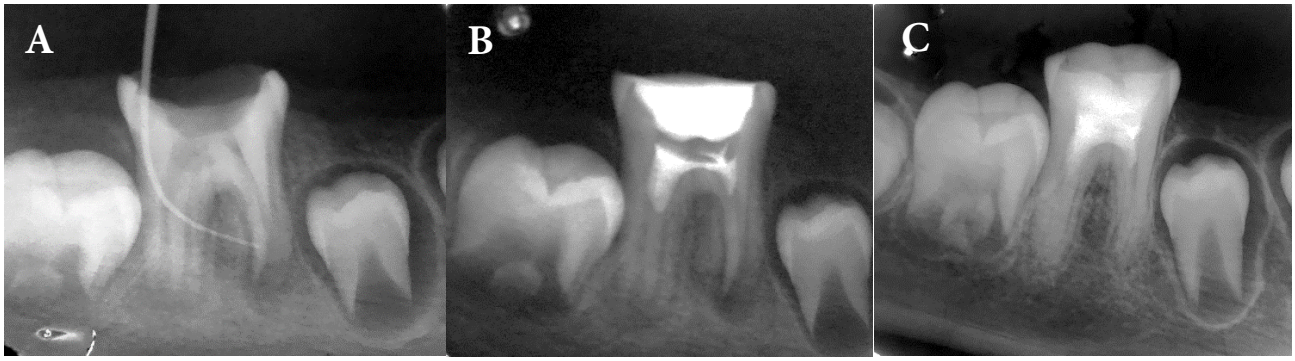

Figure 2. *A)* Initial periapical radiograph showing gutta-percha tracing of the sinus tract, occlusal caries, extending into the pulp chamber, and radiolucency on the root apices can be observed; *B)* Completion of revascularization was done; *C)* Follow-up periapical radiograph 1 year after the completion of revascularization. The periapical radiolucency had decreased and the walls of the root canal had thickened; apical closure had taken place

Criteria for predictable revascularization are still lacking. It is difficult to select proper non-vital teeth with residual vital stem cells in periapical area, which are accepted to be essential for a successful regenerative procedure [9, 10].

The aim of this study was to present a series of cases regarding revascularization, as well as gathering information on the techniques and results of this treatment method.

Case Reports

Case one

A healthy 7-year-old male patient with multiple caries was referred to the Department of Endodontics, School of Dentistry, Mashhad University of Medical Sciences, Iran. The patient's chief complaint was tooth decay, and pain on chewing on the left side of his mandible.

Clinical examinations revealed an extensive carious lesion of tooth #36 and retained roots of the adjacent deciduous tooth. The tooth was painful on percussion, but its mobility was within normal limits. Tooth #36 was not responsive to sensibility tests. On radiographs, tooth #36 presented occlusal caries extending into the pulp chamber, blunderbuss root anatomy and a radiolucency embracing the root (Figure 1A).

All treatment options were explained to the patient's parents, and after choosing the best option with consolidation with them, they signed the informed consent form.

At the first appointment, after the injection of 2% lidocaine with 1:100,000 epinephrine (Daro Pakhsh, Tehran, Iran) and rubber dam placement, access cavity was prepared. Working-length determination was confirmed radiographically. Then, the root canal system was gently irrigated with 20 mL of 2.5% NaOCl, followed by 10 mL of normal saline. CH paste was used as the intracanal medicament for three weeks.

In the next visit, local infiltration was performed using 3% mepivacaine (Daro Pakhsh, Tehran, Iran). CH was gently removed from each canal via irrigation with 17% ethylenediaminetetraacetic acid (EDTA) and final flush with normal saline. After drying the canals with sterile paper points, bleeding from the apical region towards inside the canals was induced using an overextended sterile K-file (Mani, Tochigi, Japan). After blood clot formation, MTA

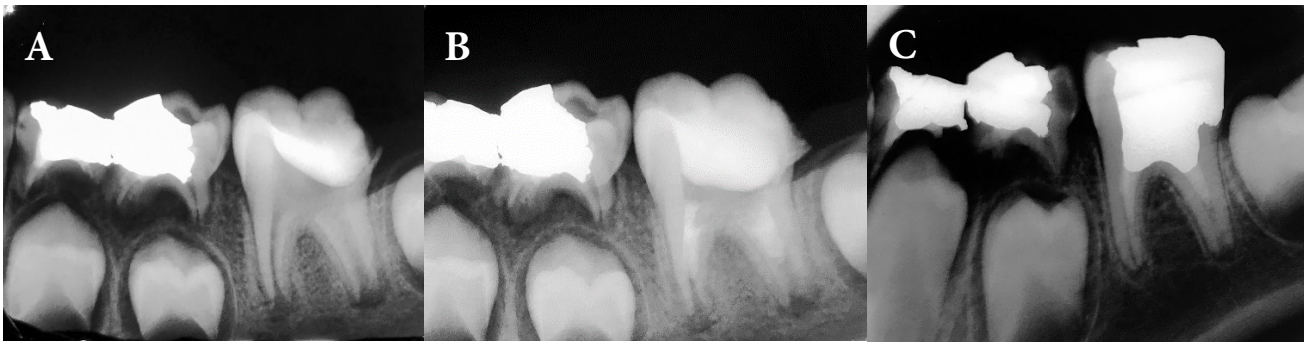

Figure 3. *A)* Initial periapical radiograph: tooth #46 with a temporary restoration (Cavit); *B)* Revascularisation completed; *C)* Follow-up periapical radiograph, 12 months after completion of revascularisation. The root canal had thickened; apical closure had taken place

(Angelus, Londrina, Paraná, Brazil) was placed on the orifices of the canals, approximately 3 mm apical to the cementoenamel junction (CEJ). Then, a moist cotton pellet was placed in the pulp chamber and the access cavity was sealed with a temporary restoration (Figure 1B).

One week later, the patient was completely asymptomatic. Thus, the cotton pellet and temporary restoration were removed, and the tooth was restored with amalgam (Cinalux; Faghihi, Tehran, Iran).

After three months, no clinical signs or symptoms were recorded. At the 12-month follow-up, the patient remained asymptomatic. In addition, continued root development and apical closure were evident on the radiographs (Figure 1C). These findings are expected to improve in the following check-ups.

Case two

A 9-year-old healthy male patient with tooth pain and an abscess on the left side of his mandible was referred to the "Department of Endodontics, School of Dentistry, Mashhad University of Medical Sciences, Iran".

In clinical examinations, tooth #46 presented a large area of occlusal caries. The tooth was not responsive to the cold and heat tests. A swelling and a sinus tract were observed in the buccal vestibular aspect of the tooth. The sinus tract was traced, and periapical radiography was performed (Figure 2A). The radiography showed occlusal caries on tooth #46, extending into the pulp chamber. There were periapical radiolucency and open apices. Clinical and radiographic evaluations pointed to pulp necrosis and a chronic apical abscess.

All treatment options and their costs, benefits and possible side effects were explained to the patient's parents, and they chose revascularization protocol for treatment. The informed consent was obtained from the patient's guardian. Revascularization treatment was carried out, following the same procedure as the previous case except that, in this case, TAP was used as an intracanal medicament.

At the second visit, the sinus tract was completely healed and soft tissue swelling was resolved. After induction of bleeding inside the canal space, MTA was applied over the blood-clot in each canal and then, a wet cotton pellet and a temporary restoration were placed over the MTA (Figure 2B). One week later, the patient was recalled. The tooth was completely asymptomatic. After ensuring the setting of MTA, permanent coronal restoration was performed with composite resin (3M ESPE, St Paul, MN, USA).

In the 3-, 6- and 12-month follow-ups; the patient had no signs or symptoms, and there was no sensitivity to percussion or palpation. After one year, the periapical radiolucency disappeared, and apical closure and completion of root development were taken place (Figure 2C)

Case three

A healthy 8-year-old male patient was referred from a private dental surgery/office to the "Department of Endodontics, School of Dentistry, Mashhad University of Medical Sciences". Tooth #46 had been sealed with a temporary restorative material (Cavit) and was not responsive to sensibility tests. The tooth was tender to percussion, and tooth mobility was within normal limits. On radiographs, tooth #46 presented blunderbuss short roots with thin dentinal walls (Figure 3A).

Treatment options were explained to the patient's parents and revascularization was considered as the treatment of choice. The informed consent was taken from the patient's parents, and revascularization was performed as the previous case using TAP as the intracanal medicament. In the second appointment, and after the induction of blood-clot formation in the canals, MTA was used as the coronal barrier on the orifice of each canal over the blood clot. Then, a wet cotton pellet and a temporary restoration were placed over the MTA

(Figure 3B). After one week, the patient was completely asymptomatic and the tooth was restored with amalgam (Cinalux; Faghihi, Tehran, Iran).

Follow-up visits were done at 1, 3, 6 and 12 months after the second appointment. In the follow-up sessions, the patient had no signs or symptoms, and the tooth was functional. After one year, the periapical radiograph showed apical closure of the mesial canals and formation of a calcified bridge at the apical third of the distal root (Figure 3C).

Discussion

The concept of regenerative endodontics (RE) was first introduced by Nygaard-Ostby in 1960 [11]. Later in 2004, Banchs and Trope [11, 12] described a revascularization protocol for the regeneration of necrotic immature teeth with open apices.

In the current case series, three necrotic immature mandibular molars were presented. The patients were 7 to 9 years of age. Pulp exposures were due to carious lesions, which had led to pulp necrosis before root maturation. Pulp revascularization was assumed to be the treatment of choice; so as to save the teeth and promote root development; an event which is not achievable by apexification procedures.

According to the revised guidelines of the American Association of Endodontics (Dec 2016), the primary goal of RE is the healing of periapical periodontitis, while the secondary goal is to increase the root length and/or thicken root canal walls. Moreover, the tertiary goal is defined as a positive response to pulp testing. The secondary and tertiary goals are preferred, but they are not essential for clinical success [13].

The present case series illustrated the successful revascularization treatment of all three cases. After the regenerative treatment, all cases showed some degree of root development and thickening of root canal walls, especially at the apical third of the root. However, none of the presented cases showed a positive response to pulp testing. An accurate case selection and efficient disinfection of the root canal system are crucial for successful regeneration [14].

Root canal disinfection establishes a suitable environment for pulpal and periapical cells to participate in tissue repair and regeneration [4]. Due to thin and fragile dentinal walls in immature teeth, the removal of microorganisms *via* mechanical instrumentation is limited. Copious irrigation and intracanal dressings are proposed for the disinfection of such canals. Different concentrations of NaOCl from 1.25% to 6%, and different concentrations of chlorhexidine (CHX) (0.12% to 2%) have been successfully used as irrigants in regenerative endodontic procedures (REPs)[15]. In the current case series, 2.5% NaOCl, as the root canal irrigant, was used [16].

In our study, and as intracanal medication, TAP and calcium hydroxide paste were employed. Both medicaments showed successful clinical and radiographic outcomes, which were in accordance with previous reports [17, 18]. The concentrations of irrigants and medicaments are important in finding a balance between canal disinfection, release of growth factors from the dentinal matrix and survival/proliferation of the stem cells of the apical papilla (SCAP)[17].

Calcium-silicate based cements such as MTA, calcium enriched mixture (CEM) cement or Biodentine have been successfully used in REPs [19]. We used MTA as a plug in the canal orifices for revascularization in all three cases, and the outcomes were satisfactory. In some studies, Biodentine was suggested since it didn't cause tooth discoloration, which may not be a concern in posterior teeth [19, 20].

Conclusion

The present case series illustrated 12-month follow-ups of revascularization in three immature necrotic teeth using MTA as a coronal barrier. The treatments were considered successful since the teeth were functional, all unfavorable signs and symptoms were relieved, and some degrees of root development were achieved. While the repair was accomplished with current protocols, further research in the field of stem cell-based pulp engineering is expected to enable true regeneration and improved root development.

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Conflict of Interest: 'None declared'.

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