



Review Article

Tooth Avulsion – Comprehensive Management. A Review

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Abstract

Teeth trauma can lead to coronal and root fractures, subluxations, luxations, and avulsions. Avulsion is characterized by the complete displacement of the tooth from its socket, affecting the periodontal ligament, cementum, alveolar bone, gingival and pulp tissues resulting in necrosis of the pulp and root resorption. Managing avulsion is often found to be very complex, consuming a lot of time and clinical skills as well as expensive as it involves multi-disciplinary approaches like endodontics and periodontal treatment, surgical and minor orthodontic movements, and also an esthetic coronal restoration of the fractured or avulsed tooth. The present review provides a deep insight into newer clinical modalities for timely and suitable management of avulsed teeth and also elaborates the rationale behind their use.

Keywords: Avulsion; Emergency Management; Endodontic Treatment; Extra oral Dry Time; Young Permanent Tooth.

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How to Cite: Neel G, Dhingra SS, Singla IK, Kumar M, Chhabra P, Kumar S. Tooth Avulsion – Comprehensive Management. A Review. IDA Lud J –*le* Dent 2018;2(4):1-11.

INTRODUCTION

Dental trauma is relatively more common in children. Among the different types of dental trauma, management of avulsed teeth is one of the most challenging. Avulsion of tooth means total displacement of tooth out of its socket. Positive healing post-avulsion necessitates emergency intervention which should be followed up by timely evaluation and possibly further treatment at the required times during the healing period.

Avulsions occur most commonly in the permanent dentition of children aged 8 to 12 years when there is loosely structured periodontal ligament surrounding erupting teeth that often exhibit short, incompletely formed roots. The incidence reported for tooth avulsion usually ranges from 1 - 16% of all traumatic injuries found among the permanent dentition. Most cases of avulsion in children occur in the maxilla; with maxillary permanent central incisors being the most prevalent.¹ For primary dentition, subluxation injury is more common than avulsion.²

Tooth avulsion ultimately leads to attachment damage and pulp necrosis. Attachment damage is mainly due to the tearing of the periodontal ligament, thus separating the tooth from its socket, leaving viable periodontal ligament cells on most of the root surface. Damage to cementum can occur at a small-localised area due to this crushing/scraping of the tooth against the socket. Tooth avulsion can result in minimal negative outcomes and better prognosis if the periodontal ligament left attached to the root surface, does not dry out.^{3,4} The hydrated periodontal ligament cells will maintain their viability, allowing healing with regenerated periodontal ligament cells when replanted without causing much destructive inflammation. Also as the crushing injury is contained within a

localized area, inflammation is limited to the area, hence the healing will occur only after the initial inflammation has subsided.

However, if tooth is excessively dried before replantation, the damaged periodontium will produce an inflammatory response on the complete root surface which is difficult to repair. The slowly moving cementoblasts usually cannot cover the whole root surface and thus bone attaches itself directly to the root surface leading to replacement resorption.^{5,6}

Pulpal necrosis is unavoidable after an avulsion injury. The necrotic pulpal tissue is supposed to be extremely susceptible to contamination by the bacteria. This deadly amalgamation of microbes inside the root canal and the propensating cemental damage happening onto the external surface of the root does result in an aggressive external inflammatory resorption. Resorption continues till the microbes are present and can lead to rapid tooth loss post replantation.⁷

Thus, the prognosis of a replanted tooth and its maintenance on the dental arch for the longest possible time appear directly related to the severity and surface area of the inflammation on the root surface, and the resultant damaged root surface that must be repaired. Treatment strategies should always be directed at avoiding or minimizing the effects of the 2 primary complications: (1) pulpal infection; and (2) attachment damage, thus tipping the balance toward favorable (cemental) rather than unfavorable (osseous replacement or inflammatory resorption) healing.

Clinical Management

EMERGENCY MANAGEMENT AT SITE OF INJURY

Best Prognosis - It is best to replant the avulsed tooth immediately and atraumatically at the site of accident. This helps to prevent drying, which damages the periodontal ligament cells.^{4,8} All efforts to replant the tooth within the first 15 – 20min are fruitful.⁹ Immediate replantation will lead to minimal attachment damage and also the likelihood of revascularization for teeth with open apices is highest. For teeth with closed apices, immediate replantation greatly reduces any expected attachment damage, thereby suspending inflammatory root resorption (IRR) or osseous replacement resorption (ORR). Endodontic therapy for closed apex teeth, however, will still be required. In case, if the tooth cannot be reimplanted at the place of the accident or if doubt exists that the tooth cannot be replanted adequately, it should be stored in special storage media until the patient can get to the dental office for replantation.

Studies suggest preferred storage media in the following order; milk, saliva (vestibule) physiologic saline or water.⁽¹⁰⁾ Water is least desirable as the hypotonicity causes rapid cell lysis and inflammation after replantation,⁽¹¹⁾ but it can be used if any of the preferred media are not available. Cell culture media in specialized transport containers, such as Hank's Balanced Salt Solution (HBSS) or ViaSpan A, have shown superior ability in maintaining the viability of the periodontal ligament fibers for extended periods.⁽¹²⁾ One of the best and most available mediums in which to store an avulsed tooth is HBSS.^{12, 13} Communities should be prompted to include the HBSS in every first aid kit available in schools, gyms, summer camps, playgrounds, ambulances, and emergency rooms. However, they are generally not available at the site of the accident where injury is likely to occur. Considering the fact that more than 60% of avulsion injuries occur close to the home or

school¹³, it should definitely prove to be beneficial to keep them in emergency first aid kits.

Management In The Dental Office

Pre-operative assessment

The patient's general status should be quickly assessed to confirm that there are no higher-priority injuries. The focus of the emergency visit is the attachment apparatus. Delicate handling of the tooth, storage in an appropriate moist environment, quick replantation, and appropriate stabilization are all important in preserving the periodontal ligament. Undesirable periodontal ligament reactions may result in replacement resorption (ankylosis) or inflammatory resorption of the root. Either reaction may cause eventual loss of the tooth unless the resorption can be controlled.

Diagnosis and Treatment Planning:

If the tooth has been replanted before the patient's arrival at the clinic, a complete history is taken to assess the likelihood of a favourable outcome including the precise time interval between injury and replantation. If the parent cannot or will not replant it, the tooth must be kept moist during the trip to the dental office. Allowing the avulsed tooth to dehydrate before replantation is damaging to a favourable prognosis. Hank's Balanced Salt Solution, isotonic saline, and pasteurized bovine milk are the most favourable known storage media. If none of these solutions is readily available, human saliva is acceptable as short term substitute storage liquid. Although tap water has been a commonly recommended storage solution (and its use would be preferable to allowing dehydration of the tooth), saliva is better storage

medium. For longer storage period, only milk or saline are preferable. Because water is hypotonic, its use leads to rapid cell lysis and increased inflammation on replantation.

History and clinical examination:

The clinical examination should include an examination of the socket area. If it shows no evidence of alveolar fracture or severe soft tissue injury, the tooth is intact and only a few minutes have elapsed since the injury, the dentist should replant the tooth immediately. Facial and palatal palpation should also be done. Palpating the socket and adjacent apical area and finger pressure onto the neighbouring teeth are used as signs to ascertain an alveolar fracture. Rinse the socket with saline gently. If a clot is found to be present in the socket, it will be displaced by itself as the tooth is repositioned. In any case, the socket walls should not be scraped with an instrument. If the tooth does not slip back into position with relative ease when finger pressure is used, local anesthesia and a radiographic evaluation are indicated. Three vertical angulations of radiographs are required to find out if any horizontal root fracture is present in adjacent teeth.¹ The remaining teeth in both the jaws should also be examined for injuries, such as crown fractures, and any soft-tissue lacerations should be noted.

Preparation of the root

Preparation of the root is related to the maturity of the tooth (open vs. closed apex) and the condition of the periodontal ligament cells. The condition of the cells is depending on the storage medium and extraoral dry time. A dry time of 60min is considered the point where root periodontal ligament cells are non-viable.

Extra – Oral Dry Time < 60 Min

Closed Apex

Clean the root surface with a stream of water or saline thereby removing the debris and dead cells. Then replant the tooth as gently as possible. If the tooth has a closed apex, revascularization is not possible¹⁴ but, because the tooth was dry for less than 60 min (replanted or placed in appropriate medium), the chance of periodontal healing gets better and a severe inflammatory response at the time of replantation is less anticipated. A dry time of less than 15–20min is considered optimal where periodontal healing would be expected.^{3,4,9} A continuing challenge is the treatment of the tooth that has been dry for more than 20 min (periodontal cell survival is assured) but less than 60min (periodontal survival unlikely). Newer strategies that are currently under investigation may prove to be quite valuable in these cases. The use of Emdogain-A (Biora, Malmo, Sweden) has been found to be valuable in cases where tooth was considered hopeless in the past and this medicament may prove extremely valuable in the 20–60 minute dry time period. Studies are going on to evaluate its potential.

Open Apex

The tooth should be soaked in doxycycline for 5min, gently rinse off the debris and then the tooth should be replanted. In an open apex tooth, revascularization of the pulpas well as continued root development is possible. *Cvek et al*¹⁴ found that in monkeys, soaking tooth in doxycycline (1mg in 20ml saline) for 5 min before replantation enhanced the chances of revascularization significantly. This was confirmed in dogs by *Yanpiset et al*¹⁵. As with the tooth with the closed apex, the open-apex tooth is then gently rinsed and replanted.

Extra-oral dry time > 60 min

Closed Apex

Delayed replantation always has a poor long-term prognosis. The procedure is as follows: Remove the periodontal ligament by placing in citric acid for 5 min, soak in fluoride or cover the root with Emdogain A, then replant. As the root has been already dried for 60min or more, the periodontal ligament cells will be necrotic and not expected to heal.^{3,4} In these cases, the root should be prepared such that it has to be as resistant to resorption (attempting to slow the osseous replacement process) and the expected eventual outcome is ankylosis and resorption of the root and the tooth will be lost eventually. Such teeth need to be soaked in citric acid for minimum 5 min to remove any remaining PDL that can begin inflammatory response on replantation. After this, soak the tooth in 2% stannous fluoride for 5 min and then replant.^{16, 17} Aledronate was found to have similar resorption slowing effects as fluoride when used topically¹⁸ but further studies need to be carried out to evaluate whether its effectiveness is superior to fluoride and justification of its added cost. Recent studies have found that Emdogain A (enamel matrix protein) is extremely beneficial in teeth that have had an excessive extra oral dry time, not only in making the root more resistant to resorption but also to stimulate the formation of new periodontal ligament from the socket.^{19,20}

Endodontic intervention in delayed replantation cases may be performed extraorally. In case of a tooth with a closed apex, no advantage exists to this additional step during emergency visit. However, in teeth with open apices, if endodontic therapy is provided post replantation, it involves apexification. In these cases, completing the root canal treatment extraorally (aseptically)

is easier to achieve a seal in the blunderbuss canal.

Open apex

If replanted, treat as like closed apex tooth. Endodontic treatment may be performed extraorally. Since these teeth are in young patients whose facial development is usually incomplete, many pediatric dentists consider the prognosis to be so poor and the potential complications of an ankylosed tooth so severe, concluding that these teeth should not be replanted. In fact, International Association of Dental Trauma (IADT) presently recommends not to replant these teeth.²¹ However, considerable debate exists whether it would be beneficial to replant the root even though the tooth will be lost inevitably due to resorption. If patients are followed carefully and the roots submerged at the appropriate time^{22, 23}, the height and more importantly, the width of the alveolar bone will be maintained, allowing for easier permanent restoration at the appropriate time when the facial development of the child is complete. Studies should be carried out to evaluate whether the present recommendations to be followed or discontinued.

Socket Treatment

The alveolar socket should be examined and rinsed with a flow of saline to remove the contaminated coagulum if needed. If there is evidence of socket collapse or fracture, the socket should be recontoured as gently as possible using a blunt instrument such as a mirror handle to remodel the bony socket.

Splinting

Splinting helps to maintain the repositioned tooth in correct position, provide patient comfort and improve function. Splint should

allow physiologic movement of the tooth during healing as rigid stabilization seems to stimulate replacement resorption of the root.^{1, 24-26} Semi-rigid (physiologic) fixation for 7–10 days is recommended.^{1, 26} One week is sufficient to create periodontal support to maintain the avulsed tooth in position.¹ The splint should allow tooth movement, able to be placed passively without causing forces on the teeth, should have no memory (so the tooth is not moved during healing), and should not impinge on the gingiva and/or prevent maintenance of oral hygiene in the area. Many splints satisfy the requirements of an acceptable splint (bonded resin and wire splint), with a new titanium trauma splint recently been shown to be particularly effective and easy to use in case if the patient is mentally disabled or has immature behavior and does not tolerate foreign objects in the mouth. It should also be effective when there are insufficient abutment teeth available for bonded resin and wire splint.²⁷ After the splint is in place, a radiograph should be taken to verify the positioning of the tooth and as a preoperative reference for further treatment and follow-up. In case the avulsion is in conjunction with alveolar fractures, it is suggested that the tooth should be splinted for a suggested period of 4–8 weeks.⁽¹⁾

Management Of The Soft Tissues

Soft tissue lacerations of the socket gingiva should be tightly sutured. Lacerations of the lip are fairly common with these types of injuries. The dentist should approach lip lacerations with some caution and the plastic surgeon must be consulted at this stage for better esthetic results.

Adjunctive Therapy

It is mandatory to prescribe systemic antibiotic immediately and continue for at

least a week following replantation. If the apex is closed extending the antibiotic therapy until the pulp is extirpated seems to be a good way to determine the duration of antibiotic coverage. Systemic antibiotics will help in preventing bacterial invasion of the necrotic pulp and, therefore, subsequent inflammatory resorption.²⁸ Tetracycline is the first choice in appropriate dose for patient age and weight. Tetracycline also decreases root resorption by affecting the motility of the osteoclasts and reducing the effectiveness of collagenase.²⁹ Doxycycline 2× per day for 7 days at appropriate dose for patient age and weight^{29,30} or Penicillin V 1000mg and 500mg 4× per day for 7 days, can be given as alternative to tetracycline, beginning at the emergency visit and continuing until the splint is removed after 7–10 days.²⁸ Chlorhexidine rinses for 7- 10 days should be advised to the patient in addition to good oral hygiene resulting in reduction in the bacterial content of the during the healing phase. Alternatively, an antibiotic-corticosteroid paste should be used as an anti-inflammatory, anti-clastic intra-canal medicament. It may be placed immediately or shortly following replantation and left for at least 2 weeks for improved healing. The need for analgesics should be assessed on an individual case basis. The patient should be sent to a physician for consultation regarding a tetanus booster within 48 h of the initial visit if the avulsed tooth has contacted soil or tetanus coverage is uncertain.

Second Visit

It should take place 7–10 days after the emergency visit. The focus in this visit is to prevent potential irritants from reaching the root canal space and reduce the inflammatory resorption. Also, systemic antibiotics and chlorhexidine rinses can be

stopped at this visit and the splint is removed.

Endodontic Treatment

Extra – oral time < 60 min

Closed Apex

Endodontic treatment is initiated after 7 to 10 days. In cases where endodontic treatment is delayed or if signs of resorption are present, treat with 'long-term' calcium hydroxide treatment before obturation. In these teeth there is no chance for the revascularization, and the endodontic treatment should be initiated at the second visit at 7–10 days.^{1,14} If therapy is initiated at this optimum time, the pulp should be necrotic without infection or, at most, only minimal infection.³¹⁻³³ Therefore, endodontic therapy with an effective inter-appointment antibacterial agent³⁴ over a relatively short period of time (7–10 days) is sufficient to ensure effective disinfection of the canal.³⁵ Long-term therapy with calcium hydroxide should be started if the patient is cooperative as it remains an excellent treatment method.^{7,33} This allows a temporary obturating material to be in place until an intact periodontal ligament space is visible. Such treatment should be considered when the injury occurred more than 2 weeks prior to start of endodontic treatment or in case radiographic evidence of resorption presents earlier.³³ The root canal is systematically instrumented and irrigated, followed by filling it with a thick mix of calcium hydroxide and saline (or anesthetic solution). The calcium hydroxide is changed after every 3 months within 6 – 24 months. The canal is obturated when we find a radiographically intact periodontal membrane. Calcium hydroxide helps in the prevention and treatment of inflammatory root resorption. But it is not the only

medicament recommended in these cases. Apart from calcium hydroxide we have medicaments directed to not only remove the stimulus for the resorbing cells but also to affect them directly. An antibiotic-corticosteroid mixture available by the name of Ledermix seems an effective intracanal medicament that inhibits the spread of dentinoclasts^{36, 37} without harming the PDL. It can easily diffuse through the roots,³⁸ and this if further boosted when used with calcium hydroxide paste.³⁹ Calcitonin, a hormone that inhibits osteoclastic bone resorption, is also an effective medication in the treatment of inflammatory root resorption.⁴⁰

Open Apex

Endodontic treatment should be avoided and revascularization should be attempted. In case of a sign of infected pulp initiate apexification procedure. Teeth with open apices possess the potential to revascularize and continue further root development. Hence, initial treatment in such cases is directed towards the re-establishment of blood supply.^{14,15} The endodontic treatment should be avoided if at all possible unless definite signs of pulp necrosis, such as periradicular inflammation, are present. The establishment of diagnosis of pulp vitality can be very puzzling in such cases. It is well known that post-trauma, diagnosing a necrotic pulp is extremely important because, due to cemental damage associated with the trauma, infection in these teeth is possibly quite damaging. External resorption happens very quickly in young permanent teeth as the dentinal tubules are very wide and freely allow the passage of irritants to the external root surface.^{14,15} Patients must be recalled after every 3–4 weeks for testing sensitivity. Laser Doppler Flowmetry is the most accepted tool for the diagnosis of revascularization in an immature tooth post

trauma.⁴¹ Yanpiset et al.⁴² have shown that the existence of revascularization can be found in as quickly as 4 weeks after avulsion by using this method. Radiographic and clinical signs must be carefully assessed for failure. At the first sign of pathology, endo treatment must be initiated and, after disinfection, apexification should be carried out.

Extra-oral time >60 min

Closed Apex

The treatment for such teeth includes endodontic treatment in similar way like those teeth with extra-oral time of < 60min.

Open Apex (if replanted)

Apexification procedure is recommended if endodontic treatment was not performed out of the mouth. The chances of revascularization is extremely poor in these teeth.^{6,33} Therefore, no attempt should be made to revitalize these teeth.

Temporary Restoration

To maintain an effective coronal seal is essential, to prevent infection of the canal between visits. The most recommended temporary restorations are reinforced zinc-oxide-eugenol cement, acid-etch composite resin, or glass-ionomer cement. Sealability of the temporary restoration depends on the depth of the restoration. A depth of at least 4mm is recommended for maintaining an effective seal. The temporary restoration is placed directly over the calcium hydroxide in the access cavity. Calcium hydroxide must be removed from walls of the cavity as it is soluble and washes out when in contact with saliva, causing a defect in the temporary restoration.

Obturation Visit

Conventionally, re-establishment of lamina dura was a sign that the canal is clean and can be obturated. Obturation of the root canal can be done after 7-10 days of the avulsion, if clinical and radiographic examinations do not indicate pathosis. However if endodontic treatment was started more than 7–10 days after the avulsion or active resorption is visible radiographically, the pulp must be disinfected prior to obturation. The canal is then re-instrumented and irrigated aseptically. After completing instrumentation, the canal is obturated with special focus on asepsis.

Permanent Restoration

A well- sealed and effective permanent restoration should be placed either at or soon after the time of obturation of the root canal. Composite resins with the addition of dentin bonding agents are usually recommended in the anterior region of the mouth due to esthetic importance and moreover they have the additional advantage of internally strengthening the tooth against fracture if another trauma should occur.

Follow-Up Care

Follow-up evaluations should be done at 3months, 6 months and yearly for at least 5 years. If osseous replacement is evident, timely revision of the long-term treatment plan is indicated. Traditionally osseous replacement has been considered irreversible and the eventual outcome is the ultimate loss of the tooth. Recently, attempts have been made to reverse early osseous replacement.³⁴ At the first sign of ankylosis (high metallic sound on percussion or lack of mobility) the tooth is dislodged with an elevator and replanted after covering with Emdogain. *Filippi et al* have shown

promising results with this procedure.³⁴ In the case of inflammatory root resorption, a new attempt at disinfection of the root canal space by standard retreatment can reverse the process. Teeth adjacent to and surrounding the avulsed tooth or teeth may show pathologic changes long after the initial accident. Therefore, these teeth should be tested at periodic recall and the results should be compared to those collected soon after the accident.

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Conflict of Interest: None

Source of Support: NiL



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