Apexogenesis in an Incompletely Developed Permanent Tooth with Pulpal Exposure

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In clinical practice it is not uncommon to find incompletely developed teeth that require some form of endodontic intervention due to extensive caries or traumatic injury. When such a clinical situation presents itself, an assessment of the pulpal status and the degree of tooth development must be made in order to develop an appropriate treatment plan that is conducive to long-term tooth retention.

It has been shown that when a direct pulp capping procedure is performed on a tooth with an exposed and inflamed pulp, the probability of pulp repair and long-term success is low.[1,2] This often will lead to pulp necrosis and arrested tooth development of the involved immature tooth. The resulting wide-open apical foramina, canals with reverse taper (blunderbuss) and thin dentinal walls, represent three major clinical concerns when an incompletely developed tooth fails to mature. As such, subsequent endodontic procedures and the remaining strength of the root structure may be compromised, resulting in a poor long-term prognosis.[3]

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Apexogenesis is a procedure that addresses the shortcomings involved with capping the inflamed dental pulp of an incompletely developed tooth. The goal of apexogenesis is the preservation of vital pulp tissue so that continued root development with apical closure may occur. Most or all of the coronal pulp is removed, often to the level of the canal orifices, and calcium hydroxide paste is placed as a wound dressing.[4-8] An aseptic technic combining the use of the rubber dam and sterile burs is strongly recommended. According to Granath *et al*,[5] the instrument of choice for tissue removal is an abrasive diamond bur at high speed with adequate water-cooling. The goal is to minimize any further damage to the underlying pulpal tissue. Following coronal pulp amputation, the pulp chamber is rinsed with sterile saline or sterile water to remove all debris. The excess liquid should then be carefully removed via vacuum or sterile cotton pellets. Air should not be blown on the exposed pulp, as this may cause desiccation and additional tissue damage. Once the pulpal bleeding is controlled,

calcium hydroxide paste is placed over the amputation site. Care must be taken to avoid placing the calcium hydroxide on a blood clot[6] and the entire pulp surface must be covered. Once this is accomplished, a restorative base material should be placed over the calcium hydroxide and then allowed to set completely. A coronal restoration should then be placed that will ensure the maximum long-term seal. The patient should be re-evaluated every three months for the first year, and then every 6 months for 2 to 4 years to determine if successful root formation is taking place and that there are no signs of pulp necrosis, root resorption or periradicular pathosis.

Many different materials have been used for pulpal wound dressing, however, the use of calcium hydroxide has been shown to be the most predictable with regard to long-term clinical success.[7] Pure calcium hydroxide paste, which has a pH of about 12.5, causes a limited and shallow chemical injury to the vital pulp tissue. The response of the vital tissue is a self-limiting inflammatory reaction, followed by the proliferation of cells and new collagen. Mineralization of the newly formed collagen starts with dystrophic calcification, which is then followed by tubular dentin formation[8] (Fig. 1). Newer materials, such as Mineral Trioxide Aggregate((MTA, Dentsply Co., Tulsa, OK) have also shown favorable clinical and histological results in pulp capping, apexogenesis and apexification cases.[9] However, long-term clinical results have not yet been reported in the dental literature.

The hard-tissue barrier that has formed does not provide an impervious seal from the oral environment. As such, a "bacteria-tight" coronal restoration is necessary to prevent oral fluids and microorganisms from reaching the exposed and healing pulpal tissue.[10]

FIGURE 1—Histologic section of dog's tooth pulp capped with calcium hydroxide. Note the complete dentin bridge at 6m. *Courtesy of Dr. Leif Tronstad.*

Controversy exists as to whether further endodontic intervention should take place following the completion of root development. However, a moderate incidence of continued calcification, internal resorption and pulp necrosis exists in teeth that have been treated in this manner (Fig. 2). As the entire coronal pulp was removed, thermal and electrical testing of the tooth is no longer possible. Since it is not possible to determine the pulp vitality or the health of the remaining pulp tissue, it has been advocated that once root development appears to be completed, the tooth should be re-entered and root canal therapy performed.[11,12] Initiation of the endodontic treatment prior to the development of root resorption, canal obliteration and the development of apical periodontitis will afford a higher long-term success rate.[13,14]

TREATMENT CONSIDERATIONS

A thorough clinical and radiographic examination must be performed prior to the initiation of any dental treatment. This procedure should only be considered for incompletely developed teeth with vital pulps without evidence of periradicular pathosis.

An assessment of pulp vitality and periradicular health must be made. Pulp sensitivity testing (thermal stimulation, electric pulp testing) will indicate the presence or absence of pulp vitality in most clinical situations.

FIGURE 2—Follow-up radiograph of molar that had apexogenesis procedure. Calcification and resorption are evident.

Other clinical tests, such as percussion and palpation, will provide information regarding inflammatory changes in the periradicular tissues. The presence of a sinus tract, swelling, coronal tooth discoloration or increased mobility will also provide information on the status of the pulp, periradicular tissues and attachment apparatus.

Radiographic examination will provide specific information regarding the extent of the carious lesion, the development of the roots, the presence of periradicular pathosis, root resorption and crown and/or root fractures.

CASE PRESENTATION

A 10-year-old male patient presented to the dental office with spontaneous pain associated with his lower right first molar that woke him up at night. Clinically, an extensive carious lesion was observed. Radiographically, the carious lesion appeared to

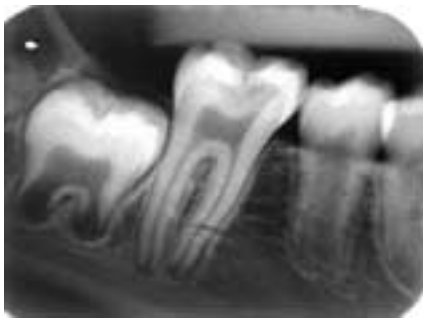

FIGURE 3—Pre-treatment radiograph, August 2000. Deep occlusal decay is apparent. Note the open apices of both roots.

FIGURE 4—One-year follow-up radiograph. Note the continued development of the root apices.

FIGURE 5—Radiograph taken after completion of endodontic treatment, July 2002.

approximate the mesial pulp horn (Fig. 3). Cold testing elicited a painful and lingering reaction and percussion testing yielded a normal response. In addition to the radiographically evident decay, it was noted that both the mesial and distal roots had incomplete apical root formation with wide-open apices. A diagnosis of irreversible pulpitis was made. It was deemed to be highly desirable in this case to keep the radicular pulp tissues "alive" in order to allow for continued root development and apical closure of the canals.

TREATMENT

After the administration of local anesthetic, the tooth was isolated with the rubber dam and the decay was carefully removed using a high-speed handpiece with water spray. After removal of all the carious dentin, a large exposure of the pulp was observed. A complete pulpotomy was performed in the hopes of removing all of the infected and inflamed pulp tissue. The coronal pulpal tissue was removed using diamond burs with copious water spray. The chamber was rinsed with water spray and time was allowed for the bleeding to stop. The chamber was once again lightly rinsed in an attempt to remove any blood clots from the surface of the remaining pulp tissue. Once hemostasis was achieved, a thick mix of calcium hydroxide paste was placed over the exposed pulp tissue at each canal orifice. IRM™ (Dentsply International Inc, Milford, DE) was placed as a base material over the calcium hydroxide and then a light cured glass ionomer material was used as the coronal restoration.

The patient was then monitored clinically and radiographically, every 3 months, to assess for continued tooth development and for signs or symptoms of pulp necrosis, root canal infection, root resorption or periradicular pathosis. At the 18-month recall examination, the radiograph revealed completed tooth development and the appearance of calcification in the coronal portion of the distal canal (Fig. 4). Therefore, conventional endodontic treatment was initiated on this tooth. The canals were explored and initially instrumented with small K-files in the presence of sodium hypochlorite. Completion of the instrumentation was performed with ProFile Series 29/.06™ taper NiTi rotary files (Dentsply,Tulsa Dental, Tulsa, OK) used in a crown-down fashion. Irrigation was accomplished with repeated rinses with 5.25% sodium hypochlorite and anhydrous 200 proof USP ethyl alcohol. The final irrigation was performed with sodium hypochlorite, ethyl alcohol and then 17% EDTA. Each irrigant was each activated with the use ultrasonic files for 10-15 seconds. The canals were then dried with sterile paper points and obturated using gutta-percha master cones with Kerr Pulp Canal Sealer, EWT™ (SybronEndo, Orange, CA). The System-B™ unit (SybronEndo, Orange, CA) served as the heat source for the continuous wave down-pack technique, and the Obtura II™ (Obtura/Spartan, Fenton, MI) was used for backfilling the canals. The access cavity was then restored with Ketac-Molar Glass Ionomer™ (ESPE America, Inc., Plymouth Meeting, PA) restorative material. A post-operative radiograph was taken (Fig. 5). This radiograph demonstrates the completely formed root apices that allowed for containment of the obturation materials within the confines of the root canal system.

CONCLUSION

A case was presented in which extensive decay necessitated endodontic intervention of an inflamed and exposed dental pulp in an incompletely developed permanent molar tooth. The radicular pulp tissues were maintained in a vital state by performing a calcium hydroxide pulpotomy, which allowed complete root formation to take place (apexogenesis). Once apical closure was judged to be complete, the root canal therapy was performed under more optimal conditions.

As such, the long-term retention of this tooth is anticipated. **OH**

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Oral Health welcomes this original article.

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