Regenerative Treatment of an Immature, Traumatized Tooth With Apical Periodontitis: Report of a Case

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Abstract
This case report describes the treatment of a necrotic immature permanent central incisor with complete crown fracture, suspected root fracture, and sinus tract, which was not treated with conventional apexification techniques. Instead, a regenerative approach based on the trauma literature’s methods for revascularization was provided. The root canal was gently debrided of necrotic tissue with a sharp spoon excavator and irrigated for only one third of its length with NaOCl and then medicated with calcium hydroxide. After 15 days the sinus tract had healed, and the tooth was asymptomatic. The tooth was accessed, calcium hydroxide was removed, bleeding was stimulated to form an intracanal blood clot, and mineral trioxide aggregate was placed coronally to the blood clot. After 8 months, a coronal calcified barrier was radiographically evident and accompanied with progressive thickening of the root wall and apical closure. Two and a half years after treatment was initiated, the tooth remained asymptomatic, and the sinus tract had not reappeared. The progressive increase in the thickness of the dentinal walls and subsequent apical development suggest that appropriate biologic responses can occur with this type of treatment of the necrotic immature permanent tooth with sinus tract. (J Endod 2008:34:611–616)

Key Words
Apical periodontitis, open apex, regeneration, revascularization

The traumatic injury of an immature permanent tooth can lead to the loss of pulp vitality and arrested root development. The consequences of interrupted development include a poor crown-root ratio, a root with very thin walls, an increased risk of fracture, and an apex that is open. The traditional endodontic management of such cases typically includes debriding the root canal, disinfecting the space, and final obturation of the system preceded either by an apexification procedure or by developing an apical barrier by using materials such as mineral trioxide aggregate (MTA) (1–4). The apexification clinical procedure, which consists of applying calcium hydroxide as an intracanal medication to induce an apical closure over time, has a certain predictability of success (1–5). Its disadvantages are the necessity of multiple visits during a relatively long period of time (an average of 12 months) and the fact that there is no expectation that the root canal walls will be strengthened (3, 5).

An alternative to traditional apexification is to place an artificial barrier at the apex to prevent the extrusion of filling materials during obturation. The material of choice is MTA for its sealing ability and its biocompatibility (4). This latest technique is convenient because it is faster than the traditional apexification. The case can be finalized within 2 appointments, and a hard tissue barrier eventually forms against the MTA (4). However, even this alternative approach has the same disadvantage of a tooth with thin dentinal walls and no further root development.

The ideal treatment to obtain further root development and thickening of dentinal walls in an immature tooth with apical periodontitis would be to stimulate the regeneration of a functional pulp-dentin complex (6–8). This outcome has been observed after reimplantation in avulsed immature permanent teeth (9). It has been proposed that reimplantation of the tooth with an open apex permits coronal proliferation of tissue, leading to replacement of the necrotized pulp and subsequent continued development of the root (9). Although the histologic identity of this pulp-like tissue is generally unknown, radiographic presentation often includes progressive thickening of the dentinal walls and apical closure. Some reports, mostly published in recent years, have shown that even the immature permanent tooth with nonvital pulp and apical periodontitis can undergo pulp regeneration or revascularization (6–8). Because the term regeneration is based on clinical and radiographic outcomes and not histologic or biochemically based assessments, one can only make a clinically functional interpretation of the healing process. It is not known whether a complete pulp-dentin complex has been regenerated. However, once the regeneration protocol is completed, these teeth can continue to develop, with the radiographic presentation of full tooth development and the clinical presentation of an asymptomatic functional tooth.

The typical revascularization protocol advocates that the immature tooth, diagnosed with apical periodontitis (7), should be accessed and irrigated with either 5% NaOCl + 3% H2O2 (7) or 5.25% NaOCl (8) and PeridexTM (Procter & Gamble, Cincinnati, OH) (6). An antimicrobial agent (either an antibiotic such as metronidazole + ciprofloxacin (7) or ciprofloxacin + metronidazole + minocycline (6) or Ca (OH)2 (8)) should be then applied into the root canal system, and the access cavity is sealed. After an average of 3 weeks, in the absence of symptoms, the tooth is re-entered, the tissue is irritated until bleeding is started and a blood clot produced, and then MTA is placed over the blood clot (6), and the access is sealed. Within the next 2 years a gradual increase in root development can be observed (6–8).

In the present case report, we describe the use of this protocol to stimulate the continued root development in a case of trauma-induced necrosis and sinus tract of an immature permanent central incisor.
Case Report

A 9-year-old girl presented at the Department of Conservative Dentistry and Endodontics of the University of Cagliari. The patient was accompanied by her mother, who reported that her daughter had suffered a traumatic injury to the maxillary central incisors about 1 month earlier. She did not have symptoms immediately after the accident, but subsequently she reported losing coronal fragments from the maxillary right central incisor. They then decided to visit a dentist. The medical history of the girl was not remarkable. The clinical examination revealed the fracture of most of the crown with pulp exposure in the right maxillary central incisor. Several crown fragments remained but were clearly fractured (Fig. 1). In addition, a sinus tract was present in the buccal mucosa, roughly corresponding to the apical third of the root (Fig. 2). A fracture also involved the incisal third of the crown of the left maxillary central incisor, with a small pulp exposure. The patient was asymptomatic, and sensitivity testing with cold elicited a negative response from the upper right central incisor and a positive response from the left central incisor. Tooth #8 was also sensitive to percussion and palpation tests; tooth #9 was not. Radiographic examination showed that both the roots were immature with open apices. The right central incisor had a small lateral apical radiolucency, and the image suggested the presence of a root fracture in the apical third (Fig. 1, arrows). The prognosis of the left central incisor was good, and it was decided to perform a shallow pulpectomy with a permanent restoration.

The prognosis of the right central incisor appeared highly unfavorable because of the combination of the following problems: (1) complete fracture of the crown, (2) pulp necrosis; (3) immature root with open apex, and (4) the radiographic appearance of a fracture of the apical third of the root (in the area where the sinus tract was traced). It was decided that attempting to perform an apexification (and therefore instrumenting the root to length) would seriously compromise the structural integrity of the tooth, possibly leading to a split tooth. It was then decided to attempt a pulp regeneration procedure.

The mother was informed that the treatment of the right central incisor (#8) would be an attempt to extend the life of the root, and that this treatment might not be effective either in the short-term or in the long-term. A special informed consent was therefore signed. Under local anesthesia and rubber dam isolation, the left maxillary central incisor pulp horn was disininfected by using a cotton pellet saturated with 5.25% NaOCl, and a very shallow pulpectomy was done, with application of Ca(OH)₂ powder followed by a drop of light-cured glass ionomer cement. The tooth was restored with temporary cement and subsequently restored with a bonded composite resin. Then the residual coronal fragments were removed from the right maxillary central incisor, and the access cavity was prepared (Figs. 2 and 3). The pulp tissue was removed mechanically for approximately 1/3 of the root length by using a small and very sharp spoon excavator. The tissue did not appear to be vital, and no bleeding could be observed. The coronal part of the canal was then irrigated with 5.25% NaOCl alternated to 3% H₂O₂; it was dried with a cotton pellet, and a Ca(OH)₂ powder medication was placed in contact with the soft tissue in the root canal by using a #10 Schilder’s plugger. The access cavity was sealed with a cotton pellet and a provisional restoration (Cavit; ESPE, Chergy Pontoise, France).

The patient was seen the next week, and she was asymptomatic. One week later, the patient returned to the clinic for the third appointment. Both teeth were asymptomatic, not sensitive to percussion or palpation, and the sinus tract had disappeared (Fig. 4). Tooth #8 did not respond to cold sensitivity test. Tooth #8 was then isolated with the rubber dam and reaccessed. Calcium hydroxide was removed by irrigation with 5.25% NaOCl, and after drying of the space, bleeding and the formation of a blood clot were stimulated. Then MTA (Pro-Root MTA; Dentsply Maillefer, Baillagues, Switzerland) was condensed for approximately 3 mm by using a Schilder’s plugger and an ultrasonic tip for 10 seconds; it was covered with a moist cotton pellet, and the access was sealed with Cavit.

When the patient returned 1 week later for her fourth appointment, a glass ionomer sealer was placed against the MTA cement, and
the tooth was restored with an adhesive composite resin. The crown was not completely restored in its anatomy as a result of a lack of retention and the desire to minimize masticatory forces applied to the tooth. It was explained to both the mother and the young girl that this would be the best option to allow the root to undergo further development (Fig. 5).

At the recall appointments (3, 6, 12, 18, 24, and 30 months), the patient was always asymptomatic, the sinus tract over the right central incisor did not reappear, and the radiographic presentation of the root fracture healed. The intraoral radiographs taken at each evaluation showed a good condition of the periapical tissues, with the continued development and closure of the root apex.

After 8 months from the beginning of treatment, it was clear that the situation was stabilized. It was also possible to observe the radiographic presence of a hard tissue bridge under the MTA in the coronal portion of the root. The cold sensitivity, percussion, and palpation tests were performed at each visit, but the response of the maxillary right central incisor was always negative. At this time, a better composite coronal restoration was placed on the tooth by using dentin pins. The tooth has remained functional with continued root development including increased dentinal wall thickness (Figs. 6–8).

Discussion

The traditional approach for treating this case of a necrotic immature permanent tooth with sinus tract would have been either apexification with calcium hydroxide medication or apexification with MTA (3, 4). However, the apexification treatment does not lead to a further thickening of dentinal walls or an increased root length. Moreover, complete instrumentation of the root canal system would have prevented any possible repair of a horizontal fracture (1, 3). A more conservative approach for this type of case would be to perform a regenerative procedure by not instrumenting the root canal and instead using only copious irrigation and the application of antimicrobial agents to preserve any remaining vital pulp tissue in the apical region. The outcome of the conservative treatment depends on the type and duration of the infection, the state of the pulp at the time treatment is started, the host, and the size of the open apex (8, 9).

The chance for revascularization of a reimplanted tooth increases by 18% if the apex is open >1.1 mm, and the tooth is reimplanted within 45 minutes (9). Iwaya et al (7) reported a case of an immature tooth with an open apex, periapical radiolucency, and sinus tract that responded with gradual root development during a 30-month follow-up period. In that case, the root canal was not mechanically cleaned to its
full length because of the patient’s sensitivity reaction to the insertion of a small broach. This observation suggested that some residual vital pulp tissue remained within the canal. In the first visit, the tooth was left open to permit the drainage of blood and purulent exudate. During the second to the fifth weekly visits, the canal was irrigated with 5% NaOCl and 3% H₂O₂, without any instrumentation. Metronidazole and ciprofloxa-
cin paste were used as an intracanal medication. At the fifth visit vital tissue was observed 5 mm apical to the root canal orifice. At the sixth visit, calcium hydroxide was placed in contact of the pulp, and the access cavity was sealed with glass ionomer cement and adhesive composite resin. Fifteen months later, the canal was reopened, and with an explorer it was possible to percuss a hard tissue bridge at the level of the orifice. Radiographic examination revealed progressive apical closure and an increase of the thickness of the canal walls. Thirty months after the initial treatment, there was a complete closure of the apex and a thickening of the root walls, with a reduction of the pulp space.

Banchs and Trope (6) applied a similar treatment in a case of immature tooth with open apex and sinus tract by applying a mixture of ciprofloxacin, metronidazole, and minocycline into the root canal system with a Lentulo spiral. At the next visit 26 days later, an endodontic explorer was used to irritate the tissue at 15-mm depth to create bleeding inside the canal. Then MTA was placed over the blood clot, and the tooth was restored. At 2-year follow-up there was closure of the apex and thickening of the dentinal walls. Interestingly, the tooth responded positively to the cold test.

Chueh and Huang (8) recently reported 4 clinical cases of immature teeth with periradicular periodontitis or abscess. The teeth were treated without instrumentation; instead, they were treated by irrigation with 2.5% sodium hypochlorite and application of Ca(OH)₂ paste medication. All 4 cases developed mature apices with increased root length and dentinal wall thickness after 7 months–5 years.

In the present case report the treatment choice was dictated by the many different problems present in the involved tooth. The crown was nonexistent, the sinus tract corresponded to the apical area where a root fracture was suspected, the root was short, and the apex was open. Traditional endodontic techniques including root canal instrumentation were not considered practical under these conditions. Calcium hydroxide was the medication of choice because of its known properties (1, 3) and because no other medication was available at that particular time in the Department because a revascularization protocol was not yet established. To obtain the best conditions within the endodontic system, copious irrigation of NaOCl (5.25%) and H₂O₂ (3%) was applied to maximize the chances for disinfection of the exposed root canal surface followed by application of Ca(OH)₂ and subsequent placement of MTA (10) once the sinus tract healed. This conservative treatment has resulted in the healing of the sinus tract and radiographic resolution of the possible root fracture, continued thickening of the root wall, and subsequent apical closure and formation of a coronal dentinal bridge. Although these outcomes provide initial measures of successful healing, it should be appreciated that the apex has not developed in the same way as the contralateral incisor (Fig. 6C).

The outcome of all these cases reported so far might have different possible explanations. The pulp was necrotic, and the therapy has produced a regeneration of a functional pulp-dentin complex; the thickening of the root canal walls and the closure of the apical foramen could be achieved by periodontal ligament tissue that grew into the canal and deposited cementum into the inner surface of the root dentin (8, 11); or the pulp was partially necrotic, and the treatment simply produced a deep pulpotomy with subsequent root development as a result of a healthy pulp-dentin complex (12).

In the first hypothesis, the outcome can be explained with survived pulp tissue, even in the presence of apical periodontitis and sinus tract, probably because of the rich blood supply through the wide open apex. It has been observed that in mature teeth there might be still remaining vital pulp tissue even when a periradicular lesion is developed (13).
addition, dental pulp of permanent teeth contains a population of stem cells that might provide a source of newly differentiated odontoblasts (14, 15). In the case of an immature tooth, stem cells have been recently described in the apical papilla that possess the ability to proliferate and form odontoblast-like cells (15). The apical papilla is a very specific stem cell tissue formation that is located apically to the differentiated pulp tissue of the developing tooth, and these stem cells are called stem cells from the apical papilla (SCAP). The apical papilla has the potential of remaining undamaged because it is loosely connected to the dental pulp and has therefore a greater potential to regenerate the pulp tissue and continue the root maturation (15). The presence of the blood clot might help the situation by acting as a scaffold (14).

In the second hypothesis, the radiographic appearance of increased root thickness might be due to the ingrowth of hard tissue (cementum, bone) (8, 11, 16). This outcome could not be considered a regenerative reaction of the pulp-dentin complex.

In the third hypothesis, the root development is simply the consequence of a very deep pulpotomy, and this would require us to carefully reconsider our ability to make a differential diagnosis between a vital, a partially vital, and a nonvital pulp.

If the first hypothesis is correct, then it would appear that if we provide a favorable disinfecting condition within the root canal system of immature teeth with apical periodontitis, then it is possible to obtain regeneration of a functional pulp-dentin complex. Because most treatments used and described so far in successful revascularization cases are different from each other (6–8), it is clear that there is some urgency to establish the most predictable protocol to treat these teeth. On the other hand, if we consider that the third hypothesis might be true, then we have to face the everlasting problem of making the correct diagnosis. There is a strong possibility that the response of the tooth to treatment in the present report would be indicative of an apexogenesis, but because the signs and symptoms were clearly referred to a necrotic pulp and periapical pathosis, the possibility of a regeneration coming from residual embryonic tissue at the apex is still to be considered.

Collectively, this emerging body of case reports can serve as a rationale for conducting future prospective clinical trials comparing conventional endodontic treatment procedures versus regenerative endodontic treatment procedures in clinical conditions of the necrotic immature permanent tooth.

The potential great advantage of providing a biologically based procedure that permits continued root development should be balanced with an informed knowledge of relative advantages and potential risks.

References