CASE REPORT

Long-term follow-ups of revascularized immature necrotic teeth: three case reports

Duck-Su Kim¹, Hae-Jin Park¹, Je-Ha Yeom¹, Ji-Sung Seo¹, Gil-Joo Ryu², Ki-Ho Park³, Seung-Il Shin⁴ and Sun-Young Kim³

Revascularization of immature necrotic teeth is a reliable treatment alternative to conventional apexogenesis or apexification. In case 1, a 12-year-old boy had his necrotic, immature mandibular left second premolar treated with a revascularization technique. At a 24-month follow-up, periapical radiolucency had disappeared and thickening of the root wall was observed. In cases 2 and 3, a 10-year-old boy had his necrotic, immature, bilateral mandibular second premolars treated with the same modality. At 48-month (in case 2) and 42-month (in case 3) follow-ups, loss of periapical radiolucencies and increases in the root wall thickness were also observed.

Keywords: revascularization; pulp necrosis; mineral trioxide aggregate; antibiotic mixture; immature tooth

INTRODUCTION

Pulp necrosis of immature teeth may give rise to complications.¹ It prevents further development of the root, leaving a tooth with thin root walls. Conventional root canal treatment techniques used in mature teeth are difficult to use in immature teeth which have various anatomical complexities.² The instrumentation and obturation of immature root canals are difficult or impossible with conventional techniques.³ Furthermore, weak teeth with thin root walls are susceptible to fracture.

Conventional apexification uses calcium hydroxide as intracanal medicament to induce apical closure over time. This is a successful treatment technique for immature teeth, but it has several disadvantages, including the need for multiple visits over a relatively long period of time (an average of 12 months). In addition, the root canal may not be reinforced.⁴ An alternative to conventional apexification with calcium hydroxide is to make an artificial apical barrier to prevent the extrusion of root canal filling materials. The material of choice is mineral trioxide aggregate (MTA) which has good sealing ability and biocompatibility.⁵ However, it does not also promote further root development.

Recently, an alternative biologically based treatment has been introduced for immature teeth with necrotic pulp.⁶ Procedures that preserve the remaining dental pulp stem cells and mesenchymal stem cells of the apical papilla can result in intracanal revascularization and continued root development.⁷ The revascularization of these teeth is based on the concept that vital stem cells in the apical papilla can survive pulpal necrosis, even in the presence of periapical infection, because the open apex provides good communication to the periapical tissues.⁸⁻⁹ The present case reports evaluated the long-term prognosis of revascularization in necrotic immature teeth, with the aim of providing reliable evidences for the revascularization technique.

CASE REPORTS

Case 1

A 12-year-old boy was referred to our department for treatment of his mandibular left second premolar. His medical history was unremarkable. When taking the dental history, the patient stated that prior to the first visit, he experienced severe pain, which had decreased over the past 5 days, but increased with chewing. Clinical examination revealed that the tooth was not responsive to electric pulp test and was sensitive to percussion. Periodontal probing depths were within normal limits (<3 mm). Radiographic examination revealed an immature tooth with periapical radiolucency (Figure 1a).

Based on the results of the clinical and radiographic examinations, a diagnosis was made of pulp necrosis with symptomatic apical periodontitis. Under local anesthesia, the tooth was isolated with a rubber dam and the access cavity was prepared. The root canal was irrigated with 10 mL of 3% sodium hypochlorite for 2 min, and then dried with sterile paper points. A creamy paste mixture of metronidazole (Samil Pharm, Seoul, Korea), ciprofloxacin (Sinil Pharm, Seoul, Korea) and cefaclor (Myungin Pharm, Seoul, Korea) in sterile saline was applied using a lentulo-spiral and tapped down into the canal with the blunt end of sterile paper points. The tooth was temporarily restored using Caviton (GC, Aichi, Japan).

The patient was asymptomatic 2 weeks later. The Caviton was removed under rubber dam isolation. The mixture of antibiotics was completely removed with 3% sodium hypochlorite and sterile saline. The apical tissue was stimulated with a No. 10 K-file to induce...
bleeding. A blood clot formed in the canal about 15 min after stimulation. MTA (Dentsply Tulsa Dental, Johnson City, TN, USA) was applied over the blood clot, followed by a moist cotton pellet (Figure 1b). Caviton was placed temporarily over the cotton pellet.

When the patient came back for 6-week follow-up, the periapical radiolucency had diminished (Figure 1d). At the 24-month follow-up, the patient was asymptomatic. The Caviton was removed carefully under rubber dam isolation. The remainder of the root canal space was obturated using an Obtura-II (Obtura Corp., Fenton, MO, USA) and a composite resin restoration (Z250; 3M ESPE, St Paul, MN, USA) was placed into the access cavity (Figure 1c).

Case 2

A 10-year-old boy was referred to our department for treatment of his mandibular left second premolar. According to the patient, he first felt moderate pain 7 days prior to presentation to our department. He then presented to a dental emergency center with sudden facial swelling and severe pain 1 day ago. His mandibular left second premolar was treated with a pulpotomy at the center. His medical history was unremarkable. Clinical examinations revealed a negative response to electric pulp test and sensitivity to percussion. In addition, buccal gingival swelling was observed. Periodontal probing depth was within normal limits (<3 mm) (Figure 2a and b). A periapical radiograph revealed an immature root with periapical radiolucency (Figure 2c). The patient stated that his pain and facial swelling had decreased following the pulpotomy treatment.

The tooth was isolated with a rubber dam and the access cavity was prepared. The root canal was irrigated with 10 mL of 3% sodium hypochlorite for 2 min, and then dried with sterile paper points. A creamy paste mixture of metronidazole (Samil Pharm), ciprofloxacin (Sinil Pharm) and cefaclor (Myungin Pharm) in sterile saline was applied into the canal using a lentulo-spiral and tapped down into the canal with the blunt end of sterile paper points. The tooth was temporarily restored using Caviton.

The patient returned to our department 2 weeks later. His buccal gingival swelling had disappeared completely, and he did not feel any discomforts (Figure 2d). The Caviton was removed under rubber dam isolation. The antibiotic mixture was thoroughly removed with 3% sodium hypochlorite and sterile saline. The apical tissue was stimulated with a No. 10 K-file to induce bleeding. A blood clot formed in the canal about 15 min after stimulation. MTA was applied over the blood clot followed by a moist cotton pellet (Figure 2e). Caviton was placed temporarily over the cotton pellet. The patient was asymptomatic 2 weeks later. The Caviton was removed carefully under rubber dam isolation. The remainder of the root canal space was obturated using an Obtura-II (Obtura Corp.), and a composite resin restoration (Z250; 3M ESPE) was placed into the access cavity (Figure 2f).

At the 2-month follow-up, the periapical radiograph revealed a decrease in the periapical radiolucency (Figure 2g). The patient exhibited no clinical discomforts. At the 48-month follow-up, the periapical radiolucency had disappeared completely (Figure 2h). Preoperative and 48-month follow-up radiographs were analyzed with same modality described for case 1 and confirmed an increase in root thickness.
Case 3
This case involved the same patient as case 2. At the 6-month follow-up of the revascularized mandibular left second premolar, slight gingival swelling was observed on the buccal surface of the mandibular right second premolar (Figure 3a). Clinical examinations revealed a sensitivity to percussion and negative response to electric pulp test. The periodontal probing depths were within normal limits (<3 mm). A periapical radiograph revealed an immature root with periapical radiolucency (Figure 3b).

The tooth was isolated with a rubber dam under local anesthesia. When the access cavity was prepared, bloody purulent discharge was evident (Figure 3c). The root canal was irrigated with 20 mL of 3% sodium hypochlorite for 5 min until the pus discharge ceased. No instrumentation was applied into the canal. The root canal was dried with sterile paper points. A creamy paste mixture of metronidazole (Samil Pharm), ciprofloxacin (Sinil Pharm) and cefaclor (Myungin Pharm) in sterile saline was applied into the canal using a lentulo-spiral and tapped down into the canal with the blunt end of
sterile paper points. The tooth was temporarily restored using Caviton.

After 1 week, the gingival swelling disappeared completely (Figure 3d). The Caviton was removed under rubber dam isolation. The antibiotic mixture was flushed thoroughly with 3% sodium hypochlorite and sterile saline. The apical tissue was stimulated with a No. 10 K-file to induce bleeding in the canal space. A blood clot formed in the canal about 15 min after stimulation. MTA was applied over the blood clot, followed by a moist cotton pellet (Figure 3e). Caviton was placed temporarily over the cotton pellet. Two weeks later, the patient was asymptomatic. The Caviton was removed and the remainder of the root canal space was obturated using an Obura-II (Obutra Corp.). A composite resin restoration (Z250; 3M ESPE) was then placed into the access cavity.

At the 2-month follow-up, a periapical radiograph showed that the periapical radiolucency had decreased (Figure 3f). The patient exhibited no clinical discomfort. At the 42-month follow-up, the periapical radiolucency had disappeared completely (Figure 3g). The preoperative and 42-month follow-up radiographs were analyzed with same modality used in cases 1 and 2, which confirmed an increase in root thickness.

**DISCUSSION**

Some reports have suggested that the revascularization technique is a reliable alternative treatment because it promotes the development of a longer and thicker root that is less susceptible to fracture.12–14 In the present case reports, the root walls and open apices of necrotic immature teeth were thickened and closed after revascularization.

Various combinations of topical antibiotics may be used to disinfect necrotic, infected root canals. One combination that is effective against bacteria commonly found in infected root canals is a mixture of ciprofloxacin, metronidazole and cefaclor. Hoshino et al. against bacteria commonly found in infected root canals is a mixture of ciprofloxacin, metronidazole and cefaclor. Hoshino et al.15 performed a laboratory study testing the antibacterial efficacy of these drugs alone and in combination against bacteria from infected dentin, infected pulp and periapical lesions. Alone, none of the drugs resulted in the complete elimination of bacteria. However, in combination, these drugs provided a consistent sterilization of all bacterial samples. In addition, Sato et al.16 determined that this drug combination was effective for eliminating bacteria in the deep layers of root dentin. However, possible complications such as crown discoloration,17 development of resistant bacterial strains8–13 and allergic reactions to the intracanal medication14–16 may occur after the use of these antibiotics.

It is difficult or impossible to obtain a perfectly standardized radiographic image. In the present case reports, preparative and final follow-up radiographs differed from each other, which precluded a proper evaluation of the radiographic changes occurring after revascularization. To minimize differences among the obtained radiographic images, we used the TurboReg plug-in of the ImageJ analysis program.

The main difference in the present case reports compared to earlier reports is the longer follow-up period. Although some successful revascularization case reports have been reported, long-term follow-up cases have rarely been reported. Thibodeau and Trope reported only a 9.5-month follow-up of a revascularized necrotic tooth.19 Shin et al. reported revascularization of a necrotic tooth after a 19-month follow-up.20 Jung et al. reported 11 revascularized teeth; however, only one case was reported with over a 2-year follow-up.21 Another clinical study reported three revascularization cases, but follow-up periods of these cases were also only between 15 and 19 months.22 The present study provides follow-up information for 24, 48 and 42 months for cases 1, 2 and 3. All of the revascularized teeth showed satisfactory clinical and radiographical performances at long-term follow-ups. Therefore, we consider that the revascularization technique can be regarded as a reliable treatment modality for clinical use.

**CONCLUSION**

These case reports demonstrate the long-term reliable prognoses of revascularization for immature necrotic teeth. In well-selected cases, the revascularization technique may be a trustworthy alternative to conventional apexogenesis or apexification.

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