Combination of Revascularization and Apexification in the Treatment of an Avulsed Tooth: A Case Report

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ABSTRACT

Aim: To demonstrate an exceptional result in the treatment of an avulsed tooth that had been stored in a dry environment for over 2 hours before being replanted.

Background: Sixteen percent of all traumatic injuries to the permanent dentition are avulsions. Maxillary central and lateral incisors are most commonly affected.

Case description: In this report, a 7-year-old girl sustained trauma to the upper right maxillary incisor during a bicycle accident. The tooth was avulsed and remained outside the oral cavity for more than 2 hours in a dry napkin before eventual reimplantation in the emergency room. Upon presentation to the endodontic clinic at the University of Southern California, the case was assessed, and the available treatment options discussed with the patient's parents. Revascularization using BC putty was the chosen mode of treatment. At a 6-month recall appointment, the patient presented with a sinus tract. A decision was then made to perform apexification using the mineral trioxide aggregate (MTA) as an apical filling material. To date, the tooth remains intact and functional.

Conclusion: Although both of the described treatment modalities are acceptable and commonly used in modern endodontics, apexification of a tooth following a failed attempt of a regenerative procedure has not been described. In this case, a chronic abscess formed and the ultimate goal of revascularization was not achieved. However, the performance of the revascularization procedure was not without benefit since it allowed the tooth to develop in both length, dentinal volume, and aided in the partial closure of the apical foramen. Additional studies are needed regarding the treatment of avulsed teeth. This case study may provide a viable treatment alternative in a number of clinical situations.

Clinical significance: The procedures described in this case report may be of clinical significance in the treatment and retention of teeth, which may otherwise be considered to have a poor prognosis and extracted.

Keywords: Apexification, Avulsion, Calcium hydroxide, Mineral trioxide aggregate, Revascularization.


INTRODUCTION

Anterior teeth are the most common part of the dentition to be traumatized during childhood.¹,² The frequency of the traumatic injuries to the dentition ranges from 13.8 to 15.1%.³,⁴ Depending on the severity of the trauma, concussion, luxation, fracture, or avulsion may occur, leading to necrosis of the pulp tissue and subsequent incomplete root formation in teeth traumatized at a young age.¹ Avulsion accounts for up to 16% of all traumatic injuries to the permanent dentition⁴,⁶ and maxillary central and lateral incisors are most commonly affected.³,⁶ The peak incidence of avulsion for the maxillary central incisors usually occurs between the ages of 7 years and 10 years.³,⁶ Endodontic treatment of permanent necrotic teeth with open apices is difficult and technique sensitive and actually harder than mature teeth given the fact that immature teeth are usually presented with blunderbuss canals and open apices.¹,² The goal of endodontic therapy is to eliminate pathogens and to prevent infection of the periapical tissues.⁷,⁸ In teeth with open apices, placement and control of filling materials is difficult due to the absence of the apical constriction that helps in containing these materials inside the tooth.¹,² External inflammatory root resorption or replacement resorption is also common sequelae of dental trauma.⁹ The limiting factor in the successful treatment of avulsed teeth is extraroot time spent outside the mouth. The risk of replacement resorption and inflammatory root resorption is mainly dependent on the duration of time between avulsion and reimplantation.¹⁰ The purpose of this case report is to present and track a case of a 9-year-old girl who presented with an avulsed maxillary central incisor that was left out of the mouth (socket) for more than an optimal length of time and stored in a less than optimal environment before eventual reimplantation. A 4-year recall of the
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**Case Description**

A 7-year-old female patient reported to the Department of Endodontics at the University of Southern California School of Dentistry with a chief complaint that she fell on face while she was bike riding and tooth 8 (following Universal Numbering System) was avulsed. The tooth was stored outside the mouth for more than 2 hours in a dry napkin before eventual reimplantation in an emergency room by the on-call resident. There was no reported loss of consciousness or altered mental status following the accident. It was verified through a thorough interview with the patient and the patient’s parents that tooth 8 was completely avulsed, and tooth 9 was subluxated. Tooth 8 was rinsed with saline and replanted. The anterior teeth were splinted. The time between avulsion and reimplantation was confirmed to be more than 2 hours. Clinical pictures were provided by the parents depicting the extent of the injuries (Fig. 1). The patient was referred to the endodontic department for further evaluation and treatment 2 weeks after the trauma. At that time, complete endodontic testing was done. Tooth 8 had no response to cold or electric pulp tester (EPT). The patient had slight tenderness to percussion and palpation with mobility grade +1. Radiographic evaluation showed incomplete root formation with a wide apical foramen (Fig. 2A). Tooth 9 responded normally to cold and EPT testing. The findings, risks, benefits, and alternative treatment options (including no treatment) were discussed with the patient and her parents. The patient’s parents fully understood that tooth 8 had a long-term poor prognosis since it was kept in a dry environment for more than 2 hours before reimplantation. The decision was made to attempt revascularization as a first line of treatment, despite the poor overall prognosis. The patient’s parents consented to the proposed treatment.

The standard strict protocol for revascularization by Law et al. was used. All endodontic procedures were performed using rubber dam isolation to assure proper asepsis, using an operating microscope (Carl Zeiss, Oberkochen, Germany), and checked for proper postoperative occlusion at each step. At the first visit, the patient was anesthetized with 2% lidocaine with 1:100,000 epinephrine. Endodontic access was performed, and the pulp verified as being necrotic. The canal was cleaned, residual pulp tissue removed as much as possible, and the canal irrigated using diluted NaOCl. The canal was filled with Ca(OH)₂ as an intracanal medicament and provisionalized with a cotton pellet and Fuji IX glass ionomer. A radiograph was taken to verify the placement of the calcium hydroxide (Fig. 2B). The parents were informed to contact the clinic if complications occurred before the next scheduled appointment and the patient discharged in a stable condition. At the second visit, the patient was doing well with no pain to percussion and palpation. The tooth mobility was within normal limits and the splint was removed. The patient was anesthetized with 3% carbocaine without epinephrine. Endodontic access was performed, and the cotton pellet was removed. The Ca(OH)₂ was irrigated from the canal using 17% EDTA. Bleeding was stimulated in the canal using a hand file, and was controlled at the cementoenamel junction (CEJ); BC putty (Bressler, root repair material) was placed over the blood, followed by a layer of glass ionomer to protect the BC putty. The tooth was then etched and bonded and a composite restoration was placed. A postoperative radiograph was taken (Fig. 2C) and instructions were given. The patient was scheduled for a 3-month follow-up. The parents were again informed to contact the clinic if any complication occurred. At the 3-month recall, a radiograph was taken showing formation of a dentinal bridge at the coronal portion of the canal and continuation of root formation at the apical portion of the root (Figs 2D and E). At the 6-month recall, the patient was asymptomatic (no pain on biting, percussion, or palpation). However, upon clinical examination, a sinus tract was noted and was traced with a gutta percha point to tooth 8 (Fig. 2F). In addition, there was no metallic sound upon percussion on tooth 8 indicating that there was no sign of ankylosed. Upon radiographic examination, there was a degree of root development suggesting that the intended procedure (revascularization) had worked until the canal was infected and that the process of root development ceased at that point. There were also some signs of root resorption. The patient was scheduled for a cone-beam computed tomography (CBCT) scan, which confirmed that the tooth was undergoing resorption (most likely inflammatory); it also elucidated the portion of the tooth that had developed following the regeneration procedure (Fig. 3A). A decision was then made to reopen the tooth, thoroughly clean the canal space, and place Ca(OH)₂ once again for 2 weeks and then reevaluate (Fig. 2G). After 2 weeks with Ca(OH)₂ in the canal, the patient was asymptomatic. There was no pain to percussion, palpation, or bite. Upon clinical examination, the sinus tract had resolved. A decision was then made to perform

Figs 1A to D: Clinical pictures immediately after placement of the avulsed tooth 8 and splinting
mineral trioxide aggregate (MTA) apexification. The patient was anesthetized with 2% Lidocaine with 1:100,000 epinephrine. Endodontic access was performed and the Ca(OH)$_2$ was removed using 17% EDTA and 4% NaOCl irrigation. The canal was dried, and a 4 mm white MTA plug (Dentsply, ProRoot MTA) was placed at the root apex (using a Collacote membrane as an apical barrier to contain the MTA). The MTA was covered with a moist cotton pellet, and the access was sealed with Fuji IX. A radiograph was taken to verify the placement and quality of the MTA plug (Fig. 2H). Postoperative instructions were given, and the patient was discharged in a stable condition. The patient was rescheduled in 2 weeks to continue her treatment. When the patient returned, no anesthesia was given. Access made and the cotton pellet removed. The MTA was verified as being completely set. Irrigation was performed using 17% EDTA and 4% NaOCl. The canal was then dried and obturated with the gutta percha and AH26 sealer using the warm vertical condensation technique. The access was etched and bonded and the tooth restored with a composite restoration. A postoperative radiograph was taken (Fig. 2I), postoperative instructions were given, and the patient was discharged in a stable condition and scheduled for a 6-month recall, with subsequent yearly follow-ups. Treatments were done by two different endodontists; one did the revascularization and the other did the apexification after failure of the first treatment. Figure 2J shows the subsequent 4-year recall with the tooth still in the mouth with a progression of healing. Upon clinical examination at the 4-year recall, the patient was asymptomatic with no pain on biting, percussion, or palpation; no evidence of ankylosis; and no significant mobility. A CBCT scan was taken (Fig. 3B) and showed signs of healing. Clinical pictures were also taken showing slight gray discoloration at the cervical area of tooth 8, which was retained, functional, and otherwise healthy (Fig. 4). A flow diagram of the treatment is provided in Flowchart 1.
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Discussion
The prognosis of avulsed teeth depends largely on the duration of time the tooth remains extraorally and how it is stored during that period. According to Andreasen, extra-alveolar time and the storage medium are the most important factors related to root resorption. After 60 minutes of dry storage, replacement resorption is very likely. After 30 minutes of dry time, inflammatory resorption is commonly encountered. The treatment options vary in the case of an avulsed tooth and can be dependent upon the stage of root formation. Apexification or revascularization procedures are considered as options in the case of an avulsed tooth with an open apex, while conventional root canal treatment is the option of choice in the case of an avulsed tooth with a completely formed apex. Apexification is performed to induce a calcific barrier in a root with an open apex or continued root development of an incompletely formed root in teeth with necrotic pulps. Revascularization is the restoration of the vascular supply to the pulp-dentin complex by triggering bleeding into an empty root canal space similar to a blood clot in surgical wound healing (no use of stem cells or growth factors). Giving the fact that the tooth in this case report was kept outside of the mouth in a dry environment for more than 2 hours, the expected prognosis would traditionally be very poor. The decision in this case to attempt revascularization was admittedly untraditional given the adverse set of circumstances. However, it was attempted as a last resort to create root growth and closure and to allow the patient every possibility to retain her tooth. Indeed, in the worst-case scenario, the tooth could be prepared for a decoronation procedure following any failed attempts at revascularization. To this end, the revascularization procedure was done following the strict guidelines described by Law et al. with the exception of the use of BC putty (a bioceramic) instead of MTA. Unfortunately, after 6 months of the treatment the procedure had not produced its desired goals and the patient came back with a sinus tract. There are several possible explanations for this failure, which include leakage, but are not limited to microleakage or the restoration. In addition, there is no concrete and accepted protocol for performing regenerative procedures on traumatized teeth. The resorptive processes that often accompany tooth avulsion may indeed be a hindrance to the success of regenerative endodontic procedures. In this case, when the treatment failed, a decision was made to reopen and reclean the root canal system. Fortunately, at that point, since there had been adequate root development to perform apexification predictably (as a result of the revascularization attempt), a decision was made to do apexification using white MTA instead of reattempting revascularization. The MTA is a biocompatible material that has shown to have superior results. Its major advantage is that MTA apexification does not require protracted treatment regimens, has superior sealing ability, and better antibacterial properties with a setting time of 3–4 hours with a pH of 12.5. The MTA acts by producing interleukins and cytokines that are released and can lead to the formation of the hard tissue. Currently, MTA apexification appears to be a more predictable procedure than revascularization.

Conclusion
Treatment of an avulsed tooth that has been subjected to less than favorable circumstances (extended extraoral time and severe desiccation) is questionable. In many cases, such teeth are not reimplemented. This case report outlines a method of treatment for such teeth, which may be viable. Revascularization in combination

Fig. 4: Four-year recall clinical pictures showing that the tooth is still in the mouth

Flowchart 1: Flow diagram of treatment

![Flowchart 1: Flow diagram of treatment](image-url)
with apexification may potentially be successful in these types of cases. It must be stressed that when doing revascularization, it is important to make sure that there is a tight coronal seal to prevent microleakage that might interfere with the treatment success and that the strict established protocol is followed. Apexification using MTA is a good alternative if revascularization fails or if there is enough root closure to contain the MTA. Additional studies are needed regarding the treatment of avulsed teeth. This case study may provide a viable treatment alternative in a number of clinical situations.

Reference