

CLINICAL RESEARCH

Revascularization of Immature Permanent Teeth With Apical Periodontitis: New Treatment Protocol?

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A new technique is presented to revascularize immature permanent teeth with apical periodontitis. The canal is disinfected with copious irrigation and a combination of three antibiotics. After the disinfection protocol is complete, the apex is mechanically irritated to initiate bleeding into the canal to produce a blood clot to the level of the cemento-enamel junction. The double seal of the coronal access is then made. In this case, the combination of a disinfected canal, a matrix into which new tissue could grow, and an effective coronal seal appears to have produced the environment necessary for successful revascularization.

Regeneration of a necrotic pulp is considered possible only after avulsion of an immature permanent tooth. The advantages of pulp revascularization lie in the possibility of further root development and reinforcement of dentinal walls by deposition of hard tissue, thus strengthening the root against fracture. After reimplantation of an avulsed immature tooth, a unique set of circumstances exists that allows regeneration to take place. The young tooth has an open apex and is short, which allows new tissue to grow into the pulp space relatively quickly. The pulp is necrotic but usually not infected, so it will act as a matrix into which the tissue can grow. It has been experimentally shown that the apical part of a pulp may remain vital and, after reimplantation, may proliferate coronally, replacing the necrotized portion of the pulp (1–3). In addition, the fact that, in most cases, the crown of the tooth is intact ensures that bacterial penetration into the pulp space through cracks (4) and defects will be a slow process. Thus, the race between the new tissue and infection of the pulp space favors the new tissue.

The notion that successful regeneration depends on a race between the new tissue and bacteria populating the pulp space is strengthened by the fact that the incidence of revascularization is enhanced if the apex shows radiographic opening of more than 1.1 mm (5) and the tooth is replanted within 45 min (thus increasing the chances for revascularization by 18%) (5). The incidence can be significantly improved if the tooth is soaked in doxycycline (6,

7) or minocycline (8) before replantation, therefore ensuring that bacteria on the root surface and apical foramen are killed and no new bacteria are able to move through the blood clot in the socket.

Regeneration of pulp tissue in a necrotic infected tooth with apical periodontitis has been thought impossible. However, if it were possible to create a similar environment as described here for the avulsed tooth, regeneration should occur. Thus, if the canal were effectively disinfected, a matrix into which new tissue could grow were created, and the coronal access were effectively sealed, regeneration should occur as in an avulsed immature tooth.

This case report describes the treatment of an immature second lower right premolar with radiographic and clinical signs of apical periodontitis with the presence of a sinus tract. The canal was disinfected without mechanical instrumentation with the use of copious irrigation followed by a mixture of antibiotics. A blood clot was then produced to the level of the cemento-enamel junction (CEJ), followed by a deep coronal restoration. With clinical and radiographic evidence of healing as early as 22 days, the large radiolucency had disappeared within 2 months, and at the 24-month recall, it was obvious that the root walls were thick and the development of the root apical to the restoration was similar to that of the adjacent and contralateral teeth.

CASE REPORTS

An 11-year-old boy of Japanese descent was referred to the endodontic clinic of the University of North Carolina by the pediatric dentistry department for evaluation on the lower right second premolar. The child had a lingual swelling of the right mandibular area 1 month previously with reported slight discomfort. On clinical examination, the patient was asymptomatic, and the tooth appeared intact, without caries (Fig. 1). The presence of occlusal tubercles on the other mandibular premolars suggested that one may have been present on this tooth, which was fractured during function, resulting in a microexposure and necrosis of the pulp. The tooth had an open apex associated with a large radiolucency (Fig. 2), and a lingual sinus tract was present that traced to the apex of the tooth (Fig. 3). Periodontal probings were within normal limits for all teeth in the lower right region. Diagnostic testing was inconclusive on cold and electric pulp testing, with sensitivity on percussion and palpation. Because of the presence of



FIG 1. Occlusal view of lower right posterior region. The second premolar appears intact without caries.



FIG 2. Preoperative radiograph. The second premolar has an open apex with a large periradicular radiolucency.

a 4-mm open apex and thin dentinal walls prone to possible future fracture (9), it was felt that an attempt to achieve regeneration of the pulp should be made by a technique similar to that described by Rule and Winter (10) and Iwaya et al. (11).



FIG 3. Radiograph showing tracing of the lingual sinus tract with a gutta-percha point.



FIG 4. Radiograph 26 days after the permanent triantibiotic paste was placed. Radiographic signs of healing are already evident.

An access cavity was made, purulent hemorrhagic drainage obtained, and the necrotic nature of the pulp confirmed. A needle was placed to within 1 mm of the apex, and the canal was slowly flushed with 20 ml of 5.25% NaOCl and 10 ml of Peridex (Zila Pharmaceuticals, Phoenix, AZ). The canal was dried with paper points, and a mixture of ciprofloxacin, metronidazole, and minocycline paste as described by Hoshino et al. (12) was prepared into a creamy consistency and spun down the canal with a lentulo spiral instrument to a depth of 8 mm into the canal. The access cavity was closed with 4 mm of Cavit (ESPE, Seefeld, Germany).

The patient returned 26 days later, asymptomatic, reporting no pain postoperatively. The sinus tract was not present, and some reduction in the radiolucency was already evident (Fig. 4). The access was opened and the canal again flushed with 10 ml of 5.25% NaOCl. The canal appeared clean and dry, with no signs of inflammatory exudate. An endodontic explorer was introduced into the canal until vital tissue was felt at a depth of 15 mm into the canal space. An explorer was used to irritate the tissue gently to create some bleeding into the canal. The bleeding was stopped at a level of 3 mm below the level of the CEJ and left for 15 min so that the blood would clot at that level. After 15 min, the presence



FIG 5. Radiograph confirming the placement of MTA approximately 3 mm below the CEJ. The MTA was carefully placed over the blood clot, followed by a wet cotton pellet and Cavit.

of the blood clot to approximately 3 mm apical of the CEJ was confirmed. Mineral trioxide aggregate (MTA; Densply Tulsa Dental, Tulsa, OK) was carefully placed over the blood clot, followed by a wet cotton pellet and Cavit (Fig. 5).

Two weeks later, the patient returned, asymptomatic, and the Cavit and cotton pellet were replaced with a bonded resin restoration (Fig. 6). The patient was scheduled for recall examination and advised to call if he was in pain or if swelling or a recurrence of the sinus tract developed.

At the 6-month recall, the patient was asymptomatic, with no signs of the sinus tract. The radiograph showed complete resolution of the radiolucency (Fig. 7). At the 1-year (Fig. 8) and 18-month (Fig. 9) follow-up examinations, the patient continued to be asymptomatic, with no signs of the sinus tract and an indication of continued development of the apex of the tooth. Pulp testing was still inconclusive. At the 2-year follow-up (Fig. 10), the patient continued to be asymptomatic, and closure of the apex and thickening of the dentinal walls was obvious. The tooth responded positively to the cold test.

DISCUSSION

It is accepted that in luxated or avulsed teeth with open apices, revascularization is a possibility (5, 13, 14). In fact, under ideal conditions and with chemical decontamination of the root surface, it is almost predictable. The explanation for this positive outcome is that although the pulp is devitalized after avulsion, it will stay free of bacteria for some time. The necrotic but sterile pulp will act as a matrix into which new tissue can grow. Because in traumatized teeth the crown is usually intact, it will take bacteria a long time to advance into the pulp space. If, in this time, the new vital tissue fills the canal space, the ingress of bacteria will be stopped.

Revascularization of a necrotic immature tooth has been assumed to be impossible because it is extremely difficult to disinfect these canals. Mechanical instrumentation, an important step in root canal treatment, cannot be performed in these teeth because the walls are so thin. Thus, the disinfection relies solely on irrigants and intracanal medications. Traditionally, calcium hydroxide has been used as the intracanal medication in apexification procedures



FIG 6. Occlusal view of bonded resin permanent restoration.



FIG 7. Six-month recall radiograph. The radiolucency has completely disappeared, and the first signs of apical closure and continued root development can be seen.

(15, 16). Although it is a proven and effective medication (17–19), its effect is to create an environment conducive to the formation of a hard tissue bridge at the apex (20, 21). However, because of its high pH, it will necrose tissue in immediate contact with it,



FIG 8. Twelve-month radiograph showing continued root development.



FIG 9. Eighteen-month radiograph showing continued root development.

destroying tissues with the potential to differentiate into new pulp. Thus, with calcium hydroxide therapy, there is no expectation that the root canal walls will be thickened or strengthened. To the contrary, in a recent study, it was claimed that long-term calcium hydroxide treatment will in fact weaken the tooth and predispose it to fracture (22). Recently, a new technique has been proposed to decrease the time to create a bridge at the apex. After disinfection of the canal, MTA is placed in the apical third of the immature root to create a stop for the filling material (23–25). This technique will also not allow new tissue to grow into the root canal, and the root remains thin and weak.

In the case presented here, after copious irrigation with sodium hypochlorite, we used a triantibiotic paste proposed by Hoshino et al. (12). They showed excellent disinfection with the use of the medication, and this case appears to reinforce these claims. It is extremely important to ensure that the irrigating needle is loose in the canal and that the NaOCl irrigation is performed very slowly. In cases reported to date, the careful application of NaOCl does not produce postoperative sequelae.



FIG 10. Twenty-four-month radiograph showing complete root development. The stage of root development is the same as that of the contralateral premolar tooth.

We created a blood clot in the canal after disinfection. This blood clot acts as a matrix for the growth of new tissue into the pulp space, similar to the necrotic pulp after a traumatic injury.

The remaining problem that we feel that was solved in this case was to create a bacteria-tight seal coronally to inhibit bacterial invasion into the pulp space before revascularization could take place. We used a double seal with MTA that has been shown to have excellent sealing properties (26–28) to a level below the CEJ covered by a bonded resin coronal seal. Again, based on the positive outcome of this case, we assume that this combination successfully sealed the tooth from coronal bacterial leakage.

An interesting question is the origin of the new pulp tissue. First, we must acknowledge that we do not know whether the vital tissue is pulp. However, based on the fact that the root continued to grow

and that the walls of the root appeared to thicken in a conventional manner, it is likely that in this case, the tissue was in fact pulp with functioning odontoblasts. In teeth with open apices, it is possible that some pulp tissue may have survived apically, even though most of the pulp is devitalized and heavily infected. Therefore, even though a large apical lesion was present, it is probable that some vital pulp tissue and Hertwig's epithelial root sheath remained. When the canal is disinfected and the inflammatory conditions reversed, these tissues can proliferate. This case has been followed for 2 years and can be considered a success in that the walls are thickened (and stronger) and the apex has formed normally. Time will tell whether the canal obliterates or whether apical periodontitis will develop at a later stage. Even if these undesirable outcomes do occur, the tooth is still likely to last for the life of the patient, which would not have been the case if it had been treated endodontically at the time of presentation.

The predictability of this procedure and the type of tissue that develops in these cases are still to be studied. In fact, our laboratory has an ongoing animal study to answer some of these questions. However, the benefit is so great compared with leaving a root with a thin and fracture-susceptible wall that, in our opinion, it is worth attempting. If no root development can be seen within 3 months, the more traditional apexification procedures can then be started.

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