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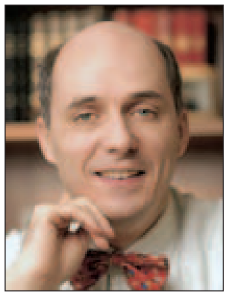
Apexification and coronal restoration after traumatic tooth avulsion: a 10 year follow-up



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This case report looks at a case of traumatic avulsion and subsequent apexification of a maxillary permanent incisor of a 6-year-old boy and a 10-year follow-up is reported. Treatment included apexification of the tooth with incomplete root formation using mineral trioxide aggregate and restoration of the immature root with a zirconia post and a coronal composite restoration. At the 10-year follow-up the tooth was asymptomatic, functional and showed radiographically intact periapical tissues.

Introduction

Dental injuries are very common in children and adolescents. According to Trope[1] the maxillary central incisors are the most frequently avulsed teeth in both the permanent and primary dentition. When a tooth is avulsed, the attachment apparatus of the root (periodontal ligament and the cemental layer) is damaged and the blood vessels at the apex of the tooth are severed, rendering the pulp necrotic[2]. Treatment is directed at minimising damage and inflammation of the periodontal membrane. In the tooth with incomplete root development, the primary treatment goal must be to promote revascularisation of the pulp tissue. In non-vital immature teeth with open apices, a number of difficulties for adequate endodontic therapy are present. The lack of an apical stop may lead to further trauma of the periapical tissues due to overextended root canal fillings and may also lead to three-dimensionally underfilled root canals prone to leakage[2]. An apexification treatment procedure is indicated in such cases. Long-term apexification with calcium hydroxide dressings has been performed with reasonable success[3]. The aim of this treatment mode is to induce the formation of a hard tissue barrier at the apex so that a root canal filling material can be properly introduced without the risk of over-extension[4]. The disadvantage of using calcium hydroxide for apexification is that it can take several months to obtain a physiological hard tissue apical barrier. The patient is required to present for treatment at multiple times and, in addition, these teeth are susceptible to fracture during treatment[2,4]. It has been demonstrated that the long-term use of calcium hydroxide can

Fig 1 Intraoral view during clinical examination two and a half weeks after the trauma . A sinus tract was present about 4 mm below the buccal-gingival margin of tooth 21.

weaken dentine and make teeth even more susceptible to fracture[5]. Mineral trioxide aggregate or MTA (Pro Root, Dentsply, Konstanz, Germany) has proved to be a potential root-end filling material. *In vitro* and *in vivo* studies have demonstrated the good sealing ability of this material, its excellent biocompatibility and low cytotoxicity, and also its effect on the induction of odontoblast activity and on the formation of a hard-tissue barrier[6-10]. Meanwhile, clinical studies have confirmed the high regenerative potential of MTA, thus justifying its use for creating an apical barrier in teeth with immature roots[11,12].

The aim of this report is to describe the treatment of an avulsed immature permanent incisor submitted to apexification with MTA, and the subsequent coronal restoration and long-term results.

■ Case report

A 6-year-old boy with no general health problems was referred to the author's endodontic office on July 6th 1999 for treatment of tooth 21. About 2.5 weeks previously, the boy had suffered an injury while rollerblading. He had hit the ground and avulsed his maxillary left central incisor (June 19th 1999). His father had recovered the tooth from the ground, wrapped it in a napkin and the boy had immediately seen the family's clinician. Following a clinical examination, it was confirmed that there were no other injuries present and the socket and the tooth was rinsed with sterile saline, and the tooth replanted. According to the patient's father, the extra-oral dry time was about 45 minutes. No antibiotic coverage and no splinting of the tooth had been performed. The patient saw his physician immediately after the replantation and a tetanus booster was administered.

The clinical examination 2.5 weeks after the trauma (Fig 1) revealed that teeth 11 and 21 were partially erupted, slightly protruded and rotated. A sinus tract was present about 4 mm below the buccal gingival margin of tooth 21 (Fig 2). Enamel craze lines in tooth 11 were clearly visible using transillumination. All other teeth were intact and free from caries. Periodontal tissues appeared healthy. The pocket depths of tooth 11 were 2 mm on the buccal, palatal, distal and mesial aspects. Sound periodontal probing was not performed for tooth 21 as it had been replanted shortly. No mobility of the adjacent teeth was present with exception of tooth 21, which showed grade 1 to 2 mobility.

In the clinical tests tooth 21 was slightly tender to palpation, percussion and biting pressure. Tooth 11 showed a delayed response to cold, heat, and electric pulp testing (Vitality tester, Analytic, Orange, CA, USA: threshold reading 67/80). Tooth 21 did not respond to any of the sensibility tests used. Periapical radiographic examination (Fig 3) showed the immature open apices of teeth 11 and 21, an intact periodontal ligament of tooth 11, as well as evidence of an inflammatory root resorption in the apical part of tooth 21.

A diagnosis of pulp necrosis and asymptomatic apical periodontitis was made for tooth 21. The following treatment plan was presented to the parents: apexification followed by non-surgical root canal therapy of tooth 21. As an alternative approach the extraction of tooth 21 followed by orthodontic treatment was discussed. The restorative treatment plan included a bonded composite restoration and a custom-made mouthguard. The parents were informed about the questionable prognosis of the tooth.

On July 7th 1999 treatment was started. Local anaesthesia was administered (1.8 ml of 2% lidocaine HCL [36 mg] with 1:100,000 adrenaline [0.018 mg]). Rubber dam was fixed with dental floss, isolating teeth 21 and 11. Using a surgical operating microscope an access cavity was prepared. Ultrasonically activated irrigation was performed with 0.5% sodium hypochlorite. Cleaning and shaping were performed using Gates Glidden drills #2 to #5 and K-type hand files. Root canal length was determined with an electrical apex locator (Root ZX, Morita, Tokyo, Japan) and the result was confirmed radiographically with a size 120 K-file (Fig 4).

Fig 2 Preoperative radiograph, sinus tract traced with a gutta-percha cone, July 6th 1999.

Fig 3 Preoperative radiograph, July 6th 1999, showing the immature open apices of teeth 11 and 21, an intact periodontal ligament of tooth 11 as well as evidence of an inflammatory root resorption in the apical part of tooth 21.

Fig 4 Working length radiograph, July 7th 1999. Root canal length was determined with an electrical apex locator (Root ZX, Morita, Tokyo, Japan) and the result confirmed radiographically with a size 120 K-file.

An aqueous calcium hydroxide suspension was packed with Schilder hand pluggers (Dentsply) and the access cavity was sealed with glass-ionomer cement (Ketac Molar, Espe, Seefeld, Germany). After removal of the rubber dam, the occlusion was checked and the patient was rescheduled for a 3 month radiographic check and replacement of the calcium hydroxide dressing if necessary. Ibuprofen 200-mg was prescribed every 6 hours if post-operative pain meant an analgesic was required.

At the second visit (September 10th 1999), the patient reported that the sinus tract initially had resolved, but had reappeared the previous week. After local anaesthesia with 1.8 ml of 2% lidocaine HCL (36 mg) with 1:100,000 adrenaline (0.018 mg), rubber dam (clamp #9T, Hu Friedy, Leimen, Germany) was applied. Under the microscope the calcium hydroxide intracanal dressing seemed to have been washed out. Gentle irrigation with 0.5% sodium hypochlorite activated by ultrasonics was performed. Cleaning and shaping to the working length was repeated, the foramen was probed with a size 150 Kerr hand file. There was no evidence of an apical barrier. Calcium hydroxide was again packed with Schilder hand pluggers and the access cavity sealed with glass-ionomer cement. The calcium hydroxide dressing was checked radiographically (Fig 5). The patient was rescheduled for a 3 month check and replacement of the calcium hydroxide dressing was carried out if necessary. Ibuprofen (200 mg) was prescribed every 6 hours (if necessary) for pain control.

At the following visit (January 4th 2000) the tooth was asymptomatic and the sinus tract was closed. After local anaesthesia and isolation using rubber dam (as previously described) the access to the root canal was reopened under the microscope. The calcium hydroxide dressing seemed washed out again and ultrasonically activated irrigation with 0.5% sodium hypochlorite cleaning and shaping to working length using K-type hand files was repeated. There still was no evidence of a hard-tissue barrier. The final irrigation consisted of a 17% EDTA rinse followed by sodium hypochlorite. The root canal was dried with sterile paper points. MTA was placed into the apical 5 mm of the canal under control with the surgical microscope (Fig 6) using a MTA carrier (Dovgan Carrier, Quality Aspirators, Duncanville, TX, USA) and condensed with Schilder hand pluggers and ultrasonics. A moistened cotton pellet (2% chlorhexidine) was placed over the material. The access cavity was closed with glass-ionomer cement. A prescription for 200 mg of ibuprofen every 6 hours as needed for pain was given to the boy's parents.

On January 21st 2000, rubber dam was applied, the temporary filling was removed, and the hardness

Fig 5 Control of the density and extension of the intracanal dressing with calcium hydroxide, September 10th 1999.

Fig 6 Root canal filling with MTA (January 4th 2000) was placed into the apical 5 mm of the canal with Schilder pluggers under control with the surgical microscope.

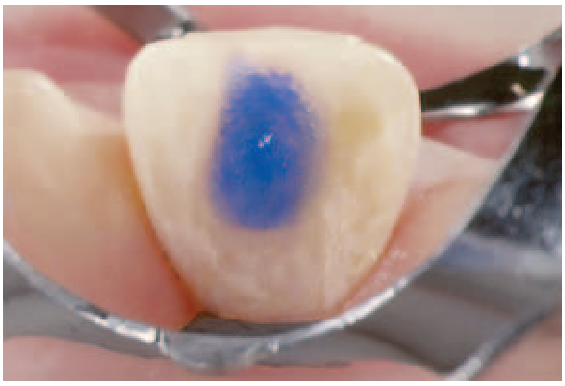

Fig 7 Conditioning of the enamel with phosphoric acid, January 21st 2000.

Fig 8 Adhesive fixation of the zirconia post with composite, January 21st 2000.

of the MTA was checked under the microscope with a sharp explorer. A zirconia post (Cerapost, ISO 110, Komet, Lemgo, Germany) was adhesively fixed into the wide root canal to strengthen the fragile root. The largest available post was inserted in an upside-down direction due to the very wide diameter of the canal. The enamel was etched by applying 34% phosphoric acid for 60 seconds (Fig 7), followed by irrigation with sterile saline. A dentine-bonding agent (Clearfill, Morita, Kuraray, Japan) was applied, and a size 3 zirconia post (Fig 8) was adhesively fixed (Panavia TC, Morita, Kuraray, Japan). The access cavity was sealed with a composite (Fig 9), (Herculite, Kerr, Romulus, MI, USA), the occlusion was checked and a postoperative radiograph was taken (Fig 10).

Six months later (July 11th 2000), a recall check was done by the family clinician. The tooth was asymptomatic. The periapical radiograph showed an intact periodontal ligament with some type of osseous-like tissue forming apically to the MTA (Fig 11). Periodontal tissues appeared healthy, pocket depths were 2 mm on the buccal and distal, and 1 mm on the palatal and mesial aspects and no increased tooth mobility was present.

On June 27th 2002, the patient was scheduled for a further recall appointment with his clinician. The tooth was still asymptomatic. Radiographically, some osseous

Fig 9 Access cavity sealed with composite, January 21st 2000.

Fig 10 Post-operative radiograph, January 21st 2000.

Fig 11 Recall radiograph, July 11th 2000.

Fig 12 Recall radiograph, June 27th 2002.

Fig 13 Recall radiograph, June 27th 2002.

structure had formed apically to the MTA, which had taken a root-like shape, to the extent that a lamina dura appeared to have formed (Figs 12 and 13). The periodontal tissues appeared healthy, pocket depths were 2 mm on the mesial and distal, and 1 mm on the palatal and buccal aspects, and no increased mobility was present. In the meantime, the patient underwent orthodontic treatment with braces and wires.

On April 24th 2006, the patient was scheduled for another recall appointment. The tooth was asymptomatic. Apically to the root-like structure exhibiting a normal periodontal ligament, there was another radioopaque area followed by a radiolucent zone (Fig 14). The periodontal tissues showed local gingivitis around the labial aspect of tooth 21, pocket depths were 3 mm on the mesial and distal, and 1 mm on the palatal and 2 mm on the buccal aspect, no mobility was present.

A 10-year recall check was performed by the patient's clinician on January 5th 2009. The tooth was asymptomatic. The periapical radiograph showed an intact periodontal ligament surrounding the root-like structure apically to the MTA (Fig 15). Periodontal tissues appeared healthy, pocket depths were within normal limits and no increased tooth mobility was present. The clinical crown of the tooth appeared slightly discoloured (Fig 16).

Fig 14 Recall radiograph, April 24th 2006.

Fig 15 Recall radiograph, January 5th 2009.

Fig 16 Intraoral view January 5th 2009.

Discussion

Although the tooth was not replanted within the first 20 minutes after avulsion, the root exhibited almost no external resorption, even 10 years after the trauma. Perhaps even revascularisation as well as continued root development would have been possible if the most recent treatment protocols[13-15] had been followed. Regenerative endodontics promotes a paradigm shift in treating endodontically involved immature permanent teeth. This ranges from performing apexification procedures to conserving any dental stem cells that might remain in the disinfected viable tissues so as to allow tissue regeneration and repair to achieve apexogenesis/maturogenesis[16].

Recent studies showed that soaking the tooth in doxycycline[17] or covering the root with minocycline[18] significantly enhanced revascularisation in dogs.

The apical barrier technique using MTA seems very promising in traumatic tooth injuries with open apices[11,12]. As MTA has been found to be able to ensure a tight closure of an apical foramen and to promote cementum coverage directly upon the MTA surface, a double seal of the root canal can be achieved[6-9]. Short-term placement of calcium hydroxide in the root canal with the purpose of disinfecting the root canal and dentinal tubules, dissolving pulp remnants and also drying up the apical zone before obturation of the root canal with MTA, appears to be a good alternative to the long-term use of calcium hydroxide from a mechanical point of view (fracture resistance)[19]. However, further prospective long-term outcome studies should be designed to compare this procedure with the traditional calcium hydroxide technique.

Reinforcement of the thin dentinal walls seems to be critical in these cases. According to Kerekes et al[4], approximately 30% of these teeth will fracture during or after endodontic treatment. Therefore, it is recommended that intracoronal adhesive restorations are placed to strengthen these teeth internally[20]. The use of a bonded all-ceramic high-toughness post made of zirconia may have helped to increase the fracture resistance of this fragile tooth and to improve the aesthetic outcome when compared with non-precious alloy posts (which may have lead to discoloration of the tooth)[21]. However, the future may be in the restoration of these teeth with tooth-coloured bonded fibre posts exhibiting almost the same modulus of elasticity as dentine and being easier to remove in cases of fracture[22].

Considering the alternative treatment options discussed earlier, the patient and his parents highly appreciated the advantages of the endodontic approach, especially in the long-term, as this meant high patient comfort, an acceptable aesthetic outcome and reasonable treatment costs.

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