

A SUMMARY OF TRAUMA IN THE YOUNG PERMANENT DENTITION



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INTRODUCTION

Dental trauma can be challenging to treat especially as a dental student where you have little experience in emergency treatment. It is therefore important to have a structured approach, to ensure correct management of the injury and therefore improve long term prognosis of the tooth in question. Research from the *International Journal of Paediatric Dentistry* has shown the general dental practitioner's knowledge of emergency treatment of dental trauma to be inadequate and that greater undergraduate education in this topic is needed.¹ It is therefore important that there is good knowledge amongst dental students so that they can carry this beyond dental school into their future practice. In this article we aim to discuss the importance of a good history from the child and/or their parent, examination, diagnosis, initial management and long term management of the six injuries to the periodontal tissues and the seven fractures of dental hard tissues and pulp of the permanent dentition.

HISTORY

When first presented with a patient who has experienced dental trauma there are a few key questions that you should ask:

- How did this injury occur? (low velocity impact tends to cause luxations, whilst high velocity impact is more likely to cause crown fractures; sharp objects favour a clean break with no luxation, blunt objects favour luxation or root fracture).²

- When did this injury happen? (timescale is a very important factor in choice of treatment and will be discussed later).
- Where were you when this injury happened? (potential contamination of wounds, it is important to check tetanus immunisation status).^{2,3}
- Did you have any loss of consciousness or suffer any head or other injuries? (serious non-dental injuries would require immediate referral to medical colleagues).⁴
- Have you had any previous injuries to this tooth? (may explain radiographic findings such as pulp canal obliteration or arrested root development).⁵
- Has this injury changed the way you bite, and if so how? (could further determine the type of injury whether it is tooth luxation or a condylar, jaw or alveolar fracture).⁵
- Has your tooth been sensitive to hot food and drink? (could indicate dentine exposure and the need for dentinal coverage).⁵

Whilst this is not an exhaustive list of questions you should ask, they are all important in piecing together a story from the patient or their parent. If there are any inconsistencies in the story along the way, delayed presentation of the trauma, bruising of soft tissues not overlying bony prominences or injuries taking the shape of a recognisable object, these could all indicate non-accidental injury (NAI). If you suspect this it is important to make it clear in the

notes, take appropriate clinical photographs for medico-legal implications and report to it to your appropriate senior.^{2,6}

A thorough trauma history is important for the purposes of diagnosis as well as formulating a treatment plan, but you should also ensure a good medical and dental history are taken. In the medical history, particularly look out for any bleeding disorders, congenital heart disease, immunosuppression, tetanus immunisation status and any allergies or medications the child is taking.² In the dental history make note of any previous injury to the dentition and how it was managed as well as gauging the child's general dental experience.

CLINICAL EXAMINATION

Extra-oral: look for any injuries outside the mouth, assess facial asymmetry (in front and behind), palpate the facial skeleton, look for facial injuries such as soft tissue swelling, abrasions, lacerations or contusions (bruising) and clean up all debris and dried blood with a wet gauze.^{2,5}

Intra-oral: assess occlusion, soft tissues inside the mouth looking for the same facial injuries as extra-orally and hard tissues to see if any teeth are missing, fractured, displaced or mobile.

A trauma grid is a good structured way to assess the teeth in question as well as the teeth either side and aid in provisional diagnosis. A radiograph is necessary for definitive diagnosis. Table 1 describes an example of a trauma case and its respective trauma grid.

Whilst the trauma grid gives structure to the examination, there are a few things to note:

- It is best not to tap freshly traumatised teeth unless you want to listen to the tone. Luxated teeth produce a high, metallic (ankylosed) sound as opposed to the dull tone of normal teeth, whilst a very dull tone may indicate root fracture.³
- Vitality tests measure nerve impulses but it is the blood supply that determines whether the pulp will undergo necrosis or recover, so the test may not be accurate.^{2,5,7}
- Immediately post-trauma (in particular luxation) and incomplete root formation are factors for a decreased response to vitality tests whilst teeth being moved by orthodontics may display heightened response to vitality tests.^{2,5}
- There is very little value in vitality testing primary teeth.^{2,5}

Table 1: Trauma Grid – a logical way of displaying diagnostic information about injured teeth and teeth adjacent to them.²

Tooth	UR2	UR1	UL1	UL2
Colour	-	+ (yellow)	+ (grey)	-
Mobility	-	-	+ (Grade I)	-
TTT	-	-	+	-
Cold / EPT	+	+	-	+
Radiographs	-	-	+	-
Note: A minus sign (-) indicates absence of a particular sign. (e.g. absence of colour change or mobility) A plus sign (+) indicates that feature is present. (e.g. tender to tap or responds to cold) TTT = tender to tap, EPT = electric pulp test. UR1: Had yellow discolouration, was not mobile or tender to tap, and was responsive to pulp sensibility testing UL1: Was darker in colour, was tender to tap, demonstrated grade I mobility, was not responsive to sensibility testing, and had a periapical radiolucency No abnormalities detected for UR2 and UL2				

Table 2: A summary of the intervals of review appointments depending on the type of trauma injury, as advised by the International Association of Dental Traumatology, IADT.³

	2 weeks	4 weeks	6-8 weeks	6 months	1 year	Yearly for 5 years
Concussion		x	x		x	
Subluxation	x	x	x	x	x	
Extrusive Luxation	x	x	x	x	x	x
Lateral Luxation	x	x	x	x	x	x
Intrusive Luxation	x	x	x	x	x	x
Avulsion	x	x	x	x	x	x
Infraction	No review necessary unless there is an association with a luxation injury					
Enamel fracture			x		x	
E-D fracture			x		x	
E-D-P fracture			x		x	
Crown-root (uncomplicated) fracture			x		x	
Crown-root (complicated) fracture			x		x	
Root fracture		x	x	x	x	x

It is important to complete a trauma grid at each review appointment to monitor for complications such as loss of vitality, initiating treatment as soon as possible if this is the case. Other things to record include any signs of infection such as an abscess or sinus and symptoms the patient is getting such as pain.² Generally review appointments should take place at the following intervals for periodontal tissue injuries: 4 weeks, 6-8 weeks, 6 months, 1 year and yearly for 5 years. For all injuries to the dental hard tissues and pulp 6-8 weeks and 1 year intervals are appropriate unless stated otherwise in this article.³ Table 2 provides a summary of these intervals depending on the injury, however it should be mentioned that these intervals of review appointments are only a guide.

RADIOGRAPHIC EXAMINATION

The three most common radiographic views for assessing trauma are periapical (PA), occlusal and orthopantomogram (OPG).

PAs show proximity of a fracture to the pulp, the stage of root development and determine the presence of root fractures, which can be done using two PAs at different lateral angulations.^{2,7}

Occlusal views can be used also for determination of root fractures using horizontal parallax with a PA or if access is difficult an anterior occlusal view radiograph will rarely miss a root fracture.²

OPGs are taken where underlying bony injury is suspected, for example an alveolar fracture or a fracture in the TMJ, where referral to a specialist centre may be required.²

Dental radiographs are not limited solely to the dentition, soft tissue exposure of the lip can be done if for example, there are suspected tooth fragments present in the lip from a laceration injury caused by an enamel-dentine fracture.²

INJURIES TO THE PERIODONTAL TISSUES

There are six injuries that involve damage to the periodontal tissues:

1) **Concussion:** Injury to the tooth supporting structures causing haemorrhage and oedema of the periodontal ligament without causing tooth mobility. Clinically the tooth is TTT and no radiographic abnormalities are present. No immediate treatment is needed, however the pulp status should be monitored at the review intervals stated in Table 2.^{2,3}

2) **Subluxation:** Injury to the tooth supporting structures causing damage to the periodontal ligament (PDL) fibres resulting in tooth mobility without any displacement. The tooth will also be tender to tap and there may be bleeding from the gingival crevice due to PDL severance, depending on the timing of presentation. Usually there are no radiographic abnormalities and again the pulpal response should be monitored until a definitive diagnosis can be made. In addition, if the patient is in discomfort upon presentation a flexible splint can be placed for up to 2 weeks to stabilise the tooth position.^{2,3} This splint is made from 0.018" round stainless steel orthodontic wire and is bonded using composite resin placed in the middle of the tooth; at least one tooth either side should be included in the splint.⁸

3) **Extrusive Luxation or Extrusion:** Partial displacement of the tooth out of its socket, giving the tooth an elongated appearance due to partial or total separation of the PDL from the tooth that can be seen radiographically, whilst the alveolar bone remains intact. Depending on the severity of the injury, the tooth may also be protruded or retruded in addition to its axial displacement. In addition, the tooth will be TTT, excessively mobile and there is normally a negative response to vitality tests. If there is a positive response, this indicates a reduced risk of long-term pulpal necrosis.^{2,3} As Table 3 shows, the maturity of the tooth greatly influences the prognosis of the tooth, with pulpal revascularisation normally occurring in immature teeth (open apex) versus mature teeth (closed apex) in extrusion injuries, therefore determining the need for eventual root canal treatment (RCT). Immediate treatment involves washing the exposed root surface with saline, digital repositioning under local anaesthetic if necessary; checking correct positioning by assessing the occlusion and taking a PA radiograph. Following this a flexible wire splint is placed for 2 weeks advising a soft diet after which pulpal condition is monitored for revascularisation. A continued lack of response at review appointments to pulp testing and/or crown discolouration in mature teeth is indicative of pulpal necrosis and RCT will be necessary.^{2,3}

4) **Lateral Luxation:** Displacement of the tooth in a direction other than axially, again with partial or total separation from the PDL and also involves fracture of either the labial, palatal or lingual alveolar bone.

Table 3 – Percentage prognosis of an immature (open apex) vs mature (closed apex) tooth that has experienced a traumatic injury of the periodontal tissues.²

Type of injury	Open apex (%)	Closed apex (%)
Concussion	100	96
Subluxation	100	85
Extrusive Luxation	95	45
Lateral Luxation	95	25
Intrusive Luxation	40	0
Avulsion	30	0

If both sides of the alveolar bone fracture the injury is known as an alveolar fracture. Clinically the tooth will not be mobile as it has been displaced into the alveolar bone as a result giving a metallic, ankylotic sound when tapped. Similar to extrusive luxation, the long term prognosis depends on the maturity of the tooth, however as Table 3 shows there is a reduced prognosis for laterally luxated compared to extruded mature teeth due to the greater degree of displacement on average. Immediate treatment requires local anaesthetic, digital pressure or forceps to reposition the tooth from its immobile position in bone, checking correct positioning with occlusion and a PA radiograph, and finally splinting the tooth for 4 weeks. The increased splinting time is due to time required for bone to heal rather than just the soft tissues in an extrusive luxation. Regular reviews as summarised in Table 2, should take place to monitor condition of the pulp, checking for pulpal necrosis and if it is present RCT is indicated to prevent root resorption.^{2,3}

5) **Intrusive luxation or Intrusion:** Displacement of the tooth axially into alveolar bone, without any tooth mobility or response to vitality tests. Radiographically the PDL space may be absent fully or in part from the root due to the extensive damage to the PDL as well as the cemento-enamel junction (CEJ) being located apically to adjacent teeth. Complete loss of the PDL space is seen radiographically when ankylosis occurs, this is the fusion of teeth to the surrounding alveolar bone. An intrusive injury has caused ankylosis of the UR1 and UR2 as shown in Figure 1, where there is loss of the PDL space. Due to pulpal

necrosis, both the UR1 and UR2 were root treated and the incisal edges elongated with composite resin to bring the UR1 back into occlusion and improve the aesthetics of both teeth. The treatment, as summarised in



Figure 1: A periapical radiograph showing ankylosis of the UR1 with loss of PDL and a clinical photograph of the dentition showing elongation of the UR1 and UR2. (with thanks to Professor Richard Welbury)

Table 4 – The classification of mild, moderate and severe intrusion as well as the treatment required depending on the type of intrusion for open vs closed apex teeth.^{2,3}

Tooth Maturity	Type of Intrusion	Amount of Intrusion (mm)	Treatment
Open Apex	Mild	≤ 3	Spontaneous
	Moderate	3 - 7	Spontaneous
	Severe	≥ 7	Orthodontic or Surgical
Closed Apex	Mild	≤ 3	Spontaneous
	Moderate	3 - 7	Orthodontic or Surgical
	Severe	≥ 7	Surgical

Table 4, varies upon the degree of intrusion; the greater the amount of intrusion, the more invasive the treatment. Spontaneous eruption is the treatment of choice for minor intrusions and leads to fewer healing complications than orthodontic and surgical repositioning. However, if there is no spontaneous movement within a few weeks, intervene with orthodontic or surgical repositioning before ankylosis occurs. Orthodontic repositioning is best for patients with delayed presentation and enables slow repositioning of the tooth as well as repair of marginal bone of the socket.^{2,3} This method uses orthodontic brackets on adjacent teeth, stainless steel wire and elastic tubing in order to extrude the tooth and therefore facilitate RCT in the future.⁹ Surgical repositioning is required when there is major intrusion into the socket and is best treated shortly after the injury.^{2,3} It involves raising a flap to reposition the tooth and then supporting it in place with a splint. RCT should be considered for all mature teeth where pulp revascularisation is unlikely following intrusive luxation, and should commence roughly 7-10 days after the injury.^{2,3,9}

6) Avulsion: The complete displacement of a tooth from its socket in alveolar bone. When dealing with an avulsion injury there are a few important things to consider before deciding on a treatment. Firstly, if the avulsed tooth isn't found it is very important to exclude an intrusive luxation injury. Secondly it is important to ascertain whether the avulsed tooth is a primary or secondary tooth, as primary teeth should never be replanted because they could damage the permanent tooth germ.^{2,3,5,8} You should also identify whether the whole tooth has been avulsed or there is a concomitant root fracture, where part of the tooth is

avulsed and the remainder is root retained.³ Finally you should assess what stage of root development the tooth is at, whether it is an immature (open apex) or mature (closed apex) tooth.

Clinically it is important to assess the viability of the PDL. If the tooth has been replanted immediately after the avulsion, the PDL cells are likely to be viable. If the tooth has been avulsed less than 60 minutes ago and the tooth has been kept in an appropriate storage medium (saliva, milk, saline) the PDL cells are likely to still be viable but have a worse long term prognosis. If the total extra oral dry time is more than 60 minutes, the PDL cells will not be viable regardless of the storage medium. The

‘Orthodontic repositioning is best for patients with delayed presentation and enables slow repositioning of the tooth as well as repair of marginal bone of the socket’

two most important factors to determine the choice of treatment when a patient presents with an avulsed tooth are the total extra-oral dry time and the stage of root development.^{3,10}

If the tooth is mature and has already been replanted prior to presentation it is important to verify the position, both clinically and radiographically. It is then advisable to splint the tooth for 2 weeks and prescribe systemic antibiotics. The tooth will have a closed apex and the pulp will

have undergone necrosis so it is important to commence RCT within 10 days.^{3,10}

If the mature tooth has not been replanted and has been kept in an appropriate storage medium, with an extra oral dry time of less than 60 minutes you should replant the tooth as soon as possible. It is important to clean the root with saline and replant with digital pressure. You should then radiographically verify the position, splint the tooth for 2 weeks and prescribe systemic antibiotics. Again, RCT should take place 7-10 days after replantation.^{3,10}

If the extra oral dry time is greater than 60 minutes ankylosis will occur following replantation and the tooth will eventually be lost. However, in the short term it is important to maintain aesthetics, function and to maintain alveolar bone. Prior to replantation non-viable tissue should be removed from the root using gauze and if there is time, RCT of the tooth should be carried out. The socket should also be irrigated prior to replantation and after replantation the tooth should be splinted for 4 weeks and antibiotics prescribed. The position should be verified radiographically.^{2,3,5,10}

In immature teeth there is an improved prognosis because there is a chance of pulp revascularisation and for this reason RCT is avoided until there is evidence of pulpal necrosis either clinically or radiographically.

Additionally, if the tooth has not been replanted on presentation, soaking the tooth in topical antibiotics such as minocycline or doxycycline 1mg per 20ml saline for 5 minutes has been shown to enhance the chances of revascularisation.^{3,8} Otherwise, the treatment of immature avulsed teeth follows the same

steps of management as mature avulsed teeth.

For both immature and mature avulsed teeth, patients should avoid participation in contact sports, be advised to have a soft diet for 2 weeks and use a chlorhexidine mouthwash twice a day for one week. Replanted teeth should be followed up at the intervals stated in Table 2 in order to monitor pulp status and periodontal healing both clinically and radiographically.

However, there is limited evidence for

Table 5: A summary table of the six injuries to their periodontal tissues and their respective treatment options³

Type of injury	Description of injury	Treatment (Permanent Dentition)
Concussion	Tooth is TTT with no displacement or mobility	No treatment indicated, monitor pulp for one year
Subluxation	Tooth is TTT with increased mobility but no displacement	Flexible splint to stabilise the tooth for 2 weeks
Extrusive Luxation	Tooth looks elongated and mobile	Reposition and stabilise tooth for 2 weeks with flexible splint. Commence RCT if necrotic pulp anticipated/evident
Lateral Luxation	Tooth displaced but not mobile and there is an ankylotic sound on percussion	Disengage tooth from bony displacement and reposition to original position. Stabilise tooth for 4 weeks using flexible splint Commence RCT if pulp necrosis occurs
Intrusive Luxation	Tooth displaced into alveolar bone axially and gives an ankylotic sound on percussion	If incomplete root formation, allow for spontaneous eruption. Consider orthodontic repositioning if no change after 3 weeks If intrusion is >7mm, consider surgical/orthodontic repositioning primarily
Avulsion	Complete displacement from its socket in alveolar bone	1) Tooth replanted prior to presentation – Clinically and radiographically verify position, splint for 2 weeks and administer systemic antibiotics 2) Presentation with extra oral dry time <60mins – Clean root with saline, replant tooth and verify position clinically and radiographically. Place a flexible splint for 2 weeks 3) Extra oral dry time >60mins – RCT of tooth either prior to replantation or within 10 days. Replant and verify position both clinically and radiographically. Splint for 4 weeks

the use of systemic antibiotics to manage luxation injuries, therefore it remains the decision of the dentist whether to prescribe them.⁷ For example if the patient was immunocompromised, this would indicate a prescription of systemic antibiotics such as amoxicillin or doxycycline (if there is an allergy to penicillin) for a luxation injury.¹¹

Table 5 summarises the six injuries to the periodontal tissues and their treatments for quick reference, and Figure 2 illustrates each of the injuries.

INJURIES TO THE DENTAL HARD TISSUES AND PULP

1) **Infraction:** An incomplete fracture or crack of the enamel without any loss of tooth

substance. The crack is often visible but the use of trans-illumination with the mirror can aid in identifying the fracture. It is often too small to identify radiographically and there isn't a need to take radiographs at review appointments unless there are symptoms present. Clinically the presence of any tenderness may indicate a luxation injury caused by the traumatic event. A large infraction may require etching and sealing with a composite resin to prevent discolouration of the fracture line.^{2,3,13}

2) **Enamel fracture:** A fracture causing loss of enamel but not exposing any dentine. Any tenderness symptoms could again be attributed to a luxation injury. Radiographically as well as clinically, enamel

loss will be visible; PA and occlusal views may be required to rule out the possibility of a root fracture or luxation injury. If the patient does not have the enamel fragment or could not find it, check the soft tissues for fragments. If the patient does have the fragment, this can be bonded back on but the time elapsed may result in dryness and discolouration of the fragment that would produce an unaesthetic result if reattached. Alternatively, the enamel lost can be replaced with composite resin; the tooth is etched, bond applied and composite placed incrementally or in bulk using crown former templates to help shape the filling.^{2,3,13}

3) **Enamel-dentine fracture:** A fracture of the enamel and dentine in a tooth but not involving the pulp. Radiographically as well as clinically, enamel and dentine loss will be visible without involvement of the pulp; PA and occlusal views may be required to rule out the possibility of a root fracture or luxation injury. The tooth should not be tender to tap and if it is, there may be a luxation injury associated. It is important to obtain good dentinal coverage in this injury to avoid the entry of bacteria into the dentinal tubules and pulpal inflammation resulting. As mentioned above, if the patient still has the fragment that fractured off, it can be replaced but the tooth surface and fragment need to be prepared appropriately.

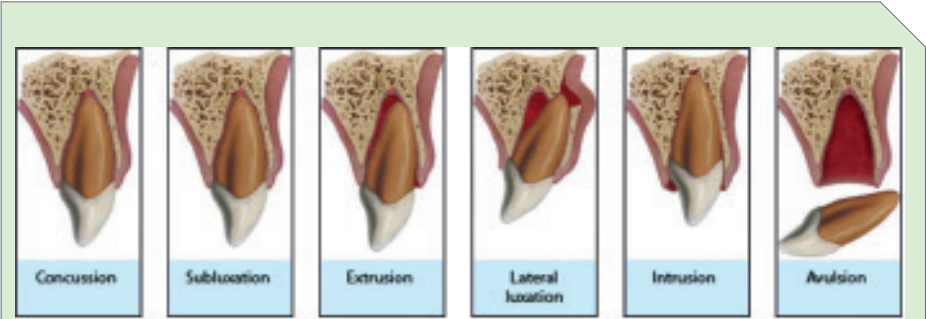


Figure 2: A series of illustrations of each of the six injuries to the periodontal tissues.³

The tooth fragment should be immediately placed in saline or milk and brought to the appointment. The fragment should be tested for fit against the tooth, both the tooth and fragment cleaned using a pumice and water slurry, a V-shaped notch should be made in the fragment to create an irregular outline for the composite to fill. The dentine exposed if close to pulp, should be protected by a calcium hydroxide lining and then the enamel and tooth fragment should be etched. Following this, bond and composite are placed, the fragment is attached in the correct position and cured for 40 seconds each labially and palatally, the composite is finished and polished accordingly to camouflage the fracture line. If the tooth fragment is not brought with the patient, if it is too dry and discoloured and so will not match the shade of the tooth, or if it is too small to be re-attached, then composite can be used to build-up the tooth, as described for enamel fractures.^{2,3,13}



Figure 3: Complicated crown fracture of the UL1 with pulp exposure (with thanks to Professor Richard Welbury)

‘If the patient does have the fragment, this can be bonded back on but the time elapsed may result in dryness and discolouration of the fragment that would produce an unaesthetic result if reattached.’

4) Enamel-dentine-pulp (complicated crown) fracture: A fracture through the enamel and dentine causing exposure of the pulp of a tooth. The exposure of pulp may cause sensitivity to stimuli such as cold. Clinically there will be loss of tooth structure and depending on the time of presentation, there will be a bright red or dark red pulp exposed, the latter of which is illustrated in Figure 3. Radiographs will show visible tooth loss and it is important to rule out root fractures or possible luxation injuries. The main aim of any treatment of this injury is to maintain vitality of the pulp, however the choice of treatment is dependent on the status of the pulp: survival, obliteration or necrosis. Whilst pulp survival is self-explanatory, pulp canal obliteration can mean successful re-vascularisation

of the pulp following the injury and may present radiographically as deposition of secondary dentine along the pulp canal walls. Pulp necrosis means death of the pulp and RCT or extraction of the tooth are the only options here. Factors that can influence the vitality of the pulp include its initial status prior to the injury, the maturity of the apex of the tooth, where an open apex

increases the chance of survival and the time since the injury, where the longer the interval between the injury and the appointment, the greater the chance of necrosis. Finally, any concurrent injuries such as luxation injuries causing PDL damage could also influence the vitality of the pulp. These principles of pulp status apply to both injuries to the periodontal tissues as well as complicated

crown fractures.^{2,3}

In an immature vital tooth there is an open apex, wide canal, thin walls and growth potential, it is possible to stimulate the pulp tissue to encourage completion of root development, known as apexogenesis. The Cvek pulpotomy is a partial removal of pulp following by a calcium hydroxide dressing. This requires local anaesthetic, rubber dam, removal of approximately 2mm of inflamed pulp using a high speed bur and water, the haemorrhage is arrested using cotton wool pellets for 20-30 seconds and a haemostatic agent such as ferric sulphate can be used if the pulp is hyperaemic. Following this a calcium hydroxide dressing or mineral trioxide aggregate (MTA) is placed and a temporary restoration is placed in glass ionomer cement (GIC) or composite resin.

If the Cvek pulpotomy fails, for example haemostasis is not achieved then a cervical or conventional pulpotomy is indicated. This involves removal of all of the coronal pulp up to the level of the cemento-enamel junction and dressing it using the same method. However, the greater access weakens the coronal structure and pulp canal obliteration occurs in 50% of cases. The patient is then followed up in 6-8 weeks for clinical assessment and radiographs to check for any symptoms and assess the need for a RCT.¹²

If a patient presents with a non-vital immature tooth with a complicated crown fracture, the pulp is necrotic and so cannot be stimulated to complete root development. Instead, a calcific apical barrier is made in the open apex tooth to effectively close it and facilitate endodontic obturation, known as apexification. The necrotic pulp is removed and the root canal cleaned out, MTA is used to create an apical barrier and the tooth is temporarily dressed with calcium hydroxide and GIC. Final obturation should only take place once there is an absence of symptoms, sinuses, mobility and there is radiographic evidence of a firm stop at the apex.^{2,3,12-14}

5) Uncomplicated crown-root fracture: A fracture involving enamel, dentine and cementum with loss of tooth structure but does not involve pulp. The crown fracture starts supragingivally and extends subgingivally. Uncomplicated crown root fractures usually present clinically with a mobile coronal aspect and are tender to touch. Radiographically it is usually difficult to determine how far the fracture extends apically. Often multiple radiographs are needed to identify the fracture including a periapical view and an occlusal view.

Often when confronted with an emergency patient presenting with an uncomplicated crown-root fracture, time is limited. In this situation temporary

splinting of the mobile segment stabilises the tooth until a definitive treatment plan is decided. Before deciding on a permanent treatment, it is vital to consider whether the tooth is restorable. For vertical fractures and fractures with significant apical extension, extraction is unavoidable. Consider leaving the root *in situ* in these situations to maintain bone levels, leaving the patient with the option of an implant retained prosthesis in the future.

If the tooth in question is restorable you can either remove the coronal fragment only, or you can remove the coronal fragment and restore the apical fragment. Often when restoring the apical fragment, subsequent gingivectomies and osteotomies are needed to get a good result. A post crown is a common permanent restoration for this type of injury. It involves endodontically treating the root of the tooth before restoring with a post retained crown. Occasionally surgical or orthodontic extrusion of the remaining tooth is needed to provide enough supragingival tooth structure to support a post crown (usually 2mm ferrule required).^{2,3}

6) Complicated crown-root fracture: A fracture which involves enamel, dentine, pulp and cementum with loss of tooth structure. Like uncomplicated crown-root fractures, they tend to present with a mobile coronal fragment and are tender to touch. Periapical and occlusal radiographs are recommended to assess the how far the fracture extends apically, however even with these views it is still usually difficult to determine. As with uncomplicated crown-root fractures if the fracture extends significantly apically or is a vertical fracture, extraction is unavoidable. The root fragment may again be left *in situ* if a future implant retained prosthesis is planned.

Emergency treatment of a complicated

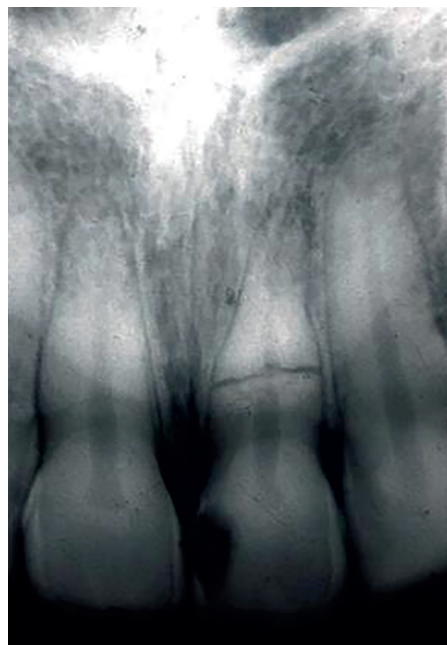


Figure 4: Horizontal middle third root fracture of UL1. (with thanks to Professor Richard Welbury)

‘If the tooth in question is restorable you can either remove the coronal fragment only, or you can remove the coronal fragment and restore the apical fragment’

crown-root fracture also involves splinting to adjacent teeth to allow for stabilisation of the coronal fragment. However as the pulp is involved, in patients with open apices it is important to try to retain pulp vitality. Therefore a Cvek pulpotomy is recommended, however in mature teeth,

RCT is required. A post crown is again a common permanent restoration for this type of injury following removal of the mobile coronal aspect. Surgical or orthodontic extrusion of the remaining tooth is often needed to provide enough supragingival tooth structure to support a post crown.^{2,3}

7) Root fracture: A fracture which involves only the root, therefore the cementum, dentine and pulp of the tooth and can be in either a horizontal or oblique direction. Horizontal fractures are diagnosable from a standard periapical view and can involve the cervical, middle or apical third of the root, with Figure 4 illustrating a middle third root fracture. Previous research has shown that in permanent incisors, root fractures of the middle third are most common (57%), followed by apical third (34%) and then cervical third (9%) root fractures.¹⁵ Oblique fractures often require an occlusal view or additional periapical views and usually involve the apical or middle third of the

root. The coronal aspect of the tooth is often mobile and may also be displaced, the tooth is usually tender to touch and there is often gingival bleeding.

The immediate treatment of a root fracture involves initially repositioning the coronal aspect of the tooth if displaced, and confirming that it has

been repositioned correctly radiographically. Stabilisation using a flexible splint is then often required for a minimum of 4 weeks, however if the fracture is more cervical it can be beneficial to splint for as long as 4 months. Root fractured teeth should be monitored at regular appointments using a trauma grid and if pulpal necrosis of the coronal portion is evident, RCT up to the fracture line should be commenced.

Figure 5 illustrates each of the seven injuries to the dental hard tissues and pulp and Table 6 provides a summary of their description and management, for quick reference.^{2,3}

CONCLUSION

Good initial management of dental trauma is essential in determining the best possible prognosis of the teeth involved and is not limited to paediatric patients.

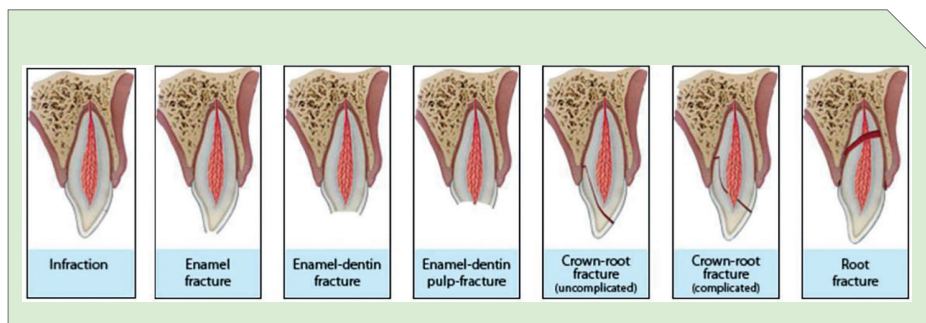


Figure 5: A series of illustrations of each of the seven injuries to the dental hard tissues and pulp.³

Table 6: A summary table of the seven injuries to dental hard tissues and pulp, and their respective treatment options³

Type of injury	Description of injury	Treatment (Permanent Dentition)
Infraction	Incomplete fracture of the enamel without loss of tooth substance	No treatment indicated, no review necessary
Enamel fracture	Fracture causing loss of enamel but not exposing dentine	Lost enamel replaced with composite
E-D Fracture	Fracture of enamel and dentine but not involving pulp	Lost enamel and dentine replaced with composite to provide dentinal coverage
E-D-P Fracture	Fracture of enamel and dentine causing exposure of the pulp	Maintain vitality of pulp by apexogenesis or apexification. If tooth is non-vital then RCT and restore with composite or crown
Uncomplicated crown-root fracture	Fracture involving enamel, dentine and cementum, but does not involve pulp	Temporarily splint tooth, if tooth is restorable post crown, if not then XLA
Complicated crown-root fracture	Fracture involving enamel, dentine, cementum and pulp	Temporarily splint tooth, maintain vitality of pulp by apexogenesis or apexification. If tooth is non-vital then RCT and restore with post crown
Root fracture	Fracture of only the root involving the cementum, dentine and pulp	Reposition crown of tooth, splint for at least 4 weeks, monitor pulp status alongside, RCT up to fracture line if tooth becomes non-vital

Adult emergency patients attending with trauma can also be treated on the same principles with the knowledge that their teeth will be mature and therefore have closed apices. It is also worth bearing in mind that the trauma case you are presented with may have multiple dental injuries, therefore good application of the appropriate management options will be

‘Adult emergency patients attending with trauma can also be treated on the same principles with the knowledge that their teeth will be mature and therefore have closed apices.’

required. We hope this article has provided a concise reference guide to dental trauma in the young permanent dentition and has helped improve confidence on the topic amongst dental students. A useful source to refer to for extra information is the Dental Trauma Guide where you will also find the IADT guidelines.

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