



Guidelines for the orthodontic management of the traumatised tooth

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Abstract

Dental trauma is common in the UK, with more than one in ten children having experienced some form of dental trauma. In addition, one in ten patients have been reported to have experienced dental trauma before orthodontic treatment. A recent survey of orthodontists' knowledge and experience of orthodontic management of traumatised teeth has highlighted large inconsistencies in management of traumatised teeth among UK orthodontists, highlighting the need for further information or training on orthodontic management of traumatised teeth.

Therefore, the following guidelines have been developed in order to provide an evidence-based approach to treat this cohort of patients. The following guidance is based on the available literature, expert opinion and UK orthodontists' consensus drawn from a recent survey.

Keywords

dental trauma, orthodontic management, guidelines

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1. Introduction

Dental trauma is common in the UK, with more than one in ten children having experienced some form of dental trauma (Pitts et al., 2013). In addition, one in ten patients have been reported to have experienced dental trauma before orthodontic treatment (Bauss et al., 2004). A recent survey of orthodontists' knowledge and experience of orthodontic management of traumatised teeth has documented large inconsistencies in management of traumatised teeth among UK orthodontists, highlighting the need for further information or training on orthodontic management of traumatised teeth (Sandler et al., 2019).

Therefore, the following guidelines have been developed in order to provide an evidence-based approach to treat this cohort of patients. The following guidance is based on the available literature, expert opinion and UK orthodontists' consensus drawn from a recent survey (Sandler et al., 2019).

2. General guidance

2.1 Clinical assessment

Orthodontic movement of previously traumatised teeth has been linked to adverse pulpal and periodontal

consequences. An increased rate of root resorption is seen in teeth where root resorption has already occurred following dental trauma (Levander and Malmgren, 1988). Furthermore, although the evidence on the development of pulp necrosis following orthodontic tooth movement of previously traumatised teeth is controversial (Duggal et al., 2015; Kindelan et al., 2008), orthodontists should still be aware of these risks and be aware of the possible need to undertake vitality tests if appropriate.

For all new orthodontic patients, it is essential to routinely ask about historic episodes of dental trauma.

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2.2. Radiographic assessment

In addition to routine orthodontic radiographic assessment, additional radiographs are needed to assess and monitor traumatised teeth during orthodontic treatment. The use of long cone periapical radiographs is usually the most useful exposure type. The use of two radiographic exposures with different horizontal or vertical angulations is helpful in identifying root fractures. The use of cone beam computed tomography (CBCT) could be indicated in certain situations, particularly when the degree of root resorption is uncertain. CBCT can be used to identify areas of root resorption not identifiable on a conventional radiograph.

2.3. Acute management of traumatised teeth

Immediate management of traumatised teeth should aim to preserve pulpal vitality and prevent damage to the periodontal ligaments. For immediate management of traumatised teeth, the reader is advised to follow:

1. The guidelines developed by the International Association of Dental Traumatology (IADT), which are widely used worldwide and freely available at <https://www.iadt-dentaltrauma.org/for-professionals.html>.
2. The dental trauma guide, <https://dentaltraumaguide.org/dtg-members-frontpage/>, which is an interactive version of the IADT guidelines.
3. The IADT mobile phone application (ToothSOS), which is designed to help the general public as well as professionals.
4. The British Society of Paediatric Dentistry guidelines on the management of avulsion, which are available at <https://www.bspd.co.uk/resources/bspd-guidelines>.

2.4. General orthodontic management considerations of traumatised teeth

- Informed consent must be gained from the patient/person with parental responsibility and they should be warned that root resorption and/or pulp necrosis and infection may occur during the active orthodontic phase.
- Baseline and regular radiographic review. The frequency of radiographic assessment is dependent on the type of orthodontic treatment provided (removable vs. fixed appliance therapy), the severity of traumatic injury and the likelihood of complications anticipated. Radiographic assessment at baseline, pre-treatment and update radiographs 6–9 months into treatment is usually recommended with such interval shortened if symptoms arise.

- Baseline and regular pulp sensibility testing. Sensibility tests, albeit very popular (Ghouth et al., 2019), are subjective and, therefore, have compromised accuracy, especially in the paediatric population. Therefore, it is advisable to use more than one test, such as electric pulp testing (EPT) and thermal tests. Recent systematic reviews (Ghouth et al., 2018; Mainkar and Kim, 2018) showed high specificity = 0.93 and low sensitivity = 0.72 when using the EPT and moderate specificity = 0.84 and sensitivity = 0.87 for cold tests.
- Modify the archwire sequence to reduce the orthodontic forces (Sandler et al., 2019). When considering orthodontic movement of traumatised teeth, it is sensible to utilise as light forces as possible. During the initial phase of treatment or if aligning recently traumatised teeth, then thermal nickel–titanium archwires are recommended. They demonstrate significantly lower force-deflection curves than superelastic archwires (40 g force for a 2–4-mm deflection of a 0.014-inch archwire). During space closure, it may be necessary to use a working archwire with slightly reduced dimensions to limit the torquing force placed on the traumatised teeth, e.g. a 0.016-inch/0.022-inch stainless-steel wire may be considered appropriate.
- Always be aware that teeth adjacent to the traumatised teeth may also have been affected.

3. Orthodontic management of traumatised teeth

Orthodontic management of traumatised teeth is dependent on the type of trauma sustained. Therefore, this orthodontic management section has been arranged into different categories: Minor damage to the periodontium; Moderate/severe damage to the periodontium; Crown or Crown/root fracture; Root fracture; Root canal treated teeth, due to trauma, obturated with gutta percha; Endodontic challenges (Pulp canal obliteration, Infection-related resorption, Replacement resorption (ankylosed teeth), Tooth auto-transplantation, Regenerative endodontic/revitalisation technique); and Conclusion.

3.1. Minor damage to the periodontium

Minor damage to the periodontium includes:

- Concussion: the tooth is usually tender to percussion with no other symptoms
- Subluxation: the tooth is usually not displaced and tender to percussion, with bleeding from the gingival sulcus

3.1.1. Orthodontic management recommended techniques

- Observation period before orthodontic movement: three months

3.2. Moderate/severe damage to periodontium

Moderate to severe damage to the periodontium includes:

- Extrusive luxation: the tooth appears longer than usual and will be mobile
- Lateral luxation: the tooth is displaced in the palatal or lingual direction, it will be immobile and may give a high metallic sound to percussion
- Intrusive luxation: the tooth will appear shorter than neighbouring teeth as it is displaced axially, it will be immobile and give a high metallic sound on percussion
- Avulsion: the tooth is completely displaced out of its socket. Such teeth may have been replanted and splinted

3.2.1. Orthodontic management recommended techniques

3.2.1.1. Acute orthodontic management

Orthodontic intervention may be required at the acute phase of trauma management in certain situations as follows:

- Lateral luxation:
 - If displaced teeth interfere with occlusion, then opening the bite using bite raising techniques, such as placement of glass ionomer stops on the occlusal surfaces of first permanent molars, or using removable appliances with posterior bite planes might be indicated. Using short-term light orthodontic forces, treatment should be aimed at eliminating any premature tooth contact.
 - In certain cases, repositioning of the tooth might not be possible due to lack of patient compliance or delayed presentation. Such displaced teeth might interfere with occlusion necessitating opening the bite using bite raising techniques or appliances such as placement of glass ionomer stops on the occlusal surfaces of permanent molars or removable appliances with bite planes. Orthodontic movement using minimal, short-term light forces aiming to remove the premature contact only rather than definitively reposition the tooth.
- Intrusive luxation:
 - Orthodontists might be involved in the immediate management of intruded teeth as per the following table which is based on the IADT guidelines (Diangelis et al., 2017). Table 1 (modified based on IADT guidelines) highlights cases requiring orthodontic intervention.

- Although IADT guidelines recommend no treatment for immature intruded teeth, orthodontic extrusion must be considered for moderate to severe cases where the risk of extensive root resorption of an immature tooth is felt to be high.
- Orthodontic versus surgical repositioning: the current evidence comparing the use of orthodontic extrusion versus surgical repositioning of intruded teeth shows no significant difference in the development of pulpal necrosis, root resorption or marginal bone loss (Al-Badri et al., 2002; Albadri et al., 2010; Andreasen et al., 2006). The use of orthodontic repositioning, unless contraindicated, is recommended in most moderate to severe cases.
- Pulp extirpation of teeth with completed root formation should be performed as soon as possible to prevent infection-related resorption. Surgical repositioning has been recommended in severe intrusion cases of mature teeth in order to allow pulp canal extirpation. Orthodontic repositioning of such teeth is still possible; however, pulpal extirpation is recommended within 3–4 weeks after trauma. Risks and benefits of surgical extrusion versus orthodontic repositioning should be considered and informed consent should be obtained.
- When using a sectional fixed appliance to realign displaced, traumatised teeth; bracket positioning on the adjacent teeth should be passive, as their role is to aid in correcting the traumatised teeth and not in aligning the adjacent teeth, as many of these patients will have mal-aligned teeth before their trauma.

3.2.1.2. Non-acute orthodontic management

- Observation period before orthodontic movement: 6–12 months
- Orthodontic management of teeth with a history of moderate to severe damage to periodontium is not recommended before complete periodontal healing has occurred, around 6–12 months. If orthodontic forces are applied 6–12 month after the trauma, and no tooth movement is observed, ankylosis should be considered (Kindelan et al., 2008).
- Occasionally, if it is suspected that a tooth will become ankylosed after trauma, then early orthodontic alignment may be attempted to prevent the tooth being ankylosed in an unfavourable position. This would carry an increased risk of root shortening during treatment. Cases like this should be managed through a specialist dental trauma unit.
- Teeth with poor long-term prognosis should be assessed by specialised interdisciplinary teams where treatment modalities such as decoronation or premolar transplantation could be considered.

- General orthodontic management considerations of traumatised teeth (refer to section 2.4)

3.3. Crown and crown/root fracture

A crown fracture that extends below the gingival margin which involved the enamel, dentine and possibly the pulp.

3.3.1. Orthodontic management recommended techniques

- Observation period before orthodontic treatment: three months.
- With immature pulpally involved teeth, treated using vital pulp therapy, crown extrusion should only proceed following radiographic signs of establishment of a hard tissue barrier or complete root formation.
- Orthodontists might be asked to extrude these teeth in order to facilitate the development of a good coronal restoration.
- These cases should be managed with close collaboration between the orthodontist and restorative or paediatric dentist.
- Careful consideration would be needed regarding the long-term viability of the remaining sub-crestal bone length and its impact on likely tooth mobility.
- Generally, fixed orthodontic appliances offer greater control over the final tooth position in comparison to removable appliances, which rely far more on patient compliance.

When extruding a fractured tooth to bring the fracture margin supragingival, it is best practice to use a stabilising archwire to the adjacent teeth, e.g. 0.018-inch stainless steel. A flexible ‘piggyback’ archwire of 0.012-inch nickel titanium can then be used to extrude the fractured tooth (force levels approximately 50 g).

3.4. Root fracture

A fracture involving the root of the tooth, in a horizontal or oblique plane. Clinical findings associated with a root fracture include the following: bleeding from gingival sulcus; tooth is tender to percussion; coronal fragment is mobile or displaced; transient crown discolouration; or negative sensibility tests.

3.4.1. Orthodontic management recommended techniques

- Observation period before orthodontic movement: 1–2 years, or shorter, if asymptomatic.
- If healing of the root fracture has occurred by connective tissue, then the coronal fragment must be treated as a tooth with a short root. Teeth should not be moved until successful endodontic treatment and connective tissue healing of the coronal fragment has occurred (Sandler et al., 2019).

- The apical root portion will retain vitality and, in the vast majority of cases, will become separated from the coronal portion, when the coronal portion is moved orthodontically.
- Specific warning with regard to the compromised crown root ratio and future tooth mobility/loss is required, specifically highlighting that orthodontic tooth movement may further compromise the crown root ratio as a result of root fracture. In most cases, a central incisor with a root length < 9 mm will exhibit clinically significant mobility.

3.5. Root canal treated teeth, due to trauma, obturated with gutta percha

A tooth that has already suffered trauma, causing the pulp to become infected or die, leading to root canal treatment with gutta percha.

3.5.1. Orthodontic management recommended techniques

- Observation period before orthodontic movement:
 - At least one postoperative radiograph is necessary to assess the success of the obturation, and to act as a baseline for assessment of apical pathology or healing. A further follow-up radiograph should be taken at one year after completion of treatment (Faculty of General Dental Practitioners, 2013).
 - The observation period depends on the nature of the original traumatic injury in a mature closed apex tooth, following an initial dressing of calcium hydroxide and obturation with Gutta Percha (Sandler et al., 2019).

3.6. Endodontic challenges

3.6.1. Pulp canal obliteration. Pulp canal obliteration often develops after dental trauma (prevalence of 4%–24%) and is characterised by the deposition of hard tissue within the root canal space with a resulting yellow discolouration of the crown (McCabe and Dummer, 2012). It may be recognised clinically as early as three months after dental injuries; however, it is mostly detected at approximately one year (Andreasen, 1970). Most teeth with pulp canal obliteration remain vital and therefore require no treatment other than radiographic monitoring. Pulp canal obliteration is a sign of continued vitality and not an indication for root canal treatment.

3.6.1.1. Orthodontic management recommended techniques.

- The risk of loss of pulpal vitality after orthodontic tooth movement and the possible difficulties encountered in performing root canal treatment in such teeth should be carefully discussed and informed consent obtained.

- Treatment objectives may be limited or modified at the start of orthodontic treatment.
- Baseline pulp and root health records must be obtained for comparisons during orthodontic treatment (response of such teeth to sensibility testing is unreliable).
- Regular close monitoring of these teeth throughout the course of orthodontic treatment is necessary.
- Where possible, partial or complete exclusion of such teeth from orthodontic forces is beneficial.
- Light, short-acting forces (< 70 g) should be used.

3.6.2. Infection-related resorption. Infection-related resorption is characterised by the radiographic appearance of loss of tooth substance together with a radiolucency involving the adjacent PDL and bone as a result of pulpal necrosis and mechanical damage to the cementum (Abbott, 2016).

3.6.2.1 Orthodontic management recommended techniques

- Orthodontic movement should only start once infection is under control with stable results.
- The risk of further tooth resorption with compromised long-term prognosis should be discussed.
- Treatment objectives may be limited or modified at the start of orthodontic treatment.
- Regular close monitoring of these teeth throughout the course of orthodontic treatment is necessary.
- Where possible, partial or complete exclusion of such teeth from orthodontic forces is beneficial.
- Teeth with poor long-term prognosis should be assessed by specialised interdisciplinary teams where treatment modalities such as decoronation or premolar transplantation could be considered.

3.6.3. Replacement resorption (ankylosed teeth). A tooth which has pathologically fused to the bone. These teeth are immobile and result in a high metallic sound on percussion. These teeth may be infra-occluded when compared to neighbouring teeth, depending on how long it has been ankylosed.

3.6.3.1. Orthodontic management recommended techniques

- Management by a multidisciplinary team (MDT) is recommended as such cases require long-term planning that may include advanced techniques such as decoronation and tooth auto-transplantation.
- Treatment objectives may be limited or modified at the start of orthodontic treatment with a clear view of long-term plans (a plan for loss of the tooth should be formulated).

- Baseline pulp and root health records must be obtained for comparisons during orthodontic treatment.
- It may be possible to consider forced luxation of the ankylosed tooth followed by orthodontic extrusion to the final desired position (Jang et al., 2002).
- Leave the tooth off of the archwire or utilise the tooth for anchorage (see 2.4 above).

3.6.4. Tooth auto-transplantation. Tooth auto-transplantation is currently performed by specialised auto-transplantation interdisciplinary centres around the country in the management of teeth with poor long-term prognosis. While orthodontic treatment is usually performed within the same auto-transplantation unit, certain cases might receive orthodontic treatment at orthodontic specialist clinics. In such cases, clear communication and agreement between the lead orthodontist, at the auto-transplantation centre, and the treating orthodontist is essential for the success of these complex cases. Points to consider are:

- Clear referral pathways to prevent unnecessary delays and unnecessary complications
- Pre-orthodontic treatment plan (if required)
- Usually transplantation of a premolar tooth to replace a poor prognosis upper central incisor
- Timing of tooth auto-transplantation when premolar root is three-quarters formed
- Post-transplantation orthodontic treatment plan
- Timing of orthodontic movement of auto-transplanted teeth
- Transplanted premolars develop vertically as the patient grows maintaining and possibly developing alveolar bone

3.6.5. Regenerative endodontic/revitalisation technique. The regenerative endodontic technique (RET) is used for the management of necrotic immature permanent teeth in children. RET aims to facilitate an increase in root length and promote thickening of dentinal walls.

3.6.5.1. Orthodontic management recommended techniques

- Treatment objectives may be limited or modified at the start of orthodontic treatment.
- It is advisable to delay orthodontic treatment until stable final results have been observed with a minimum review period of two years.
- The observation period also depends on the nature of the original traumatic injury (Sandler et al., 2019).
- Teeth with poor long-term prognosis should be assessed by specialised interdisciplinary teams where treatment modalities such as decoronation or premolar transplantation could be considered.

Table 1. Management of luxation injuries.

Root development stage	Degree of intrusion	Spontaneous re-eruption	Orthodontic movement	Surgical repositioning
Immature	Up to 7mm	For 2-4 weeks	If no re-eruption after 2-4 weeks	
	> 7mm		Ortho or Surgical	
Mature	Mild <3 mm	For 2-4 weeks	If no re-eruption after 2-4 weeks	
	Moderate 3-7mm		Ortho or Surgical	
	Severe >7mm		Surgical*	

*Root canal treatment is recommended in 2–3 weeks with calcium hydroxide as an intracanal medicament.

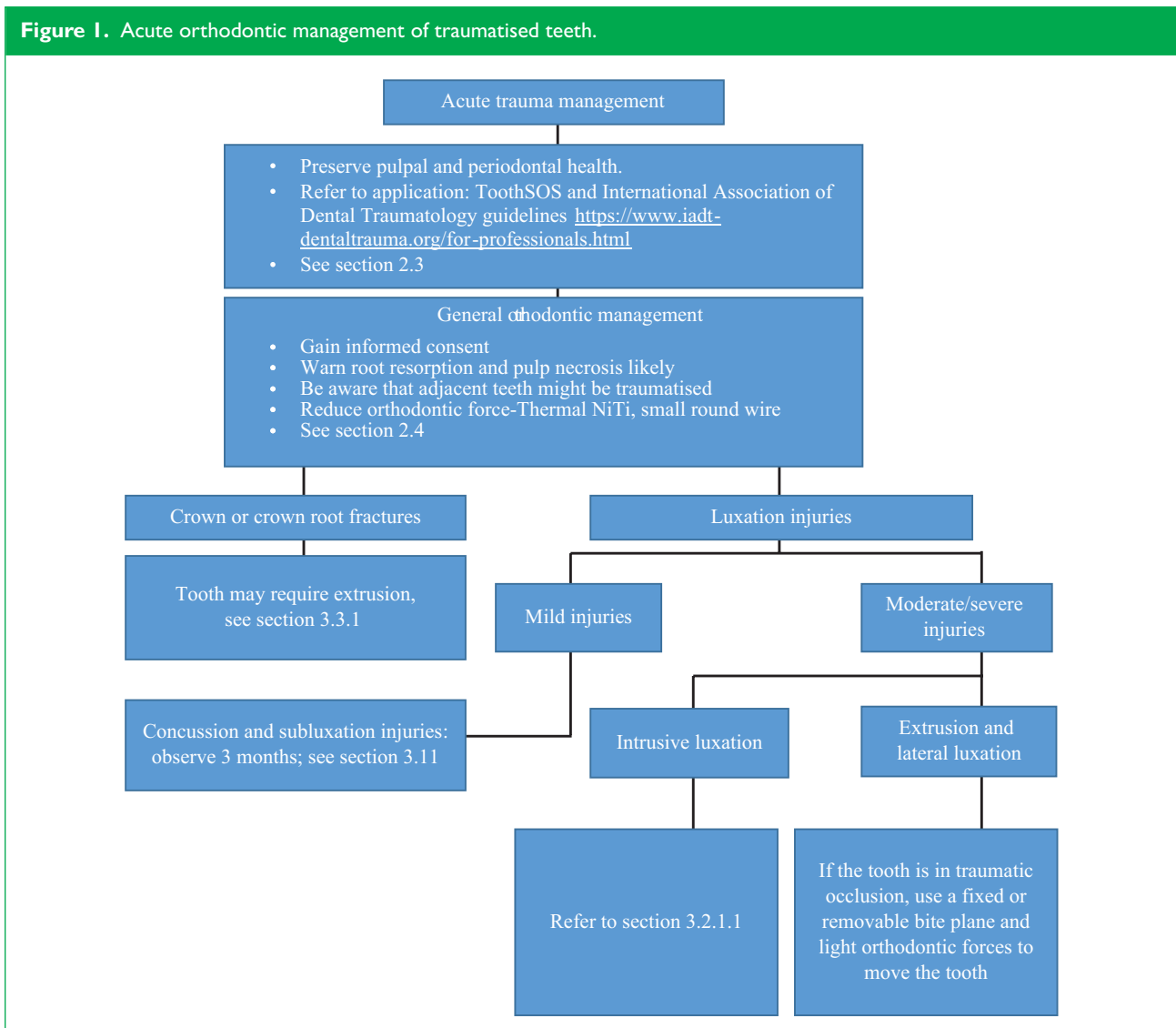


Figure 2. Non-acute orthodontic management of traumatised teeth.**Non-acute orthodontic management of traumatised teeth****Moderate–severe luxation injuries 3.2.1.2**

- Observation for 6–12 months
- Delay until complete periodontal healing occurred
- If no movement observed after 6–12 months of orthodontic movement, assume tooth is ankylosed

Crown and crown/root fractures 3.3.1

- Observation for three months. In immature pulpally involved teeth treated using vital pulp therapy, crown extrusion should only proceed following radiographic signs of establishment of a hard tissue barrier or complete root formation.
- When extruding a fractured tooth, use a stabilising archwire to the adjacent teeth. A flexible ‘piggyback’ archwire of 0.012-inch nickel titanium can then be used to extrude the fractured tooth (force levels approximately 50 g).

Root fracture 3.4

Observe for 1–2 years or less if asymptomatic. If root fracture healed with connective tissue, treat tooth as short rooted. Do not move tooth until successful endodontic treatment is achieved. Apical portion will remain vital. Warn re ‘short’ root mobility problems

Root-treated teeth 3.5

Have one post endodontic treatment radiograph for assessment of obturation and one year after endodontic treatment is completed. Observation period depends on the nature of the original trauma in a mature closed apex tooth.

Pulp canal obliteration 3.6.1

Crown may present with yellow discolouration. This is not an indication for endodontic treatment, as tooth is still vital. Radiographic monitoring is advised. Reduce or eliminate orthodontic forces on affected teeth, light short acting forces are advised if necessary. Warn patients of problems if endodontic treatment is required. Limit objectives. Monitor regularly.

Infection-related resorption 3.6.2

Only start orthodontic treatment once infection is under control. A MDT is recommended.

Replacement resorption 3.6.3

MDT– auto-transplantation/decoronation. Limited objectives. Keep pulp and root health records at baseline and during treatment. Consider luxation and orthodontic treatment to align to final position. Leave tooth off archwire or utilise for anchorage.

Regenerative/revitalisation endodontic technique (RET) 3.6.5

Review teeth for two years before starting orthodontic treatment. MDT assessment is advised.

- RET is a new, rapidly expanding field; therefore, orthodontists are likely to encounter patients where such treatment has been provided. This technique is, as yet, unpredictable and thus

probably for use where < 50% root length of non-vital tooth present. It is recommended to refer these patients for treatment by specialised centres. Concerns with regards to the orthodontic

movement of RET-treated teeth exist, including long-term internal root resorption and possible loss of newly formed pulpal tissues. Current evidence would suggest waiting a minimum of two years before undertaking orthodontics on teeth treated with RET, especially in cases showing no continuation of root development or apical closure.

4. Conclusions

These guidelines were put together in response to research highlighting the need for further training and education in orthodontic management of traumatised teeth. The management of traumatised teeth is a challenge that affects orthodontists regularly. It is important for orthodontists to be aware of the different types of trauma, their respective management and how it will impact upon treatment.


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References

- Abbott PV. (2016) Prevention and management of external inflammatory resorption following trauma to teeth. *Australian Dental Journal* 61: 82–94.
- Al-Badri S, Kinirons M, Cole B and Welbury R. (2002) Factors affecting resorption in traumatically intruded permanent incisors in children. *Dental Traumatology* 18: 73–76.
- Albadri S, Zaitoun H and Kinirons MJ. (2010) UK National Clinical Guidelines in Paediatric Dentistry: treatment of traumatically intruded permanent incisor teeth in children. *International Journal of Paediatric Dentistry* 20: 1–2.
- Andreasen JO. (1970) Luxation of permanent teeth due to trauma. A clinical and radiographic follow-up study of 189 injured teeth. *Scandinavian Journal of Dental Research* 78: 273–286.
- Andreasen JO, Bakland LK and Andreasen FM. (2006) Traumatic intrusion of permanent teeth. Part 3. A clinical study of the effect of treatment variables such as treatment delay, method of repositioning, type of splint, length of splinting and antibiotics on 140 teeth. *Dental Traumatology* 22: 99–111.
- Bauss O, Rohling J and Schweska-Polly R. (2004) Prevalence of traumatic injuries to the permanent incisors in candidates for orthodontic treatment. *Dental Traumatology* 20: 61–66.
- Diangelis AJ, Andreasen JO, Ebeleseder KA, Kenny DJ, Trope M, Sigurdsson A, Andersson L, Bourguignon C, Flores MT, Hicks ML, Lenzi AR, Malmgren B, Moule AJ, Pohl Y and Tsukiboshi M. (2017) Guidelines for the Management of Traumatic Dental Injuries: 1. Fractures and Luxations of Permanent Teeth. *Paediatric Dentistry* 39: 401–411.
- Duggal MS, Kindelan J and Nazzal H. (2015) Upper incisor trauma and the orthodontic patient—Principles of management. *Seminars in Orthodontics* 21: 59–70.
- Faculty of General Dental Practitioners. (2013) Selection Criteria for Dental Radiography: Endodontic follow-up. Available at: <https://www.fgdp.org.uk/selection-criteria-dental-radiography/65-endodontic-follow>.
- Ghouth N, Duggal MS, Banihani A and Nazzal H. (2018) The diagnostic accuracy of laser Doppler flowmetry in assessing pulp blood flow in permanent teeth: A systematic review. *Dental Traumatology* 34: 311–319.
- Ghouth N, Duggal MS and Nazzal H. (2019) The use of dental pulp tests in children with dental trauma: a national survey of the British Society of Paediatric Dentistry's members. *British Dental Journal* 226: 207–212.
- Jang KT, Kim J, Lee SH, Kim CC, Hahn SH and Garcia-Godoy F. (2002) Reposition of intruded permanent incisor by a combination of surgical and orthodontic approach: a case report. *Journal of Clinical Paediatric Dentistry* 26: 341–345.
- Kindelan SA, Day PF, Kindelan J, Spencer JR and Duggal MS. (2008) Dental trauma: an overview of its influence on the management of orthodontic treatment. Part 1. *Journal of Orthodontics* 35: 68–78.
- Levander E and Malmgren O. (1988) Evaluation of the risk of root resorption during orthodontic treatment: a study of upper incisors. *European Journal of Orthodontics* 10: 30–38.
- Mainkar A and Kim SG. (2018) Diagnostic Accuracy of 5 Dental Pulp Tests: A Systematic Review and Meta-analysis. *Journal of Endodontics* 44: 694–702.
- McCabe PS and Dummer PM. (2012) Pulp canal obliteration: an endodontic diagnosis and treatment challenge. *International Endodontic Journal* 45: 177–197.
- Pitts N, Chadwick B and Anderson T. (2013) *Children's Dental Health Survey 2013. Report 2: Dental Disease and Damage in Children England, Wales and Northern Ireland*. Leeds: Health & Social Care Information Centre; 2015.
- Sandler C, Barry S, Littlewood S, Al-Musfir T and Nazzal H. (2019) Orthodontic management of traumatized teeth: A national survey of UK orthodontists. *Dental Traumatology* 35: 241–250.