



Getting it right at every stage: Top tips for traumatic dental injury review: Part 1

By Clement Seeballuck,¹ Sean Dolan² and Julie K. Kilgariff³

Relevance

Following initial stabilisation of traumatic dental injuries (TDIs) to permanent teeth, follow-up is likely to be required. This is often best carried out in general dental practice, easing barriers to accessing dental care, particularly in rural and isolated communities, and potentially enhancing the cost-effectiveness and sustainability of dental care. It is important that general dental practitioners (GDPs) are aware of which TDIs are the more serious, and most likely to develop problematic consequences, requiring follow-up and potentially further dental intervention.

In a previous article, the immediate management of TDIs was discussed.¹ An accurate diagnosis will inform initial management, treatment required and the follow-up regime. For follow-up to be effective, it is helpful if the clinician is aware of the original trauma diagnosis and follow-up be in accordance with recognised guidelines.^{2,3} Follow-up aims to facilitate early diagnosis, treatment and/or referral of deleterious problems occurring as a result of the trauma, particularly because many problematic sequelae are asymptomatic and develop many months, or years, after the TDI.^{4,5,6}

This article and the second part, guide and inform TDI follow-up, the investigations and special tests recommended, the reliability of these, and TDI sequelae to monitor for.

1. Confirm TDI diagnosis

Trauma is seldom an anticipated or predictable event, with a range of case severity occurring, often with concurrent medical injuries, and potentially out-of-hours. This can lead to challenging circumstances identifying, diagnosing and stabilising TDIs, particularly when patient co-operation may be limited due to patient age and/or distress. In medical A&E services, access to take periapical and other intra-oral radiographs can be limited and impact the accurate diagnoses of injuries. For example, without a periapical, root fractures may not be identified and the injury insufficiently stabilised.⁷

It is therefore important when examining a historical trauma case for the first time, that the history and examination be carried out thoroughly and an open mind kept until the diagnosis is clarified. Be aware of potential misdiagnoses when initial management has been undertaken by a different clinician. If correspondence and/or dental records are available, reviewing these together with previous and current radiographs is sensible. Once the diagnosis is confirmed, or an informed best guess made, the International Association of Dental Traumatology (IADT)² guidance should be referred to for recommended follow-up regimes and likely complications. The various relevant current guidelines in relation to TDIs have previously been discussed and readers are directed to this.¹ Pre-existing guidelines⁸ have recently been reviewed and changes to

recommended dental materials, follow-up timings and diagnostic imaging regimes made.

2. Patient education

Patients and, in the case of minors, their advocates, must be made aware of potential TDI sequelae, the need for follow-up and problematic signs/symptoms to look out for. Figure 1 illustrates a case example where the patient failed to return for review and at four months post injury, a hopeless outlook for the previously traumatised tooth evident. Although earlier attendance may not have changed the outlook in this case, it is essential patients understand the importance of TDI follow-up as early intervention can improve some outcomes.

Providing patients with the right information is therefore crucial and integral to shared decision making and informed, valid consent.^{9,10,11} Highlighting what patients should self-monitor for can be incorporated into a wider discussion regarding prognosis, expected outcome(s) and long-term treatment planning. There are evidence-based resources developed specifically for the public to refer to.^{12,13,14,15} Patient information leaflets can be useful^{16,17} provided they are appropriately designed.^{18,19} Today, patients have unlimited access to online resources, of which content may not be quality assured. Therefore, providing accurate, comprehensive information directly to patients during dental visits may better guide realistic expectations and inform a self-monitoring toolkit of what to look out for and act on. Asking patients to make a dental appointment should they notice signs or symptoms such as pain, swelling, sinus tract and tooth discolouration may enhance outcomes. ➔



Fig. 1 Tooth 31 was replanted following avulsion. The patient re-attended some four months later, having missed intervening appointments. Replacement resorption is seen and the outlook for 31 hopeless

¹Clinical Lecturer in Paediatric Dentistry, Dundee Dental Hospital and Research School, Dundee, DD1 4HR, UK; ²Specialty Training Registrar in Restorative Dentistry, Glasgow Dental Hospital and School, Glasgow, G2 3JZ, UK; ³Consultant in Endodontics, Dundee Dental Hospital & Research School, Dundee, DD1 4HR, UK.

3. Be aware of potential TDI sequelae

Table 1 summarises potential dental sequelae commonly encountered following a traumatic dental injury. The pulpal and periradicular diagnosis referred to are those used in the American Association of Endodontists 2008 Diagnostic Guidelines.²⁰ The impact of these injuries on tooth survival has been colour coded: green (*) indicates sequelae unlikely to reduce tooth survival, amber (†) highlights those which may reduce tooth survival, and red (‡) are sequelae likely to reduce tooth survival.

A consequence of TDI can be the premature loss of a tooth, such as an avulsed tooth not recovered at the time of injury, or a tooth subsequently becoming unrestorable, such as that seen in Figure 1. Premature tooth loss must be factored into treatment planning. The patient age, tooth eruption stage and occlusion will require consideration, along with potential specialist referral. In most cases, retaining teeth or a poor outlook and maintaining the space of teeth already lost due to TDI is recommended whilst treatment planning takes place.

TDI sequelae identified at follow-up	Signs	Symptoms	Significance & impact on tooth survival	Management
Change in tooth structure due to damage or subsequent loss of a coronal tooth fragment*	Fractured tooth Cracks, crazing/infractures within tooth structure	Patient may complain of sharp edges and/or aesthetic changes. Depending on extent of crack/fracture signs, and symptoms of reversible or irreversible pulpitis may be present.	Unlikely to reduce tooth survival. Impacts quality of life mainly, aesthetically, and potential functional implications (speech/mastication). Pain may be present, due to dentine or pulp exposure and microbial ingress either directly (if the pulp is exposed) or indirectly via exposed dentinal tubules.	Evaluate extent of fracture to inform management. Cracks or crazes in the tooth can allow a portal of entry for infection, resin sealing of the crack may prevent this, decreasing permeability. ²¹ Pulpal exposure: A pulpotomy is carried out under aseptic conditions. Thereafter, the tooth fragment (if present) can be rehydrated (in saline) and reattached adhesively. ²² Reattachment can be done regardless of whether there is a pulpal exposure.
Pulp canal obliteration due to deposition of reactionary dentine*	Yellow darkening of the tooth crown when viewed directly or via transillumination. Reduced or reducing response to sensibility testing because of reactionary dentine deposition (ie, vital pulp) Radiographic signs of a narrowing root canal system.	Nil, unless pulpal necrosis has occurred, but this is rare.	Unlikely to reduce tooth survival. Adversely affects aesthetics.	Unless overt signs or symptoms of pulpal necrosis are identified, management of the patient's aesthetic requirements only are required, along with clinical and radiographic monitoring in accordance with the TDI injury type. Previous luxation injuries are most associated with pulpal obliteration. Only 1% of such cases subsequently undergo pulpal necrosis. ²³
Pulpal necrosis†	Greyish darkening of the tooth crown. Negative response to sensibility testing. In immature teeth with open apices, radiographic signs of arrested tooth development will be seen (cession of root development, no closure of root end). Compare it to contralateral tooth, in relation to the patient's age.	May have associated symptoms of pulpal necrosis and periradicular changes, such as intra or extra-oral swelling or a sinus tract, etc. Patient may complain regarding tooth discolouration.	May reduce tooth survival. Endodontic treatment is indicated. Highest success rates occur in the absence of periradicular radiographic changes. Diagnostic delay makes periradicular changes more likely. External inflammatory root resorption (EIRR) in acute or chronic periradicular inflammation can arise. This is due to microbial products from the necrotic pulp diffusing through dentinal tubules and stimulating osteoclastic resorption on the external root face.	Confirm pulpal necrosis using two or more investigations and/or tests and complete non-surgical endodontic treatment (in accordance with ESE guidelines, ²² prior to addressing any aesthetic concerns. Internal or external tooth whitening may be indicated. Products containing or releasing between 0.1 and 6% hydrogen peroxide cannot be used on under 18-year-olds unless used for treating or preventing disease. ²⁴
Periapical or periradicular periodontitis†	Radiographically, widening of the periodontal ligament space (PDL), loss of lamina dura, and/or a frank radiolucency may be present.	Cases may be symptomatic (for example, affected teeth display tenderness to percussion), or asymptomatic.	May reduce tooth survival because presence of periradicular radiolucencies decrease endodontic treatment success.	In the absence of clinical signs or symptoms, seek further information to confirm pulpal necrosis (such as sensibility testing) prior to embarking on endodontic management. This is because widening of the PDL or a radiolucency can indicate microbes are present within the root canal system or can be due to the TDI severing of the neurovascular bundle causing localised inflammation. ²⁵

Table 1 TDI sequelae, significance, and management (cont. from page 83)

TDI sequelae identified at follow-up	Signs	Symptoms	Significance & impact on tooth survival	Management
Acute apical abscess ⁵	Swelling of adjacent tissues	Spontaneous pain. Tooth tender to percussion and sulcular palpation	Potential for systemic involvement such as fever and lymphadenopathy. Indicative of pulpal necrosis and microbial colonisation of the root canal system.	Drainage is indicated, through the root canal system, removal of the tooth or incision into swollen soft tissue. Systemic involvement indicates antimicrobials may be required and readers are directed to relevant guidance. ²⁶
Chronic apical abscess ⁵	Sinus present on soft tissue that may be discharging or suppurating. A radiograph using a gutta percha point to trace the sinus can identify the causative tooth. ²⁶	Patient may present with little to no complaint	May revert to an acute apical abscess if drainage is halted. Can progress to a cystic lesion. ²⁴	The cause of the sinus is the tooth. Plan for tooth extraction or root canal treatment.
Tooth discolouration following endodontic management and access cavity restoration*	Intrinsic discolouration of the clinical crown can arise as a result of dental materials used.	Patient may complain regarding tooth discolouration.	Unlikely to reduce tooth survival. Adversely affects aesthetic outcome	In recent years, modern endodontic materials, such as Mineral Trioxide Aggregate (MTA) (a calcium silicate-based cement, CSC) have been associated with tooth discolouration because of bismuth oxide contents, although contamination of endodontic materials with blood may be a factor also. Historically, amalgam used in access cavities can leach and affecting the crown colour. Other factors include secondary caries surrounding a leaking restoration. No significant discolouration has been found with modern generation CSCs which do not contain bismuth oxide. ²⁷
Internal inflammatory root resorption ¹	Initially none, may be incidental radiographic finding. To occur, pulp must have some vitality, although can become necrotic eventually.	Often whilst pulp vital. Potentially irreversible pulpitis symptoms ensue. If necrosis occurs, signs and symptoms commensurate with this may occur.	May reduce tooth survival if resorption perforates tooth root. Early identification and management key. Coronal portion of pulp is often necrotic, apically it may be vital. ²⁸	Root canal treatment is indicated +/- antibiotic- corticosteroid pastes. ²⁸ To obturate the tooth effectively, the extent of resorption requires to be known and heated obturation techniques needed. Referral to a specialist may be required.
External invasive root resorption (cervical root resorption) ⁵	The pulp is most often vital. Patient may present noting a pink spot from the shine through of granulation tissue invading the tooth crown. The resorbed cervical area contains inflamed tissue that bleeds profusely on periodontal probing. ²⁹ The aetiology is unclear, and trauma is but one implicating factor. A cause-and-effect relationship has not been established. ³⁰	Patients may report a change in aesthetics, bleeding on brushing from gingival inflammation in the resorbed area or pulpitis symptoms. Asymptomatic cases are also seen.	May reduce tooth survival. The extent of lesion must be considered when assessing the restorability. ³⁰ Cases that have remained more coronal and have not entered the pulp have a better prognosis. ³⁰	Referral to a Restorative or Endodontic specialist is recommended as soon as possible to explore management options before the lesion potentially becomes too extensive to predictably treat.
External inflammatory root resorption (EIRR) ⁵	Occurs as a result of pulpal necrosis. Radiographically lamina dura is no longer evident at the site of the resorption.	As per pulpal necrosis and the associated periradicular diagnosis.	May reduce tooth survival. Root canal system is infected. ²⁸ See 'Significance & impact' section of pulpal necrosis above.	Confirm pulpal necrosis (eg, sensibility testing), extirpate as soon as possible to halt resorption. EIRR generally has a predictable outcome. ²⁸ If diagnosed late, or if the crown: root ratio is less than 1:1, the outlook for the tooth may be reduced.
External replacement resorption and ankylosis ⁵	Ankylosis may be determined by a high percussive note, loss of PDL space radiographically and absence of physiologic mobility. This may be accompanied by external replacement resorption. ³¹	If the patient is younger and growing, a step in the occlusal level is likely to arise. Changes in gingival margin height can also occur and be noticeable.	Likely to reduce tooth survival. Progressive. Bone replaces entire tooth, leading to eventual tooth loss.	Monitor and plan for tooth loss and replacement. Focus on maintaining aesthetics as best possible.

Key: Row colour: *green; †amber; ‡red. The impact of these injuries on tooth survival has been colour coded: green indicates sequelae unlikely to reduce tooth survival, amber highlights those which may reduce tooth survival, and red are sequelae likely to reduce tooth survival.

Swellings, sinus tracts and evidence of periradicular inflammation	Position & aesthetics of TDI affected teeth	Condition of TDI affected tooth structure
<p>Swellings: Occurring adjacent to tooth root warrants investigation into the pulpal status.</p> <p>Swellings elsewhere, for example lip tissue, can indicate the presence of unaccounted for tooth fragments. Use radiographs to examine for this.</p>	<p>Was tooth moved in position at the time of injury? Is it returned to pre-injury position?</p> <p>Has the tooth subsequently moved in position or become infraoccluded? This warrants further clinical and radiographic investigation. A high percussion note, and lack of physiologic mobility may indicate ankylosis</p>	<p>Is there caries requiring intervention? Are existing restorations satisfactory aesthetically and functionally?</p>
<p>Sinus tract: If present, thread gutta percha in and radiograph to deduce the sinus source.</p> <p>Two sinus tracts from the same tooth can indicate vertical root fracture.</p>	<p>Are aesthetics acceptable? Tooth colour and shape? Gingival architecture in relation to the smile line?</p>	<p>Is there evidence of exposed dentine, craze/infracton lines or overt cracks which may require sealing and/or further investigation? Transillumination may aid in identifying these issues.</p>
<p>Palpation over the root and sulci of the previously injured tooth may reveal swellings and/or tenderness, indicative of periosteal inflammation or root end fenestration. The time since the TDI and periradicular status will impact these findings.</p>	<p>Is the occlusion acceptable? Is the tooth functional in intercuspal position and involved in lateral guidance? Is the TDI affected tooth subject to occlusal trauma/jiggling forces?</p>	
<p>Percussion of the previously injured tooth aims to identify inflammation in the PDL, caused by recent injury, occlusal trauma or pulpal and periradicular problems.</p>		
Periodontal condition	Sensibility tests	Radiographs
<p>Mobility: Score using an index such as Millers classification.</p> <p>Increasing mobility is generally concerning. Screen for parafunctional habits, occlusal disharmony, along with deteriorating TDI injury.</p>	<p>Cold tests: Use in combination with other sensibility tests to increase accuracy. Less accurate when used on crowned teeth. Negative response = pulp may be necrotic. Prolonged, exaggerated response = pulpal inflammation (pulp still vital)</p>	<p>Follow IADT guidelines, or take as needed based on new signs, symptoms and/or clinical findings.</p>
<p>Increased periodontal pocketing and bleeding on probing may be indicative of pre-existing or new periodontal disease, or be associated with the TDI, such as cervical third root fractures and cervical root resorption, etc.</p>	<p>Electric pulp tester: Use in combination with other sensibility tests to increase accuracy. May identify vitality more accurately than necrosis. Negative response = pulp may be necrotic. Prolonged, exaggerated response = pulpal inflammation (pulp still vital)</p>	<p>Compare previous and new images. Look for:</p> <ul style="list-style-type: none"> • Changes in root length and shape • Alveolar changes around the root and around root fractures • Changes to the shape and size of the root canal system • Radiolucencies superimposed on root structure.
<p>Crown: root ratio: When treatment planning previously TDI affected teeth, consider if the ratio is 1:1 or more. (less than 1:1 = less predictable). The crown: root ratio may be affected by root fractures, previous or new periodontal disease and EIRR, etc.</p>		
<p>Percussion of the previously injured tooth aims to identify inflammation in the PDL, caused by recent injury, occlusal trauma or pulpal and periradicular problems.</p>		

Fig. 2 Follow-up examination, special tests and investigation summary^{2,37,41,42,43,44}

4. Review and document TDI follow-up systematically

At each follow-up appointment, the aim is to identify if there has been deterioration of the injured tooth or teeth and whether aesthetics and function are satisfactory. A patient history should be gathered and clinical examination of the TDI affected teeth (including neighbouring and opposing teeth), surrounding tissues and a check of static and functional occlusion of TDI affected teeth made. IADT guidelines² signpost review periods and when to sensibility test and radiograph TDI affected teeth, depending on the injury previously sustained.

Comprehensive documentation is crucial for clinical notes.³² A standardised method of recording a trauma review, such as using a pro forma, may help to mitigate human factors regarding information collection and enhance information gain.^{33,34} These can be designed to include information signposting appropriate review intervals in relation to the injury sustained.

At TDI review appointment, ensuring a clear, accurate trauma diagnosis has previously been established and recorded. Enquiries should be made as to the development of signs or symptoms of pulpal, periodontal or periradicular disease. Using a pain recognised pain scale or pain assessment tool³⁵ can aid in capturing a pain history if problems are reported. The patient's view on the aesthetics of the TDI

affected teeth should be explored, together with asking about changes in tooth position and/or occlusion.

Sensibility tests are an important element of trauma review, but these do always reveal true pulpal status.^{36,37} Combining several tests and correlating these with signs and symptoms to determine pulpal diagnosis is the most robust approach, although still not 100% accurate.³⁸ Pulse oximetry is reportedly the most diagnostically accurate test,³⁹ however this, together with laser doppler flowmetry are not commonly available or undertaken in dental clinics.

Figure 2 summarises the clinical examination, investigations and special tests frequently undertaken at TDI follow-up. Videos demonstrating how to undertake these tests are available on the Dundee School of Dentistry YouTube Channel.⁴⁰

Conclusion

This article has discussed the importance of TDI diagnosis, the communication of TDI injury sequelae with patients and in the case of minors, their guardians; the potential sequelae of TDIs and how these might impact tooth survival. The second part of this article expands on this and considers late trauma presentation, when to retain or extract teeth and the role of dental implants in TDI affected individuals.

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