

UK National Clinical Guidelines in Paediatric Dentistry*

Treatment of avulsed permanent teeth in children

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Introduction

The following guidelines are intended to assist in the management and treatment of avulsed teeth in children. They should be used by practitioners in combination with their own professional judgement. Although it is impossible to guarantee a good long-term prognosis or permanent retention of a tooth which has been re-implanted following avulsion, timely treatment of the tooth in the appropriate manner maximizes the chance of success. Further detail is available under 'Explanatory notes'.

Management

1. Management at site of accident (Grade B)

1.1. If telephone advice is sought, and re-implantation is appropriate (see Additional considerations), advise reimplantation of the tooth immediately. If the tooth is contaminated, rinse in milk or tap water prior to reimplantation. The tooth may be held in place by gently biting on a clean folded handkerchief until splinting can be carried out. Advise to attend a dental surgeon immediately.

1.2. If immediate re-implantation is not possible, place tooth in a vessel containing suitable storage medium – in order of preference: cold fresh milk, normal saline, saliva (in buccal sulcus). Advise to attend a dental surgeon immediately.

(Note: Grading of recommendation refers to levels of evidence as outlined previously (Gregg, T.A. *International Journal of Paediatric Dentistry* 1997; **7**: 267–268))

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2. Initial management by dental surgeon

2.1. History

During examination place tooth in cold fresh milk or normal saline to prevent unnecessary drying.

Elicit careful medical, dental and accident history, clearly written. Be alert to concomitant injury including head injury, facial fracture or lacerations. Seek medical examination as necessary

Avoid unnecessary delay before re-implantation.

2.2. Re-implantation (Grade B)

Replant as soon as possible if re-implantation is appropriate (see Additional considerations). Local anaesthesia is required if there is alveolar fracture and manipulation is required. Local anaesthetic is also preferable in some cases to enable accurate re-implantation *but* it is still possible to re-implant a tooth if patient compliance prevents the administration of local anaesthetic.

Preparation of socket – avoid unnecessary manipulation. If clot is present gently irrigate socket with saline in syringe and use suction to remove clot, but avoid curettage.

Handling of tooth – handle by crown not root. Do not scrape or scrub root surface. If contaminated wash in normal saline, and only if necessary gently dab with gauze soaked in saline to remove stubborn debris.

If alveolar bone fragments prevent re-implantation withdraw tooth and place in saline. Introduce a blunt instrument into the socket to reposition bone, and once again attempt re-implantation.

Do not commence root canal treatment prior to re-implantation except in special circumstances; see 4.4 Additional considerations.

2.3. Splinting (Grade B)

Splint to adjacent teeth non-rigidly for 7–10 days. Acid etch/resin either alone or in combination with soft arch wire is most commonly recommended; however, other types such as a removable acrylic splint or orthodontic brackets and wire are also acceptable.

All patients should be reviewed following re-implantation within 48 hours, at which time the splint is checked and modified if necessary.

Home care advice during splinting includes avoidance of biting on splinted teeth, consumption of a soft diet, and maintenance of good oral hygiene by tooth brushing and rinsing with chlorhexidine mouthwash.

If excessive mobility persists after 10 days, replace splint until mobility acceptable.

2.4. Antibiotics and tetanus

Prescribe appropriate antibiotics to commence as soon as possible.

A tetanus booster may be required if environmental contamination has occurred. If in doubt refer to physician within 48 hours.

3. Follow-up management by dental surgeon

3.1. Endodontic treatment – open apex teeth in young patients – short extra-oral time (Grade B)

In open apex teeth in young patients when the tooth has been out of the socket for a short period only it is acceptable to delay endodontic intervention to allow for the possibility of pulp revascularization.

Review in 2 weeks then at 3–4-week intervals; at review look for clinical signs of non-vitality (tenderness, tooth discoloration, swelling/sinus), test vitality and take intra-oral radiograph.

If clinical and radiographic signs of non-vitality develop commence endodontic treatment. Thorough mechanical cleansing of the canal is essential regardless of which dressings are used. Clean canal mechanically and fill with calcium hydroxide. An antibacterial intra-canal dressing may be placed for 1–2 weeks prior to placement of calcium hydroxide to help to ensure that the canal is free from infection. If calcium hydroxide is used alone then this should be placed no sooner than 7 days following re-implantation. The access cavity should be temporarily sealed with fast-setting zinc oxide and eugenol or glass ionomer cement.

Calcium hydroxide is left inside the canal until apexification has occurred. Regular clinical and radiographic review is necessary. It may be necessary to place fresh calcium hydroxide if follow-up radiographs reveal that there are voids in the existing calcium hydroxide root canal dressing. Some authorities recommend renewing the calcium hydroxide root canal dressing every 3 months, but this is not proven to be absolutely necessary.

3.2. Endodontic treatment – all other teeth (Grade C)

Commence endodontic treatment in all teeth with closed or almost closed apex regardless of extra-oral time and open apex teeth with prolonged extra-oral time.

Remove pulp as soon as tooth stable enough for access cavity to be prepared – ideally within 10 days. If an acid etch/resin splint has been used endodontic treatment can be commenced prior to its removal.

Thorough mechanical cleansing of the canal is essential regardless of which dressings are used. Clean canal mechanically and fill with calcium hydroxide. An antibacterial intra-canal dressing may be placed for 1–2 weeks prior to placement of calcium hydroxide to help to ensure that the canal is free from infection. If calcium hydroxide is used alone then this should be placed no sooner than 7 days following re-implantation. The access cavity should be temporarily sealed with fast-setting zinc oxide and eugenol or glass ionomer cement.

Calcium hydroxide is left inside the canal for a period of 6–12 months before final obturation with gutta percha.

Regular clinical and radiographic review is necessary. It may be necessary to place fresh calcium hydroxide if follow-up radiographs reveal that there are voids in the existing calcium hydroxide root canal dressing. Some authorities recommend renewing the calcium hydroxide root canal dressing every 3 months, but this is not proven to be absolutely necessary.

4. Additional considerations (Grade C)

4.1. When not to replant – in most cases re-implantation of an avulsed tooth is the best treatment. However, in a few cases re-implantation is not appropriate. These are as follows: primary tooth; where other injuries are severe and warrant

preferential emergency treatment/intensive care; where medical history indicates that the patient would be put at risk by re-implantation of a tooth; where an immature permanent tooth with a short root and wide open apex is involved, and the extra-oral time is extremely prolonged, the prognosis is very poor. In many of these cases re-implantation may not be warranted (see Explanatory notes 4.1).

4.2. Replanted permanent teeth require follow-up evaluation for a minimum of 2–3 years to determine outcome. Inflammatory resorption, replacement resorption, ankylosis, infraocclusion and discoloration are all potential complications which may occur. If progressive resorption occurs, prosthetic assessment, and/or orthodontic assessment may be required.

4.3. At follow-up visits adjacent teeth should also be examined as these may have been damaged as a result of the same accident and should not be overlooked.

4.4. In cases of extremely prolonged periods of extra-oral time in teeth with closed apices, where an undesirable storage medium has been used (i.e. tap water, or dry storage), a different method of treatment has been suggested. The treatment involves complete removal of the periodontal membrane and immersion of the tooth in a fluoride solution. As further drying and handling of the tooth root is unlikely to worsen the prognosis in such a case, some authors suggest that endodontic treatment may be completed extra-orally before re-implantation.

4.5. Some recent articles have suggested soaking of avulsed teeth in a pH balanced solution prior to re-implantation to reconstitute periodontal ligament cells. Further, it has been suggested that soaking of avulsed teeth in an antibiotic solution prior to re-implantation improves the prognosis and may be more effective than systemic antibiotics. These suggestions remain controversial.

Explanatory notes

The incidence of traumatic avulsion of teeth has been reported as 0.5–16% of all traumatized teeth [1,2]. Upper central incisor teeth are most frequently avulsed, and in the age group 7–9 years [1,3]. It has long been recognized that it is possible to replant a tooth following avulsion, and that replanted teeth may function for many years. Andreasen found in monkeys that, under ideal conditions, complete healing of the pulp and periodontal ligament of replanted teeth can occur [1]. However, such

conditions do not occur in the real-life situation and healing of replanted teeth is subject to complications. The main complication is that of root resorption which is related to necrosis of part or all of the periodontal ligament and may be further complicated by necrosis of the pulp and/or infection. Although the damage caused directly by the injury is beyond the control of the clinician, the provision of appropriate treatment both immediately and upon review improves the prognosis of replanted teeth.

1. Management of site of accident

1.1. Extra-oral time

The period between tooth avulsion and re-implantation is normally outside the control of a dentist, but this period is important with regard to the prognosis of the tooth. It has been reported that the length of time that a tooth spends out of the mouth influences the development of root resorption and pulpal healing. Andreasen & Hjorting-Hansen found that 90% of teeth replanted within 30 minutes did not develop root resorption when reviewed at an interval ranging between 1 and 13 years; however this much-quoted finding was based on 10 teeth and as such the reporting of this as a percentage may be misleading [4]. Andersson & Bodin found that teeth replanted within 15 minutes following the avulsion have a favourable long-term prognosis and furthermore that most of the teeth with no resorption had been replanted within 10 minutes [5]. Andersson, Bodin & Sorensen concluded that teeth replanted after 60 minutes would become ankylosed and resorbed within 3–7 years in young patients whereas a tooth replanted under similar conditions in older patients might remain in function for a considerably longer time [6]. However, Mackie & Worthington found no significant relationship between the time that the avulsed tooth was out of the mouth and root resorption [7]. In terms of pulpal healing Andreasen *et al.* found that the likelihood of pulpal revascularization was reduced as the extra-oral dry time increased, and similarly with storage in a moist medium for longer than 5 minutes [8].

1.2. Storage medium

The medium in which the tooth has been stored prior to re-implantation has been shown to affect

the incidence of root resorption and pulp healing. Prolonged drying of the root presents the worst prognosis because of loss of vitality of the periodontal ligament [9–11] and dehydration of the pulp [8]. Ideally the tooth should be re-implanted into the socket as soon as possible, but in cases where this cannot be carried out, maintaining the root in a moist environment has been shown to improve the prognosis. However, storage in tap water has been demonstrated to be an unsatisfactory medium [9]. A critical period of dry storage has been reported to be between 18 and 30 minutes after which a marked increase in root resorption is seen [12]. Cold fresh milk appears to be the best medium for storage of the tooth during transportation to a dentist [4] although alternatives such as saliva, blood, saline and an 'emergency tooth preserving system' have all been suggested [14]. The 'emergency tooth preserving system' contains a pH-balanced cell reconstitution fluid called Hank's solution. Recent USA literature has found that avulsed teeth soaked in this solution prior to re-implantation suffer less resorption [15]. Also, increased pulp revascularization has been claimed following soaking of avulsed teeth in a 5% doxycycline solution prior to re-implantation [16].

2. Initial management by dental surgeon

2.1. History

As with all cases of trauma, it is essential to record details of the accident clearly in writing because of the possibility of legal action on the part of the patient. A thorough history should be taken and examination should exclude facial fracture. Mucosal lacerations may require suturing. The parent/carers should be alerted to be suspicious of any subsequent dizziness, neck pain, amnesia or symptoms of head injury. If there are symptoms of head injury a medical assessment should be arranged immediately.

2.2. Re-implantation

The handling of the tooth prior to re-implantation is highly important to avoid further damage to the periodontal membrane [1]. Therefore during examination of the patient prior to re-implantation, the tooth should be placed in a safe place in milk or saline. Re-implantation of a tooth may be carried out without anaesthesia, especially if presentation to the dentist is soon after avulsion, and a soft blood

clot only is present. In many cases local anaesthetic is desirable to enable adequate socket preparation and the positioning of the tooth. If there is a clot present in the socket this can be washed out with a syringe and saline and an aspirator. It is not desirable to curette the socket, as this will cause further damage to or removal of the periodontal ligament cells which remain in the socket.

A past favoured method of treatment involved carrying out root canal treatment of avulsed teeth prior to re-implantation. In most cases this method of treatment is no longer acceptable as it imparts a poorer prognosis because of increased damage to the periodontal ligament cells by prolonged drying and handling. It is also desirable to maintain a patent root canal as a vehicle for application of medicaments to reduce infection and/or resorption. However, in a few special cases it may be acceptable to complete endodontic treatment prior to re-implantation – see section 4: additional considerations.

2.3. Splinting

It has been suggested that minimizing the time duration of splinting and using a non-rigid splint will improve the outcome of the re-implanted tooth and reduced the occurrence of ankylosis [8,17,18]. There are a number of suitable types of non-rigid splint [19–22] which will depend on the facilities available. Care must be taken in application, i.e. avoid impinging on gingivae or creating areas of stagnation. The immediate splint is often placed in an emergency situation and requires to be simple but effective. In such cases a review appointment should be arranged ideally within 48 hours of the accident. At this review the splint should be checked and if necessary modified or removed and replaced.

2.4. Systemic antibiotics and tetanus

It has been suggested that the provision of systemic antibiotics reduces the occurrence of root resorption and in particular inflammatory resorption if taken promptly [23,24]. In cases of environmental contamination a tetanus booster may be required.

3. Follow-up management by dental surgeon

3.1, 3.2. Endodontic treatment

Early removal of the pulp has been advocated as this will prevent the production of inflammatory

products by a necrotic pulp, and thus minimize the chance of inflammatory resorption [25]. Although the advice regarding teeth with a wide open apex is to delay endodontic treatment on the basis that revascularization of the pulp is possible [1], this involves a risk of failure due to inflammatory root resorption [26], and clinicians must be aware of the consequences of too conservative an approach. Inflammatory resorption appears to occur more rapidly in young patients and the proposed reason for this is that the dentine tubules, which have not yet become less patent as is the case with advancing age, readily transmit inflammatory products from the pulp to the root surface [27]. Therefore it is proposed only to delay endodontic treatment in those cases where the apex is wide open and the tooth has been re-implanted promptly. In cases where delay of endodontic treatment has been chosen, the clinician must carry out careful review of the patient so that pulp removal can be carried out at the first sign of inflammatory resorption. All other re-implanted teeth should have endodontic treatment.

Endodontic dressings. Use of an intra-canal medicament has been advocated as this has been shown to reduce the occurrence of root resorption [23,24]. Inflammatory resorption may be arrested by endodontic treatment which removes the source of inflammation, but ankylosis may still occur because of irreversible damage to the periodontal ligament [27]. The high pH of calcium hydroxide renders it bacteriostatic and therefore a suitable intra-canal dressing where inflammatory resorption has occurred. It may be that placing calcium hydroxide in the root canal encourages healing [1]; however, there is no conclusive evidence regarding this and some authors have shown that presence of calcium hydroxide in the root canal may in some circumstances increase the occurrence of ankylosis [28,29]. Also, in experimentally induced inflammatory resorption placement of an intra-canal antibiotic and corticosteroid paste was found to eliminate the inflammatory resorption [30]. Some authorities recommend the use of an intra-canal polyantibiotic paste used containing neomycin sulphate, polymyxin B sulphate, nystatin, polyethylene glycol 1300 and polyethylene glycol 1500. This is also acceptable. If an antibiotic dressing is used this should be replaced by calcium hydroxide after a period of 1–2 weeks. If calcium hydroxide is placed as the sole dressing this should not be placed until the tooth has been replanted for over 7 days as insertion of

calcium hydroxide any sooner than this can in fact cause damage to the healing periodontal ligament [1,31]. Different authors have suggested varied periods of placement of calcium hydroxide. Some suggest that in closed apices early obturation with gutta-percha is as acceptable as delaying this until calcium hydroxide has been placed for several months [32]. Although it is controversial, most still advise the latter, therefore it is recommended that calcium hydroxide should be left in the root canal for 6–12 months before obturation, and changed during this time if indicated. An indication to replace with fresh calcium hydroxide would be if radiographically there was no evidence of any material present in the root canal, or if there are voids in the existing dressing. Some authorities recommend renewing the calcium hydroxide root canal dressing every 3 months, but this is not proven to be absolutely necessary. As well as preventing inflammatory resorption, calcium hydroxide stimulates apexification in open apex cases. No matter which medicaments are used, it is of the greatest importance that the root canal is thoroughly mechanically cleansed.

4. Additional considerations

4.1. When not to replant

Although in many cases a replanted tooth survives only a matter of years, during this period it serves as a natural space maintainer whilst growth occurs, and also enables alveolar height to be preserved. Therefore in most cases re-implantation of an avulsed tooth is the best treatment. However, in certain instances of excessively prolonged extra-oral time/poor storage medium, or where the tooth is grossly carious/general oral condition is poor, or patient co-operation is poor, a clinician may judge that re-implantation is better not to be attempted. In a few cases re-implantation is clearly not appropriate. These are as follows:

Primary teeth: these should not be replanted because of the possibility of damage to an underlying developing permanent tooth.

Other injuries: where other injuries are severe and require preferential emergency treatment or intensive care.

Medical history: avulsed teeth should not be replanted in cases where to do so would place the patient at risk. For example, patients with depressed

immunity as in acute lymphoblastic leukaemia who are at risk from infection. It may be possible in some cases to safely re-implant teeth in such individuals but this should only be carried out in liaison with the specialist physician in charge of their medical care, and a follow-up review and treatment regime must be strictly adhered to.

Immature permanent tooth with short root, wide open apex and prolonged dry extra-oral time: if the dry extra-oral time is long then replacement resorption is inevitable. As replacement resorption occurs at a higher rate in a young person and these teeth already have a short root, the prognosis is very poor. In most of these cases re-implantation is not warranted; however, in some cases one may feel that for psychological reasons it is worth replanting even though the tooth will only last for a short time.

4.2. Follow-up evaluation

Inflammatory resorption may be detected as early as 2 weeks post re-implantation [1]. Radiographically inflammatory resorption is characterized by loss of root surface accompanied by loss of adjacent bone and an area of radiolucency. Clinically a tooth with inflammatory resorption may be mobile and tender.

Replacement resorption may be diagnosed within 2 months of re-implantation, however frequently is not detected until more than 6 months have elapsed [6]. Radiographically replacement resorption is characterized by loss of root surface with loss of periodontal ligament space and lamina dura, and bone is seen to be in direct contact with the root surface. Clinically the tooth has no physiological mobility and may give a high note on percussion. If no form of resorption has been detected in the first 2 years following re-implantation then the risk of root resorption occurring is considerably reduced [1]. Successive visits for radiographs to identify root resorption are required so that any necessary plans may be made for prosthetic replacement of the tooth should its loss become inevitable.

4.3. In cases of extremely prolonged periods of extra-oral time in teeth with closed apices, where an undesirable storage medium has been used (i.e. tap water, or dry storage) a different method of treatment has been suggested [1,15,33]. In such circumstances of delay and poor storage, replacement resorption is inevitable as few or no periodontal ligament cells remain viable, and as such treatment is aimed to retard the resorptive process.

The treatment involves complete removal of the periodontal membrane and immersion of the tooth in a fluoride solution. The fluoride incorporated in the root surface is thought to retard replacement resorption. As further drying and handling of the tooth root is unlikely to worsen the prognosis in such a case, some authors suggest that under these circumstances endodontic treatment may be completed extra-orally before re-implantation [1,33].

4.4. Some recent articles have suggested soaking of avulsed teeth in a pH balanced solution prior to re-implantation to reconstitute periodontal ligament cells [15]. Also, increased pulp revascularization has been claimed following soaking of avulsed teeth in a 5% doxycycline solution prior to re-implantation [16].

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