Successful Non-surgical Root Canal Treatment of a Maxillary Central Incisor with a Horizontal Mid-Root Fracture

Two Articles as Useful Reference Material for Your Practice:

IADT guidelines for the management of traumatic dental injuries

Root Fractures in permanent teeth comprise anywhere from 0.5 – 7% of dental trauma cases \(^1\)\(^2\). A careful diagnosis of a “horizontal root fracture must be made”, in order to distinguish it from a luxation, which may present clinically in a similar fashion \(^3\): A steep occlusal exposure and various PA’s in different angles may lead to a diagnosis \(^4\). Nowadays, if available, a cone beam CT may help in the diagnosis. The sagittal view may be particularly useful.

A complete examination of the structures affected by the traumatic incident should be carried out as soon as is feasible. This should include radiographs of lacerated soft tissues (lips etc.), if tooth fragments are unaccounted for. Vitality testing, palpation, periodontal examination, assessment of mobility and of the occlusal relationships post trauma are essential, to provide a baseline against which later examination results can be compared. Good notes are essential, as many of these cases may end up on an insurance assessor’s desk in years to come. Excellent communication with the patient (or his/her guardians, if applicable) is essential, as there may be little understanding in the community of the possible long-term sequelae of severe dental trauma.

If bleeding is evident, the patient’s tetanus status should be assessed, and the administration of antibiotics can be considered.

Various considerations must be taken into account when assessing the viability of the tooth after a root fracture:

1. The **crown-to-root ratio** can be defined as the ratio of the part of the continuous tooth that protrudes from the bone, to the part of the continuous tooth that is embedded in bone. A crown-to-root ratio of 1:1 or lesser can be considered favourable. After a fracture at mid root level, the effective root length may have been halved, which may tip the crown-to-root ratio into unfavourable territory, from a point of view of stability.
2. Periodontal involvement of the coronal fragment may lead to a situation where even minimal apical migration of epithelium can create a communication between the fracture site and the oral cavity\(^4\), which would likely lead to loss of the coronal fragment.

If a tooth is deemed to have a fair prognosis, it should generally be splinted for 4 weeks to 4 months. A more coronal fracture site would dictate a longer splinting time. Apical migration of epithelium as a result of difficult access for OH must be avoided\(^4\).

The apical segment is almost invariably vital\(^4\), and often the coronal fragment may remain vital as well\(^1,2,4\), with pulp calcification a common sequel\(^1\).

If pain develops or if there is a sinus tract, RCT of the coronal segment is indicated. This must be carried out along the guidelines for RCT in teeth with an open apex\(^4\). Mineral Trioxide Aggregate may be useful in these cases\(^5\).

The following example describes a case in which a patient presented approximately one month after falling onto a hard surface. There had been no displacement of the coronal fragment, and the patient was unaware that a root fracture had occurred.

Eventually pain developed, and the referring dentist correctly diagnosed a horizontal root fracture. The surrounding tissues seemed unaffected when the patient presented. The tooth was firm, out of occlusion, and had not been splinted.
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Patient: 44 yo female, referred by her general dentist for assessment #11 post trauma.

Medical Hx: No relevant medical Hx

Dental Hx: About a month earlier the patient had tripped and knocked her front teeth. There was no displacement of the coronal fragment, and no obvious other damage occurred. The patient did not pay any further attention until a month later, when she complained of pain associated with #11. It is noteworthy that the tooth did not show any mobility, despite not having been splinted.

Chief complaint: “My dentist referred me to have this tooth [11] treated. I fell about a month ago.”

Objective findings:

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<tr>
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<th>12</th>
<th>11</th>
<th>21</th>
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<tbody>
<tr>
<td>Percussion</td>
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<td>Palpation</td>
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<td>CO₂</td>
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</tbody>
</table>

R = normally responsive   AR = Abnormally responsive   NR = non-responsive   WNL = within normal limits

Radiographic (PA): Periapical Radiographs and a CBCT were taken, showing the location of a fracture line in the apical part of the middle 1/3 of the root. Note the image of the fracture line in the sagittal view of the cone beam CT, allowing a much better assessment of the remaining “effective root length” than the view in the PA, which is very dependent upon the angulation of the radiation source. As a coincidental finding, a compound odontoma as well as a supernumerary tooth are seen. If present, compound odontomas are commonly found in the anterior maxilla (Fig.1-3).

Assessment #11,21: Pulpal Diagnosis: #11: necrotic (coronal segment)  
Periradicular diagnosis: #11: acute periradicular periodontitis of the coronal segment
Treatment: The options and prognoses of various treatment modalities (RCT vs. implant) were explained to the patient. The patient decided to have tooth #11 treated non-surgically.

Under LA and rubber dam tooth #11 was accessed, and the root canal was located. It is noteworthy that in cases with open apex (this is a “quasi – open apex case”, as we are treating to the fracture line only) the electronic apex locator is not useful in determining the working length. Instead, a working length radiograph was taken (to the fracture line only) (Fig.4).

Due to the lack of mobility of the tooth and the length of time that had passed since the accident, a decision was taken not to splint this tooth. This is an exception, and in most cases splinting will be required.

After a 6 week dressing period (the patient went on an overseas vacation) with Ca(OH)$_2$ (Fig.5), #11 was obturated, using Mineral Trioxide Aggregate (MTA®). The result is shown in Fig.6.

Follow-up (12 months): A 12-month review was scheduled with the patient. The tooth has normal mobility, and there are no signs of periradicular inflammation or ankylosis. The periodontal probing is WNL. The radiograph taken suggests no inflammatory changes, neither around the apical segment, nor at the apical extent of the coronal segment. There appears to be hard tissue (bone ?) interposed between the two segments (Fig. 7). The neighbouring teeth test WNL = unchanged.

Discussion: In this case it was the fact that pain had developed, which made RCT of the coronal fragment necessary. Often even the coronal segment may remain vital. This is more likely in younger patients, after traumatic incidents that are less severe and result in a lesser separation of the fragments. A large “fracture foramen” i.e. the presence of a large diameter vital pulp will increase the chances of the coronal segment staying vital.

Due to the reduced “effective root length” and unfavourable crown-to-root ratio, excursive contacts on a root-fractured tooth should be avoided.

Trauma cases represent a small percentage of the work load of an average dental practice. Arguably we see more of these cases during the summer months and during school holidays.

Trauma cases often have an uncertain long-term prognosis, and it is important that this be conveyed and explained to the patient when feasible,
i.e. when the initial phase of treatment (stopping the bleeding, repositioning of teeth, splinting, suturing etc.) is completed.

As dentists we may be the first to see these patients, in which case we have to think outside the square. Referrals to the GP or other specialists (medical and dental) may be required. A referral to an endodontist could be considered at this time.

Proper diagnosis and excellent notes are essential, as many of these cases will lead to substantial financial expenditure by the patient over time, and patients will often seek to recover costs from a third party, such as an insurance company.
Fig. 1 – preoperative PA

Fig. 2 - showing the location of the fracture in the CBCT
Fig. 3 – showing a compound odontoma and a supernumerary tooth as a coincidental findings.

Fig. 4 – working length radiograph to the fracture line

Fig. 5 – Ca(OH)₂ in situ

Fig. 6 – MTA® in situ, composite filling placed
Fig. 7 – 1 year review showing an excellent outcome, with establishment of near normal periapical conditions along the fracture line. There are no signs of periapical inflammation.

Case treated and compiled by Dr Torsten H Steinig
Bibliography

International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 1. Fractures and luxations of permanent teeth

Abstract – Traumatic dental injuries (TDIs) of permanent teeth occur frequently in children and young adults. Crown fractures and luxations are the most commonly occurring of all dental injuries. Proper diagnosis, treatment planning and follow-up are important for improving a favorable outcome. Guidelines should assist dentists and patients in decision making and for providing the best care effectively and efficiently. The International Association of Dental Traumatology (IADT) has developed a consensus statement after a review of the dental literature and group discussions. Experienced researchers and clinicians from various specialties were included in the group. In cases where the data did not appear conclusive, recommendations were based on the consensus opinion of the IADT board members. The guidelines represent the best current evidence based on literature search and professional opinion. The primary goal of these guidelines is to delineate an approach for the immediate or urgent care of TDIs. In this first article, the IADT Guidelines for management of fractures and luxations of permanent teeth will be presented.
Traumatic dental injuries (TDIs) occur with great frequency in preschool, school-age children, and young adults comprising 5% of all injuries for which people seek treatment (1, 2). A 12-year review of the literature reports that 25% of all school children experience dental trauma and 33% of adults have experienced trauma to the permanent dentition, with the majority of injuries occurring before age nineteen (3). Luxation injuries are the most common TDIs in the primary dentition, whereas crown fractures are more commonly reported for the permanent dentition (1, 4, 5) TDIs present a challenge to clinicians worldwide. Consequently, proper diagnosis, treatment planning and follow up are critical to assure a favorable outcome.

Guidelines, among other things, should assist dentists, other healthcare professionals, and patients in decision making. Also, they should be credible, readily understandable, and practical with the aim of delivering appropriate care as effectively and efficiently as possible.

The following guidelines by the International Association of Dental Traumatology (IADT) represent an updated set of guidelines based on the original guidelines published in 2007 (6–8). The update was accomplished by doing a review of the current dental literature using EMBASE, MEDLINE, and PUBMED searches from 1996 to 2011 as well as a search of the journal of Dental Traumatology from 2000 to 2011. Search words included tooth fractures, root fractures, tooth luxation, lateral luxation and permanent teeth, intruded permanent teeth, and luxated permanent teeth.

The primary goal of these guidelines is to delineate an approach for the immediate or urgent care of TDIs. It is understood that subsequent treatment may require secondary and tertiary interventions involving specialist consultations, services, and/or materials/methods not always available to the primary treating clinician.

The IADT published its first set of guidelines in 2001 and updated them in 2007 (6–13). As with the previous guidelines, the working group included experienced investigators and clinicians from various dental specialties and general practice. This revision represents the best evidence based on the available literature and expert professional judgment. In cases where the data did not appear conclusive, recommendations are based on the consensus opinion of the working group followed by review by the members of the IADT Board of Directors. It is understood that guidelines are to be applied with evaluation of the specific clinical circumstances, clinicians’ judgment, and patients’ characteristics, including but not limited to compliance, finances, and understanding of the immediate and long-term outcomes of treatment alternatives versus non-treatment. The IADT cannot and does not guarantee favorable outcomes from strict adherence to the Guidelines, but believe that their application can maximize the chances of a favorable outcome.

Guidelines undergo periodic updates. These 2012 Guidelines in this journal will appear in three parts:

Part I: Fractures and luxations of permanent teeth

Part II: Avulsion of permanent teeth

Part III: Injuries in the primary dentition

Guidelines offer recommendations for diagnosis and treatment of specific TDIs; however, they do not provide the comprehensive nor detailed information found in textbooks, the scientific literature, and, most recently, the Dental Trauma Guide (DTG) that can be accessed on http://www.dentaltraumaguide.org. Additionally, the DTG, also available on the IADT’s web page http://www.iadt-dentaltrauma.org, provides a visual and animated documentation of treatment procedures as well as estimations of prognosis for the various TDIs.

General recommendations/considerations

Clinical examination

Detailed description of protocols, methods, and documentation for clinical assessment of TDIs can be found in current textbooks (1, 14, 15).

Radiographic examination

Several projections and angulations are routinely recommended, but the clinician should decide which radiographs are required for the individual. The following are suggested:

- Periapical radiograph with a 90° horizontal angle with central beam through the tooth in question.
- Occlusal view.
- Periapical radiograph with lateral angulations from the mesial or distal aspect of the tooth in question.

Emerging imaging modalities such as cone-beam computerized tomography (CBCT) provide enhanced visualization of TDIs, particularly root fractures and lateral luxations, monitoring of healing, and complications. Availability is limited, and its use not currently considered routine; however, specific information is available in the scientific literature (16, 17).

Splinting type and duration

Current evidence supports short-term, non-rigid splints for splinting of luxated, avulsed, and root-fractured teeth. While neither the specific type of splint nor the duration of splinting for root-fractured and luxated teeth are significantly related to healing outcomes, it is considered best practice to maintain the repositioned tooth in correct position, provide patient comfort and improved function (18, 19).

Use of antibiotics

There is limited evidence for use of systemic antibiotics in the management of luxation injuries and no evidence that antibiotic coverage improves outcomes for root-fractured teeth. Antibiotic use remains at the discretion of the clinician as TDI’s are often accompanied by soft tissue and other associated injuries, which may require other surgical intervention. In addition, the patient’s medical status may warrant antibiotic coverage (19, 20).

Sensibility tests

Sensibility testing refers to tests (cold test and/or electric pulp test) attempting to determine the condition of the
pulp. At the time of injury, sensibility tests frequently give no response indicating a transient lack of pulpal response. Therefore, at least two signs and symptoms are necessary to make the diagnosis of necrotic pulp. Regular follow up controls are required to make a pulpal diagnosis.

**Immature versus mature permanent teeth**

Every effort should be made to preserve pulpal vitality in the immature permanent tooth to ensure continuous root development. The vast majority of TDIs occur in children and teenagers where loss of a tooth has lifetime consequences. The immature permanent tooth has considerable capacity for healing after traumatic pulp exposure, luxation injury, and root fractures. Pulp exposures secondary to TDIs are amenable to proven conservative pulp therapies that maintain vital pulp vitality. Extrusion, intrusion, and lateral luxation injuries have high rates of PCO (32, 33) Subluxated and crown-fractured teeth also may exhibit PCO, although with less frequency (34). Additionally, PCO is a common occurrence following root fractures (35, 36).

### Permanent teeth

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Radiographic findings</th>
<th>Treatment</th>
<th>Follow up</th>
<th>Favorable outcome</th>
<th>Unfavorable outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infraction</td>
<td>An incomplete fracture (crack) of the enamel without loss of tooth structure</td>
<td>No radiographic abnormalities</td>
<td>In case of marked infraction, etching and sealing with resin to prevent discoloration of the infraction lines; otherwise, no treatment is necessary</td>
<td>No follow up is generally needed for infraction injuries unless they are associated with a luxation injury or other fracture types</td>
<td>Asymptomatic</td>
</tr>
<tr>
<td>Enamel fracture</td>
<td>A complete fracture of the enamel</td>
<td>Enamel loss is visible</td>
<td>If the tooth fragment is available, it can be bonded to the tooth</td>
<td>6–8 weeks C** 1 year C**</td>
<td>Asymptomatic</td>
</tr>
<tr>
<td></td>
<td>Loss of enamel. No visible sign of exposed dentin</td>
<td>Radiographs recommended: periapical, occlusal, and eccentric exposures. They are recommended in order to rule out the possible presence of a root fracture or a luxation injury</td>
<td>Contouring or restoration with composite resin depending on the extent and location of the fracture</td>
<td>Continue to next evaluation</td>
<td>Asymptomatic</td>
</tr>
<tr>
<td></td>
<td>Not tender. If tenderness is observed, evaluate the tooth for a possible luxation injury or root fracture injury</td>
<td>Radiograph of lip or cheek to search for tooth fragments or foreign materials</td>
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<td></td>
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<tr>
<td></td>
<td>Normal mobility</td>
<td></td>
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<tr>
<td></td>
<td>Sensibility pulp test usually positive</td>
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</tbody>
</table>

### Treatment guidelines for fractures of teeth and alveolar bone

- Infraction
- Enamel fracture

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### 1. Treatment guidelines for fractures of teeth and alveolar bone

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Radiographic findings</th>
<th>Treatment</th>
<th>Follow-up procedures for fractures of teeth and alveolar bone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enamel–dentin fracture</td>
<td>• A fracture confined to enamel and dentin with loss of tooth structure, but not exposing the pulp</td>
<td>• Enamel–dentin loss is visible</td>
<td>• If a tooth fragment is available, it can be bonded to the tooth. Otherwise, perform a provisional treatment by covering the exposed dentin with glass ionomer or a more permanent restoration using a bonding agent and composite resin, or other accepted dental restorative materials</td>
</tr>
<tr>
<td></td>
<td>• Percussion test: not tender. If tenderness is observed, evaluate the tooth for possible luxation or root fracture injury</td>
<td>• Radiographs recommended: periapical, occlusal, and eccentric exposure to rule out tooth displacement or possible presence of root fracture</td>
<td>6–8 weeks C++ 1 year C++</td>
</tr>
<tr>
<td></td>
<td>• Normal mobility</td>
<td>• Radiograph of lip or cheek lacerations to search for tooth fragments or foreign materials</td>
<td>Favorable outcome</td>
</tr>
<tr>
<td></td>
<td>• Sensibility pulp test usually positive</td>
<td>• Enamel–dentin loss is visible</td>
<td>• Positive response to pulp testing</td>
</tr>
<tr>
<td>Enamel–dentin–pulp fracture</td>
<td>• A fracture involving enamel and dentin with loss of tooth structure and exposure of the pulp.</td>
<td>• Radiographs recommended: periapical, occlusal, and eccentric exposures to rule out tooth displacement or possible presence of root fracture</td>
<td>• Continuing root development in immature teeth</td>
</tr>
<tr>
<td></td>
<td>• Normal mobility</td>
<td>• Radiograph of lip or cheek lacerations to search for tooth fragments or foreign materials</td>
<td>• Continue to next evaluation</td>
</tr>
<tr>
<td></td>
<td>• Percussion test: not tender. If tenderness is observed, evaluate for possible luxation or root fracture injury</td>
<td>• Exposed pulp sensitive to stimuli</td>
<td>• Endodontic therapy appropriate for stage of root development is indicated</td>
</tr>
<tr>
<td></td>
<td>• Exposed pulp sensitive to stimuli</td>
<td>• Calcium hydroxide is a suitable material to be placed on the pulp wound in such procedures</td>
<td>6–8 weeks C++ 1 year C++</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In patients with mature apical development, root canal treatment is usually the treatment of choice, although pulp capping or partial pulpotomy also may be selected</td>
<td>• Asymptomatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If tooth fragment is available, it can be bonded to the tooth</td>
<td>• Positive response to pulp testing</td>
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<tr>
<td></td>
<td></td>
<td>• Future treatment for the fractured crown may be restoration with other accepted dental restorative materials</td>
<td>• Continuing root development in immature teeth</td>
</tr>
</tbody>
</table>
1. Treatment guidelines for fractures of teeth and alveolar bone

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Radiographic findings</th>
<th>Treatment</th>
<th>Follow up</th>
<th>Favorable outcome</th>
<th>Unfavorable outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crown-root fracture without pulp exposure</td>
<td>A fracture involving enamel, dentin, and cementum with loss of tooth structure, but not exposing the pulp</td>
<td>Emergency treatment</td>
<td>6-8 weeks C**</td>
<td>Asymptomatic</td>
<td>Symptomatic response to pulp testing</td>
</tr>
<tr>
<td></td>
<td>Crown fracture extending below gingival margin</td>
<td>As an emergency treatment, a temporary stabilization of the loose segment to adjacent teeth can be performed until a definitive treatment plan is made</td>
<td>1 year C**</td>
<td>Positive response to pulp testing</td>
<td>Negative response to pulp testing</td>
</tr>
<tr>
<td></td>
<td>Percussion test: tender</td>
<td>Non-emergency treatment alternatives</td>
<td></td>
<td>Continuing root development in immature teeth</td>
<td>Signs of apical periodontitis</td>
</tr>
<tr>
<td></td>
<td>Coronal fragment mobile</td>
<td>Fragment removal only</td>
<td></td>
<td>Continue to next evaluation</td>
<td>No continuing root development in immature teeth</td>
</tr>
<tr>
<td></td>
<td>Sensibility pulp test usually positive for apical fragment</td>
<td>Removal of the coronal crown–root fragment and subsequent restoration of the apical fragment exposed above the gingival level</td>
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<td>Endodontic therapy appropriate for stage of root development is indicated</td>
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<td></td>
<td>Fragment removal and gingivectomy (sometimes ostectomy)</td>
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<td>Removal of the coronal crown–root segment with subsequent endodontic treatment and restoration with a post-retained crown. This procedure should be preceded by a gingivectomy, and sometimes ostectomy with osteoplasty</td>
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<td>Orthodontic extrusion of apical fragment</td>
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<td>Removal of the coronal segment with subsequent endodontic treatment and orthodontic extrusion of the remaining root with sufficient length after extrusion to support a post-retained crown</td>
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<td>Surgical extrusion</td>
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<td>Removal of the mobile fractured fragment with subsequent surgical repositioning of the root in a more coronal position</td>
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<td>Root submergence</td>
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<td>Implant solution is planned</td>
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<td>Extraction</td>
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<td></td>
<td>Extraction with immediate or delayed implant-retained crown restoration or a conventional bridge. Extraction is inevitable in crown–root fractures with a severe apical extension, the extreme being a vertical fracture</td>
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</tbody>
</table>
### 1. Treatment guidelines for fractures of teeth and alveolar bone

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Radiographic findings</th>
<th>Treatment</th>
<th>Follow-up procedures for fractures of teeth and alveolar bone</th>
<th>Favorable and unfavorable outcomes include some, but not necessarily all, of the following</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crown-root fracture with pulp exposure</td>
<td>A fracture involving enamel, dentin, and cementum and exposing the pulp</td>
<td>Apical extension of fracture usually not visible</td>
<td>As an emergency treatment a temporary stabilization of the loose segment to adjacent teeth</td>
<td>Favorable outcome</td>
</tr>
<tr>
<td></td>
<td>Percussion test: tender</td>
<td>Radiographs recommended: periapical and occlusal exposure</td>
<td>In patients with open apices, it is advantageous to preserve pulp vitality by a partial pulpotomy. This treatment is also the choice in young patients with completely formed teeth. Calcium hydroxide compounds are suitable pulp capping materials. In patients with mature apical development, root canal treatment can be the treatment of choice</td>
<td>Unfavorable outcome</td>
</tr>
<tr>
<td></td>
<td>Coronal fragment mobile</td>
<td>Emergency treatment</td>
<td>Non-Emergency Treatment</td>
<td>Asymptomatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• As an emergency treatment a temporary stabilization of the loose segment to adjacent teeth</td>
<td>Alternatives</td>
<td>• Symptomatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• In patients with open apices, it is advantageous to preserve pulp vitality by a partial pulpotomy. This treatment is also the choice in young patients with completely formed teeth. Calcium hydroxide compounds are suitable pulp capping materials. In patients with mature apical development, root canal treatment can be the treatment of choice</td>
<td>• Positive response to pulp testing</td>
<td>• Negative response to pulp testing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Fragments removal and gingivectomy (sometimes ostectomy)</td>
<td>Orthodontic extrusion of apical fragment</td>
<td>• Signs of apical periodontitis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Removal of the coronal fragment with subsequent endodontic treatment and restoration with a post-retained crown. This procedure should be preceded by a gingivectomy and sometimes ostectomy with osteoplasty. This treatment option is only indicated in crown-root fractures with palatal subgingival extension</td>
<td>Removal of the coronal segment with subsequent endodontic treatment and orthodontic extrusion of the remaining root with sufficient length after extrusion to support a post-retained crown</td>
<td>• No continuing root development in immature teeth</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Orthodontic extrusion of apical fragment</td>
<td>Surgical extrusion</td>
<td>• Endodontic therapy appropriate for stage of root development is indicated</td>
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<td></td>
<td>Removal of the coronal segment with subsequent endodontic treatment and orthodontic extrusion of the remaining root with sufficient length after extrusion to support a post-retained crown</td>
<td>Removal of the mobile fractured fragment with subsequent surgical repositioning of the root in a more coronal position</td>
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<tr>
<td></td>
<td></td>
<td>Surgical extrusion</td>
<td>Root submergence</td>
<td>An implant solution is planned, the root fragment may be left in situ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Root submergence</td>
<td>Extraction</td>
<td>Extraction</td>
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</tbody>
</table>
2. Treatment guidelines for luxation injuries

<table>
<thead>
<tr>
<th>Clinical findings</th>
<th>Radiographic findings</th>
<th>Treatment</th>
<th>Follow up</th>
<th>Favorable outcome</th>
<th>Unfavorable outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root fracture</td>
<td></td>
<td>The fracture involves the root of the tooth and is in a horizontal or oblique plane</td>
<td>4 weeks S, C**</td>
<td>Positive response to pulp testing (false negative possible up to 3 months)</td>
<td>Symptomatic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fractures that are in the horizontal plane can usually be detected in the regular periapical 90° angle film with the central beam through the tooth. This is usually the case with fractures in the cervical third of the root</td>
<td>4–6 weeks C**</td>
<td>Signs of repair between fractured segments</td>
<td>Negative response to pulp testing (false negative possible up to 3 months)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If the plane of fracture is more oblique, which is common with apical third fractures, an occlusal view or radiographs with varying horizontal angles is more likely to demonstrate the fracture including those located in the middle third of the root</td>
<td>6 months C**</td>
<td>Endodontic therapy appropriate for stage of root development is indicated</td>
<td>Extrusion of the coronal segment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If pulp necrosis develops, root canal treatment of the coronal tooth segment to the fracture line is indicated to preserve the tooth</td>
<td>1 year C**</td>
<td></td>
<td>Radiolucency at the fracture line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monitoring the status of the pulp is recommended</td>
<td>5 years C**</td>
<td></td>
<td>Clinical signs of periodontitis or abscess associated with the fracture line</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Transient crown discoloration (red or gray) may occur</td>
<td></td>
<td></td>
<td>Endodontic therapy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reposition, if displaced, the coronal segment of the tooth as soon as possible</td>
<td></td>
<td></td>
<td>Endodontic therapy appropriate for stage of root development is indicated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check position radiographically</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stabilize the tooth with a flexible splint for 4 weeks</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Reposition any displaced segment and then splint</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suture gingival laceration if present</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Stabilize the segment for 4 weeks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reposition procedures for luxated permanent teeth</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Alveolar fracture         |                       | The fracture involves the alveolar bone and may extend to adjacent bone    |                                        | Symptomatic                                                                       |
|                           |                       | Segment mobility and dislocation with several teeth moving together are common |                                        | Negative response to pulp testing (false negative possible up to 3 months)        |
|                           |                       | An occlusal change because of misalignment the fractured alveolar segment is often noted |                                        | Signs of apical periodontitis                                                    |
|                           |                       | Sensibility testing may or may not be positive                             |                                        | Endodontic therapy appropriate for stage of root development is indicated        |
|                           |                       | Fracture lines may be located at any level, from the marginal bone to the root apex |                                        |                                                                                   |
|                           |                       | In addition to the 3 angulations and occlusal film, additional views such as a panoramic radiograph can be helpful in determining the course and position of the fracture lines |                                        |                                                                                   |
2. Treatment guidelines for luxation injuries

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<tr>
<th>Clinical findings</th>
<th>Radiographic findings</th>
<th>Treatment</th>
<th>Follow-up procedures for luxated permanent teeth</th>
<th>Favorable and unfavorable outcomes include some, but not necessarily all, of the following</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concussion</td>
<td>• The tooth is tender to touch or tapping; it has not been displaced and does not have increased mobility&lt;br&gt;• Sensibility tests are likely to give positive results&lt;br&gt;• No radiographic abnormalities</td>
<td>• No treatment is needed&lt;br&gt;• Monitor pulpal condition for at least 1 year</td>
<td>4 weeks C**&lt;br&gt;6–8 weeks C**&lt;br&gt;1 year C**</td>
<td>• Asymptomatic&lt;br&gt;• Positive response to pulp testing&lt;br&gt;• False negative possible up to 3 months&lt;br&gt;• Continuing root development in immature teeth&lt;br&gt;• Intact lamina dura&lt;br&gt;• Symptomatic&lt;br&gt;• Negative response to pulp testing&lt;br&gt;• False negative possible up to 3 months&lt;br&gt;• No continuing root development in immature teeth, signs of apical periodontitis&lt;br&gt;• Endodontic therapy appropriate for stage of root development is indicated</td>
</tr>
<tr>
<td>Subluxation</td>
<td>• The tooth is tender to touch or tapping and has increased mobility; it has not been displaced&lt;br&gt;• Bleeding from gingival crevice may be noted&lt;br&gt;• Sensibility testing may be negative initially indicating transient pulpal damage&lt;br&gt;• Monitor pulpal response until a definitive pulpal diagnosis can be made&lt;br&gt;• Radiographic abnormalities are usually not found</td>
<td>• Normally no treatment is needed; however, a flexible splint to stabilize the tooth for patient comfort can be used for up to 2 weeks</td>
<td>2 weeks S*, C**&lt;br&gt;4 weeks C**&lt;br&gt;6–8 weeks C**&lt;br&gt;6 months C**&lt;br&gt;1 year C**</td>
<td>• Asymptomatic&lt;br&gt;• Positive response to pulp testing&lt;br&gt;• False negative possible up to 3 months&lt;br&gt;• Continuing root development in immature teeth&lt;br&gt;• Intact lamina dura&lt;br&gt;• Symptomatic&lt;br&gt;• Negative response to pulp testing&lt;br&gt;• False negative possible up to 3 months&lt;br&gt;• External inflammatory resorption&lt;br&gt;• No continuing root development in immature teeth, signs of apical periodontitis&lt;br&gt;• Endodontic therapy appropriate for stage of root development is indicated</td>
</tr>
<tr>
<td>Extrusive luxation</td>
<td>• The tooth appears elongated and is excessively mobile&lt;br&gt;• Sensibility tests will likely give negative results&lt;br&gt;• Increased periodontal ligament space apically&lt;br&gt;• Reposition the tooth by gently re-inserting it into the tooth socket&lt;br&gt;• Stabilize the tooth for 2 weeks using a flexible splint&lt;br&gt;• In mature teeth where pulp necrosis is anticipated or if several signs and symptoms indicate that the pulp of mature or immature teeth became necrotic, root canal treatment is indicated</td>
<td>• Reposition the tooth by gently re-inserting it into the tooth socket&lt;br&gt;• Stabilize the tooth for 2 weeks using a flexible splint&lt;br&gt;• In mature teeth where pulp necrosis is anticipated or if several signs and symptoms indicate that the pulp of mature or immature teeth became necrotic, root canal treatment is indicated</td>
<td>2 weeks S*, C**&lt;br&gt;4 weeks C**&lt;br&gt;6–8 weeks C**&lt;br&gt;6 months C**&lt;br&gt;1 year C**&lt;br&gt;Yearly 5 years C**</td>
<td>• Asymptomatic&lt;br&gt;• Clinical and radiographic signs of normal or healed periodontium&lt;br&gt;• Positive response to pulp testing (false negative possible up to 3 months)&lt;br&gt;• Marginal bone height corresponds to that seen radiographically after repositioning&lt;br&gt;• Continuing root development in immature teeth&lt;br&gt;• Symptoms and radiographic sign consistent with apical periodontitis&lt;br&gt;• Negative response to pulp testing (false negative possible up to 3 months)&lt;br&gt;• If breakdown of marginal bone, splint for an additional 3–4 weeks&lt;br&gt;• External inflammatory root resorption&lt;br&gt;• Endodontic therapy appropriate for stage of root development is indicated</td>
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</table>
| **Lateral Luxation** | • The tooth is displaced, usually in a palatal/lingual or labial direction  
• It will be immobile and percussion usually gives a high, metallic (ankylosic) sound  
• Fracture of the alveolar process present  
• Sensibility tests will likely give negative results | • The widened periodontal ligament space is best seen on eccentric or occlusial exposures | 2 weeks S+, C**  
4 weeks C**  
6–8 weeks C**  
6 months C**  
1 year C**  
Yearly for 5 years C** | • Asymptomatic  
• Clinical and radiographic signs of normal or healed periodontium  
• Positive response to pulp testing (false negative possible up to 3 months)  
• Marginal bone height corresponds to that seen radiographically after repositioning  
• Continuing root development in immature teeth  
• Tooth in place or erupting  
• Intact lamina dura  
• No signs of resorption  
• Continuing root development in immature teeth |
| **Intrusive luxation** | • The tooth is displaced axially into the alveolar bone  
• It is immobile, and percussion may give a high, metallic (ankylosic) sound  
• Sensibility tests will likely give negative results | • The periodontal ligament space may be absent from all or part of the root  
• The cemento-enamel junction is located more apically in the intruded tooth than in adjacent non-injured teeth, at times even apical to the marginal bone level | Teeth with incomplete root formation  
• Allow eruption without intervention  
• If no movement within few weeks, initiate orthodontic repositioning  
• If tooth is intruded more than 7 mm, reposition surgically or orthodontically  
• Monitor the pulpal condition  
• If the pulp becomes necrotic, root canal treatment is indicated to prevent root resorption | 2 weeks S+, C**  
4 weeks C**  
6–8 weeks C**  
6 months C**  
1 year C**  
Yearly for 5 years C** | • Symptoms and radiographic signs consistent with apical periodontitis  
• Negative response to pulp testing (false negative possible up to 3 months)  
• If breakdown of marginal bone, splint for an additional 3–4 weeks  
• External inflammatory root resorption or replacement resorption  
• Endodontic therapy appropriate for stage of root development is indicated |

C**, clinical and radiographic examination; S+, splint removal; S+++, splint removal in cervical third fractures.

1For crown-fractured teeth with concomitant luxation injury, use the luxation follow-up schedule.

2Whenever there is evidence of external inflammatory root resorption, root canal therapy should be initiated immediately, with the use of calcium hydroxide as an intra-canal medication.
Patient instructions

Patient compliance with follow-up visits and home care contributes to better healing following a TDI. Both patients and parents of young patients should be advised regarding care of the injured tooth/teeth for optimal healing, prevention of further injury by avoidance of participation in contact sports, meticulous oral hygiene, and rinsing with an antibacterial such as chlorhexidine gluconate 0.1% alcohol free for 1–2 weeks.

Additional resources

Besides the general recommendations mentioned earlier, clinicians are encouraged to access the DTG, the journal Dental Traumatology, and other journals for information pertaining to treatment delay (37), intrusive luxations 38–47), root fractures (48–52), pulpal management of fractured and luxated teeth (34, 53–64, splinting (18, 39, 65–68), and antibiotics (69).

Acknowledgements

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References


Andreasen JO, Bakland LK, Andreasen FM. Traumatic intrusion of permanent teeth. Part 2. A clinical study of the effect of preinjury and injury factors such as age, sex, stage of root development, tooth location and extent of injury including number of intruded teeth on 140 intruded permanent teeth. Dent Traumatol 2006;22:90–8.


Abstract – Avulsion of permanent teeth is one of the most serious dental injuries, and a prompt and correct emergency management is very important for the prognosis. The International Association of Dental Traumatology (IADT) has developed a consensus statement after a review of the dental literature and group discussions. Experienced researchers and clinicians from various specialties were included in the task group. The guidelines represent the current best evidence and practice based on literature research and professionals’ opinion. In cases where the data did not appear conclusive, recommendations were based on the consensus opinion or majority decision of the task group. Finally, the IADT board members were giving their opinion and approval. The primary goal of these guidelines is to delineate an approach for the immediate or urgent care of avulsed permanent teeth.
Avulsion of permanent teeth is seen in 0.5–3% of all dental injuries (1, 2). Numerous studies show that this injury is one of the most serious dental injuries, and the prognosis is very much dependent on the actions taken at the place of accident and promptly after the avulsion (2–27). Replantation is in most situations the treatment of choice, but cannot always be carried out immediately.

An appropriate emergency management and treatment plan are important for a good prognosis. There are also individual situations when replantation is not indicated (e.g., severe caries or periodontal disease, non-cooperating patient, severe medical conditions (e.g., immunosuppression and severe cardiac conditions) which must be dealt with individually. Replantation may successfully save the tooth, but it is important to realize that some of the replanted teeth have lower chances of long-term survival and may even be lost or extracted at a later stage.

Guidelines for the emergency management are useful for delivering the best care possible in an efficient manner. The International Association of Dental Traumatology (IADT) has developed a consensus statement after an update of the dental literature and discussions in expert groups. Experienced international researchers and clinicians from various specialties and general dentistry were included in the groups. In cases in which the data did not appear conclusive, recommendations were based on the consensus opinion and in some situations on majority decision among the IADT board members. All recommendations are not evidence based on a high level. The guidelines should therefore be seen as the current best evidence and practice based on literature research and professionals’ opinion.

Guidelines should assist dentists, other healthcare professionals, and patients in decision making. Also, they should be credible, readily understandable, and practical with the aim of delivering appropriate care as effectively and efficiently as possible.

It is understood that guidelines are to be applied with judgment of the specific clinical circumstances, clinicians’ judgments, and patients’ characteristics, including, but not limited to compliance, finances and understanding of the immediate and long-term outcomes of treatment alternatives vs non-treatment. The IADT cannot and does not guarantee favorable outcomes from strict adherence to the Guidelines, but believe that their application can maximize the chances of a favorable outcome. Guidelines undergo periodic updates. The following guidelines by the IADT represent an updated set of guidelines based on the original guidelines published in 2007 (28–30).

In this article, one of a series of three articles, the IADT Guidelines for management of avulsed permanent teeth are presented. Literature has been searched using Medline and Scopus databases using the search words: avulsion, exarticulation, and replantation. The task group has then discussed the emergency treatment in detail and reached consensus of what to recommend today as best practice for the emergency management. This text is aiming at giving the concise, short necessary advice for treatment in the emergency situation. More detailed description of protocols, methods, and documentation for clinical assessment and diagnosis of different dental injuries can be found in articles, textbooks, and manuals (2, 24) and in the interactive web site Dental Trauma Guide http://dentaltraumaguide.org.

The final decision regarding patient care remains primarily in the hand of the treating dentist. For ethical reasons, it is important that the dentist provides the patient and guardian with pertinent information relating to treatment so also the patient and guardian has as much influence in the decision-making process as possible.

First aid for avulsed teeth at the place of accident (2, 10, 24, 25, 31–55)

Dentists should always be prepared to give appropriate advice to the public about first aid for avulsed teeth. An avulsed permanent tooth is one of the few real emergency situations in dentistry. In addition to increasing the public awareness by, for example, mass media campaigns, healthcare professionals, guardians and teachers should receive information on how to proceed following these severe unexpected injuries. Also, instructions may be given by telephone to people at the emergency site. Immediate replantation is the best treatment at the place of accident. If for some reasons this cannot be carried out, there are alternatives such as using various storage media.

If a tooth is avulsed, make sure it is a permanent tooth (primary teeth should not be replanted).

- Keep the patient calm.
- Find the tooth and pick it up by the crown (the white part). Avoid touching the root.
- If the tooth is dirty, wash it briefly (max 10 s) under cold running water and reposition it. Try to encourage the patient/guardian to replant the tooth. Once the tooth is back in place, bite on a handkerchief to hold it in position.
- If this is not possible, or for other reasons when replantation of the avulsed tooth is not possible (e.g., an unconscious patient), place the tooth in a glass of milk or another suitable storage medium and bring with the patient to the emergency clinic. The tooth can also be transported in the mouth, keeping it inside the lip or cheek if the patient is conscious. If the patient is very young, he/she could swallow the tooth – therefore it is advisable to get the patient to spit in a container and place the tooth in it. Avoid storage in water!
- If there is access at the place of accident to special storage or transport media (e.g., tissue culture/transport medium, Hanks balanced storage medium (HBSS or saline) such media can preferably be used.
- Seek emergency dental treatment immediately.
The poster ‘Save a Tooth’ is written for the public and is available in several languages: English, Spanish, Portuguese, French, Icelandic, Italian, Arabic, and Turkish and can be obtained at the IADT website: http://www.iadt-dentaltrauma.org.

Treatment guidelines for avulsed permanent teeth (56–95)

Choice of treatment is related to the maturity of the root (open or closed apex) and the condition of the periodontal ligament cells. The condition of the cells is depending on the storage medium and the time out of the mouth, especially the dry time is critical for survival of the cells. After a dry time of 60 min or more, all periodontal ligament (PDL) cells are non-viable. For this reason, the dry time of the tooth, before it was placed replanted or placed in a storage medium, is very important to assess from the patient’s history.

From a clinical point of view, it is important for the clinician to roughly assess the condition of the cells by classifying the avulsed tooth into one of the following three groups before starting treatment:

- The PDL cells are most likely viable (i.e., the tooth has been replanted immediately or after a very short time at the place of accident).
- The PDL cells may be viable but compromised. The tooth has been kept in storage medium (e.g., tissue culture medium, HBSS, saline, milk, or saliva and the total dry time has been <60 min).
- The PDL cells are non-viable. Examples of this is when the trauma history tells us that the total extra-oral dry time has been more than 60 min regardless of if the tooth was stored in an additional medium or not, or if the storage medium was non-physiologic.

1. Treatment guidelines for avulsed permanent teeth with closed apex

1a. The tooth has been replanted before the patient’s arrival at the clinic

- Leave the tooth in place.
- Clean the area with water spray, saline, or chlorhexidine.
- Suture gingival lacerations, if present.
- Verify normal position of the replanted tooth both clinically and radiographically.
- Apply a flexible splint for up to 2 weeks (see Splinting).
- Administer systemic antibiotics (see Antibiotics).
- Check tetanus protection (see Tetanus).
- Give patient instructions (see Patient instructions).
- Initiate root canal treatment 7–10 days after replantation and before splint removal. (see Endodontic considerations).

Follow-up
See: Follow-up procedures.

1b. The tooth has been kept in a physiologic storage medium or osmolality balanced medium and/or stored dry, the extra-oral dry time has been less than 60 min

Physiologic storage media include tissue culture medium and cell transport media. Examples of osmolality balanced media are HBSS, saline, and milk. Saliva can also be used.

- Clean the root surface and apical foramen with a stream of saline and soak the tooth in saline thereby removing contamination and dead cells from the root surface.
- Administer local anesthesia.
- Irrigate the socket with saline.
- Examine the alveolar socket. If there is a fracture of the socket wall, reposition it with a suitable instrument.
- Replant the tooth slowly with slight digital pressure. Do not use force.
- Suture gingival lacerations, if present.
- Verify normal position of the replanted tooth both clinically and radiographically.
- Apply a flexible splint for up to 2 weeks, keep away from the gingiva.
- Administer systemic antibiotics (see Antibiotics).
- Check tetanus protection (see Tetanus).
- Give patient instructions (see Patient instructions).
- Initiate root canal treatment 7–10 days after replantation and before splint removal (see Endodontic considerations).

Follow-up
See: Follow-up procedures.

1c. Dry time longer than 60 min or other reasons suggesting non-viable cells

Delayed replantation has a poor long-term prognosis. The periodontal ligament will be necrotic and not expected to heal. The goal in delayed replantation is, in addition to restoring the tooth for esthetic, functional and psychological reasons, to maintain alveolar bone contour However, the expected eventual outcome is ankylosis and resorption of the root and the tooth will be lost eventually.

The technique for delayed replantation is as follows:

- Remove attached non-viable soft tissue carefully, for example, with gauze. The best way to this has not yet been decided (see Future areas of research).
- Root canal treatment to the tooth can be carried out prior to reimplantation or later (see Endodontic considerations).
- In cases of delayed replantation, root canal treatment should be either carried out on the tooth prior to reimplantation or it can be carried out 7–10 days later like in other reimplantation situations (see Endodontic considerations).

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Follow-up
See: Follow-up procedures.

In children and adolescents ankylosis is frequently associated with infra-position. Careful follow-up is required and good communication is necessary to ensure the patient and guardian of this likely outcome. Decoronation may be necessary later when infra-position (>1 mm) is seen. For more detailed information of this procedure, the reader is referred to textbooks.

2. Treatment guidelines for avulsed permanent teeth with an open apex

2a. The tooth has been replanted before the patient’s arrival at the clinic

- Administer local anesthesia.
- Irrigate the socket with saline.
- Examine the alveolar socket. If there is a fracture of the socket wall, reposition it with a suitable instrument.
- Replant the tooth.
- Suture gingival lacerations, if present.
- Verify normal position of the replanted tooth clinically and radiographically.
- Stabilize the tooth for 4 weeks using a flexible splint (see Splinting).
- Administration of systemic antibiotics (see Antibiotics).
- Check tetanus protection (see Tetanus).
- Give patient instructions (see Patient instructions).

To slow down osseous replacement of the tooth, treatment of the root surface with fluoride prior to replantation has been suggested (2% sodium fluoride solution for 20 min) but it should not be seen as an absolute recommendation.

Follow-up
See: Follow-up procedures.

2b. The tooth has been kept in a physiologic storage medium or osmolality balanced medium and/or stored dry, the extra-oral dry time has been <60 min

Physiologic storage media include tissue culture medium and cell transport media. Examples of osmolality balanced media are HBSS, saline, and milk. Saliva can also be used.
- If contaminated, clean the root surface and apical foramen with a stream of saline.
- Topical application of antibiotics has been shown to enhance chances for revascularization of the pulp and can be considered if available (see Antibiotics).
- Administer local anesthesia.
- Examine the alveolar socket.
- If there is a fracture of the socket wall, reposition it with a suitable instrument.
- Remove the coagulum in the socket and replant the tooth slowly with slight digital pressure.
- Suture gingival lacerations, especially in the cervical area.
- Verify normal position of the replanted tooth clinically and radiographically. Apply a flexible splint for up to 2 weeks (see Splinting).
- Administer systemic antibiotics (see Antibiotics).
- Check tetanus protection (see Tetanus).
- Give patient instructions (see Patient instructions).
- The goal for replanting still-developing (immature) teeth in children is to allow for possible revascularization of the pulp space. The risk of infection-related root resorption should be weighed up against the chances of revascularization. Such resorption is very rapid in teeth of children. If revascularization does not occur, root canal treatment may be recommended (see Endodontic considerations).

Follow-up
See Follow-up procedures.

2c. Dry time longer than 60 min or other reasons suggesting non-viable cells

Delayed replantation has a poor long-term prognosis. The periodontal ligament will be necrotic and not expected to heal. The goal in delayed replantation is to restore the tooth to the dentition for esthetic, functional, and psychological reasons and to maintain alveolar contour. The eventual outcome will be ankylosis and resorption of the root.

The technique for delayed replantation is as follows:
- Remove attached non-viable soft tissue carefully, for example, with gauze. The best way to this has not yet been decided (see Future areas of research).
- Root canal treatment to the tooth can be carried out prior to replantation or later (see Endodontic considerations).
- Administer local anesthesia.
- Remove the coagulum from the socket with a stream of saline. Examine the alveolar socket. If there is a fracture of the socket wall, reposition it with a suitable instrument.
- Replant the tooth slowly with slight digital pressure. Suture gingival laceration. Verify normal position of the replanted tooth clinically and radiographically.
- Stabilize the tooth for 4 weeks using a flexible splint (see Splinting).
- Administer systemic antibiotics (see Antibiotics).
- Check tetanus protection (see Tetanus).
- Give patient instructions (see Patient instructions).

To slow down osseous replacement of the tooth, treatment of the root surface with fluoride prior to replantation (2% sodium fluoride solution for 20 min) has been suggested but it should not be seen as an absolute recommendation.

Follow-up
See Follow-up procedures.

Ankylosis is unavoidable after delayed replantation and must be taken into consideration.

In children and adolescents ankylosis is frequently associated with infraposition. Careful follow-up is required and good communication is necessary to ensure the patient and guardian of this likely outcome. Decoration may be necessary when infraposition (>1 mm) is seen. For more detailed information of this procedure the reader is referred to textbooks.

Anesthetics (64–66)

Patients and guardians are recommended by us to do replantation at the place of accident without anesthesia. In the clinic, however, where local anesthetics are available, there is no need to omit local anesthesia, especially as there are often concomitant injuries. Concern is sometimes raised whether there are risks of compromising healing by using vasoconstrictor in the anesthesia. Evidence is weak for omitting vasoconstrictor in the oral and maxillofacial region and must be further documented before any recommendations against the use of it can be given (see suggested future areas of research at the end of this article). Block anesthesia (e.g., infraorbital nerve block) may be considered as an alternative to infiltration anesthesia in more severely injured areas and must be related to the clinicians’ experience of such blocking techniques.

Antibiotics (67–76)

The value of systemic administration of antibiotics in human after replantation is still questionable as clinical studies have not demonstrated its value. Experimental studies have, however, usually shown positive effects upon both periodontal and pulpal healing especially when administered topically. For this reason, antibiotics are in most situations recommended after replantation of teeth. In addition, the patient’s medical status or concomitant injuries may warrant antibiotic coverage.

For systemic administration, tetracycline is the first choice in appropriate dose for patient age and weight the first week, can be given as alternative to tetracycline.

Topical antibiotics (minocycline or doxycycline, 1 mg per 20 ml of saline for 5 min soak) appear experimentally to have a beneficial effect in increasing the chance of pulpal space revascularization and periodontal healing and may be considered in immature teeth (2b).

Tetanus (2, 24, 25)

Refer the patient to a physician for evaluation of need for a tetanus booster if the avulsed tooth has contacted soil or tetanus coverage is uncertain.

Splinting of replanted teeth (77–83)

It is considered best practice to maintain the repositioned tooth in correct position, provide patient comfort and improve function. Current evidence supports short-term, flexible splints for splinting of replanted teeth. Studies have shown that periodontal and pulpal healing is promoted if the replanted tooth is given a chance for slight motion and the splinting time is not too long. Given this there is so far no specific type of splint related to healing outcomes. The splint should be placed on the buccal surfaces of the maxillary teeth to enable lingual access for endodontic procedures and to avoid occlusal interference.

Replanted permanent teeth should be splinted up to 2 weeks. Various types of acid etch bonded splints have been widely used to stabilize avulsed teeth because they allow good oral hygiene and are well tolerated by the patients. For a detailed description of how to make a splint, the reader is referred to articles, textbooks, manuals, and the web site Dental Trauma Guide http://www.dentaltraumaguide.org.

Patient instructions (2, 24, 25)

Patient compliance with follow-up visits and home care contributes to satisfactory healing following an injury. Both patients and guardians of young patients should be advised regarding care of the replanted tooth for optimal healing and prevention of further injury.

- Avoid participation in contact sports.
- Soft diet for up to 2 weeks. Thereafter normal function as soon as possible.
- Brush teeth with a soft toothbrush after each meal.
- Use a chlorhexidine (0.1%) mouth rinse twice a day for 1 week.

Endodontic considerations (62, 84–93)

If root canal treatment is indicated (teeth with closed apex), the ideal time to begin treatment is 7–10 days postreplantation. Calcium hydroxide is recommended as an intra-canal medication for up to 1 month followed by root canal filling with an acceptable material. Alternatively if an antibiotic-corticosteroid paste is chosen to be used as an anti-inflammatory, anti-elastic intra-canal medicament, it may be placed immediately or shortly following replantation and left.
for at least 2 weeks. If the antibiotic in the paste is dechlorotetracycline, there is a risk of tooth discoloration and care should be taken to confine the paste to the root canal and avoid contact of the paste with the pulp chamber walls.

If the tooth has been dry for more than 60 min before replantation. The root canal treatment may be carried out extra-orally prior to replantation.

In teeth with open apexes, which have been replanted immediately or kept in appropriate storage media prior to replantation, pulp revascularization is possible. The risk of infection-related root resorption should be weighed up against the chances of obtaining pulp space revascularization. Such resorption is very rapid in teeth of children. For very immature teeth, root canal treatment should be avoided unless there is clinical or radiographic evidence of pulp necrosis.

Follow-up procedures (2, 6–9, 24, 25)

Clinical control
Replanted teeth should be monitored by clinical and radiographic control after 4 weeks, 3 months, 6 months, 1 year, and yearly thereafter. Clinical and radiographic examination will provide information to determine outcome. Evaluation may include the findings described as follows.

Favorable outcome
Closed apex
Asymptomatic, normal mobility, normal percussion sound. No radiographic evidence of resorption or periodontal osteitis: the lamina dura should appear normal.

Open apex
Asymptomatic, normal mobility, normal percussion sound. Radiographic evidence of arrested or continued root formation and eruption. Pulp canal obliteration is to be expected.

Unfavorable outcome
Closed apex
Symptomatic, excessive mobility or no mobility (ankylosis) with high-pitched percussion sound. Radiographic evidence of resorption (inflammatory, infection-related resorption, or ankylosis-related replacement resorption). When ankylosis occurs in a growing patient, infraposition of the tooth is highly likely to occur leading to disturbance of alveolar and facial growth over the short-, medium-, and long term.

Open apex
Symptomatic, excessive mobility or no mobility (ankylosis) with high-pitched percussion sound. In the case of ankylosis, the crown of the tooth will appear to be in an infraposition. Radiographic evidence of resorption (inflammatory, infection-related resorption, or ankylosis-related replacement resorption) or absence of continued root formation. When ankylosis occurs in a growing patient, infraposition of the tooth is highly likely to occur leading to disturbance of alveolar and facial growth over the short-, medium-, and long term.

Loss of tooth
In cases where teeth are lost in the emergency phase or will be lost later after trauma, discussions with colleagues, where available, who have expertise with managing such cases is prudent especially in growing patients. Ideally these discussions should take place before the tooth shows signs of infraposition. Appropriate treatment options may include decoronation, autotransplantation, resin retained bridge, denture, orthodontic space closure with composite modification and sectional osteotomy. Such treatment decisions are based on a full discussion with the child and parents, clinician’s expertise and aim to keep all options open until maturity is reached. After growth is completed, implant treatment can also be considered. The clinician is referred to textbooks and articles for further readings regarding these procedures.

Future areas of research – methods discussed but not included as recommendations in the guidelines this time
A number of promising treatment procedures for avulsed teeth have been discussed in the consensus group. Some of these treatment suggestions do have certain experimental evidence, and some of them are even used today in clinical practice: according to the group members, there is currently insufficient weight or quality of clinical and/or experimental evidence for some of these methods to be recognized as recommendations in the guidelines this time. These and some other important fields are examples where the group advocates further research and documentation:

- Methods for removal of non-viable PDL.
- Conditioning the PDL with extra-oral storage in tissue culture media prior to replantation.
- Conditioning the PDL with enamel matrix protein prior to replantation for teeth with short extra-oral periods.
- Topical treatment of root surface with fluoride for teeth with long extra-oral period.
- Revascularization of pulp space and methods promoting this.
- Optimal splint types with regard to periodontal and pulpal healing.
- Effect on adrenaline content of local anesthesia on healing.
- Reducing the inflammation with corticosteroids.
- Extra-oral root filling of teeth with less than a 60 min drying period.
- Use of titanium posts for root elongation and as alternatives to conventional root canal treatment.
- Long-term development of alveolar crest following replantation and decoronation.

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References


