Dentoalveolar Trauma in the Permanent Dentition

11

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Learning Outcomes
By the end of this chapter, readers will:

- Accurately obtain a thorough history following dentoalveolar trauma to the permanent dentition
- Critically assess a patient presenting with dentoalveolar trauma to the permanent dentition
- Initiate appropriate emergency management for all permanent dentition traumatic dental injuries
- Produce an appropriate treatment plan for definitive management for each permanent dentition traumatic dental injury, including the need to refer for specialist input
- Identify delayed complications of dentoalveolar trauma including pulpal necrosis, pulp canal obliteration, infection-related and replacement resorption

11.1 Incidence and Prevention

A traumatic dental injury in a child is not uncommon. In the United Kingdom, Child Dental Health Surveys have shown consistent prevalence figures of 10–15% for children experiencing trauma to their permanent incisors. In most cases, parents will attend their general dental practitioner (GDP) for emergency management. Appropriate

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S. Albadri, C. L. Stevens (eds.), *Paediatric Dentistry for the General Dental Practitioner*, BDJ Clinician's Guides,
https://doi.org/10.1007/978-3-030-66372-8_11

emergency management has the greatest influence on the overall prognosis of any involved teeth. Successfully managing an acute trauma is likely to decrease the overall treatment burden as known complications such as pulp necrosis, root resorption and tooth loss are influenced by the quality of the emergency management.

Complex traumatic dental injuries may often require specialist support and would merit an urgent referral, usually via the telephone, for management in secondary and tertiary centres. However, even in these cases, attempting emergency management will improve the prognosis for the child as a delay in treatment will affect the prognosis. Despite it being more common to experience trauma in the evenings and at weekends, it is essential that any child patient who presents to a GDP is managed appropriately.

Traumatic dental injuries are often accidental. The peak age of trauma to permanent teeth is 11–12 years of age. During these years, children are acquiring new skills and exploring new activities in sport and play that predispose them to trauma. Although uncommon, road traffic accidents and interpersonal violence/assault are aetiologies that need to be considered when trauma presents. The latter being more prevalent in the adolescent population.

The most commonly affected tooth is the maxillary central incisor with boys approximately twice as likely to experience a traumatic dental injury in comparison to females. Although traumatic dental injuries are often as a result of an accident, there are individuals who are at a greater risk. These include children who participate in contact sports or have an increased overjet with or without incompetent lips.

11.1.1 Prevention

Efforts by healthcare professionals should be made to attempt to prevent injuries from happening when known aetiological factors are identified. Children who participate in contact sports should be provided with a custom-made mouth guard, which in the mixed-dentition, may require regular replacement. An early orthodontic assessment for children with an increased overjet (>9 mm) or incompetent lips at rest should be carried out as these factors are known to double the risk of dental trauma. Parafunctional habits e.g. opening cans/bottles should be identified and discouraged, as well as the wear of intra-oral piercings.

11.2 History and Examination

11.2.1 Overview

A comprehensive history and clinical examination are essential to make an accurate diagnosis. Having the correct diagnosis will guide the treatment plan and is likely to lead to more improved outcomes. Accurate documentation of these findings is essential, especially in patients where non-accidental injury (NAI) is suspected.

Depending on the age of the child, the history should be taken primarily from the child although involving the parent in the discussions is essential to ensure a complete history is obtained. Despite the importance of adopting a systematic approach to the history and examination process, in the same way you would for any paediatric patient, children with acute bleeding or respiratory issues and/or those requiring replantation of an avulsed tooth will necessitate a change to this sequence. In some cases, prompt referral for medical attention may be required.

The following sections will highlight the salient points that should be recorded when taking a history and examining a child that has sustained a traumatic dental injury.

11.2.2 History

11.2.2.1 General

1. Head injury assessment?

   Loss of consciousness, vomiting or amnesia should raise concerns about a possible head injury. Immediate referral to a medical emergency department for assessment is required.
2. Any treatment elsewhere?

   Has the child received any treatment prior to attending which may alter how they are managed? For example, has an avulsed tooth been replanted but not splinted?

11.2.2.2 Dental

1. When did injury occur?

   The time interval between injury and treatment influences both decision-making and the prognosis of injuries.
2. Where did injury occur?

   This may indicate the need to refer for tetanus prophylaxis when there has been soil contamination of the wound, and the child has not had a ‘booster’ injection within the last 5 years.
3. How did injury occur?

   Determining the nature of the trauma, including the pattern and extent of injury, will help determine the type of injury expected. Safeguarding concerns should be raised when there are inconsistencies between the history and clinical findings.
4. Lost teeth/fragments?

   Have these been accounted for? If not, associated soft tissue injuries should be examined clinically and radiographically, and consideration should be given to a chest radiograph to exclude inhalation.
5. Tooth related factors?

   When avulsions are noted, information such as extra-oral time, extra-oral dry time and the storage medium are essential to ascertain the likely prognosis and inform management.

6. Previous dental experience?
   Has the child ever received any dental treatment, or will this be their first exposure? Are there any dental anxieties reported which could complicate the provision of treatment? Has there been a history of previous dental trauma? Will the age and parental/child attitudes affect the choice of treatment modality provided?

11.2.2.3 Medical

Certain medical conditions will impact on the management of a dental trauma. In some cases, liaison with the child's physician should be carried out pre-treatment; however, this is not always achievable and, in these situations, obtaining advice from a specialist paediatric dentist should be sought. The following three conditions are likely to have the greatest impact on the provision of emergency trauma management:

1. Congenital heart disease and severe immunosuppression
   In some cases, these may alter your immediate management, for example an avulsed tooth is not replanted due to the tooth acting as a focus of infection where prolonged endodontic treatment would be required.
2. Bleeding disorders
   Important to consider when a tooth/fragment requires extraction, or whether to decide to suture a lacerated soft tissues injury. Additional local haemostatic measures may be required.
3. Allergies
   Consideration to alternative antibiotics when a penicillin allergy is noted.

11.2.3 Examination

11.2.3.1 Overall Patient Assessment

It is essential to assess the patient from head to toe. Injuries may extend beyond the head and neck regions or may not be obvious. Signs of shock (pallor, cold skin, irregular pulse, hypotension) or symptoms of head injury (dizziness, loss of consciousness, persistent nausea/vomiting) require urgent referral for medical attention. Identification of suspicious signs of physical abuse, or if the pattern and extent of injuries sustained appear to be inconsistent with the history that has been given, then concerns of possible NAI should be raised. Refer to Chap. 7 for more details on how to manage NAI.

11.2.3.2 Maxillofacial Assessment

A thorough assessment of the maxillofacial region should follow a general assessment. The presence of swelling, bruising or lacerations in this region may indicate

underlying bony and tooth injuries. Bilateral palpation of the skull and facial bones (zygoma, maxilla, mandible) should be carried out to identify any lacerations or fractures. A new facial asymmetry, areas of paraesthesia, step-deformities or limitation in mandibular movements may indicate a fracture. For a more detailed description on maxillofacial assessments, including cranial nerve examination, refer to Chap. 6.

Lacerations, haemorrhage or swelling of the oral mucosa (and/or gingivae) should be examined for foreign material or tooth fragments. Radiographs may be required if lost tooth fragments are unaccounted for during clinical inspection (see Fig. 11.1a–c). Lacerations of lips or tongue may require suturing (see Fig. 11.2). The suturing technique of choice is simple interrupted resorbable sutures. On occasions,

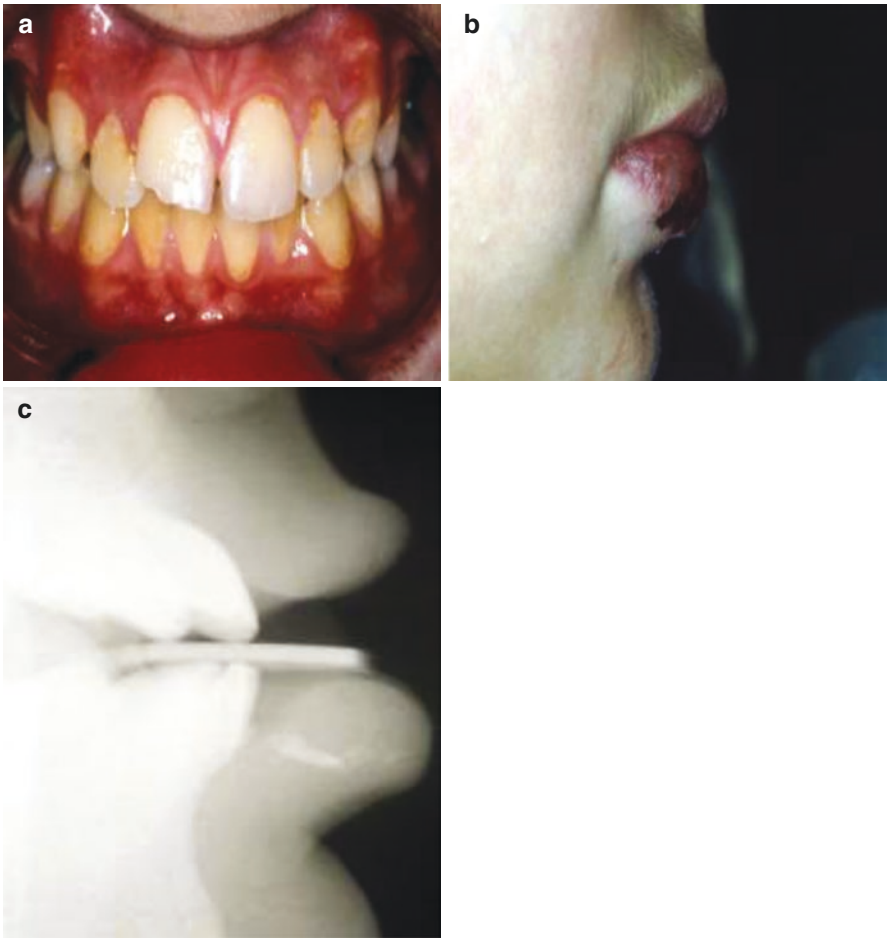

Fig. 11.1 (**a**–**c**) Confirmation of a tooth fragment, sustained from an enamel dentine fracture, located in the lower lip (*with permission from Professor R Welbury*)

Fig. 11.2 Closure of a lacerated lower lip of a 7-year old using resorbable sutures

Clinical Tip
Always suspect, until proven otherwise, that any unaccounted fragments of teeth are in soft tissues if an associated laceration is noted. Clinical palpation and plain film imaging will help in these situations. Careful dissection of the fragment is required, followed by a generous saline flush, prior to closure of the wound.

soft tissue lacerations of the oral mucosa, that have stopped bleeding, do not require suturing and usually heal very quickly with little scarring.

11.2.3.3 Dentoalveolar Assessment

After assessing the maxillofacial region, a detailed examination of the dentoalveolar region should be completed. The following should be assessed and recorded:

1. Crowns of the teeth for the presence and extent of fractures or pulp exposures
2. Displacement of teeth (lateral luxation, intrusion, extrusion or avulsion)
3. Disturbances in occlusion
4. Assessment of mobility

   Mobility is assessed in horizontal and vertical directions. Excessive mobility may suggest root fracture or tooth displacement; however, if several teeth move together en bloc, then a fracture of the alveolar process is suspected.
5. Assessment of percussion

   Percussion should be assessed in horizontal and vertical directions and be compared with a contralateral uninjured tooth. A duller note may indicate root fracture.

6. Assessment of colour
   Early colour changes can be visible if there is pulp breakdown.
7. General Condition of remaining dentition
   A general assessment of the remaining dentition should be carried out to elicit any dental caries, periodontal disease, non-carious tooth surface loss or dental anomalies that may require attention after the acute trauma.

Recording these baseline checks will be essential in the follow-up period as any changes will identify whether there is pulpal necrosis, resorption or signs of ankylosis associated with the traumatised teeth. Having a standardised trauma chart may be useful as an aide memoire for each visit to help record these findings and visualise any trends (see Fig. 11.3).

11.2.3.4 Sensibility Testing

Why?

Ascertaining the pulpal status of traumatised teeth is essential in combination with clinical and radiographic investigations. Radiographic variations in the root outline or periodontal ligament space could be misinterpreted as periradicular infection associated with pulp necrosis, and this highlights that radiographic findings should not be the sole reason to commence endodontic management. Sensibility tests such as thermal and electric testing serve to provide an estimation of pulp vitality, i.e. blood supply to the tooth. These tests comprise one aspect of trauma charting and are important indicators for clinical management as well as an important medico-legal consideration.

Diagnostically, thermal/electric tests record a tooth's ability to respond to a stimulus with a positive response, suggesting the pulp tissue remains vital. Simplistically, these responses may help diagnose one of three pulpal states: Pulpal health, Pulpal

Teeth	UR2	UR1	UL1	UL2
Colour	N	N	N	N
Mobility	N	N	I	N
Sinus	–ve	–ve	–ve	–ve
TTP (Buccal)	–ve	–ve	–ve	–ve
TTP (Apical)	–ve	–ve	–ve	–ve
Electric Pulp Test	+ve (29)	NR	+ve (19)	+ve (24)
Cold test	NR	NR	NR	NR
N = Normal NR = No Response +ve = Positive Response –ve = Negative Response				

Fig. 11.3 An example of a completed trauma chart

inflammation and pulpal necrosis. However, neither thermal nor electric testing is completely reliable, and as such multiple tests should be used in conjunction with other clinical and radiographic findings. Furthermore, caution should be used when carrying out sensibility tests on a child patient as several factors such as apical development, patient co-operation, recent trauma and maturity may influence the response obtained.

What?

- Thermal:
  - Cold, e.g. refrigerant spray
  - Hot, e.g. warmed gutta percha
- Electric: electric pulp testers
- Test cavity: high-speed drill

How?

Cold testing is considered the first-line strategy for assessing pulp sensibility. Whilst ethyl chloride has historically been used, the use of newer alternatives such as Endo Frost (Roeko, Langenau, Germany) has gained popularity due to their ability to achieve lower temperatures. Spray is applied to a cotton wool pledget and adapted to the mid-labial surface of the tooth. Teeth should first be tested with dry cotton wool to assess for patient compliance. It is not uncommon for traumatised teeth to be tender to percussion, which can sometimes lead to false positive findings. Adjacent teeth should be tested due to their close proximity to the trauma, and the contralateral tooth should be tested as a positive control. It is highly likely that the contralateral tooth is also the adjacent tooth, and in these situations, an opposing tooth or a known healthy tooth may be used as a positive control to ensure the patient is aware of the sensation to be expected.

Whilst electric pulp testers can be used to confirm the findings of the initial cold test, their presence in dental practices is less common, and their use in teeth with immature apices is unreliable due to delayed neural maturation in the dental pulp. False-positive responses from inaccurate tip placement or stimulation of the adjacent tooth further complicates their use. Electric pulp testers may be more useful in situations where pulp canal obliteration is present or to confirm pulpal necrosis.

Clinical Tip

If you are in doubt about the reliability of the sensibility tests results then repeating these tests, changing the order of teeth you test or applying a placebo, i.e. cotton wool with no endo frost, are ways to help overcome potential false-positives or false-negative results.

11.2.4 Radiography

Radiographic examination is an important aid when diagnosing and monitoring potential complications. Long cone periapical radiographs are the gold standard image and provide a baseline assessment of the traumatised teeth. They should be taken, even if the traumatic dental injury is considered obvious or mild. In addition, an upper standard occlusal will provide a radiograph at a different angle to identify the presence of root fractures (see Fig. 11.4a, b). If an upper standard occlusal is not available, then a second periapical taken with a horizontal or vertical parallax may be equally as diagnostic and is likely to be more accessible in general practice. In most traumatic injuries, radiographic examination would be completed prior to any emergency clinical management. However, the only exception would be replantation of an avulsed permanent tooth, and in these cases, radiographic examination post-replantation would be justified to check repositioning as well as assessing adjacent teeth.

For monitoring purposes, long cone periapical radiographs allow root development, apical status and periodontal ligament space to be assessed. These radiographic features are of importance when assessing pulpal, periapical or periodontal changes.

Soft tissue radiographs may be appropriate where fragments of teeth are missing or where foreign bodies can be palpated. This is commonly identified acutely due to an associated lip laceration. An unusual radio-opacity projected over the teeth or roots of traumatised teeth where associated soft tissue trauma occurred should raise suspicion of a foreign body.

In more complex dentoalveolar trauma or where patients present in the mixed dentition, a panoramic radiograph (DPT) can be justified to assess the extent of the trauma, developing dentition and any associated bony fractures or pathologies. It is not uncommon for patients to present during, or having undergone, orthodontic

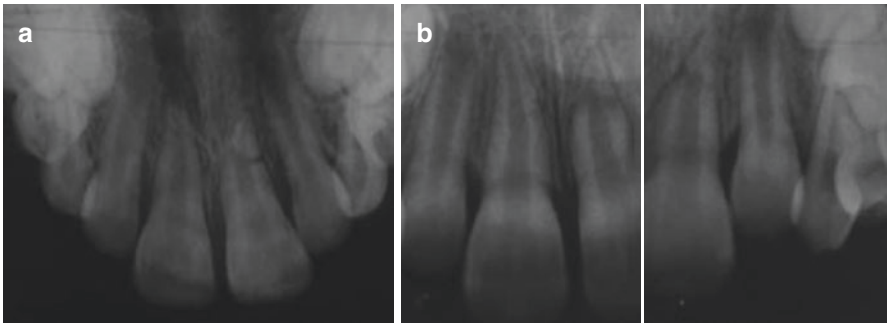

Fig. 11.4 Occlusal (**a**) radiograph confirms the apical 1/3 root fracture in the upper left central incisor, which was less apparent on the periapicals (**b**)

treatment, and in these cases, previous radiographs could be requested. Pressure-induced root resorption following orthodontic treatment is a common finding that can complicate assessment. Assessment of adjacent teeth and any previous radiographs may be necessary in these cases.

11.3 Trauma Management Considerations

This section briefly summarises the three main concepts relating to emergency management of traumatic dental injuries.

In addition to managing traumatic dental injuries, the dental profession has a role in improving the public knowledge on managing these injuries. The provision of public information needs to be clear and concise, so that parents, bystanders and front-line medical staff are aware of the most appropriate treatment to provide. The 'Save your Tooth' poster and 'ToothSOS' application for smartphones are examples of useful resources that can be used to provide instructions on what to do when in an emergency situation, including avulsion of a permanent tooth.

As detailed previously, appropriate management relies upon an accurate diagnosis, which is reliant upon a thorough history and assessment.

11.3.1 Protect the Dentine-Pulp Complex

Enamel and enamel dentine fractures are the most common traumatic dental injuries encountered. Whilst most enamel fractures are small, in some cases it may be difficult to fully elucidate whether dentine has been exposed, and in these cases, it may be safer to consider both as one entity. Where dentine has been exposed, some degree of pulpal inflammation is expected. The residual dentine thickness, length of time the dentine has been exposed, maturity of the apex and any associated periodontal ligament (PDL) trauma will influence the subsequent risk of irreversible pulpitis and pulpal necrosis. For this reason, immediate protection of dentine with a well-bonded composite restoration, or composite bandage, is imperative.

11.3.2 Vital Pulp Therapy for the Traumatically Exposed Pulp

Vital pulp therapy is the treatment of choice when the dental pulp becomes exposed following trauma. Vital pulp therapy is an important treatment strategy for teeth with mature and immature apices. In immature teeth, preservation of uninflamed radicular pulp supports continued root development. Whilst in mature teeth, vital pulp tissue provides pulpal defence in the form of secondary and tertiary dentine.

Vital pulp therapy strategies include:

- Direct pulp cap—application of restorative material onto exposed pulp without pulp amputation
- Partial pulpotomy (Cvek)—up to 4 mm of coronal pulp partially removed in 2 mm increments
- Total pulpotomy (complete)—complete removal of coronal pulp leaving radicular pulp only

Small pinprick exposures that present within 24 h can be managed with a direct pulp cap using a setting calcium hydroxide or non-discolouring calcium silicate cement.

Patients that attend with large pulpal exposures or delayed presentations greater than 24 h require removal of contaminated coronal pulp tissue. If performed under ideal conditions and assuming all inflamed pulp tissue is removed, partial/total pulpotomy is associated with higher success rates than direct pulp cap (see Fig. 11.5).

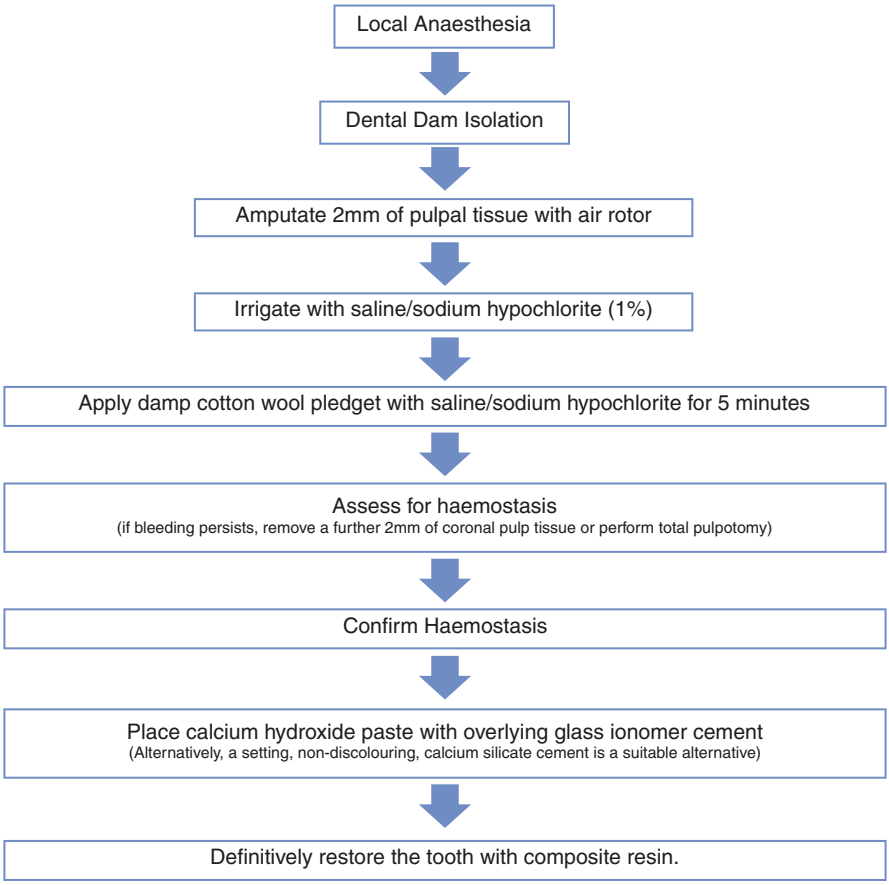

Fig. 11.5 Partial/total pulpotomy flowchart

Clinical Tip
If any doubt exists regarding the degree of contamination or the size of a pulp exposure, partial/total pulpotomy should be performed.

11.3.3 Reposition or Replant Permanent Teeth

Teeth that require repositioning or replanting will require a period of stabilisation post-injury to maintain the tooth in its correct position whilst providing comfort and allowing function to slowly improve. Historically, both flexible and rigid splints have been advocated; however, all guidelines now only recommend a flexible splint. A flexible splint allows the injured tooth to be subjected to slight mobility and function which has been shown to promote periodontal and pulp healing. A flexible splint includes only one adjacent un-injured tooth either side of the injured tooth (see Fig. 11.6). Several types of splits exist, e.g. acid-etched composite and stainless wire, orthodontic brackets and wires with little evidence suggesting one is better than the other; however, one continuous line of resin-bonded composite is not advocated. It is important however to ensure the gingival margins are kept clean, and endodontic access is still achievable.

In all cases of traumatic dental injuries, it is essential to minimise further damage and reduce secondary infections during the healing phase by providing appropriate home care advice. This advice should include a soft diet and care when biting to avoid excessive trauma to the injured tooth. Avoiding contact sport for up to 4 weeks is advised, with ongoing use of a mouthguard thereafter recommended. Maintaining good oral hygiene, by tooth brushing, and rinsing with chlorhexidine mouthwash are key. Pain control should be advised.

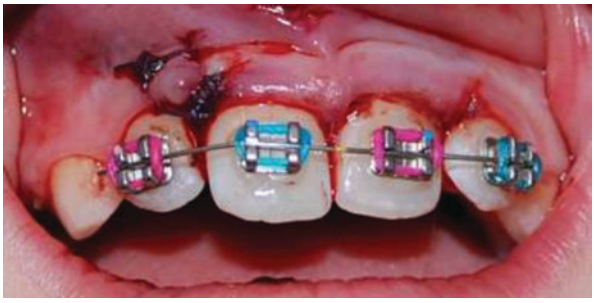

Fig. 11.6 A flexible splint, following lateral luxations to the upper central incisor teeth (UR1/UL1), bonded to one adjacent uninjured tooth

Complete repositioning or replantation is essential for good long-term outcomes. Any delay makes future repositioning/replanting harder whilst reducing the chance of pulp and periodontal cell vitality. Patients/parents will often have smartphones and are capable of producing a recent and high quality photograph, or selfie, of their pre-trauma smile. Assessment of this, along with any radiographs will enable the degree of luxation to be assessed. Furthermore, a post-repositioning periapical radiograph will help to confirm complete reduction, which serves to increase the possibility of pulp vitality especially in immature apices.

Clinical Tip
All traumatic dental injuries that require a splint should be passive and flexible, that is bonded to only one adjacent un-injured tooth either side of the injured tooth/teeth.

When a mature tooth is intruded or avulsed, elective endodontic treatment will be required within 2–3 weeks of the injury. In these cases, endodontic access with an appropriate intracanal medicament could serve to reduce the risk of root resorption as these injuries carry a greater risk of PDL damage and subsequent resorptive changes.

Clinical Tip
Two radiographs with a horizontal parallax may help in assessing the root canal configuration especially for traumatised lower anterior teeth, which can commonly be ribbon shaped or have multiple canals.

11.4 Management of Fracture Injuries

The management of fracture injuries is described in Table 11.1.

Table 11.1 presents the full range of tooth fracture diagnoses and their recommended management.

Table 11.1 Management of fracture injuries

Enamel infracture A crack confined to enamel with no loss of tooth	
	*Emergency management (presentation within 24 h):* • Ensure no associated injuries or root fractures • Initial assessment of pulp vitality
	Definitive management: • No treatment required • Marked discolouration within the fracture line may be etched and sealed if necessary
	Follow-up: • No follow-up is generally required
Enamel fracture Crown fracture (dentine not exposed)	
	*Emergency management:* • Smooth sharp edges/re-contour crown shape (small fractures) *or* • Re-bond tooth fragment (if available) with composite resin (note: bevelling of the fragment margin may improve aesthetic outcome) *or* • Definitive restoration with composite resin
	Definitive management: • Follow emergency management
	Follow-up: • Clinical and radiographic review at: – 6–8 weeks – 1 year

Table 11.1 (continued)

Enamel-dentine fracture Crown fracture (pulp not exposed)	
	*Emergency management:* • Re-bond tooth fragment (if available) with composite resin (note: desiccated tooth fragment may require rehydration in water or saline if transported dry. Bevelling of the fragment margin may improve aesthetic outcome) *or* • Cover exposed dentine with bonded flowable composite resin
	Definitive management: • Re-bond tooth fragment (if available) with composite resin *or* • Definitive restoration with composite resin (Indirect pulp cap with setting calcium hydroxide or non-discolouring calcium silicate cement with a small GIC covering may be used where residual dentine thickness is less than 0.5 mm or pulpal blush is evident)
	Follow-up: • Clinical and radiographic review at: – 6–8 weeks – 1 year
Enamel-dentine-pulp fracture Crown fracture (pulp exposed)	
 	*Emergency management (presentation within 24 h):* • Place direct pulp cap (if pin-point exposure) *or* • Partial or total pulpotomy (if more than pin-point) • Re-bond tooth fragment (if available) with composite resin(note: desiccated tooth fragment may require rehydration in water or saline if transported dry. Bevelling of the fragment margin may improve aesthetic outcome) *or* • Cover exposed dentine with composite resin
	Definitive management: • Following emergency management, a definitive restoration with composite resin (unless fragment already re-bonded). • Delayed presentation with vital pulp tissue: partial or total pulpotomy is indicated (see pulpotomy flowchart) (Fig. 11.5) *or* • If pulpal necrosis confirmed, commence root canal treatment
	Follow-up: • Clinical and radiographic review at: – 6–8 weeks – 3 months – 6 months – 1 year

(continued)

Table 11.1 (continued)

Crown-root fracture without pulp involvement Crown fracture extending into the root (pulp not exposed)	
	*Emergency management:* • Stabilise mobile fragment to the non-mobile portion with composite resin. This may serve as definitive restoration *or* • Splint to the adjacent where bonding to the non-mobile portion is not possible *or* • Remove excessively mobile fragments and cover exposed dentine with bonded flowable composite resin
	Definitive management (dependent upon the extent of fracture, patient age and co-operation): • If tooth adequately restored during emergency stabilisation, then monitor • Fragment removal and restoration (may be feasible where subgingival extent is minimal) *or* • Fragment removal, gingivectomy and restoration (suitable for fractures extending palatally—may also require osseous re-contouring) *or* • Extraction of entire tooth if unrestorable with subsequent bridge/denture/implant *Alternative management strategies:* Specialist referral for*:* • Surgical Extrusion • Orthodontic extrusion • Root submergence • Autotransplantation
	Follow-up: • Clinical and radiographic review at: – 1 week – 6–8 weeks – 3 months – 6 months – 1 year
Crown-root fracture with pulp involvement Crown fracture extending into the root (pulp exposed)	

Table 11.1 (continued)

	*Emergency management:* • Stabilise mobile fragment to the non-mobile portion with composite resin as *temporary* measure or splint to the adjacent teeth if bonding to the non-mobile fragment is not possible. This approach is appropriate where pulpal management cannot be completed during emergency visit *or* • Remove coronal fragment and perform the most appropriate vital pulp therapy (see Fig. 11.5) and cover with bonded flowable composite resin
	Definitive management: • If pulpal management still required and tooth vital, remove coronal fragment and perform the most appropriate vital pulp therapy. If tooth non-vital or post-crown required, RCT will be necessary • Definitive restoration of remaining tooth: – Direct composite restoration – Fractures extending palatally may require gingivectomy and osseous recontouring – A post-crown may be required where insufficient coronal tooth tissue for composite bonding • Extraction of entire tooth if unrestorable with subsequent bridge/denture/implant *Alternative management strategies:* Specialist referral for: • Surgical extrusion • Orthodontic extrusion • Root submergence • Autotransplantation
	Follow-up: • Clinical and radiographic review at: – 1 week – 6–8 weeks – 3 months – 6 months – 1 year

(continued)

Table 11.1 (continued)

Root fracture

Fracture confined to the root. Coronal fragment may be mobile with associated tenderness. Classified by location within the root, i.e. apical, middle or coronal 1/3. Bleeding from gingival sulcus may be only sign

Emergency management:

- Displaced fragments should be repositioned with digital manipulation. Check repositioning radiographically.
- Flexible splint for 4 weeks(note: coronal 1/3 fractures may require stabilisation for up to 4 months)

Definitive management (dependent upon the extent of fracture):

- RCT if pulp necrosis is identified(note: RCT should extend up to the fracture line as the apical portion often retains vitality. This may require root end closure/apexification procedures)
- If coronal fragment remains mobile at 4 months, then management strategies would be similar to those described in the crown-root fracture with pulp exposure section

Follow-up:

- Clinical and radiographic review at:
  - 4 weeks (splint removal)
  - 6–8 weeks
  - 4 months (splint removal if extended splinting required)
  - 6 months
  - 1 year
  - Annually for 5 years

Alveolar fracture

A fracture of the alveolar bone that may involve multiple teeth. Often mobility of an entire segment of teeth is identified or associated mucosal tearing is visible. Patients will frequently complain of malocclusion. Assessment of periapical status is notoriously difficult when the fracture line traverses periodontal ligament and is associated with the apex of teeth

Emergency management:

- A panoramic radiograph may be beneficial to assess the full extent of the fracture
- Reposition the fractured segment
- Flexible splint for 4 weeks

Definitive management (dependent upon the extent of fracture):

- RCT may be required for teeth that are subsequently deemed to be non-vital(note: caution is advised diagnosing periapical lesions where fracture lines are associated with root apices)

Follow-up:

- Clinical and radiographic review at:
  - 4 weeks (splint removal)
  - 6–8 weeks
  - 4 months
  - 6 months
  - 1 year
  - Annually for 5 years

11.5 Management of Luxation Injuries

Table 11.2 describes the management and follow-up arrangement of luxation injuries. It presents the full range of luxation injuries and their recommended management.

11.6 Management of Avulsion Injuries

An avulsion of a permanent tooth is regarded as one of the most serious traumatic injuries that a child could sustain. An avulsed tooth is completely displaced *out* of its socket. Clinically the socket is found empty or filled with a coagulum (see Fig. 11.7). The prognosis is very much dependent on how prompt emergency management is following the injury. Replantation, in most cases, is the treatment of

Table 11.2 Management of luxation injuries

Concussion Tooth is tender with no mobility	
	*Emergency management:* • Ensure no associated injuries or root fractures *Definitive management:* • Monitoring of pulp vitality *Follow-up:* • Clinical and radiographic review at: – 4 weeks – 1 year
Subluxation Tooth is tender with increased mobility (no crown displacement)	
	*Emergency management:* • Flexible splint for 2 weeks (if excessive mobility, or tenderness on biting) *Definitive management:* • Monitoring of pulp vitality • Appropriate endodontic management, for the tooth's stage of development, where pulp necrosis or resorption is confirmed (note: this may require root end closure/apexification procedure, if immature, which may require onward referral to a specialist) *Follow-up:* • Clinical and radiographic review at: – 2 weeks (splint removal) – 3 months – 6 months – 1 year

(continued)

Table 11.2 (continued)

Extrusion
Tooth appears elongated (partial avulsion) and is MOBILE with a widened PDL space radiographically

Emergency management:
- Reposition the tooth fully into the socket
- Flexible splint for *2 weeks*

Definitive management:
- Monitor pulp vitality
- Appropriate endodontic management, for the tooth's stage of development, where pulp necrosis or resorption is confirmed (note: this may require root end closure/apexification procedure, if immature, which may require onward referral to a specialist)

Follow-up:
- Clinical and radiographic review at:
  - 2 weeks (splint removal)
  - 4 weeks
  - 8 weeks
  - 3 months
  - 6 months
  - 1 year
  - Annually for 5 years

Lateral luxation
Displacement of the tooth in a labial or palatal direction with an associated fracture of the alveolar plate. Tooth is frequently IMMOBILE. Radiographically, the tooth will appear elongated or foreshortened

Emergency management:
- Reposition the tooth with digital manipulation or with forceps. Firm pressure over the apex of the tooth may be required to help disengage the impacted root
- Flexible splint for *4 weeks*

Definitive management:
- Monitor pulp vitality
- Appropriate endodontic management, for the tooth's stage of development, where pulp necrosis or resorption is confirmed (note: this may require root end closure/apexification procedure, if immature, which may require onward referral to a specialist)

Follow-up:
- Clinical and radiographic review at:
  - 2 weeks
  - 4 weeks (splint removal)
  - 8 weeks
  - 3 months
  - 6 months
  - 1 year
  - Annually for 5 years

Table 11.2 (continued)

Intrusion Displacement of the tooth apically into the socket. Tooth is frequently IMMOBILE with a HIGH-PITCHED SOUND on percussion		
MILD ≤3 mm	MODERATE = 3–7 mm	SEVERE ≥7 mm
	*Emergency management:* • Assess apex status radiographically • IMMATURE APEX: – Allow spontaneous re-eruption **irrespective of degree of intrusion** for 4 weeks – If fails to re-erupt, orthodontic repositioning required • MATURE APEX: – *Mild* Allow spontaneous re-eruption for up to 8 weeks If re-eruption does not occur, then: Surgically reposition with forceps *or* Orthodontically reposition – *Moderate* Surgically reposition with forceps (preferable) *or* Orthodontic repositioning – *Severe* Surgically reposition with forceps • Any tooth that is surgically repositioned, will require the placement of a flexible splint for *4 weeks*	
	Definitive management: • IMMATURE APEX: – Monitor pulp vitality – Root canal treatment where pulp necrosis confirmed – MATURE APEX: RCT to commence within 2–3 weeks(corticosteroid-antibiotic paste or non-setting calcium hydroxide dressing as intracanal medicament)	
	Follow-up: • Clinical and Radiographic review at: – 2 weeks – 4 weeks (splint removal) – 8 weeks – 3 months – 6 months – 1 year – Annually for 5 years	

choice. This is time-critical to maximise a favourable outcome. It is important to bear in mind that replanted teeth have a high chance of long-term complications. However, replanting will keep future treatment options open and as such this is the immediate management of choice. An avulsed tooth can always be extracted, at a later date, following a multidisciplinary assessment.

Fig. 11.7 An 8-year old who has sustained avulsion injuries to both upper central incisor teeth (UR1/UL1)

Prognosis is determined by the survival of the periodontal ligament cells (PDL). To determine prognosis, and treatment plan, there are four key pieces of information required:

- Type of storage medium (appropriate examples would be milk, physiological saline or saliva)
- Extra-alveolar time (the total time between the avulsion occurring and the tooth not being in its socket)
- Extra-alveolar dry time (the total time between the avulsion occurring and the tooth not being in an appropriate storage medium)
- Maturity of the root (open or closed)

Having this information is important to understand how likely the PDL cells are to survive as after an extra-alveolar dry time of 30 minutes, it is known that most PDL cells are non-viable. Therefore, it is critical to minimise the dry time for an avulsed tooth, and if immediate replantation is not possible, then to store it in an appropriate storage medium.

As mentioned, replantation is usually the treatment of choice. However, there are times where replanting may not be indicated:

- Patient has other injuries associated with the trauma (e.g. head injury) which warrant preferential treatment
- Severe dental caries or periodontal disease
- An uncooperative patient
- Severe cognitive impairment where adjunctive pharmacological techniques are required for management
- Medically compromised patient e.g. immunosuppression, or severe cardiac condition, where the avulsed tooth could as a potential source of infection

In these cases, it would be pertinent to seek the urgent opinion of a specialist in paediatric dentistry on whether replantation should be undertaken.

11.6.1 First-Aid Management for an Avulsion Injury

As an avulsion is unlikely to occur in a dental setting, it is accepted that dentists should be prepared to provide appropriate first aid advice for an avulsed tooth via telephone. Instructions, as detailed below, should be given to the parent, teacher or responsible person with the child. This advice is likely to significantly improve the chances of success as immediate replantation, at the site of the accident, is the treatment of choice:

1. Make sure the avulsed tooth is a permanent tooth (primary teeth should not be replanted)
2. Keep the patient calm
3. Pick the tooth up by the white part (crown) and avoid touching the root
4. If dirty, rinse gently in milk, physiological saline or the patient's saliva
5. Replant it to its original position
6. Get the child to bite on a handkerchief or napkin to hold it in place
7. Advise them to attend your practice immediately

If for some reason this cannot be carried out, then the advice should be to place the tooth in an appropriate storage medium, that is immediately available at the emergency site, as soon as possible. The patient should then be brought immediately to complete replantation.

11.6.2 Antibiotics

It has been advocated that administering systemic antibiotics after an avulsion could prevent infection-related (inflammatory) root resorption. However, with antimicrobial resistance now a global concern, the value of such practices is questionable. In addition, there is limited evidence to support the use of systemic antibiotics in relation to improved pulp or periodontal outcomes. Therefore, the prescription of antibiotics is at the clinician's discretion and should be fully justified.

However, there are situations where antibiotics may be indicated: there has been additional contamination of the tooth or soft tissues; there is injury to multiple teeth, soft tissues or other parts of the body which may necessitate the need for antibiotics; the medical status may make the child more prone to infections. In these cases, amoxicillin or penicillin-based antibiotics remain first choice. If the patient is not allergic, then an alternative broad-spectrum antibiotic, e.g. erythromycin, should be considered. Tetracycline and doxycycline have been shown to be effective in animal studies however the risk of discoloration of permanent teeth must be considered and are generally not recommended for patients under 12 years of age.

11.6.3 Avulsion Management: The Evidence Behind the Guidelines

Guideline development is based on the best available evidence. Unfortunately, there remains a lack of high-quality evidence to support some of the recommendations in the most recent update of the International Association of Dental Traumatology (IADT) avulsion guideline.

One example of where low-quality evidence exists is the relating to the extra-oral dry time and PDL cell viability. These guidelines suggest that an extra-oral dry time of greater than 30 minutes will make most PDL cells non-viable. This however is based on two animal studies. Of course, it would not be possible to investigate this in humans, as replanting and then removing at different time points to assess cell viability would not be ethical. The authors acknowledge this and pragmatically suggest that poorer outcomes are often expected when the extra-oral dry time is greater than 60 minutes, thus allowing some flexibility given the shortcomings of the evidence to support it.

Another example is the use of a pre-replantation topical antibiotic soak to help promote pulp revascularisation. This guideline recommends its use; however, the specific type, duration of use and methods of application cannot be recommended based on a lack of evidence. Some animal studies have shown a tetracycline soak prior to replanting is beneficial; however, this has not been corroborated by human studies.

As it stands, the current guideline is based on the best available evidence that is currently obtainable, and clinical management should be practiced in line with these guidelines. The Table 11.3 presents the recommended management for avulsion injuries:

11.7 Follow-Up and Long-Term Prognosis

The burden of care is often high during the initial phase of managing a traumatic dental injury. However, appropriate follow-up is essential as sequelae such as loss of vitality, resorption and infraocclusion can occur. Further treatment options, such as decoronation, autotransplantation and elective extraction may be indicated, and these cases are best referred for multidisciplinary management. If in any doubt, then a referral to your local dental hospital, or specialist service would be merited.

11.7.1 Pulpal Necrosis

Loss of vitality is the most common sequelae from a traumatised tooth. It is more apparent with severe injuries, mature teeth or those that are delayed in their presentation. Avulsions and intrusions have a high risk of pulpal death and the initial

Table 11.3 Management of avulsion injuries

Avulsion: immature (open) apex

Emergency management:

IADT guidelines

- Provide telephone advice if requested (see above)
- If already replanted, check repositioning radiographically
- If not replanted and if indicated to replant, then:
  - Remove any gross debris by agitating in the storage medium or rinsing with saline
  - Leave the tooth in the storage medium until ready to replant
  - Administer local anaesthesia, preferably with no vasoconstrictor
  - Irrigate the socket with sterile saline. If a fracture of the socket wall is apparent, reposition the fractured segment with a suitable instrument e.g. a flat plastic
  - Replant the tooth slowly with slight digital pressure
  - Verify position radiographically
- Flexible splint for 2 weeks
- Consider antibiotics and tetanus (see above)

Definitive management:

IADT guidelines

Any extra-oral time

- Teeth with an extra-oral time of greater than 60 min have a poor long-term success, however, replantation is still recommended for immediate management
- Monitor pulp vitality and continued root development
- Appropriate endodontic management, for the tooth's stage of development, where pulp necrosis or resorption is confirmed (note: this may require root end closure/apexification/regenerative endodontic procedures which may require onward referral to a specialist)

Follow-up:

- Clinical and radiographic review at:
  - 2 weeks (splint removal)
  - 4 weeks
  - 3 months
  - 6 months
  - 1 year
  - Annually for 5 years

Avulsion: mature (closed) apex

Emergency management:

IADT guidelines

- Provide telephone advice if requested (see above)
- If already replanted, check repositioning radiographically
- If not replanted and if indicated to replant, then:
  - Remove any gross debris by agitating in the storage medium or rinsing with saline
  - Leave the tooth in the storage medium until ready to replant
  - Administer local anaesthesia, preferably with no vasoconstrictor
  - Irrigate the socket with sterile saline. If a fracture of the socket wall is apparent, reposition the fractured segment with a suitable instrument e.g. a flat plastic
  - Replant the tooth slowly with slight digital pressure
  - Verify position radiographically
- Flexible splint for 2 weeks
- Consider antibiotics and tetanus (see above)

(continued)

Table 11.3 (continued)

Definitive management: *IADT guidelines* *Any extra-oral dry time* • Teeth with an extra-oral time of greater than 60 min have a poor long-term success; however, replantation is still recommended for immediate management • Initiate endodontic treatment within 2 weeks of sustaining the injury (usually within 7–10 days) • Dress with calcium hydroxide for up to 1 month • Obturate with gutta percha within 1 month of endodontic access(note: if corticosteroid-antibiotic paste is preferred, then this should be placed immediately or shortly after the injury, and left in-situ for 6 weeks before obturating)
Follow-up: • Clinical and radiographic review at: – 2 weeks (splint removal) – 4 weeks – 3 months – 6 months – 1 year – Annually for 5 years

management will often include elective endodontic therapy. Despite this, any traumatic dental injury can undergo pulpal death. Pulpal necrosis often occurs in the first year post injury, but delayed loss of vitality can occur. It is essential that appropriate follow-up, using clinical and radiographic techniques as described above, are undertaken up to five years post injury.

Luxation injuries and avulsions frequently sever the apical blood supply. Whilst a small percentage of immature teeth may spontaneously revascularise, mature teeth do not respond in a similar manner and endodontic treatment will be required. When monitoring immature teeth for pulpal revascularisation, radiographic evidence of continued root development should be observed, and if not, endodontic treatment involving apexification with calcium-silicate cements is the most appropriate management strategy.

Delayed presentations will increase the risk of loss of vitality as the emergency management to maintain a healthy pulp-dentine complex will not have been completed and bacterial invasion/resorption will have commenced. Any delayed presentations should raise suspicions of non-accidental injury and a possible safeguarding referral.

11.7.2 Resorption

Infection-related (inflammatory) resorption and replacement resorption (ankylosis) are the most common resorptive defects observed after a traumatic dental injury. Infection-related resorption can be further divided into internal and external. Infection-related resorption is caused by a necrotic pulp. Extirpation, adequate

disinfection of the root canal space and placement of a non-setting calcium hydroxide intracanal dressing should halt the resorptive process, as the source of infection has been removed, however further progression can occur. In these instances, loss of the tooth is inevitable and a temporary prosthetic replacement should be made available. In an attempt to prevent infection related resorption in avulsed, and severely intruded mature teeth, the pulps are electively extirpated 7–10 days after the trauma to remove the source of infection before the resorptive process is initiated.

Replacement resorption will clinically manifest as an ankylotic tooth with a high percussive note. Replacement resorption can be regarded as a favourable outcome over infection-related resorption as bone replaces the resorbing root. In adults, it is usually a slow process, compared to infection-related resorption, and will help maintain bone for future prosthetic replacement. If ankylosis is noted before the age of 10 years, or before the pubertal growth spurt, then there is an increased risk of more rapid ankylosis with subsequent infraocclusion. Prompt referral for multidisciplinary management is required in these cases and a small amount of composite edge bonding may be suitable whilst referrals are pending.

11.7.3 Pulp Canal Obliteration

Pulp canal obliteration, or sclerosis, is regarded as a favourable outcome following a traumatic dental injury. Active deposition of tertiary dentine will narrow the pulp canal chamber and reduce the risk of pulpal necrosis. Despite the narrowing, pulp remnants usually remain with low incidence of pulpal necrosis. Approximately 75% of teeth displaying pulp canal obliteration are symptom free and require no further management unless discolouration is pronounced.

11.8 Managing Trauma in the ‘New-Normal’ Dental Environment

The previous sections have discussed how to manage trauma in what would be regarded as normal circumstances. The implications of COVID-19 are likely to change the way permanent dental traumas are managed without compromising the quality of care and outcomes for patients.

The acute injury still requires to be seen in the usual manner. However, it might be that remote consultations by video conferencing or use of photographs could be used instead to provide initial support for dentists, or for follow-up visits that do not require a clinical or radiographic intervention. In addition, splinting using conventional wire and composite could be superseded by orthodontic brackets and wire, thus, minimising the need for an aerosol generating procedure.

As it currently stands, the acute management of a permanent dentition trauma, that be covering the dentine, replantation or repositioning, in the ‘new normal’ remains similar to what was done prior to COVID-19. However, this pandemic has

provided the opportunity to re-organise how trauma patients are followed up, thus minimising the number of visits for patients whilst maximising the use of clinical time for alternative dental procedures.

Further Reading

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