Received: 19 May 2020 | Accepted: 19 May 2020
DOI: 10.1111/edt.12574

COMPREHENSIVE REVIEW

Dental Traumatology WILEY

International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: General introduction

Liran Levin[1] | Peter F. Day[2] | Lamar Hicks[3] | Anne O'Connell[4] | Ashraf F. Fouad[5] | Cecilia Bourguignon[6] | Paul V. Abbott[7]

[1]Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada

[2]School of Dentistry at the University of Leeds, Community Dental Service, Bradford District Care NHS Trust, Leeds, UK

[3]Division of Endodontics, University of Maryland School of Dentistry, UMB, Baltimore, MD, USA

[4]Paediatric Dentistry, Dublin Dental University Hospital, Trinity College Dublin, The University of Dublin, Dublin, Ireland

[5]Adams School of Dentistry, University of North Carolina, Chapel Hill, NC, USA

[6]Private Practice, Paris, France

[7]UWA Dental School, University of Western Australia, Perth, WA, Australia

Correspondence
Liran Levin, Chair of the IADT Guidelines Committee, Faculty of Medicine & Dentistry, University of Alberta, 5-468 Edmonton Clinic Health Academy, 11405 - 87 Avenue NW, 5th Floor, Edmonton, AB T6G 1C9, Canada.
Email: liran@ualberta.ca

Abstract

Traumatic dental injuries (TDIs) occur most frequently in children and young adults. Older adults also suffer TDIs but at significantly lower rates than individuals in the younger cohorts. Luxation injuries are the most common TDIs in the primary dentition, whereas crown fractures are more commonly reported for the permanent teeth. Proper diagnosis, treatment planning and follow up are very important to assure a favorable outcome. These updates of the International Association of Dental Traumatology's (IADT) Guidelines include a comprehensive review of the current dental literature using EMBASE, MEDLINE, PUBMED, Scopus, and Cochrane Databases for Systematic Reviews searches from 1996 to 2019 and a search of the journal *Dental Traumatology* from 2000 to 2019. The goal of these guidelines is to provide information for the immediate or urgent care of TDIs. It is understood that some follow-up treatment may require secondary and tertiary interventions involving dental and medical specialists with experience in dental trauma. As with previous guidelines, the current working group included experienced investigators and clinicians from various dental specialties and general practice. The current revision represents the best evidence based on the available literature and expert opinions. In cases where the published data were not conclusive, recommendations were based on the consensus opinions of the working group. They were then reviewed and approved by the members of the IADT Board of Directors. It is understood that guidelines are to be applied using careful evaluation of the specific clinical circumstances, the clinician's judgment, and the patient's characteristics, including the probability of compliance, finances and a clear understanding of the immediate and long-term outcomes of the various treatment options vs non-treatment. The IADT does not, and cannot, guarantee favorable outcomes from adherence to the Guidelines. However, the IADT believes that their application can maximize the probability of favorable outcomes.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
© 2020 The Authors. *Dental Traumatology* published by John Wiley & Sons Ltd

KEYWORDS
avulsion, luxation, prevention, tooth fracture, trauma

1 | INTRODUCTION

Traumatic dental injuries (TDIs) occur frequently in children and young adults, comprising 5% of all injuries. Twenty-five percent of all school children experience dental trauma and 33% of adults have experienced trauma to the permanent dentition, with the majority of the injuries occurring before age 19. Luxation injuries are the most common TDIs in the primary dentition, whereas crown fractures are more commonly reported for the permanent teeth. Proper diagnosis, treatment planning and follow up are important to assure a favorable outcome.

These updates of the International Association of Dental Traumatology's (IADT) Guidelines include a review of the current dental literature using EMBASE, MEDLINE, PUBMED, and Scopus searches from 1996 to 2019 and a search of the journal *Dental Traumatology* from 2000 to 2019.

The goal of these guidelines is to provide information for the immediate and urgent care of TDIs. It is understood that some of the subsequent treatment may require secondary and tertiary interventions involving specialists with experience in dental trauma.

The IADT published its first set of guidelines in 2001 and updated them in 2007. A further update was published in *Dental Traumatology* in 2012. As with previous guidelines, the current working group included experienced investigators and clinicians from various dental specialties and general practice. The current revision represents the best evidence based on the available literature and expert professional judgment. In cases where the data were not conclusive, recommendations were based on the consensus opinion of the working group, then reviewed and approved by the members of the IADT Board of Directors.

It is understood that guidelines are to be applied with evaluation of the specific clinical circumstances, clinicians' judgment and patients' characteristics, including but not limited to the probability of compliance, finances and an understanding of the immediate and long-term outcomes of treatment options vs non-treatment. The IADT does not, and cannot, guarantee favorable outcomes from adherence to the Guidelines, but the IADT believes that their application can maximize the chances of a favorable outcome.

These Guidelines offer recommendations for the diagnosis and treatment of specific TDIs. However, they provide neither the comprehensive nor the detailed information found in textbooks, the scientific literature, or the Dental Trauma Guide (DTG). The DTG can be accessed at http://www.dentaltraumaguide.org. In addition, the IADT website http://www.iadt-dentaltrauma.org provides connection to the journal *Dental Traumatology* and other dental trauma information.

2 | GENERAL RECOMMENDATIONS

2.1 | Special considerations for trauma to primary teeth

A young child is often difficult to examine and treat due to lack of cooperation and because of fear. This situation is distressing for both the child and the parents. It is important to keep in mind that there is a close relationship between the root apex of the injured primary tooth and the underlying permanent tooth germ. Tooth malformation, impacted teeth and eruption disturbances in the developing permanent dentition are some of the consequences that can occur following severe injuries to primary teeth and/or alveolar bone. A child's maturity and ability to cope with the emergency situation, the time for shedding of the injured tooth, and the occlusion are all important factors that influence treatment. Multiple traumatic episodes are also common in children and this may affect the outcomes following trauma to a tooth.

2.2 | Immature vs mature permanent teeth

Every effort should be made to preserve the pulp in the immature permanent tooth to ensure continued root development. A large majority of TDIs occur in children and teenagers where loss of a tooth has lifetime consequences. The immature permanent tooth has considerable capacity for healing after traumatic pulp exposure, luxation injury, or root fracture.

2.3 | Avulsion of permanent teeth

The prognosis for avulsed permanent teeth is heavily dependent on the actions taken at the place of accident. Promotion of public awareness of first-aid treatment for the avulsed tooth is strongly encouraged. Treatment choices and prognosis for the avulsed tooth are largely dependent on the viability of the periodontal ligament (PDL), and the maturity of the root. *See the IADT's specific Guidelines for managing avulsed teeth.*[1]

2.4 | Patient/parent instructions

Patient compliance with follow-up visits and home care contributes to better healing following a TDI. Both the patient and the parents of a young patient should be advised regarding care of the injured tooth or teeth for optimal healing, preventing further injury, employing meticulous oral hygiene, and rinsing with an antibacterial agent

TABLE 1 Primary dentition follow-up regimes

	1 W	4 W	8 W	3 M	6 M	1 Y	At 6 Y old	Generic outcomes to consider collecting as identified by the Core Outcome Set	Injury-specific outcomes to consider collecting as identified by the Core Outcome Set
Enamel fracture	No follow up								
Enamel/dentin fracture			*					Periodontal healing (including bone loss, gingival recession, mobility, and ankylosis/resorption) Pulp healing (including infection) Pain Discoloration Tooth loss Quality of life (days off work, school, and sport) Aesthetics (patient perception) Trauma-related dental anxiety Number of clinic visits Impact on development of permanent successor	Quality of restoration Loss of restoration
Crown fracture	*		*			* (Radiograph only if endodontic treatment carried out)			Quality of restoration Loss of restoration
Crown/root fracture	*		*			* (Radiograph only if endodontic treatment carried out)			If crown restored: Quality of restoration Loss of restoration
Root fracture	*	*S	*			*			Realignment —where spontaneous repositioning undertaken
Alveolar fracture	*	*SR	*			*R	*		
Concussion	*		*					Periodontal healing (including bone loss, gingival recession, mobility, and ankylosis/resorption) Pulp healing (including infection) Pain Discoloration Tooth loss Quality of life (days off work, school, and sport) Aesthetics (patient perception) Trauma-related dental anxiety Number of clinic visits Impact on development of permanent successor	
Subluxation	*		*						
Extrusion	*		*			*			Realignment —where spontaneous repositioning undertaken
Lateral luxation	*	*S	*		*	*			Realignment —where spontaneous repositioning undertaken
Intrusion	*		*		*	*	*		Realignment —where spontaneous repositioning undertaken Infra-occlusion
Avulsion	*		*				*	Pain Tooth loss Aesthetics Quality of life Trauma-related dental anxiety Number of clinic visits Impact on development of permanent successor	

Note: At these follow-up visits consider collecting the generic and injury-specific outcomes as identified by the Core Outcome Set—Kenny et al Dent Traumatol 2018.

* = clinical review appointment.

S = splint removal.

R = radiograph advised even if no clinical signs or symptoms.

TABLE 2 Permanent dentition follow-up regimes

	2 W	4 W	6-8 W	3 M	4 M	6 M	1 Y	Yearly up to at least 5 Y	Generic outcomes to consider collecting as identified by the Core Outcome Set	Injury-specific outcomes to consider collecting as identified by the Core Outcome Set
Infraction	No follow up									
Enamel fracture			*R				*R		Periodontal healing (including bone loss, gingival recession, mobility, and ankylosis/resorption) Pulp healing (including infection)# Pain Discoloration Tooth loss Quality of life (days off work, school, and sport) Aesthetics (patient perception) Trauma-related dental anxiety Number of clinic visits	Quality of restoration Loss of restoration
Enamel/dentin fracture			*R				*R			
Crown fracture			*R	*R		*R	*R			
Crown/root fracture			*R	*R		*R	*R	*R		Quality of restoration Loss of restoration
Root fracture (apical third, mid-third)		*S*R	*R		*R	*R	*R	*R		Root fracture repair
Root fracture (cervical third)		*R	*R		*S*R	*R	*R	*R		
Alveolar fracture		*S*R	*R		*R	*R	*R	*R		Infra-occlusion
Concussion		*R					*R		Periodontal healing (including bone loss, gingival recession, mobility, and ankylosis/resorption) Pulp healing (including infection)# Pain Discoloration Tooth loss Quality of life (days off work, school, and sport) Aesthetics (patient perception) Trauma-related dental anxiety Number of clinic visits	
Subluxation	(*S) *R			*R		*R	*R			
Extrusion	*S*R	*R	*R	*R		*R	*R	*R		Infra-occlusion
Lateral luxation	*R	*S*R	*R	*R		*R	*R	*R		
Intrusion	*R	(*S) *R	*R	*R		*R	*R	*R		Infra-occlusion Realignment —where spontaneous repositioning undertaken
Avulsion (mature tooth)	*S*R	*R		*R		*R	*R	*R		Infra-occlusion
Avulsion (immature tooth)	*S*R	*R	*R	*R		*R	*R	*R		

Note: At these follow-up visits consider collecting the generic and injury-specific outcomes as identified by the Core Outcome Set—Kenny et al Dent Traumatol 2018[2].

* = clinical review appointment.

S = splint removal.

R = radiograph advised even if no clinical signs or symptoms.

= for immature permanent teeth with necrotic and infected pulps, consider the following additional outcomes: root length, root width, and late stage crown fracture.

TABLE 3 Splinting durations for the permanent and primary dentitions

	2 W	4 W	4 M
Permanent dentition			
Subluxation	* (if splinted)		
Extrusion	*		
Lateral luxation		*	
Intrusion		*	
Avulsion	*		
Root fracture (apical third, mid-third)		*	
Root fracture (cervical third)			*
Alveolar fracture		*	
Primary dentition			
Root fracture		* (if splinting required)	
Lateral luxation		* (if splinting required)	
Alveolar fracture		*	

such as alcohol-free chlorhexidine gluconate 0.12% for 1-2 weeks. Alternatively, with a young child, it is desirable to apply the chlorhexidine to the affected area with a cotton swab.

2.5 | Summary tables for follow up, splinting duration and core outcomes

To help summarise activities for the follow-up appointment and splinting regimes, Tables 1-3 are presented for different injuries in the primary and permanent dentitions. The core outcome variables, explained in the next paragraph, are also included.

2.6 | Core outcome set

When the worldwide trauma literature is reviewed, it is dominated by one center in Copenhagen. The lifetime work of Dr Andreasen and his research group is remarkable in both its longevity and the prolific publication of their results. One of the key fundamentals of scientific research is replication, where the results found in one center with one group of patients are also consistently seen across other patient groups. It is essential that the results from other centers are published even when they confirm the findings from earlier studies. By increasing the number of studies available for clinicians and researchers to analyze, the ability to compare, contrast and combine studies as appropriate is enhanced.

The IADT recently developed a core outcome set (COS) for traumatic dental injuries (TDI) in children and adults.[2] This is one of the first COS developed in dentistry and follows a robust consensus methodology and is underpinned by a systematic review of the outcomes used in the trauma literature.[3] A number of outcomes were identified as recurring throughout the different injury types. These outcomes were then included as "generic"—that is relevant to all TDI. Injury-specific outcomes were also determined as those outcomes related only to one or more particular TDI. Additionally, the study established what, how, when and by whom these outcomes should be measured. Tables 1 and 2 show the generic and injury-specific outcomes to be recorded at the follow-up review appointments for the different traumatic injuries. Further information for each outcome is described in the original paper.[2]

CONFLICT OF INTEREST

The authors confirm that they have no conflict of interest.

ETHICAL APPROVAL

No ethic approval was required for this paper.

ORCID

Liran Levin https://orcid.org/0000-0002-8123-7936
Peter F. Day https://orcid.org/0000-0001-9711-9638
Anne O'Connell https://orcid.org/0000-0002-1495-3983
Ashraf F. Fouad https://orcid.org/0000-0001-6368-1665
Paul V. Abbott https://orcid.org/0000-0001-5727-4211

REFERENCES

1. Fouad AF, Abbott PV, Tsilingaridis G, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 2. Avulsion of permanent teeth [published online ahead of print, 2020 May 27].. Dent Traumatol. 2020. https://doi.org/10.1111/edt.12573
2. Kenny KP, Day PF, Sharif MO, Parashos P, Lauridsen E, Feldens CA, et al. What are the important outcomes in traumatic dental injuries? An international approach to the development of a core outcome set. Dent Traumatol. 2018;34:4–11.
3. Sharif MO, Tejani-Sharif A, Kenny K, Day PF. A systematic review of outcome measures used in clinical trials of treatment interventions following traumatic dental injuries. Dent Traumatol. 2015;31:422–8.

How to cite this article: Levin L, Day PF, Hicks L, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: General introduction. *Dent Traumatol.* 2020;36:309–313. https://doi.org/10.1111/edt.12574

Received: 19 May 2020 | Accepted: 19 May 2020
DOI: 10.1111/edt.12578

COMPREHENSIVE REVIEW

Dental Traumatology WILEY

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

Cecilia Bourguignon[1] | Nestor Cohenca[2] | Eva Lauridsen[3] | Marie Therese Flores[4] | Anne C. O'Connell[5] | Peter F. Day[6] | Georgios Tsilingaridis[7,8] | Paul V. Abbott[9] | Ashraf F. Fouad[10] | Lamar Hicks[11] | Jens Ove Andreasen[12] | Zafer C. Cehreli[13] | Stephen Harlamb[14] | Bill Kahler[15] | Adeleke Oginni[16] | Marc Semper[17] | Liran Levin[18]

[1]Specialist Private Practice, Paris, France
[2]Department of Pediatric Dentistry, University of Washington and Seattle Children's Hospital, Seattle, WA, USA
[3]Resource Center for Rare Oral Diseases, Copenhagen University Hospital, Copenhagen, Denmark
[4]Department of Pediatric Dentistry, Faculty of Dentistry, Universidad de Valparaíso, Valparaíso, Chile
[5]Paediatric Dentitsry, Dublin Dental University Hospital, Trinity College Dublin, The University of Dublin, Dublin, Ireland
[6]School of Dentistry, University of Leeds and Community Dental Service Bradford District Care NHS Trust, Leeds, UK
[7]Division of Orthodontics and Pediatric Dentistry, Department of Dental Medicine, Karolinska Institutet, Huddinge, Sweden
[8]Center for Pediatric Oral Health Research, Stockholm, Sweden
[9]UWA Dental School, University of Western Australia, Nedlands, WA, Australia
[10]Adams School of Dentistry, University of North Carolina, Chapel Hill, NC, USA
[11]Division of Endodontics, University of Maryland School of Dentistry, UMB, Baltimore, MD, USA
[12]Department of Oral and Maxillofacial Surgery, Resource Centre for Rare Oral Diseases, University Hospital in Copenhagen (Rigshospitalet), Copenhagen, Denmark
[13]Department of Pediatric Dentistry, Faculty of Dentistry, Hacettepe University, Ankara, Turkey
[14]Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia
[15]School of Dentistry, The University of Queensland, St Lucia, Qld, Australia
[16]Faculty of Dentistry, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria
[17]Specialist Private Practice, Bremen, Germany
[18]Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada

Correspondence
Liran Levin, Chair of the IADT Guidelines Committee, Faculty of Medicine & Dentistry, University of Alberta, 5-468 Edmonton Clinic Health Academy, 11405 - 87 Avenue NW, 5th Floor, Edmonton, AB T6G 1C9, Canada.
Email: liran@ualberta.ca

Abstract

Traumatic dental injuries (TDIs) of permanent teeth occur frequently in children and young adults. Crown fractures and luxations of these teeth are the most commonly occurring of all dental injuries. Proper diagnosis, treatment planning, and follow up are important for achieving a favorable outcome. Guidelines should assist dentists and patients in decision making and in providing the best care possible, both effectively and efficiently. The International Association of Dental Traumatology (IADT) has developed these Guidelines as a consensus statement after a comprehensive

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
© 2020 The Authors. *Dental Traumatology* published by John Wiley & Sons Ltd.

review of the dental literature and working group discussions. Experienced researchers and clinicians from various specialties and the general dentistry community were included in the working group. In cases where the published data did not appear conclusive, recommendations were based on the consensus opinions of the working group. They were then reviewed and approved by the members of the IADT Board of Directors. These Guidelines represent the best current evidence based on literature search and expert opinion. The primary goal of these Guidelines is to delineate an approach for the immediate or urgent care of TDIs. In this first article, the IADT Guidelines cover the management of fractures and luxations of permanent teeth. The IADT does not, and cannot, guarantee favorable outcomes from adherence to the Guidelines. However, the IADT believes that their application can maximize the probability of favorable outcomes.

KEYWORDS
avulsion, luxation, prevention, tooth fracture, trauma

1 | INTRODUCTION

The vast majority of traumatic dental injuries (TDI) occur in children and teenagers where loss of a tooth has lifetime consequences. Treatments for these younger age groups may be different than in adults, mainly due to immature teeth and pubertal facial growth. The purpose of these Guidelines is to improve management of injured teeth and minimize complications resulting from trauma.

2 | CLINICAL EXAMINATION

Trauma involving the dento-alveolar region is a frequent occurrence which can result in the fracture and displacement of teeth, crushing, and/or fracturing of bone, and soft tissue injuries including contusions, abrasions, and lacerations. Available current literature provides protocols, methods, and documentation for the clinical assessment of traumatic dental injuries (TDI), trauma first aid, patient examination, factors that affect treatment planning decisions, and the importance of communicating treatment options and prognosis to traumatized patients.[1–3]

The combination of two different types of injuries occurring concurrently to the same tooth will be more detrimental than a single injury, creating a negative synergistic effect. Concurrent crown fractures significantly increase the risk of pulp necrosis and infection in teeth with concussion or subluxation injuries and mature root development.[4] Similarly, crown fractures with or without pulp exposure significantly increase the risk of pulp necrosis and infection in teeth with lateral luxation.[5,6]

Kenny et al[7] have developed a core outcome set (COS) for TDIs in children and adults. Outcomes were identified as recurring throughout the different injury types. These outcomes were then identified as "generic" or "Injury-specific." Generic outcomes are relevant to all TDIs while "Injury-specific outcomes" are related to only one or more specific TDIs. Additionally, the core outcome set also established what, how, when, and by whom these outcomes should be measured (Tables 1-13).

3 | RADIOGRAPHIC EXAMINATION

Several conventional two-dimensional imaging projections and angulations are recommended.[2,8,9] The clinician should evaluate each case and determine which radiographs are required for the specific case involved. A clear justification for taking a radiograph is essential. There needs to be a strong likelihood that a radiograph will provide the information that will positively influence the selection of the treatment provided. Furthermore, initial radiographs are important as they provide a baseline for future comparisons at follow-up examinations. The use of film holders is highly recommended to allow standardization and reproducible radiographs.

Since maxillary central incisors are the most frequently affected teeth, the radiographs listed below are recommended to thoroughly examine the injured area:

1. One parallel periapical radiograph aimed through the midline to show the two maxillary central incisors.
2. One parallel periapical radiograph aimed at the maxillary right lateral incisors (should also show the right canine and central incisor).
3. One parallel periapical radiograph aimed at the maxillary left lateral incisor (should also show the left canine and central incisor).
4. One maxillary occlusal radiograph.
5. At least one parallel periapical radiograph of the lower incisors centered on the two mandibular centrals. However, other radiographs may be indicated if there are obvious injuries of the

mandibular teeth (eg, similar periapical radiographs as above for the maxillary teeth, mandibular occlusal radiograph).

The radiographs aimed at the maxillary lateral incisors provide different horizontal (mesial and distal) views of each incisor, as well as showing the canine teeth. The occlusal radiograph provides a different vertical view of the injured teeth and the surrounding tissues, which is particularly helpful in the detection of lateral luxations, root fractures, and alveolar bone fractures.[2,8,9]

The above radiographic series is provided as an example. If other teeth are injured, then the series can be modified to focus on the relevant tooth/teeth. Some minor injuries, such as enamel infractions, may not require all of these radiographs.

Radiographs are necessary to make a thorough diagnosis of dental injuries. Tooth root and bone fractures, for instance, may occur without any clinical signs or symptoms and are frequently undetected when only one radiographic view is used. Additionally, patients sometimes seek treatment several weeks after the trauma occurred when clinical signs of a more serious injury have subsided. Thus, dentists should use their clinical judgment and weigh the advantages and disadvantages of taking several radiographs.

Cone beam computerized tomography (CBCT) provides enhanced visualization of TDIs, particularly root fractures, crown/root fractures, and lateral luxations. CBCT helps to determine the location, extent, and direction of a fracture. In these specific injuries, 3D imaging can be useful and should be considered, if available.[9–11] A guiding principle when considering exposing a patient to ionizing radiations (eg, either 2D or 3D radiographs) is whether the image is likely to change the management of the injury.

4 | PHOTOGRAPHIC DOCUMENTATION

The use of clinical photographs is strongly recommended for the initial documentation of the injury and for follow-up examinations. Photographic documentation allows monitoring of soft tissue healing, assessment of tooth discoloration, the re-eruption of an intruded tooth, and the development of infra-positioning of an ankylosed tooth. In addition, photographs provide medico-legal documentation that could be used in litigation cases.

5 | PULP STATUS EVALUATION: SENSIBILITY AND VITALITY TESTING

5.1 | Sensibility tests

Sensibility testing refers to tests (cold test and electric pulp test) used to determine the condition of the pulp. It is important to understand that sensibility testing assesses neural activity and not vascular supply. Thus, this testing might be unreliable due to a transient lack of neural response or undifferentiation of A-delta nerve fibers in young teeth.[12–14] The temporary loss of sensibility is a frequent finding during post-traumatic pulp healing, especially after luxation injuries.[15] Thus, the lack of a response to pulp sensibility testing is not conclusive for pulp necrosis in traumatized teeth.[16–19] Despite this limitation, pulp sensibility testing should be performed initially and at each follow-up appointment in order to determine if changes occur over time. It is generally accepted that pulp sensibility testing should be done as soon as practical to establish a baseline for future comparison testing and follow up. Initial testing is also a good predictor for the long-term prognosis of the pulp.[12–15,20]

5.2 | Vitality tests

The use of pulse oximetry, which measures actual blood flow rather than the neural response, has been shown to be a reliable non-invasive and accurate way of confirming the presence of a blood supply (vitality) in the pulp.[14,21] The current use of pulse oximetry is limited due to the lack of sensors specifically designed to fit dental dimensions and the lack of power to penetrate through hard dental tissues.

Laser and ultrasound Doppler flowmetry are promising technologies to monitor pulp vitality.

6 | STABILIZATION/SPLINTING: TYPE AND DURATION

Current evidence supports short-term, passive, and flexible splints for splinting of luxated, avulsed, and root-fractured teeth. In the case of alveolar bone fractures, splinting of the teeth may be used for bone segment immobilization. When using wire-composite splints, physiological stabilization can be obtained with stainless steel wire up to 0.4 mm in diameter.[22] Splinting is considered best practice in order to maintain the repositioned tooth in its correct position and to favor initial healing while providing comfort and controlled function.[23–25] It is critically important to keep composite and bonding agents away from the gingiva and proximal areas to avoid plaque retention and secondary infection. This allows better healing of the marginal gingiva and bone. Splinting time (duration) will depend on the injury type. Please see the recommendations for each injury type (Tables 1-13).

7 | USE OF ANTIBIOTICS

There is limited evidence for the use of systemic antibiotics in the emergency management of luxation injuries and no evidence that antibiotics improve the outcomes for root-fractured teeth. Antibiotic use remains at the discretion of the clinician as TDIs are often accompanied by soft tissue and other associated injuries, which may require other surgical intervention. In addition, the patient's medical status may warrant antibiotic coverage.[26,27]

8 | PATIENT INSTRUCTIONS

Patient compliance with follow-up visits and home care contribute to better healing following a TDI. Both patients and parents or guardians should be advised regarding care of the injured tooth/teeth and tissues for optimal healing, prevention of further injury by avoidance of participation in contact sports, meticulous oral hygiene, and rinsing with an antibacterial agent such as chlorhexidine gluconate 0.12%.

9 | FOLLOW UPS AND DETECTION OF POST-TRAUMATIC COMPLICATIONS

Follow ups are mandatory after traumatic injuries. Each follow up should include questioning of the patient about any signs or symptoms, plus clinical and radiographic examinations and pulp sensibility testing. Photographic documentation is strongly recommended. The main post-traumatic complications are as follows: pulp necrosis and infection, pulp space obliteration, several types of root resorption, breakdown of marginal gingiva and bone. Early detection and management of complications improves prognosis.

10 | STAGE OF ROOT DEVELOPMENT—IMMATURE (OPEN APEX) VS MATURE (CLOSED APEX) PERMANENT TEETH

Every effort should be made to preserve the pulp, in both mature and immature teeth. In immature permanent teeth, this is of utmost importance in order to allow continued root development and apex formation. The vast majority of TDIs occur in children and teenagers, where loss of a tooth has lifetime consequences. The pulp of an immature permanent tooth has considerable capacity for healing after a traumatic pulp exposure, luxation injury, or root fracture. Pulp exposures secondary to TDIs are amenable to conservative pulp therapies, such as pulp capping, partial pulpotomy, shallow or partial pulpotomy, and cervical pulpotomy, which aim to maintain the pulp and allow for continued root development.[28–31] In addition, emerging therapies have demonstrated the ability to revascularize/revitalize teeth by attempting to create conditions allowing for tissue in-growth into the root canals of immature permanent teeth with necrotic pulps.[32–37]

11 | COMBINED INJURIES

Teeth frequently sustain a combination of several injuries. Studies have demonstrated that crown-fractured teeth, with or without pulp exposure and with a concomitant luxation injury, experience a greater frequency of pulp necrosis and infection.[38] Mature permanent teeth that sustain a severe TDI after which pulp necrosis and infection is anticipated are amenable to preventive endodontic treatment.

Since prognosis is worse in combined injuries, the more frequent follow-up regimen for luxation injuries prevails over the less frequent regime for fractures.

12 | PULP CANAL OBLITERATION

Pulp canal obliteration (PCO) occurs more frequently in teeth with open apices which have suffered a severe luxation injury. It usually indicates the presence of viable tissue within the root canal. Extrusion, intrusion, and lateral luxation injuries have high rates of PCO.[39,40] Subluxated and crown-fractured teeth also may exhibit PCO, although with lower frequency.[41] Additionally, PCO is a common occurrence following root fractures.[42,43]

13 | ENDODONTIC CONSIDERATIONS FOR LUXATED AND FRACTURED TEETH

13.1 | Fully developed teeth (mature teeth with closed apex)

The pulp may survive after the trauma, but early endodontic treatment is typically advisable for fully developed teeth that have been intruded, severely extruded, or laterally luxated. Calcium hydroxide is recommended as an intra-canal medicament to be placed 1-2 weeks after trauma for up to 1 month followed by root canal filling.[44] Alternately, a corticosteroid/antibiotic paste can be used as an anti-inflammatory and anti-resorptive intra-canal medicament to prevent external inflammatory (infection-related) resorption. If such a paste is used, it should be placed immediately (or as soon as possible) following repositioning of the tooth and then left in situ for at least 6 weeks.[45–48] Medicaments should be carefully applied within the root canal system while avoiding contact with the access cavity walls due to possible discoloration of the crown.[48]

13.2 | Incompletely developed teeth (immature teeth with open apex)

The pulp of fractured and luxated immature teeth may survive and heal, or there may be spontaneous pulp revascularization following luxation. Thus, root canal treatment should be avoided unless there is clinical or radiographic evidence of pulp necrosis or periapical infection on follow-up examinations. The risk of infection-related (inflammatory) root resorption should be weighed against the chances of obtaining pulp space revascularization. Such resorption is very rapid in children. Hence, regular follow ups are mandatory so root canal treatment can be commenced as soon as this type of resorption is detected (see below). Incompletely developed teeth that have been intruded and also have a crown fracture (combined traumatic injuries) are at higher risk of pulp necrosis and infection and, therefore, immediate or early root canal treatment might be

considered in these cases. Other endodontic treatment of teeth with incompletely developed roots may involve apexification or pulp space revascularization/revitalization techniques.

13.3 | Endodontic treatment for external inflammatory (infection-related) root resorption

Whenever there is evidence of infection-related (inflammatory) external resorption, root canal treatment should be initiated immediately. The canal should be medicated with calcium hydroxide.[49] The calcium hydroxide should be placed for 3 weeks and replaced every 3 months until the radiolucencies of the resorptive lesions disappear. Final obturation of the root canal can be performed when bone repair is visible radiographically.

13.4 | Dental dam field isolation during endodontic treatment

Endodontic treatment should always be undertaken under dental dam isolation. The dental dam retainer can be applied on one or more neighboring teeth to avoid further trauma to the injured tooth/teeth and to prevent the risk of fracturing an immature tooth. Dental floss or other stabilizing cords may also be used instead of metal retainers.

14 | CORE OUTCOME SET

The International Association for Dental Traumatology (IADT) recently developed a core outcome set (COS) for traumatic dental injuries (TDIs) in children and adults.[7] This is one of the first COS developed in dentistry and is underpinned by a systematic review of the outcomes used in the trauma literature and follows a robust consensus methodology. Some outcomes were identified as recurring throughout the different injury types. These outcomes were then identified as "generic" (ie, relevant to all TDIs). Injury-specific outcomes were also determined as those outcomes related only to one or more individual TDIs. Additionally, the study established what, how, when, and by whom these outcomes should be measured. Table 2 in the General Introduction section[66] of the Guidelines shows the generic and injury-specific outcomes to be recorded at the follow-up review appointments recommended for the different traumatic injuries. Further information for each outcome is described in the original article.[7]

15 | ADDITIONAL RESOURCES

Besides the general recommendations above, clinicians are encouraged to access the IADT's official publication, the journal *Dental Traumatology*, the IADT website (www.iadt-dentaltrauma.org), the free ToothSOS app and the Dental Trauma Guide (www.dentaltraumaguide.org).

TABLE 1 Permanent teeth: Treatment guidelines for enamel infractions

Enamel infraction	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcomes	Unfavorable outcomes
An incomplete fracture (crack or crazing) of the enamel, without loss of tooth structure	• No sensitivity to percussion or palpation • Evaluate the tooth for a possible associated luxation injury or root fracture, especially if tenderness is observed • Normal mobility • Pulp sensibility tests usually positive	• No radiographic abnormalities • Recommended radiographs: - One parallel periapical radiograph - Additional radiographs are indicated if signs or symptoms of other potential injuries are present	• In case of severe infractions, etching and sealing with bonding resin should be considered to prevent discoloration and bacterial contamination of the infractions. • Otherwise, no treatment is necessary	• No follow up is needed if it is certain that the tooth suffered an infraction injury only • If there is an associated injury such as a luxation injury, that injury-specific follow-up regimen prevails	• Asymptomatic • Positive response to pulp sensibility testing • Continued root development in immature teeth	• Symptomatic • Pulp necrosis and infection • Apical periodontitis • Lack of further root development in immature teeth

TABLE 2 Permanent teeth: Treatment guidelines for uncomplicated crown fractures involving enamel only

Uncomplicated crown fracture (enamel-only fracture)	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcomes	Unfavorable outcomes
 A coronal fracture involving enamel only, with loss of tooth structure	• Loss of enamel • No visible sign of exposed dentin • Evaluate the tooth for a possible associated luxation injury or root fracture, especially if tenderness is present • Normal mobility • Pulp sensibility tests usually positive	• Enamel loss is visible • Missing fragments should be accounted for: - If fragment is missing and there are soft tissue injuries, radiographs of the lip and/or cheek are indicated to search for tooth fragments and/or foreign materials • Recommended radiographs: - One parallel periapical radiograph - Additional radiographs are indicated if signs or symptoms of other potential injuries are present	• If the tooth fragment is available, it can be bonded back on to the tooth • Alternatively, depending on the extent and location of the fracture, the tooth edges can be smoothed, or a composite resin restoration placed	Clinical and radiographic evaluations are necessary: • after 6-8 wk • after 1 y • If there is an associated luxation or root fracture, or the suspicion of an associated luxation injury, the luxation follow-up regimen prevails and should be used. Longer follow ups will be needed	• Asymptomatic • Positive response to pulp sensibility testing • Good quality restoration • Continued root development in immature teeth	• Symptomatic • Pulp necrosis and infection • Apical periodontitis • Loss of restoration • Breakdown of the restoration • Lack of further root development in immature teeth

TABLE 3 Permanent teeth: Treatment guidelines for uncomplicated crown fractures involving enamel and dentin

Uncomplicated crown fracture (enamel-dentin fracture)	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcomes	Unfavorable outcomes
 A fracture confined to enamel and dentin without pulp exposure	• Normal mobility • Pulp sensibility tests usually positive • No sensitivity to percussion or palpation • Evaluate the tooth for a possible associated luxation injury or root fracture, especially if tenderness is present	• Enamel-dentin loss is visible. • Missing fragments should be accounted for: - If fragment is missing and there are soft tissue injuries, radiographs of the lip and/or cheek are indicated to search for tooth fragments and/or foreign materials • Recommended radiographs: - One parallel periapical radiograph - Additional radiographs are indicated if signs or symptoms of other potential injuries are present	• If the tooth fragment is available and intact, it can be bonded back on to the tooth. The fragment should be rehydrated by soaking in water or saline for 20 min before bonding • Cover the exposed dentin with glass-ionomer or use a bonding agent and composite resin • If the exposed dentin is within 0.5 mm of the pulp (pink but no bleeding), place a calcium hydroxide lining and cover with a material such as glass-ionomer	Clinical and radiographic evaluations are necessary: • after 6-8 wk • after 1 y • If there is an associated luxation, root fracture or the suspicion of an associated luxation injury, the luxation follow-up regimen prevails and should be used. Longer follow ups will be needed	• Asymptomatic • Positive response to pulp sensibility testing • Good quality restoration Continued root development in immature teeth	• Symptomatic • Pulp necrosis and infection • Apical periodontitis. • Lack of further root development in immature teeth • Loss of restoration • Breakdown of the restoration

TABLE 4 Permanent teeth: Treatment guidelines for complicated crown fractures

Complicated crown fracture (enamel-dentin fracture with pulp exposure)	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcomes	Unfavorable outcomes
 A fracture confined to enamel and dentin with pulp exposure	• Normal mobility • No sensitivity to percussion or palpation. • Evaluate the tooth for a possible associated luxation injury or root fracture, especially if tenderness is present • Exposed pulp is sensitive to stimuli (eg, air, cold, sweets)	• Enamel-dentin loss is visible • Missing fragments should be accounted for: - If fragment is missing and there are soft tissue injuries, radiographs of the lip and/or cheek are indicated to search for tooth fragments and/or foreign debris • Recommended radiographs: - One parallel periapical radiograph - Additional radiographs are indicated if signs or symptoms of other potential injuries are present	• In patients where teeth have immature roots and open apices, it is very important to preserve the pulp. Partial pulpotomy or pulp capping are recommended in order to promote further root development • Conservative pulp treatment (eg, partial pulpotomy) is also the preferred treatment in teeth with completed root development • Non-setting calcium hydroxide or non-staining calcium silicate cements are suitable materials to be placed on the pulp wound • If a post is required for crown retention in a mature tooth with complete root formation, root canal treatment is the preferred treatment • If the tooth fragment is available, it can be bonded back on to the tooth after rehydration and the exposed pulp is treated • In the absence of an intact crown fragment for bonding, cover the exposed dentin with glass-ionomer or use a bonding agent and composite resin	Clinical and radiographic evaluations are necessary: • after 6-8 wk • after 3 mo • after 6 mo • after 1 y • If there is an associated luxation, root fracture or the suspicion of an associated luxation injury, the luxation follow-up regimen prevails and should be used. Longer follow ups will be needed	• Asymptomatic • Positive response to pulp sensibility testing • Good quality restoration • Continued root development in immature teeth	• Symptomatic • Discoloration • Pulp necrosis and infection • Apical periodontitis • Lack of further root development in immature teeth • Loss of restoration • Breakdown of the restoration

TABLE 5 Permanent teeth: Treatment guidelines for uncomplicated crown-root fractures

Uncomplicated crown-root fracture (crown-root fracture without pulp exposure)	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcomes	Unfavorable outcomes
 A fracture involving enamel, dentin and cementum (Note: Crown-root fractures typically extend below the gingival margin)	• Pulp sensibility tests usually positive • Tender to percussion. • Coronal, or mesial or distal, fragment is usually present and mobile • The extent of the fracture (sub- or supra-alveolar) should be evaluated	• Apical extension of fracture usually not visible • Missing fragments should be accounted for: - If fragment is missing and there are soft tissue injuries, radiographs of the lip and/or cheek are indicated to search for tooth fragments or foreign debris • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph • CBCT can be considered for better visualization of the fracture path, its extent, and its relationship to the marginal bone; also, useful to evaluate the crown-root ratio and to help determine treatment options	• Until a treatment plan is finalized, temporary stabilization of the loose fragment to the adjacent tooth/teeth or to the non-mobile fragment should be attempted • If the pulp is not exposed, removal of the coronal or mobile fragment and subsequent restoration should be considered • Cover the exposed dentin with glass-ionomer or use a bonding agent and composite resin Future Treatment Options: • *The treatment plan is dependent, in part, on the patient's age and anticipated co-operation. Options include:* • Orthodontic extrusion of the apical or non-mobile fragment, followed by restoration (may also need periodontal re-contouring surgery after extrusion) • Surgical extrusion • Root canal treatment and restoration if the pulp becomes necrotic and infected • Root submergence • Intentional replantation with or without rotation of the root • Extraction • Autotransplantation	Clinical and radiographic evaluations are necessary: • after 1 wk • after 6-8 wk • after 3 mo • after 6 mo • after 1 y • then yearly for at least 5 ys	• Asymptomatic • Positive response to pulp sensibility testing • Continued root development in immature teeth • Good quality restoration	• Symptomatic • Discoloration • Pulp necrosis and infection • Apical periodontitis • Lack of further root development in immature teeth • Loss of restoration • Breakdown of the restoration • Marginal bone loss and periodontal inflammation

TABLE 6 Permanent teeth: Treatment guidelines for complicated crown-root fractures

Complicated crown-root fracture (crown-root fracture with pulp exposure)	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcomes	Unfavorable outcomes
 A fracture involving enamel, dentin, cementum and the pulp (Note: Crown-root fractures typically extend below the gingival margin)	• Pulp sensibility tests usually positive • Tender to percussion. • Coronal, or mesial or distal, fragment is usually present and mobile • The extent of the fracture (sub- or supra-alveolar) should be evaluated	• Apical extension of fracture usually not visible • Missing fragments should be accounted for: - If fragment is missing and there are soft tissue injuries, radiographs of the lip and/or cheek are indicated to search for tooth fragments or foreign debris • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph • CBCT can be considered for better visualization of the fracture path, its extent, and its relationship to the marginal bone; also useful to evaluate the crown-root ratio and to help determine treatment options	• Until a treatment plan is finalized, temporary stabilization of the loose fragment to the adjacent tooth/teeth or to the non-mobile fragment should be attempted • *In immature teeth with incomplete root formation*, it is advantageous to preserve the pulp by performing a partial pulpotomy. Rubber dam isolation is challenging **but** should be tried. - Non-setting calcium hydroxide or non-staining calcium silicate cements are suitable materials to be placed on the pulp wound • *In mature teeth with complete root formation*, removal of the pulp is usually indicated - Cover the exposed dentin with glass-ionomer or use a bonding agent and composite resin Future Treatment Options: • *The treatment plan is dependent, in part, on the patient's age and anticipated co-operation. Options include*: • Completion of root canal treatment and restoration • Orthodontic extrusion of the apical segment (may also need periodontal re-contouring surgery after extrusion) • Surgical extrusion • Root submergence • Intentional replantation with or without rotation of the root • Extraction • Autotransplantation	Clinical and radiographic evaluations are necessary: • after 1 wk • after 6-8 wk • after 3 mo • after 6 mo • after 1 y • then yearly for at least 5 y	• Asymptomatic • Continued root development in immature teeth • Good quality restoration	• Symptomatic • Pulp necrosis and infection • Apical periodontitis • Lack of further root development in immature teeth • Loss of restoration • Breakdown of the restoration • Marginal bone loss and periodontal inflammation

TABLE 7 Permanent teeth: Treatment guidelines for root fractures

Root fracture	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcomes	Unfavorable outcomes
 A fracture of the root involving dentin, pulp and cementum. The fracture may be horizontal, oblique or a combination of both.	• The coronal segment may be mobile and may be displaced • The tooth may be tender to percussion • Bleeding from the gingival sulcus may be seen • Pulp sensibility testing may be negative initially, indicating transient or permanent neural damage	• The fracture may be located at any level of the root • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph • Root fractures may be undetected without additional imaging • In cases where the above radiographs provide insufficient information for treatment planning, CBCT can be considered to determine the location, extent and direction of the fracture	• If displaced, the coronal fragment should be repositioned as soon as possible. • Check repositioning radiographically • Stabilize the mobile coronal segment with a passive and flexible splint for 4 wk. If the fracture is located cervically, stabilization for a longer period of time (up to 4 mo) may be needed • Cervical fractures have the potential to heal. Thus, the coronal fragment, especially if not mobile, should not be removed at the emergency visit • No endodontic treatment should be started at the emergency visit • It is advisable to monitor healing of the fracture for at least one year. Pulp status should also be monitored • Pulp necrosis and infection may develop later. It usually occurs in the coronal fragment only. Hence, endodontic treatment of the coronal segment only will be indicated. As root fracture lines are frequently oblique, determination of root canal length may be challenging. An apexification approach may be needed. The apical segment rarely undergoes pathological changes that require treatment • In mature teeth where the cervical fracture line is located above the alveolar crest and the coronal fragment is very mobile, removal of the coronal fragment, followed by root canal treatment and restoration with a post-retained crown will likely be required. Additional procedures such as orthodontic extrusion of the apical segment, crown lengthening surgery, surgical extrusion or even extraction may be required as future treatment options (similar to those for crown-root fractures outlined above).	Clinical and radiographic evaluations are necessary: • after 4 wk S^{+} • after 6-8 wk • after 4 mo S^{++} • after 6 mo • after 1 y • then yearly for at least 5 y	• Positive response to pulp sensibility testing; however, a false negative response is possible for several months. Endodontic treatment should not be started solely on the basis of no response to pulp sensibility testing • Signs of repair between the fractured segments • Normal or slightly more than physiological mobility of the coronal fragment	• Symptomatic • Extrusion and/or excessive mobility of the coronal segment • Radiolucency at the fracture line • Pulp necrosis and infection with inflammation in the fracture line

Note: S^{+} = splint removal (for mid-root and apical third fractures); S^{++} = splint removal (for cervical third fractures).

TABLE 8 Permanent teeth: Treatment guidelines for alveolar fractures

Alveolar fracture	Clinical Findings	Imaging, radiographic assessment, and findings	Treatment	Follow Up	Favorable outcomes	Unfavorable outcomes
 The fracture involves the alveolar bone and may extend to adjacent bones.	• The alveolar fracture is complete and extends all the way from the buccal to the palatal bone in the maxilla and from the buccal to the lingual bony surface in the mandible • Segment mobility and displacement with several teeth moving together are common findings • Occlusal disturbances due to displacement and misalignment of the fractured alveolar segment are often seen • Teeth in the fractured segment may not respond to pulp sensibility testing	• Fracture lines may be located at any level, from the marginal bone to the root apex • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph • In cases where the above radiographs provide insufficient information for treatment planning, a panoramic radiograph and/or CBCT can be considered to determine the location, extent and direction of the fracture	• Reposition any displaced segment • Stabilize the segment by splinting the teeth with a passive and flexible splint for 4 wk • Suture gingival lacerations if present • Root canal treatment is contraindicated at the emergency visit • Monitor the pulp condition of all teeth involved, both initially and at follow ups, to determine if or when endodontic treatment becomes necessary	Clinical and radiographic evaluations are necessary: • after 4 wk S^+ • after 6-8 wk • after 4 mo • after 6 mo • after 1 y • then yearly for at least 5 y Bone and soft tissue healing must also be monitored	• Positive response to pulp sensibility testing (a false negative response is possible for several months) • No signs of pulp necrosis and infection • Soft tissue healing • Radiographic signs of bone repair • Slight tenderness of the bone to palpation may remain at the fracture line and/or on mastication for several months	• Symptomatic • Pulp necrosis and infection • Apical periodontitis • Inadequate soft tissue healing • Non-healing of the bone fracture • External inflammatory (infection-related) resorption

Note: S^+ = splint removal.

TABLE 9 Permanent teeth: Treatment guidelines for concussion injuries of the teeth

Concussion	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcome	Unfavorable outcome
	• Normal mobility • The tooth is tender to percussion and touch • The tooth will likely respond to pulp sensibility testing	• No radiographic abnormalities • Recommended radiographs: - One parallel periapical radiograph - Additional radiographs are indicated if signs or symptoms of other potential injuries are present	• No treatment is needed. • Monitor pulp condition for at least one year, but preferably longer	Clinical and radiographic evaluations are necessary: • after 4 wk • after 1 y	• Asymptomatic • Positive response to pulp sensibility testing; however, a false negative response is possible for several months. Endodontic treatment should not be started solely on the basis of no response to pulp sensibility testing • Continued root development in immature teeth • Intact lamina dura	• Symptomatic • Pulp necrosis and infection • Apical periodontitis • No further root development in immature teeth

TABLE 10 Permanent teeth: Treatment guidelines for subluxation injuries of the teeth

Subluxation	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable Outcome	Unfavorable outcome
 An injury to the tooth-supporting structures with abnormal loosening, but without displacement of the tooth	The tooth is tender to touch or light tapping • Tooth has increased mobility but is not displaced • Bleeding from the gingival crevice may be present • The tooth may not respond to pulp sensibility testing initially indicating transient pulp damage	• Radiographic appearance is usually normal • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph	• Normally no treatment is needed • A passive and flexible splint to stabilize the tooth for up to 2 wk may be used but only if there is excessive mobility or tenderness when biting on the tooth • Monitor the pulp condition for at least one year, but preferably longer	Clinical and radiographic evaluations are necessary: • after 2 wk S^+ • after 12 wk • after 6 mo • after 1 yr	• Asymptomatic • Positive response to pulp sensibility testing; however, a false negative response is possible for several months. Endodontic treatment should not be started solely on the basis of no response to pulp sensibility testing • Continued root development in immature teeth • Intact lamina dura	• Symptomatic • Pulp necrosis and infection • Apical periodontitis • No further root development in immature teeth • External inflammatory (infection-related) resorption – if this type of resorption develops, root canal treatment should be initiated immediately, with the use of calcium hydroxide as an intra-canal medicament. Alternatively, corticosteroid/antibiotic medicament can be used initially, which is then followed by calcium hydroxide

Note: S^+ = splint removal.

TABLE 11 Permanent teeth: Treatment guidelines for extrusive luxation injuries of the teeth

Extrusive luxation	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcome	Unfavorable outcome
Displacement of the tooth out of its socket in an incisal/axial direction	• The tooth appears elongated • The tooth has increased mobility • The tooth will appear elongated incisally • Likely to have no response to pulp sensibility tests	• Increased periodontal ligament space both apically and laterally • Tooth will not be seated in its socket and will appear elongated incisally • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph	• Reposition the tooth by gently pushing It back into the tooth socket under local anesthesia • Stabilize the tooth for 2 wk using a passive and flexible splint. If breakdown/fracture of the marginal bone, splint for an additional 4 wk • Monitor the pulp condition with pulp sensibility tests • If the pulp becomes necrotic and infected, endodontic treatment appropriate to the tooth's stage of root development is indicated	Clinical and radiographic evaluations are necessary: • after 2 wk S^+ • after 4 wk • after 8 wk • after 12 wk • after 6 mo • after 1 y • then yearly for at least 5 y • Patients (and parents, where relevant) should be informed to watch for any unfavorable outcomes and the need to return to clinic if they observe any • Where unfavorable outcomes are identified, treatment is often required. This is outside the scope of these guidelines. Referral to a dentist with the relevant expertise, training and experience is advised	• Asymptomatic • Clinical and radiographic signs of normal or healed periodontium. • Positive response to pulp sensibility testing; however, a false negative response is possible for several months. Endodontic treatment should not be started solely on the basis of no response to pulp sensibility testing • No marginal bone loss • Continued root development in immature teeth	• Symptomatic • Pulp necrosis and infection • Apical periodontitis • Breakdown of marginal bone • External inflammatory (infection-related) resorption – if this type of resorption develops, root canal treatment should be initiated immediately, with the use of calcium hydroxide as an intra-canal medicament. Alternatively, corticosteroid/antibiotic medicament can be used initially, which is then followed by calcium hydroxide

Note: S^+ = splint removal.

TABLE 12 Permanent teeth: Treatment guidelines for lateral luxation injuries of the teeth

Lateral luxation	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable Outcome	Unfavorable outcome
 Displacement of the tooth in any lateral direction, usually associated with a fracture or compression of the alveolar socket wall or facial cortical bone	• The tooth is displaced, usually in a palatal/lingual or labial direction • There is usually an associated fracture of the alveolar bone • The tooth is frequently immobile as the apex of the root is "locked" in by the bone fracture • Percussion will give a high metallic (ankylotic) sound • Likely to have no response to pulp sensibility tests	• A widened periodontal ligament space which is best seen on radiographs taken with horizontal angle shifts or occlusal exposures • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph	• Reposition the tooth digitally by disengaging it from its locked position and gently reposition it into its original location under local anesthesia. - Method: Palpate the gingiva to feel the apex of the tooth. Use one finger to push downwards over the apical end of the tooth, then use another finger or thumb to push the tooth back into its socket • Stabilize the tooth for 4 wk using a passive and flexible splint. If breakdown/fracture of the marginal bone or alveolar socket wall, additional splinting may be required • Monitor the pulp condition with pulp sensibility tests at the follow-up appointments • At about 2 wk post-injury, make an endodontic evaluation: • Teeth with incomplete root formation: - Spontaneous revascularization may occur. - If the pulp becomes necrotic and there are signs of inflammatory (infection-related) external resorption, root canal treatment should be started as soon as possible. - Endodontic procedures suitable for immature teeth should be used • Teeth with complete root formation: - The pulp will likely become necrotic. - Root canal treatment should be started, using a corticosteroid-antibiotic or calcium hydroxide as an intra-canal medicament to prevent the development of inflammatory (infection-related) external resorption	Clinical and radiographic evaluations are necessary: • after 2 wk • after 4 wk S^+ • after 8 wk • after 12 wk • after 6 mo • after 1 y • then yearly for at least 5 y • Patients (and parents, where relevant) should be informed to watch for any unfavorable outcomes and the need to return to clinic if they observe any • Where unfavorable outcomes are identified, treatment is often required. This is outside the scope of these guidelines. Referral to a dentist with the relevant expertise, training and experience is advised	• Asymptomatic • Clinical and radiographic signs of normal or healed periodontium • Positive response to pulp sensibility testing; however, a false negative response is possible for several months. Endodontic treatment should not be started solely on the basis of no response to pulp sensibility testing • Marginal bone height corresponds to that seen radiographically after repositioning • Continued root development in immature teeth	• Symptomatic • Breakdown of marginal bone • Pulp necrosis and infection • Apical periodontitis • Ankylosis • External replacement resorption • External inflammatory (infection-related) resorption • External inflammatory (infection-related) resorption – if this type of resorption develops, root canal treatment should be initiated immediately, with the use of calcium hydroxide as an intra-canal medicament. Alternatively, corticosteroid/antibiotic medicament can be used initially, which is then followed by calcium hydroxide

Note: S^+ = splint removal.

TABLE 13 Permanent teeth: Treatment guidelines for intrusive luxation injuries of the teeth

Intrusive luxation	Clinical findings	Imaging, radiographic assessment, and findings	Treatment	Follow up	Favorable outcome	Unfavorable
 Displacement of the tooth in an apical direction into the alveolar bone	• The tooth is displaced axially into the alveolar bone • The tooth is immobile • Percussion will give a high metallic (ankylotic) sound • Likely to have no response to pulp sensibility tests	• The periodontal ligament space may not be visible for all or part of the root (especially apically) • The cemento-enamel junction is located more apically in the intruded tooth than in adjacent non-injured teeth • Recommended radiographs: - One parallel periapical radiograph - Two additional radiographs of the tooth taken with different vertical and/or horizontal angulations - Occlusal radiograph	Teeth with incomplete root formation (immature teeth): • Allow re-eruption without intervention (spontaneous repositioning) for all intruded teeth independent of the degree of intrusion • If no re-eruption within 4 wk, initiate orthodontic repositioning • Monitor the pulp condition • In teeth with incomplete root formation spontaneous pulp revascularization may occur. However, if it is noted that the pulp becomes necrotic and infected or that there are signs of inflammatory (infection-related) external resorption at follow-up appointments, root canal treatment is indicated and should be started as soon as possible when the position of the tooth allows. Endodontic procedures suitable for immature teeth should be used. • Parents must be informed about the necessity of follow-up visits Teeth with complete root formation (mature teeth): • Allow re-eruption without intervention if the tooth is intruded less than 3 mm. If no re-eruption within 8 wk, reposition surgically and splint for 4 wk with a passive and flexible splint Alternatively, reposition orthodontically before ankylosis develops • If the tooth is intruded 3-7 mm, reposition surgically (preferably) or orthodontically • If the tooth is intruded beyond 7mm, reposition surgically • In teeth with complete root formation, the pulp almost always becomes necrotic. Root canal treatment should be started at 2 wk or as soon as the position of the tooth allows, using a corticosteroid-antibiotic or calcium hydroxide as an intra-canal medication. The purpose of this treatment is to prevent the development of inflammatory (infection-related) external resorption	Clinical and radiographic evaluations are necessary: • after 2 wk • after 4 wk S^+ • after 8 wk • after 12 wk • after 6 mo • after 1 y • then yearly for at least 5 y • Patients (and parents, where relevant) should be informed to watch for any unfavorable outcomes and the need to return to clinic if they observe any • Where unfavorable outcomes are identified, treatment is often required. This is outside the scope of these guidelines. Referral to a dentist with the relevant expertise, training and experience is advised	• Asymptomatic • Tooth in place or is re-erupting • Intact lamina dura • Positive response to pulp sensibility testing; however, a false negative response is possible for several months. Endodontic treatment should not be started solely on the basis of no response to pulp sensibility testing • No signs of root resorption • Continued root development in immature teeth	• Symptomatic • Tooth locked in place/ankylotic tone to percussion • Pulp necrosis and infection • Apical periodontitis • Ankylosis • External replacement resorption • External inflammatory (infection-related) resorption – if this type of resorption develops, root canal treatment should be initiated immediately, with the use of calcium hydroxide as an intra-canal medicament. Alternatively, corticosteroid/antibiotic medicament can be used initially, which is then followed by calcium hydroxide

Note: S^+ = splint removal.

CONFLICT OF INTEREST

The authors declare there are no competing interests for the above manuscript. No funding was received for the presented work. Images Courtesy of the Dental Trauma Guide.

ETHICAL STATEMENT

No ethic approval was required for this paper.

ORCID

Cecilia Bourguignon https://orcid.org/0000-0003-2753-649X
Nestor Cohenca https://orcid.org/0000-0002-0603-5437
Eva Lauridsen https://orcid.org/0000-0003-0859-7262
Marie Therese Flores https://orcid.org/0000-0003-2412-190X
Anne C. O'Connell https://orcid.org/0000-0002-1495-3983
Peter F. Day https://orcid.org/0000-0001-9711-9638
Georgios Tsilingaridis https://orcid.org/0000-0001-5361-5840
Paul V. Abbott https://orcid.org/0000-0001-5727-4211
Ashraf F. Fouad https://orcid.org/0000-0001-6368-1665
Bill Kahler https://orcid.org/0000-0002-4181-3871
Liran Levin https://orcid.org/0000-0002-8123-7936

REFERENCES

1. Moule A, Cohenca N. Emergency assessment and treatment planning for traumatic dental injuries. Aust Dent J. 2016;61(Suppl 1):21–38.
2. Andreasen FM, Andreasen JO, Tsukiboshi M, Cohenca N. Examaination and diagnosis of dental injuries. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth, 5th edn. Oxford, UK: Wiley Blackwell; 2019. p. 295–326.
3. Andreasen JO, Bakland L, Flores MT, Andreasen FM, Andersson L. Traumatic dental injuries. A manual, 3rd edn. Chichester, UK: Wiley-Blackwell; 2011.
4. Lauridsen E, Hermann NV, Gerds TA, Ahrensburg SS, Kreiborg S, Andreasen JO. Combination injuries 1. The risk of pulp necrosis in permanent teeth with concussion injuries and concomitant crown fractures. Dent Traumatol. 2012;28:364–70.
5. Lauridsen E, Hermann NV, Gerds TA, Ahrensburg SS, Kreiborg S, Andreasen JO. Combination injuries 2. The risk of pulp necrosis in permanent teeth with subluxation injuries and concomitant crown fractures. Dent Traumatol. 2012;28:371–8.
6. Lauridsen E, Hermann NV, Gerds TA, Ahrensburg SS, Kreiborg S, Andreasen JO. Combination injuries 3. The risk of pulp necrosis in permanent teeth with extrusion or lateral luxation and concomitant crown fractures without pulp exposure. Dent Traumatol. 2012;28:379–85.
7. Kenny KP, Day PF, Sharif MO, Parashos P, Lauridsen E, Feldens CA, et al. What are the important outcomes in traumatic dental injuries? An international approach to the development of a core outcome set. Dent Traumatol. 2018;34:4–11.
8. Molina JR, Vann WF Jr, McIntyre JD, Trope M, Lee JY. Root fractures in children and adolescents: diagnostic considerations. Dent Traumatol. 2008;24:503–9.
9. Cohenca N, Silberman A. Contemporary imaging for the diagnosis and treatment of traumatic dental injuries: a review. Dent Traumatol. 2017;33:321–8.
10. Cohenca N, Simon JH, Mathur A, Malfaz JM. Clinical indications for digital imaging in dento-alveolar trauma. Part 2: root resorption. Dent Traumatol. 2007;23:105–13.
11. Cohenca N, Simon JH, Roges R, Morag Y, Malfaz JM. Clinical indications for digital imaging in dento-alveolar trauma. Part 1: traumatic injuries. Dent Traumatol. 2007;23:95–104.
12. Fulling HJ, Andreasen JO. Influence of maturation status and tooth type of permanent teeth upon electrometric and thermal pulp testing. Scand J Dent Res. 1976;84:286–90.
13. Fuss Z, Trowbridge H, Bender IB, Rickoff B, Sorin S. Assessment of reliability of electrical and thermal pulp testing agents. J Endod. 1986;12:301–5.
14. Gopikrishna V, Tinagupta K, Kandaswamy D. Comparison of electrical, thermal, and pulse oximetry methods for assessing pulp vitality in recently traumatized teeth. J Endod. 2007;33:531–5.
15. Bastos JV, Goulart EM, de Souza Cortes MI. Pulpal response to sensibility tests after traumatic dental injuries in permanent teeth. Dent Traumatol. 2014;30:188–92.
16. Dummer PM, Hicks R, Huws D. Clinical signs and symptoms in pulp disease. Int Endod J. 1980;13:27–35.
17. Kaletsky T, Furedi A. Reliability of various types of pulp testers as a diagnostic aid. J Am Dent Assoc. 1935;22:1559–74.
18. Teitler D, Tzadik D, Eidelman E, Chosack A. A clinical evaluation of vitality tests in anterior teeth following fracture of enamel and dentin. Oral Surg Oral Med Oral Pathol. 1972;34:649–52.
19. Zadik D, Chosack A, Eidelman E. The prognosis of traumatized permanent anterior teeth with fracture of the enamel and dentin. Oral Surg Oral Med Oral Pathol. 1979;47:173–5.
20. Alghaithy RA, Qualtrough AJ. Pulp sensibility and vitality tests for diagnosing pulpal health in permanent teeth: a critical review. Int Endod J. 2017;50:135–42.
21. Gopikrishna V, Tinagupta K, Kandaswamy D. Evaluation of efficacy of a new custom-made pulse oximeter dental probe in comparison with the electrical and thermal tests for assessing pulp vitality. J Endod. 2007;33:411–4.
22. Kwan SC, Johnson JD, Cohenca N. The effect of splint material and thickness on tooth mobility after extraction and replantation using a human cadaveric model. Dental Traumatol. 2012;28:277–81.
23. Kahler B, Heithersay GS. An evidence-based appraisal of splinting luxated, avulsed and root-fractured teeth. Dent Traumatol. 2008;24:2–10.
24. Oikarinen K, Andreasen JO, Andreasen FM. Rigidity of various fixation methods used as dental splints. Endod Dent Traumatol. 1992;8:113–9.
25. Andreasen JO, Andreasen FM, Mejare I, Cvek M. Healing of 400 intra-alveolar root fractures. 2. Effect of treatment factors such as treatment delay, repositioning, splinting type and period and antibiotics. Dental Traumatol. 2004;20:203–11.
26. Hammarstrom L, Blomlof L, Feiglin B, Andersson L, Lindskog S. Replantation of teeth and antibiotic treatment. Endod Dent Traumatol. 1986;2:51–7.
27. Andreasen JO, Storgaard Jensen S, Sae-Lim V. The role of antibiotics in presenting healing complications after traumatic dental injuries: a literature review. Endod Topics. 2006;14:80–92.
28. Cvek M. A clinical report on partial pulpotomy and capping with calcium hydroxide in permanent incisors with complicated crown fracture. J Endod. 1978;4:232–7.
29. Fuks AB, Cosack A, Klein H, Eidelman E. Partial pulpotomy as a treatment alternative for exposed pulps in crown- fractured permanent incisors. Endod Dent Traumatol. 1987;3:100–2.
30. Fuks AB, Gavra S, Chosack A. Long-term followup of traumatized incisors treated by partial pulpotomy. Pediatr Dent. 1993;15:334–6.
31. Bimstein E, Rotstein I. Cvek pulpotomy - revisited. Dent Traumatol. 2016;32:438–42.
32. Chueh LH, Ho YC, Kuo TC, Lai WH, Chen YH, Chiang CP. Regenerative endodontic treatment for necrotic immature permanent teeth. J Endod. 2009;35:160–4.

33. Hagglund M, Walden M, Bahr R, Ekstrand J. Methods for epidemiological study of injuries to professional football players: developing the UEFA model. Br J Sports Med. 2005;39:340–6.
34. Huang GT. A paradigm shift in endodontic management of immature teeth: conservation of stem cells for regeneration. J Dent. 2008;36:379–86.
35. Jung IY, Lee SJ, Hargreaves KM. Biologically based treatment of immature permanent teeth with pulpal necrosis: a case series. J Endod. 2008;34:876–87.
36. Thibodeau B, Teixeira F, Yamauchi M, Caplan DJ, Trope M. Pulp revascularization of immature dog teeth with apical periodontitis. J Endod. 2007;33:680–9.
37. Trope M. Treatment of the immature tooth with a non-vital pulp and apical periodontitis. Dent Clin North Am. 2010;54:313–24.
38. Robertson A, Andreasen FM, Andreasen JO, Noren JG. Long-term prognosis of crown-fractured permanent incisors. The effect of stage of root development and associated luxation injury. Int J Paediatr Dent. 2000;10:191–9.
39. Holcomb JB, Gregory WB Jr. Calcific metamorphosis of the pulp: its incidence and treatment. Oral Surg Oral Med Oral Pathol. 1967;24:825–30.
40. Neto JJ, Gondim JO, de Carvalho FM, Giro EM. Longitudinal clinical and radiographic evaluation of severely intruded permanent incisors in a pediatric population. Dent Traumatol. 2009;25:510–4.
41. Robertson A. A retrospective evaluation of patients with uncomplicated crown fractures and luxation injuries. Endod Dent Traumatol. 1998;14:245–56.
42. Andreasen FM, Andreasen JO, Bayer T. Prognosis of root-fractured permanent incisors-prediction of healing modalities. Endod Dent Traumatol. 1989;5:11–22.
43. Amir FA, Gutmann JL, Witherspoon DE. Calcific metamorphosis: a challenge in endodontic diagnosis and treatment. Quintessence Int. 2001;32:447–55.
44. Cvek M. Prognosis of luxated non-vital maxillary incisors treated with calcium hydroxide and filled with gutta percha. Endod Dent Traumatol. 1992;8:45–55.
45. Abbott PV. Prevention and management of external inflammatory resorption following trauma to teeth. Aust Dent J. 2016;61(Suppl. 1):S82–S94.
46. Bryson EC, Levin L, Banchs F, Abbott PV, Trope M. Effect of immediate intracanal placement of ledermix paste on healing of replanted dog teeth after extended dry times. Dent Traumatol. 2002;18:316–21.
47. Chen H, Teixeira FB, Ritter AL, Levin L, Trope M. The effect of intracanal anti-inflammatory medicaments on external root resorption of replanted dog teeth after extended extra-oral dry time. Dent Traumatol. 2008;24:74–8.
48. Day PF, Gregg TA, Ashley P, Welbury RR, Cole BO, High AS, et al. Periodontal healing following avulsion and replantation of teeth: A multi-centre randomized controlled trial to compare two root canal medicaments. Dent Traumatol. 2012;28:55–64.
49. Trope M, Moshonov J, Nissan R, Buxt P, Yesilsoy C. Short vs. Long-term calcium hydroxide treatment of established inflammatory root resorption in replanted dog teeth. Endod Dent Traumatol. 1995;11:124–8.
50. Andreasen JO, Andreasen FM, Skeie A, Hjorting-Hansen E, Schwartz O. Effect of treatment delay upon pulp and periodontal healing of traumatic dental injuries – a review article. Dent Traumatol. 2002;18:116–28.
51. Andreasen JO, Bakland LK, Andreasen FM. 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 Traumatol. 2006;22:99–111.
52. Andreasen JO, Bakland LK, Andreasen FM. Traumatic intrusion of permanent teeth. Part 2. A clinical study of the effect of preinjury and injury factors, such as sex, age, stage of root development, tooth location, and extent of injury including number of intruded teeth on 140 intruded permanent teeth. Dental Traumatol. 2006;22:90–8.
53. Andreasen JO, Bakland LK, Matras RC, Andreasen FM. Traumatic intrusion of permanent teeth. Part 1. An epidemiological study of 216 intruded permanent teeth. Dental Traumatol. 2006;22:83–9.
54. Welbury R, Kinirons MJ, Day P, Humphreys K, Gregg TA. Outcomes for root-fractured permanent incisors: a retrospective study. Ped Dent. 2002;24:98–102.
55. Andreasen JO, Andreasen FM, Mejare I, Cvek M. Healing of 400 intra-alveolar root fractures. 1. Effect of pre-injury and injury factors such as sex, age, stage of root development, fracture type, location of fracture and severity of dislocation. Dental Traumatol. 2004;20:192–202.
56. Andreasen JO, Hjorting-Hansen E. Intraalveolar root fractures: radiographic and histologic study of 50 cases. J Oral Surg. 1967;25:414–26.
57. Cvek M, Andreasen JO, Borum MK. Healing of 208 intra-alveolar root fractures in patients aged 7–17 years. Dental Traumatol. 2001;17:53–62.
58. Bakland LK. Revisiting traumatic pulpal exposure: materials, management principles, and techniques. Dent Clin North Am. 2009;53:661–73.
59. Bogen G, Kim JS, Bakland LK. Direct pulp capping with mineral trioxide aggregate: an observational study. J Am Dent Assoc. 2008;139:305–15.
60. Cavalleri G, Zerman N. Traumatic crown fractures in permanent incisors with immature roots: a follow-up study. Endod Dent Traumatol. 1995;11:294–6.
61. About I, Murray PE, Franquin JC, Remusat M, Smith AJ. The effect of cavity restoration variables on odontoblast cell numbers and dental repair. J Dent. 2001;29:109–17.
62. Murray PE, Smith AJ, Windsor LJ, Mjor IA. Remaining dentine thickness and human pulp responses. Int Endod J. 2003;36:33–43.
63. Subay RK, Demirci M. Pulp tissue reactions to a dentin bonding agent as a direct capping agent. J Endod. 2005;31:201–4.
64. Berthold C, Thaler A, Petschelt A. Rigidity of commonly used dental trauma splints. Dent Traumatol. 2009;25:248–55.
65. von Arx T, Filippi A, Lussi A. Comparison of a new dental trauma splint device (TTS) with three commonly used splinting techniques. Dent Traumatol. 2001;17:266–74.
66. Levin L, Day P, Hicks L, O'Connell AC, Fouad AF, Bourguigon C, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: General Introduction. Dent Traumatol. 2020;36:309–13.

How to cite this article: Bourguignon C, Cohenca N, Lauridsen E, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 1. Fractures and luxations. *Dent Traumatol.* 2020;36:314–330. https://doi.org/10.1111/edt.12578

Received: 19 May 2020 | Accepted: 19 May 2020
DOI: 10.1111/edt.12573

COMPREHENSIVE REVIEW

Dental Traumatology WILEY

International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 2. Avulsion of permanent teeth

Ashraf F. Fouad[1] | Paul V. Abbott[2] | Georgios Tsilingaridis[3,4] | Nestor Cohenca[5] | Eva Lauridsen[6] | Cecilia Bourguignon[7] | Anne O'Connell[8] | Marie Therese Flores[9] | Peter F. Day[10] | Lamar Hicks[11] | Jens Ove Andreasen[12] | Zafer C. Cehreli[13] | Stephen Harlamb[14] | Bill Kahler[15] | Adeleke Oginni[16] | Marc Semper[17] | Liran Levin[18]

[1]Adams School of Dentistry, University of North Carolina, Chapel Hill, NC, USA
[2]UWA Dental School, University of Western Australia, Crawley, WA, Australia
[3]Division of Orthodontics and Pediatric Dentistry, Department of Dental Medicine, Karolinska Institutet, Huddinge, Sweden
[4]Center for Pediatric Oral Health Research, Stockholm, Sweden
[5]Department of Pediatric Dentistry, University of Washington and Seattle Children's Hospital, Seattle, WA, Australia
[6]Resource Center for Rare Oral Diseases, Copenhagen University Hospital, Copenhagen, Denmark
[7]Private Practice, Paris, France
[8]Paediatric Dentistry, Dublin Dental University Hospital, Trinity College Dublin, The University of Dublin, Dublin, Ireland
[9]Department of Pediatric Dentistry, Faculty of Dentistry, Universidad de Valparaíso, Valparaíso, Chile
[10]School of Dentistry, Community Dental Service Bradford District Care NHS Trust, University of Leeds, Leeds, UK
[11]Division of Endodontics, University of Maryland School of Dentistry, UMB, Baltimore, MD, USA
[12]Department of Oral and Maxillofacial Surgery, Resource Centre for Rare Oral Diseases, University Hospital in Copenhagen (Rigshospitalet), Copenhagen, Denmark
[13]Department of Pediatric Dentistry, Faculty of Dentistry, Hacettepe University, Ankara, Turkey
[14]Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia
[15]School of Dentistry, The University of Queensland, St Lucia, QLD, Australia
[16]Faculty of Dentistry, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria
[17]Specialist Private Practice, Bremen, Germany
[18]Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada

Correspondence
Liran Levin, Chair of the IADT Guidelines Committee, Faculty of Medicine & Dentistry, University of Alberta, 5-468 Edmonton Clinic Health Academy, 11405 - 87 Avenue NW, 5th Floor, Edmonton, AB T6G 1C9, Canada.
Email: liran@ualberta.ca

Abstract

Avulsion of permanent teeth is one of the most serious dental injuries. Prompt and correct emergency management is essential for attaining the best outcome after this injury. The International Association of Dental Traumatology (IADT) has developed these Guidelines as a consensus statement after a comprehensive review of the dental literature and working group discussions. It represents the current best evidence and practice based on that literature search and expert opinions. Experienced researchers and clinicians from various specialties and the general dentistry community

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
© 2020 The Authors. *Dental Traumatology* published by John Wiley & Sons Ltd

were included in the working group. In cases where the published data did not appear conclusive, recommendations were based on consensus opinions or majority decisions of the working group. They were then reviewed and approved by the members of the IADT Board of Directors.

The purpose of these Guidelines is to provide clinicians with the most widely accepted and scientifically plausible approaches for the immediate or urgent care of avulsed permanent teeth.

The IADT does not, and cannot, guarantee favorable outcomes from adherence to the Guidelines. However, the IADT believes that their application can maximize the probability of favorable outcomes.

KEYWORDS

avulsion, luxation, prevention, tooth fracture, trauma

1 | INTRODUCTION

Avulsion of permanent teeth is seen in 0.5%–16% of all dental injuries.[1,2] Numerous studies have shown that this injury is one of the most serious dental injuries, and the prognosis is very much dependent on the actions taken at the place of accident and promptly following the avulsion.[3-17] Replantation is, in most situations, the treatment of choice but cannot always be carried out immediately. Appropriate emergency management and a treatment plan are important for a good prognosis. There are also individual situations when replantation is not indicated (eg, severe caries or periodontal disease, an uncooperative patient, severe cognitive impairment requiring sedation, severe medical conditions such as immunosuppression, and severe cardiac conditions) which must be dealt with individually. Although replantation may save the tooth, it is important to realize that some of the replanted teeth have low probability of long-term survival and may be lost or condemned to extraction at a later stage. However, not replanting a tooth is an irreversible decision and therefore saving it should be attempted. In this regard, a recent study has shown that replanted teeth have higher chances of long-term survival after following the IADT treatment guidelines, compared to previous studies.[18]

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

Guidelines should assist dentists, other healthcare professionals, and patients in decision-making. Also, they should be clear, readily understandable, and practical with the aim of delivering appropriate care as effectively and efficiently as possible. Guidelines are to be applied with the clinician's judgment of the specific clinical circumstances and patient characteristics, including but not limited to compliance, finances, and understanding of the immediate and long-term outcomes of treatment alternatives vs non-treatment. The IADT cannot and does not guarantee favorable outcomes from strict adherence to the Guidelines, but believes that their application can maximize the chances of a favorable outcome. Guidelines undergo periodic updates. The following guidelines by the International Association of Dental Traumatology (IADT) represent a revision and update of the previous guidelines that were published in 2012.[19-21]

In these IADT Guidelines for management of avulsed permanent teeth, the literature has been searched using Medline and Scopus databases utilizing the search words: avulsion, exarticulation and replantation. The task group discussed treatment in detail and reached consensus as to what to recommend as the current best practice for emergency management. This text aims to provide concise and necessary advice for treatment in the emergency situation.

The final decision regarding patient care remains primarily with the treating dentist. However, the consent to implement the final decision rests with the patient, parent, or guardian. For ethical reasons, it is important that the dentist provides the patient and guardian with pertinent information relating to treatment to ensure they are maximally involved in the decision-making process.

2 | FIRST AID FOR AVULSED TEETH AT THE PLACE OF ACCIDENT

Dentists should be prepared to give appropriate advice to the public about first aid for avulsed teeth.[2,11,22-27] An avulsed permanent tooth is one of the few real emergency situations in dentistry. In addition to increasing the public awareness by mass media campaigns or other means of communication, parents, guardians and teachers should receive information on how to proceed following these

severe and unexpected injuries. Also, instructions may be given by telephone to people at the emergency site. Immediate replantation of the avulsed tooth is the best treatment at the place of the accident. If for some reason this cannot be carried out, there are alternatives such as using different types of storage media.

If a tooth is avulsed, make sure it is a permanent tooth (primary teeth should not be replanted) and follow these recommended instructions:

1. Keep the patient calm.
2. Find the tooth and pick it up by the crown (the white part). Avoid touching the root. Attempt to place it back immediately into the jaw.
3. If the tooth is dirty, rinse it gently in milk, saline or in the patient's saliva and replant or return it to its original position in the jaw.[28,29]
4. It is important to encourage the patient/guardian/teacher/other person to replant the tooth immediately at the emergency site.
5. Once the tooth has been returned to its original position in the jaw, the patient should bite on gauze, a handkerchief or a napkin to hold it in place.
6. If replantation at the accident site is not possible, or for other reasons when replantation of the avulsed tooth is not feasible (eg, an unconscious patient), place the tooth, as soon as possible, in a storage or transport medium that is immediately available at the emergency site. This should be done quickly to avoid dehydration of the root surface, which starts to happen in a matter of a few minutes. In descending order of preference, milk, HBSS, saliva (after spitting into a glass for instance), or saline are suitable and convenient storage mediums. Although water is a poor medium, it is better than leaving the tooth to air-dry.[28,29]
7. The tooth can then be brought with the patient to the emergency clinic.
8. See a dentist or dental professional immediately.

The poster "Save a Tooth" is available in multiple languages: Arabic, Basque, Bosnian, Bulgarian, Catalan, Czech, Chinese, Dutch, English, Estonian, French, Georgian, German, Greek, Hausa, Hebrew, Hindi (India), Hungarian, Icelandic, Indonesian Bahasa, Italian, Kannada (India), Korean, Latvian, Marathi (India), Persian, Polish, Portuguese, Russian, Sinhalese, Slovenian, Spanish, Tamil (India), Thai, Turkish, Ukrainian, and Vietnamese. This educational resource can be obtained at the IADT website: http://www.iadt-dentaltrauma.org

The IADT's free app, "ToothSOS" for mobile phones, is another useful source of information for patients, providing instructions on what to do in an emergency situation after a dental injury, including avulsion of a permanent tooth.

3 | TREATMENT GUIDELINES FOR AVULSED PERMANENT TEETH

The choice of treatment is related to the maturity of the root (open or closed apex) and the condition of the periodontal ligament (PDL) cells. The condition of the PDL cells is dependent on the time out of the mouth and on the storage medium in which the avulsed tooth was kept. Minimizing the dry time is critical for survival of the PDL cells. After an extra-alveolar dry time of 30 minutes, most PDL cells are non-viable.[30,31] For this reason, information regarding the dry time of the tooth prior to replantation or prior to being placed in a storage medium is very important to obtain as part of the history.

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

1. The PDL cells are most likely viable. The tooth has been replanted immediately or within a very short time (about 15 minutes) at the place of accident.
2. The PDL cells may be viable but compromised. The tooth has been kept in a storage medium (eg, milk, HBSS (Save-a-Tooth or similar product), saliva, or saline, and the total extra-oral dry time has been <60 minutes).
3. The PDL cells are likely to be non-viable. The total extra-oral dry time has been more than 60 minutes, regardless of the tooth having been stored in a medium or not.

These three groups provide guidance to the dentist on the prognosis of the tooth. Although exceptions to the prognosis do occur, the treatment will not change, but may guide the dentist's treatment decisions.

3.1 | Treatment guidelines for avulsed permanent teeth with a closed apex

3.1.1 | The tooth has been replanted at the site of injury or before the patient's arrival at the dental clinic

1. Clean the injured area with water, saline, or chlorhexidine.
2. Verify the correct position of the replanted tooth both clinically and radiographically.
3. Leave the tooth/teeth in place (except where the tooth is malpositioned; the malpositioning needs to be corrected using slight digital pressure).
4. Administer local anesthesia, if necessary, and preferably with no vasoconstrictor.
5. If the tooth or teeth were replanted in the wrong socket or rotated, consider repositioning the tooth/teeth into the proper location up to 48 hours after the traumatic incident.
6. Stabilize the tooth for 2 weeks using a passive flexible splint such as wire of a diameter up to 0.016" or 0.4 mm[32] bonded to the tooth and adjacent teeth. Keep the composite and bonding agents away from the gingival tissues and proximal areas. Alternatively, nylon fishing line (0.13-0.25 mm) can be used to create a flexible splint, using composite to bond it to the teeth.

Nylon (fishing line) splints are not recommended for children when there are only a few permanent teeth for stabilization of the traumatized tooth. This stage of development may result in loosening or loss of the splint.[33] In cases of associated alveolar or jawbone fracture, a more rigid splint is indicated and should be left in place for about 4 weeks.

7. Suture gingival lacerations, if present.
8. Initiate root canal treatment within 2 weeks after replantation (refer to Endodontic Considerations).
9. Administer systemic antibiotics.[34,35] (see: "Antibiotics")
10. Check tetanus status.[36] (see: "Tetanus")
11. Provide post-operative instructions. (see: "Patient instructions")
12. Follow up. (see: "Follow-up procedures")

3.1.2 | The tooth has been kept in a physiologic storage medium or stored in non-physiologic conditions, with the extra-oral dry time less than 60 minutes

Physiologic storage media include tissue culture media and cell transport media. Examples of osmolality-balanced media are milk and Hanks' Balanced Salt Solution (HBSS).

1. If there is visible contamination, rinse the root surface with a stream of saline or osmolality-balanced media to remove gross debris.
2. Check the avulsed tooth for surface debris. Remove any debris by gently agitating it in the storage medium. Alternatively, a stream of saline can be used to briefly rinse its surface.
3. Put or leave the tooth in a storage medium while taking a history, examining the patient clinically and radiographically, and preparing the patient for the replantation.
4. Administer local anesthesia, preferably without a vasoconstrictor.[37]
5. Irrigate the socket with sterile saline.
6. Examine the alveolar socket. If there is a fracture of the socket wall, reposition the fractured fragment into its original position with a suitable instrument.
7. Removal of the coagulum with a saline stream may allow better repositioning of the tooth.
8. Replant the tooth slowly with slight digital pressure. Excessive force should not be used to replant the tooth back into its original position.
9. Verify the correct position of the replanted tooth both clinically and radiographically.
10. Stabilize the tooth for 2 weeks using a passive, flexible wire of a diameter up to 0.016" or 0.4 mm.[32] Keep the composite and bonding agents away from the gingival tissues and proximal areas. Alternatively, nylon fishing line (0.13-0.25 mm) can be used to create a flexible splint, using composite to bond it to the teeth. Nylon (fishing line) splints are not recommended for children when there are only a few permanent teeth as stabilization of the traumatized tooth may not be guaranteed. In cases of associated alveolar or jawbone fracture, a more rigid splint is indicated and should be left in place for about 4 weeks.
11. Suture gingival lacerations, if present.
12. Initiate root canal treatment within 2 weeks after replantation (refer to "Endodontic Considerations").[38,39]
13. Administer systemic antibiotics.[34,35] (see: "Antibiotics")
14. Check tetanus status.[36] (see: "Tetanus")
15. Provide post-operative instructions. (see: "Post-operative instructions")
16. Follow up. (see: "Follow-up procedures")

3.1.3 | Extra-oral dry time longer than 60 minutes

1. Remove loose debris and visible contamination by agitating the tooth in physiologic storage medium, or with gauze soaked in saline. Tooth may be left in storage medium while taking a history, examining the patient clinically and radiographically, and preparing the patient for the replantation.
2. Administer local anesthesia, preferably without vasoconstrictor.
3. Irrigate the socket with sterile saline.
4. Examine the alveolar socket. Remove coagulum if necessary. If there is a fracture of the socket wall, reposition the fractured fragment with a suitable instrument.
5. Replant the tooth slowly with slight digital pressure. The tooth should not be forced back to place.
6. Verify the correct position of the replanted tooth both clinically and radiographically.
7. Stabilize the tooth for 2 weeks[40] using a passive flexible wire of a diameter up to 0.016" or 0.4 mm.[32] Keep the composite and bonding agents away from the gingival tissues and proximal areas. Alternatively, nylon fishing line (0.13-0.25 mm) can be used to create a flexible splint, with composite to bond it to the teeth. A more rigid splint is indicated in cases of alveolar or jawbone fracture and should be left in place for about 4 weeks.
8. Suture gingival lacerations, if present.
9. Root canal treatment should be carried out within 2 weeks (refer to Endodontic Considerations).
10. Administer systemic antibiotics.[34,35] (see: "Antibiotics")
11. Check tetanus status.[36] (see: "Tetanus")
12. Provide post-operative instructions. (see: "Post-operative instructions")
13. Follow up. (see: "Follow-up procedures")

Delayed replantation has a poor long-term prognosis.[41] The periodontal ligament becomes necrotic and is not expected to regenerate. The expected outcome is ankylosis-related (replacement) root resorption. The goal of replantation in these cases is to restore, at least temporarily, esthetics and function while maintaining alveolar bone contour, width, and height. Therefore, the decision to replant a permanent tooth is almost always the correct

decision even if the extra-oral dry time is more than 60 minutes. Replantation will keep future treatment options open. The tooth can always be extracted, if needed, and at the appropriate point following prompt inter-disciplinary assessment. Parents of pediatric patients should be informed that decoronation or other procedures such as autotransplantation might be necessary later if the replanted tooth becomes ankylosed and infra-positioned, depending on the patient's growth rate[41-46] and the likelihood of eventual tooth loss. The rate of ankylosis and resorption varies considerably and can be unpredictable.

3.2 | Treatment guidelines for avulsed permanent teeth with an open apex

3.2.1 | The tooth has been replanted before the patient's arrival at the clinic

1. Clean the area with water, saline, or chlorhexidine.
2. Verify the correct position of the replanted tooth both clinically and radiographically.
3. Leave the tooth in the jaw (except where the tooth is malpositioned; the malpositioning needs to be corrected using slight digital pressure).
4. Administer local anesthesia, if necessary, and preferably with no vasoconstrictor.
5. If the tooth or teeth were replanted in the wrong socket or rotated, consider repositioning the tooth/teeth into the proper location for up to 48 hours after the trauma.
6. Stabilize the tooth for 2 weeks using a passive and flexible wire of a diameter up to 0.016" or 0.4 mm.[32] Short immature teeth may require a longer splinting time.[47] Keep the composite and bonding agents away from the gingival tissues and proximal areas. Alternatively, nylon fishing line (0.13-0.25 mm) can be used to create a flexible splint, using composite to bond it to the teeth. In cases of associated alveolar or jawbone fracture, a more rigid splint is indicated and should be left in place for 4 weeks.
7. Suture gingival lacerations, if present.
8. Pulp revascularization, which can lead to further root development, is the goal when replanting immature teeth in children. The risk of external infection-related (inflammatory) root resorption should be weighed against the chances of revascularization. Such resorption is very rapid in children. If spontaneous revascularization does not occur, apexification, pulp revitalization/revascularization,[48,49] or root canal treatment should be initiated as soon as pulp necrosis and infection is identified (refer to Endodontic Considerations).
9. Administer systemic antibiotics.[34,35] (see: "Antibiotics")
10. Check tetanus status.[36] (see: "Tetanus")
11. Provide post-operative instructions. (see: "Post-operative instructions")
12. Follow up. (see: "Follow-up procedures")

In immature teeth with open apices, there is a potential for spontaneous healing to occur in the form of new connective tissue with a vascular supply. This allows continued root development and maturation. Hence, endodontic treatment should not be initiated unless there are definite signs of pulp necrosis and infection of the root canal system at follow-up appointments.

3.2.2 | The tooth has been kept in a physiologic storage medium or stored in non-physiologic conditions, and the extra-oral time has been less than 60 minutes

Examples of physiologic or osmolality-balanced media are milk and HBSS.

1. Check the avulsed tooth and remove debris from its surface by gently agitating it in the storage medium. Alternatively, a stream of sterile saline or a physiologic medium can be used to rinse its surface.
2. Place or leave the tooth in a storage medium while taking the history, examining the patient clinically and radiographically and preparing the patient for the replantation.
3. Administer local anesthesia, preferably without vasoconstrictor.
4. Irrigate the socket with sterile saline.
5. Examine the alveolar socket. Remove coagulum, if necessary. If there is a fracture of the socket wall, reposition the fractured segment with a suitable instrument.
6. Replant the tooth slowly with slight digital pressure.
7. Verify the correct position of the replanted tooth both clinically and radiographically.
8. Stabilize the tooth for 2 weeks using a passive and flexible wire of a diameter up to 0.016" or 0.4 mm.[32] Keep the composite and bonding agents away from the gingival tissues and proximal areas. Alternatively, nylon fishing line (0.13-0.25 mm) can be used to create a flexible splint, with composite to bond it to the teeth. In cases of associated alveolar or jawbone fracture, a more rigid splint is indicated and should be left for about 4 weeks.
9. Suture gingival lacerations, if present.
10. Revascularization of the pulp space, which can lead to further root development, is the goal when replanting immature teeth in children. The risk of external infection-related (inflammatory) root resorption should be weighed against the chances of revascularization. Such resorption is very rapid in children. If spontaneous revascularization does not occur, apexification, pulp revitalization/revascularization,[48,49] or root canal treatment should be initiated as soon as pulp necrosis and infection is identified (refer to Endodontic Considerations).
11. Administer systemic antibiotics.[34,35] (see: "Antibiotics")
12. Check tetanus status.[36] (see: "Tetanus")
13. Provide post-operative instructions. (see: "Post-operative instructions")
14. Follow up. (see: "Follow-up procedures")

3.2.3 | Extra-oral time longer than 60 minutes

1. Check the avulsed tooth and remove debris from its surface by gently agitating it in the storage medium. Alternatively, a stream of saline can be used to rinse its surface.
2. Place or leave the tooth in a storage medium while taking the history, examining the patient clinically and radiographically and preparing the patient for the replantation.
3. Administer local anesthesia, preferably with no vasoconstrictor.
4. Irrigate the socket with sterile saline.
5. Examine the alveolar socket. If there is a fracture of the socket wall, reposition the fractured segment with a suitable instrument.
6. Replant the tooth slowly with slight digital pressure.
7. Verify the correct position of the replanted tooth both clinically and radiographically.
8. Stabilize the tooth for 2 weeks using a passive and flexible wire of a diameter up to 0.016" or 0.4 mm.[32] Keep the composite and bonding agents away from the gingival tissues and proximal areas. Alternatively, nylon fishing line (0.13-0.25 mm) can be used to create a flexible splint, with composite to bond it to the teeth. In cases of associated alveolar or jawbone fracture, a more rigid splint is indicated and should be left for about 4 weeks.
9. Suture gingival lacerations, if present.
10. Revascularization of the pulp space, which can lead to further root development and maturation, is the goal when replanting immature teeth in children. The risk of external infection-related (inflammatory) root resorption should be weighed against the chances of revascularization. Such resorption is very rapid in children. If spontaneous revascularization does not occur, apexification, pulp revitalization/revascularization, or root canal treatment should be initiated as soon as pulp necrosis and infection is identified (refer to Endodontic Considerations).
11. Administer systemic antibiotics.[34,35] (see: "Antibiotics")
12. Check tetanus status.[36] (see: "Tetanus")
13. Provide post-operative instructions. (see: "Post-operative instructions")
14. Follow up. (see: "Follow-up procedures")

Delayed replantation has a poor long-term prognosis.[41] The periodontal ligament becomes necrotic and is not expected to regenerate. The expected outcome is ankylosis-related (replacement) root resorption. The goal of replantation in these cases is to restore esthetics and function, at least temporarily, while maintaining alveolar bone contour, width and height. Therefore, the decision to replant a tooth is almost always the correct decision even if the extra-oral time is more than 60 minutes. Replantation will keep future treatment options open. The tooth can always be extracted later if needed, and at the appropriate point following a prompt inter-disciplinary assessment. Parents should be informed that decoronation or other procedures such as autotransplantation might be necessary if the replanted tooth becomes ankylosed and infra-positioned depending on the patient's growth[41-46] and the likelihood of tooth loss. The rate of ankylosis and resorption varies considerably and can be unpredictable.

4 | ANESTHETICS

The best treatment for an avulsed tooth is immediate replantation at the site of the accident, which is usually not painful. While local anesthesia is not available when teeth are replanted at the site of injury, once the patient arrives at a dental or medical facility, pain control by means of local anesthesia is always recommended.[50-55] There are concerns as to whether there are risks of compromising healing by using a vasoconstrictor in the anesthetic solution. However, there is little evidence to support omitting a vasoconstrictor in the oral and maxillofacial region. Regional anesthesia (eg, infraorbital nerve block) may be considered as an alternative to infiltration anesthesia in more severe injury cases and must be determined by the clinician's experience of providing such block injections.[51,52]

5 | SYSTEMIC ANTIBIOTICS

Even though the value of systemic administration of antibiotics is highly questionable, the periodontal ligament of an avulsed tooth often becomes contaminated by bacteria from the oral cavity, the storage medium, or the environment in which the avulsion occurred. Therefore, the use of systemic antibiotics after avulsion and replantation has been recommended to prevent infection-related reactions and to decrease the occurrence of inflammatory root resorption.[34,35] Additionally, the patient's medical status or concomitant injuries may warrant antibiotic coverage. In all cases, appropriate dosage for the patient's age and weight should be calculated. Amoxicillin or penicillin remain the first choices due to their effectiveness on oral flora and low incidence of side effects. Alternative antibiotics should be considered for patients with an allergy to penicillin. The effectiveness of tetracycline administered immediately after avulsion and replantation has been demonstrated in animal models.[35] Specifically, doxycycline is an appropriate antibiotic to use because of its antimicrobial, anti-inflammatory and anti-resorptive effects. However, the risk of discoloration of permanent teeth must be considered before systemic administration of a tetracycline in young patients. Tetracycline or doxycycline are generally not recommended for patients under 12 years of age.[56]

6 | TOPICAL ANTIBIOTICS

The effect of topical antibiotics placed on the root surface prior to replantation with respect to pulp revascularization remains controversial.[8,57,58] While animal studies have shown great potential,[59-61] human studies have failed to demonstrate improved pulp revascularization when teeth are soaked in topical antibiotics.[62] Therefore, a specific antibiotic, duration of use, or methods of application

cannot be recommended based on human studies (see future areas of research).

7 | TETANUS

Although most people receive tetanus immunization and boosters, it cannot be assumed that this is always the case.[36,63,64] Refer the patient to a physician for evaluation of the need for a tetanus booster.

8 | STABILIZATION OF REPLANTED TEETH (SPLINTING)

Avulsed teeth always require stabilization to maintain the replanted tooth in its correct position, provide patient comfort and improve function.[32,47,65-72] Current evidence supports short-term, passive and flexible splints for stabilization of replanted teeth. Studies have shown that periodontal and pulp healing are promoted if the replanted tooth is subjected to slight mobility and function,[66] achieved with stainless steel wire up to a diameter of 0.016" or 0.4 mm[32] or with nylon fishing line (0.13-0.25 mm), and bonded to the teeth with composite resin. Replanted permanent teeth should be stabilized for a period of 2 weeks depending on the length and degree of maturation of the root. An animal study has shown that more than 60% of the mechanical properties of the injured PDL return within 2 weeks following injury.[69] However, the likelihood of successful periodontal healing after replantation is not likely to be affected by splinting duration.[47]

Wire (or nylon line) and composite stabilization should be placed on the labial surfaces to avoid occlusal interference and to enable palatal/lingual access for endodontic procedures. Various types of wire (or nylon line) and acid etch bonded stabilization have been used to stabilize avulsed teeth as they allow good oral hygiene and they are well tolerated by patients.[72] It is critically important to keep the composite and bonding agents away from the marginal gingiva and interproximal areas to avoid plaque retention and secondary infection, and to allow relatively easy cleaning by the patient. The patient and parent should be advised that on removal of the splint, the injured tooth may be mobile. An additional week of splinting is appropriate only if excessive trauma from the opposing dentition might further traumatize the tooth or if the avulsed tooth is unable to remain in the correct position. An assessment of this should be made after the splint is removed and the occlusion checked.

9 | PATIENT INSTRUCTIONS

Patient compliance with follow-up visits and home care contributes to satisfactory healing following an injury.[2,24,25,27,29] Both patients and parents or guardians of young patients should be advised regarding care of the replanted tooth for optimal healing and prevention of further injury. They should be advised to:

1. Avoid participation in contact sports.
2. Maintain a soft diet for up to 2 weeks, according to the tolerance of the patient.[65]
3. Brush their teeth with a soft toothbrush after each meal.
4. Use a chlorhexidine (0.12%) mouth rinse twice a day for 2 weeks.

10 | ENDODONTIC CONSIDERATIONS

When endodontic treatment is indicated (teeth with closed apex),[17,73-81] treatment should be initiated within 2 weeks post-replantation. Endodontic treatment should always be undertaken after isolation with the dental dam. This may be achieved by placing the dental dam retainer on neighboring uninjured teeth to avoid further trauma to the injured tooth/teeth. Calcium hydroxide is recommended as an intracanal medicament for up to 1 month followed by root canal filling.[82,83] If a corticosteroid or corticosteroid/antibiotic mixture is chosen to be used as an anti-inflammatory and anti-resorptive intracanal medicament, it should be placed immediately or shortly after replantation and left in situ for at least 6 weeks.[76,78,84] Medicaments should be carefully applied to the root canal system with care to avoid placement in the crown of the tooth. Some medicaments have been shown to discolor teeth, leading to patient dissatisfaction.[77]

In teeth with open apices, spontaneous pulp space revascularization may occur. Thus, root canal treatment should be avoided unless there is clinical or radiographic evidence of pulp necrosis and infection of the root canal system on follow-up examinations. The risk of infection-related (inflammatory) root resorption should be weighed against the chances of obtaining pulp space revascularization. Such resorption is very rapid in children.

In cases where pulp necrosis and infection of the root canal system are diagnosed, root canal treatment, apexification or pulp space revascularization/revitalization should be performed. In cases where ankylosis is expected and decoronation is anticipated, proper consideration of the intracanal materials used and their duration is indicated.

11 | FOLLOW-UP PROCEDURES

11.1 | Clinical control

Replanted teeth should be monitored clinically and radiographically at 2 weeks (when the splint is removed), 4 weeks, 3 months, 6 months, one year, and yearly thereafter for at least five years.[2,6-9,25,26,85] Clinical and radiographic examination will provide information to determine the outcome. Evaluation may include the findings described below.

For open apex teeth where spontaneous pulp space revascularization is possible, clinical and radiographic reviews should be more frequent owing to the risk of infection-related (inflammatory) resorption and the rapid loss of the tooth and supporting bone when

this is not identified quickly. Evidence of root and/or bone resorption anywhere around the circumference of the root should be interpreted as infection-related (inflammatory) resorption. Radiographic absence of periodontal ligament space, the replacement of root structure by bone, together with a metallic sound to percussion, should be interpreted as ankylosis-related (replacement) resorption. It is worth noting that the two types of resorption may occur concurrently. For these reasons, replanted teeth with an open apex should be monitored clinically and radiographically at 2 weeks (when the splint is removed), 1, 2, 3, 6 months, one year, and yearly thereafter for at least five years.[2,6-9,25,26,85]

11.2 | Favorable outcomes

11.2.1 | Closed apex

Asymptomatic, functional, normal mobility, no sensitivity to percussion, and normal percussion sound. No radiolucencies and no radiographic evidence of root resorption. The lamina dura appears normal.

11.2.2 | Open apex

Asymptomatic, functional, normal mobility, no sensitivity to percussion, and normal percussion sound. Radiographic evidence of continued root formation and tooth eruption. Pulp canal obliteration is expected and can be recognized radiographically sometime during the first year after the trauma. It is considered to be the mechanism by which the "pulp" heals after replantation of avulsed immature permanent teeth.[86]

11.3 | Unfavorable outcomes

11.3.1 | Closed apex

Patient may or may not have symptoms; presence of swelling or sinus tract; the tooth may have excessive mobility or no mobility (ankylosis) with high-pitched (metallic) percussion sound. Presence of radiolucencies. Radiographic evidence of infection-related (inflammatory) resorption, ankylosis-related (replacement) resorption, or both. When ankylosis occurs in a growing patient, infra-position of the tooth is highly likely to create disturbances in alveolar and facial growth over the short, medium and long term.

11.3.2 | Open apex

The patient may or may not have symptoms; presence of swelling or sinus tract; the tooth may have excessive mobility or no mobility (ankylosis) with high-pitched percussion sound. In the case of ankylosis, the tooth may gradually become infra-positioned. Presence of radiolucencies. Radiographic evidence of infection-related (inflammatory) resorption, ankylosis-related (replacement) resorption, or absence of continued root formation. When ankylosis occurs in a growing patient, infra-position of the tooth is highly likely to create disturbances of alveolar and facial growth over the short, medium and long term.

12 | LONG-TERM FOLLOW-UP CARE (LOSS OF TOOTH OR INFRA-OCCLUSION)

Follow-up care requires good coordination between the initial provider of treatment and specialists in secondary care services (eg, an inter-disciplinary team such as an orthodontist and pediatric dentist and/or endodontist) with the appropriate experience and training in the holistic management of complex dento-alveolar trauma. The team will benefit from other specialists who will provide longer-term care such as a bonded bridge, a transplant, or an implant. In situations where access to an inter-disciplinary team may not be possible, dentists can only be expected to provide follow-up care and treatment within their experience, training and competence.

Patients or parents and children need to be fully informed of the prognosis of an avulsed tooth as soon as possible. They should be fully engaged in the decision-making process. Furthermore, the potential costs of and time required for different treatment options should be openly discussed.

In cases where teeth are lost in the emergency phase after trauma, or will likely be lost later, discussions with appropriate colleagues who have expertise with managing these cases are prudent, especially in growing patients. Ideally, these discussions should take place before the tooth shows signs of infra-position. Appropriate treatment options may include decoronation, autotransplantation, a resin-retained bridge, a removable partial denture or orthodontic space closure with or without composite resin modification. Treatment decisions are based on a full discussion with the patient or the child and parents and the clinician's expertise with the aim to keep all options open until maturity is reached. The decision to perform decoronation is made when the ankylosed tooth shows evidence of infra-occlusion that is deemed esthetically unacceptable and cannot be corrected by simple restorative treatment.[41,45] After growth is completed, implant treatment can be considered. Readers are referred to relevant textbooks and journal articles for further reading regarding these procedures.

13 | CORE OUTCOME SET

The IADT recently developed a core outcome set (COS) for traumatic dental injuries (TDI) in children and adults.[87] This is one of the first COS developed in dentistry and follows a robust consensus methodology and is underpinned by a systematic review of the outcomes used in the trauma literature.[88] A number of outcomes were identified as recurring throughout the different injury types. These outcomes were then included as "generic"—that is relevant to all TDI.

Injury-specific outcomes were also determined as those outcomes related only to one or more particular TDI. Additionally, the study established what, how, when and by whom these outcomes should be measured. Further information for each outcome is described in the original paper.[87]

Generic outcomes:

1. Periodontal healing
2. Pulp space healing (for open apex teeth)
3. Pain
4. Discoloration
5. Tooth loss
6. Quality of life
7. Esthetics (patient perception)
8. Trauma-related dental anxiety
9. Number of clinic visits

Injury-specific outcomes:

1. Infra-occlusion

14 | FUTURE AREAS OF RESEARCH—TOPICS DISCUSSED BUT NOT INCLUDED AS RECOMMENDATIONS IN THESE GUIDELINES

Several promising treatment procedures for avulsed teeth have been discussed in the consensus group. Some of these treatment suggestions have certain experimental evidence, and some are used in clinical practice. According to the working group members, there is currently insufficient weight or quality of clinical and/or experimental evidence for some of these methods to be recommended in these Guidelines. The group advocates further research and documentation for the following:

- Revascularization of the pulp space—see guidelines published by the American Association of Endodontists (AAE)[89] and the European Society of Endodontology (ESE).[90]
- Optimal splint types and length of time relative to periodontal and pulp healing.
- Effect on healing when a local anesthetic containing vasoconstrictors is used.
- Effects of topical and systemic antibiotics on healing and root resorption.
- Effect of intracanal corticosteroids on healing and root resorption.
- Long-term development or establishment of the alveolar crest following replantation and decoronation.
- Effect of periodontal regeneration on the restoration of normal function.
- Periodontal healing following tooth replantation.
- Home care following tooth replantation.

CONFLICT OF INTEREST

The authors confirm that they have no conflict of interest.

ETHICAL APPROVAL

No ethic approval was required for this paper.

DISCLAIMER

These guidelines are intended to provide information for healthcare providers caring for patients with dental injuries. They represent the current best evidence based on literature research and professional opinion. As is true for all guidelines, the healthcare provider must use clinical judgment dictated by the conditions present in any given traumatic situation. The IADT does not guarantee favorable outcomes from following the Guidelines, but using the recommended procedures can maximize the chances of success.

ORCID

Ashraf F. Fouad https://orcid.org/0000-0001-6368-1665
Paul V. Abbott https://orcid.org/0000-0001-5727-4211
Georgios Tsilingaridis https://orcid.org/0000-0001-5361-5840
Nestor Cohenca https://orcid.org/0000-0002-0603-5437
Eva Lauridsen https://orcid.org/0000-0003-0859-7262
Anne O'Connell https://orcid.org/0000-0002-1495-3983
Marie Therese Flores https://orcid.org/0000-0003-2412-190X
Peter F. Day https://orcid.org/0000-0001-9711-9638
Bill Kahler https://orcid.org/0000-0002-4181-3871
Liran Levin https://orcid.org/0000-0002-8123-7936

REFERENCES

1. Glendor U, Halling A, Andersson L, Eilert-Petersson E. Incidence of traumatic tooth injuries in children and adolescents in the county of Vastmanland, Sweden. Swed Dent J. 1996;20:15–28.
2. Andreasen JO, Andreasen FM, Avulsions TG. Andreasen. In:Andreasen JO, Andreasen FM, Andersson L, editors: Textbook and color atlas of traumatic injuries to the teeth. Oxford: Wiley Blackwell, 2019; p. 486–520.
3. Andreasen JO, Hjørting-Hansen E. Replantation of teeth. I. Radiographic and clinical study of 110 human teeth replanted after accidental loss. Acta Odontol Scand. 1966;24:263–86.
4. Andersson L, Bodin I, Sorensen S. Progression of root resorption following replantation of human teeth after extended extraoral storage. Endod Dent Traumatol. 1989;5:38–47.
5. Andersson L, Bodin I. Avulsed human teeth replanted within 15 minutes–a long-term clinical follow-up study. Endod Dent Traumatol. 1990;6:37–42.
6. Andreasen JO, Borum MK, Andreasen FM. Replantation of 400 avulsed permanent incisors. 3. Factors related to root growth. Endod Dent Traumatol. 1995;11:69–75.
7. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 4. Factors related to periodontal ligament healing. Endod Dent Traumatol. 1995;11:76–89.
8. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 2. Factors related to pulpal healing. Endod Dent Traumatol. 1995;11:59–68.
9. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. 1. Diagnosis of healing complications. Endod Dent Traumatol. 1995;11:51–8.

10. Barrett EJ, Kenny DJ. Survival of avulsed permanent maxillary incisors in children following delayed replantation. Endod Dent Traumatol. 1997;13:269–75.
11. Barrett EJ, Kenny DJ. Avulsed permanent teeth: a review of the literature and treatment guidelines. Endod Dent Traumatol. 1997;13:153–63.
12. Ebeleseder KA, Friehs S, Ruda C, Pertl C, Glockner K, Hulla H. A study of replanted permanent teeth in different age groups. Endod Dent Traumatol. 1998;14:274–8.
13. Andreasen JO, Andreasen FM, Skeie A, Hjørting-Hansen E, Schwartz O. Effect of treatment delay upon pulp and periodontal healing of traumatic dental injuries - a review article. Dent Traumatol. 2002;18:116–28.
14. Kargul B, Welbury R. An audit of the time to initial treatment in avulsion injuries. Dent Traumatol. 2009;25:123–5.
15. Tzigkounakis V, Merglova V, Hecova H, Netolicky J. Retrospective clinical study of 90 avulsed permanent teeth in 58 children. Dent Traumatol. 2008;24:598–602.
16. Bastos JV, de Souza I, Cortes M, Andrade Goulart EM, Colosimo EA, Gomez RS, et al. Age and timing of pulp extirpation as major factors associated with inflammatory root resorption in replanted permanent teeth. J Endod. 2014;40:366–71.
17. Day PF, Duggal M, Nazzal H. Interventions for treating traumatised permanent front teeth: Avulsed (knocked out) and replanted. Cochrane Database Syst Rev. 2019;2:CD006542.
18. Wang G, Wang C, Qin M. A retrospective study of survival of 196 replanted permanent teeth in children. Dent Traumatol. 2019;35:251–8.
19. Andersson L, Andreasen JO, Day P, Heithersay G, Trope M, DiAngelis AJ, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 2. Avulsion of permanent teeth. Dent Traumatol. 2012;28:88–96.
20. DiAngelis AJ, Andreasen JO, Ebeleseder KA, Kenny DJ, Trope M, Sigurdsson A, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 1. Fractures and luxations of permanent teeth. Dent Traumatol. 2012;28:2–12.
21. Malmgren B, Andreasen JO, Flores MT, Robertson A, DiAngelis AJ, Andersson L, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 3. Injuries in the primary dentition. Dent Traumatol. 2012;28:174–82.
22. Al-Asfour A, Andersson L. The effect of a leaflet given to parents for first aid measures after tooth avulsion. Dent Traumatol. 2008;24:515–21.
23. Al-Asfour A, Andersson L, Al-Jame Q. School teachers' knowledge of tooth avulsion and dental first aid before and after receiving information about avulsed teeth and replantation. Dent Traumatol. 2008;24:43–9.
24. Al-Jame Q, Andersson L, Al-Asfour A. Kuwaiti parents' knowledge of first-aid measures of avulsion and replantation of teeth. Med Princ Pract. 2007;16:274–9.
25. Al-Sane M, Bourisly N, Almulla T, Andersson L. Laypeoples' preferred sources of health information on the emergency management of tooth avulsion. Dent Traumatol. 2011;27:432–7.
26. Andersson L, Al-Asfour A, Al-Jame Q. Knowledge of first-aid measures of avulsion and replantation of teeth: An interview of 221 kuwaiti schoolchildren. Dent Traumatol. 2006;22:57–65.
27. Flores MT, Andersson L, Andreasen JO, Bakland LK, Malmgren B, Barnett F, et al. Guidelines for the management of traumatic dental injuries. Ii. Avulsion of permanent teeth. Dent Traumatol. 2007;23:130–6.
28. Adnan S, Lone MM, Khan FR, Hussain SM, Nagi SE. Which is the most recommended medium for the storage and transport of avulsed teeth? A systematic review. Dent Traumatol. 2018;34:59–70.
29. Flores MT, Al Sane M, Andersson L. Information to the public, patients and emergency services on traumatic dental injuries. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth. Oxford: Wiley Blackwell, 2019; p. 992–1008.
30. Andreasen JO. Effect of extra-alveolar period and storage media upon periodontal and pulpal healing after replantation of mature permanent incisors in monkeys. Int J Oral Surg. 1981;10:43–53.
31. Barbizam JVB, Massarwa R, da Silva LAB, da Silva RAB, Nelson-Filho P, Consolaro A, et al. Histopathological evaluation of the effects of variable extraoral dry times and enamel matrix proteins (enamel matrix derivatives) application on replanted dogs' teeth. Dent Traumatol. 2015;31:29–34.
32. Kwan SC, Johnson JD, Cohenca N. The effect of splint material and thickness on tooth mobility after extraction and replantation using a human cadaveric model. Dent Traumatol. 2012;28:277–81.
33. Ben Hassan MW, Andersson L, Lucas PW. Stiffness characteristics of splints for fixation of traumatized teeth. Dent Traumatol. 2016;32:140–5.
34. Hammarstrom L, Blomlof L, Feiglin B, Andersson L, Lindskog S. Replantation of teeth and antibiotic treatment. Endod Dent Traumatol. 1986;2:51–7.
35. Sae-Lim V, Wang CY, Choi GW, Trope M. The effect of systemic tetracycline on resorption of dried replanted dogs' teeth. Endod Dent Traumatol. 1998;14:127–32.
36. Rhee P, Nunley MK, Demetriades D, Velmahos G, Doucet JJ. Tetanus and trauma: a review and recommendations. J Trauma. 2005;58:1082–8.
37. Stevenson T, Rodeheaver G, Golden G, Edgerton MD, Wells J, Edlich R. Damage to tissue defenses by vasoconstrictors. J Am Coll Emerg Phys. 1975;4:532–5.
38. Trope M, Moshonov J, Nissan R, Buxt P, Yesilsoy C. Short vs. Long-term calcium hydroxide treatment of established inflammatory root resorption in replanted dog teeth. Endod Dent Traumatol. 1995;11:124–8.
39. Trope M, Yesilsoy C, Koren L, Moshonov J, Friedman S. Effect of different endodontic treatment protocols on periodontal repair and root resorption of replanted dog teeth. J Endod. 1992;18:492–6.
40. Andreasen JO. Periodontal healing after replantation of traumatically avulsed human teeth: assessment by mobility testing and radiography. Acta Odontol Scand. 1975;33:325–35.
41. Malmgren B, Malmgren O. Rate of infraposition of reimplanted ankylosed incisors related to age and growth in children and adolescents. Dent Traumatol. 2002;18:28–36.
42. Malmgren B, Malmgren O, Andreasen JO. Alveolar bone development after decoronation of ankylosed teeth. Endod Topics. 2006;14:35–40.
43. Trope M. Avulsion and replantation. Refuat Hapeh Vehashinayim. 2002;19:6–15, 76.
44. Trope M. Clinical management of the avulsed tooth: present strategies and future directions. Dent Traumatol. 2002;18:1–11.
45. Malmgren B, Tsilingaridis G, Malmgren O. Long-term follow up of 103 ankylosed permanent incisors surgically treated with decoronation - a retrospective cohort study. Dent Traumatol. 2015;31:184–9.
46. Cohenca N, Stabholz A. Decoronation-a conservative method to treat ankylosed teeth for preservation of alveolar ridge prior to permanent prosthetic reconstruction: literature review and case presentation. Dent Traumatol. 2007;23:87–94.
47. Hinckfuss S, Messer LB. Splinting duration and periodontal outcomes for replanted avulsed teeth: a systematic review. Dent Traumatol. 2009;25:150–7.
48. Kahler B, Rossi-Fedele G, Chugal N, Lin LM. An evidence-based review of the efficacy of treatment approaches for immature permanent teeth with pulp necrosis. J Endod. 2017;43:1052–7.

49. Kim SG, Malek M, Sigurdsson A, Lin LM, Kahler B. Regenerative endodontics: a comprehensive review. Int Endod. J. 2018;51(12):1367–88.
50. Barnett P. Alternatives to sedation for painful procedures. Pediatr Emerg Care. 2009;25:415–9.
51. Mariano ER, Watson D, Loland VJ, Chu LF, Cheng GS, Mehta SH, et al. Bilateral infraorbital nerve blocks decrease postoperative pain but do not reduce time to discharge following outpatient nasal surgery. Can J Anaesth. 2009;56:584–9.
52. Karkut B, Reader A, Drum M, Nusstein J, Beck M. A comparison of the local anesthetic efficacy of the extraoral versus the intraoral infraorbital nerve block. J Am Dent Assoc. 2010;141:185–92.
53. Petrino JA, Boda KK, Shambarger S, Bowles WR, McClanahan SB. Challenges in regenerative endodontics: a case series. J Endod. 2010;36:536–41.
54. Ahn J, Pogrel MA. The effects of 2% lidocaine with 1:100,000 epinephrine on pulpal and gingival blood flow. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1998;85:197–202.
55. Kim S, Edwall L, Trowbridge H, Chien S. Effects of local anesthetics on pulpal blood flow in dogs. J Dent Res. 1984;63:650–2.
56. Andreasen JO, Storgaard Jensen S, Sae-Lim V. The role of antibiotics in presenting healing complications after traumatic dental injuries: a literature review. Endod Topics. 2006;14:80–92.
57. Cvek M, Cleaton-Jones P, Austin J, Lownie J, Kling M, Fatti P. Effect of topical application of doxycycline on pulp revascularization and periodontal healing in reimplanted monkey incisors. Endod Dent Traumatol. 1990;6:170–6.
58. Kling M, Cvek M, Mejare I. Rate and predictability of pulp revascularization in therapeutically reimplanted permanent incisors. Endod Dent Traumatol. 1986;2:83–9.
59. Cvek M, Cleaton-Jones P, Austin J, Lownie J, Kling M, Fatti P. Pulp revascularization in reimplanted immature monkey incisors–predictability and the effect of antibiotic systemic prophylaxis. Endod Dent Traumatol. 1990;6:157–69.
60. Ritter AL, Ritter AV, Murrah V, Sigurdsson A, Trope M. Pulp revascularization of replanted immature dog teeth after treatment with minocycline and doxycycline assessed by laser doppler flowmetry, radiography, and histology. Dent Traumatol. 2004;20:75–84.
61. Yanpiset K, Trope M. Pulp revascularization of replanted immature dog teeth after different treatment methods. Endod Dent Traumatol. 2000;16:211–7.
62. Tsilingaridis G, Malmgren B, Skutberg C, Malmgren O. The effect of topical treatment with doxycycline compared to saline on 66 avulsed permanent teeth–a retrospective case-control study. Dent Traumatol. 2015;31:171–6.
63. McClure CC, Cataldi JR, O'Leary ST. Vaccine hesitancy: Where we are and where we are going? Clin Ther. 2017;39:1550–62.
64. Trope M. Avulsion of permanent teeth: theory to practice. Dent Traumatol. 2011;27:281–94.
65. Andersson L, Lindskog S, Blomlof L, Hedstrom KG, Hammarstrom L. Effect of masticatory stimulation on dentoalveolar ankylosis after experimental tooth replantation. Endod Dent Traumatol. 1985;1:13–6.
66. Andreasen JO. The effect of splinting upon periodontal healing after replantation of permanent incisors in monkeys. Acta Odontol Scand. 1975;33:313–23.
67. Berthold C, Auer FJ, Potapov S, Petschelt A. Influence of wire extension and type on splint rigidity–evaluation by a dynamic and a static measuring method. Dent Traumatol. 2011;27:422–31.
68. Kahler B, Heithersay GS. An evidence-based appraisal of splinting luxated, avulsed and root-fractured teeth. Dent Traumatol. 2008;24:2–10.
69. Mandel U, Viidik A. Effect of splinting on the mechanical and histological properties of the healing periodontal ligament in the vervet monkey (*Cercopithecus aethiops*). Arch Oral Biol. 1989;34:209–17.
70. Oikarinen K. Tooth splinting-a review of the literature and consideration of the versatility of a wire-composite splint. Endod Dent Traumatol. 1990;6:237–50.
71. Oikarinen K, Andreasen JO, Andreasen FM. Rigidity of various fixation methods used as dental splints. Endod Dent Traumatol. 1992;8:113–9.
72. von Arx T, Filippi A, Lussi A. Comparison of a new dental trauma splint device (tts) with three commonly used splinting techniques. Dent Traumatol. 2001;17:266–74.
73. Abbott PV, Heithersay GS, Hume WR. Release and diffusion through human tooth roots in vitro of corticosteroid and tetracycline trace molecules from ledermix paste. Endod Dent Traumatol. 1988;4:55–62.
74. Abbott PV, Hume WR, Heithersay GS. Effects of combining ledermix and calcium hydroxide pastes on the diffusion of corticosteroid and tetracycline through human roots in vitro. Endod Dent Traumatol. 1989;5:188–92.
75. Andreasen JO. The effect of pulp extirpation or root canal treatment of periodontal healing after replantation of permanent incisors in monkeys. J Endod. 1981;7:245–52.
76. Bryson EC, Levin L, Banchs F, Abbott PV, Trope M. Effect of immediate intracanal placement of ledermix paste on healing of replanted dog teeth after extended dry times. Dent Traumatol. 2002;18:316–21.
77. Day PF, Duggal MS, High AS, Robertson A, Gregg TA, Ashley PF, et al. Discoloration of teeth after avulsion and replantation: results from a multicenter randomized controlled trial. J Endod. 2011;37:1052–7.
78. Day PF, Gregg TA, Ashley P, Welbury RR, Cole BO, High AS, et al. Periodontal healing following avulsion and replantation of teeth: A multi-centre randomized controlled trial to compare two root canal medicaments. Dent Traumatol. 2012;28:55–64.
79. Kirakozova A, Teixeira FB, Curran AE, Gu F, Tawil PZ, Trope M. Effect of intracanal corticosteroids on healing of replanted dog teeth after extended dry times. J Endod. 2009;35:663–7.
80. Wong KS, Sae-Lim V. The effect of intracanal ledermix on root resorption of delayed-replanted monkey teeth. Dent Traumatol. 2002;18:309–15.
81. Stewart CJ, Elledge RO, Kinirons MJ, Welbury RR. Factors affecting the timing of pulp extirpation in a sample of 66 replanted avulsed teeth in children and adolescents. Dent Traumatol. 2008;24:625–7.
82. Andreasen JO, Farik B, Munksgaard EC. Long-term calcium hydroxide as a root canal dressing may increase risk of root fracture. Dent Traumatol. 2002;18:134–7.
83. Rosenberg B, Murray PE, Namerow K. The effect of calcium hydroxide root filling on dentin fracture strength. Dent Traumatol. 2007;23:26–9.
84. Chen H, Teixeira FB, Ritter AL, Levin L, Trope M. The effect of intracanal anti-inflammatory medicaments on external root resorption of replanted dog teeth after extended extra-oral dry time. Dent Traumatol. 2008;24:74–8.
85. Levin L, Day P, Hicks L, O'Connell AC, Fouad AF, Bourguigon C, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: General introduction. Dent Traumatol. 2020;36:309–13.
86. Abd-Elmeguid A, ElSalhy M, Yu DC. Pulp canal obliteration after replantation of avulsed immature teeth: a systematic review. Dent Traumatol. 2015;31:437–41.
87. Kenny KP, Day PF, Sharif MO, Parashos P, Lauridsen E, Feldens CA, et al. What are the important outcomes in traumatic dental injuries? An international approach to the development of a core outcome set. Dental Traumatol. 2018;34:4–11.
88. Sharif MO, Tejani-Sharif A, Kenny K, Day PF. A systematic review of outcome measures used in clinical trials of treatment

interventions following traumatic dental injuries. Dental Traumatol. 2015;31:422–8.
89. American Association of Endodontists. Regenrative Endodontics. Available from https://www.aae.org/specialty/clinical-resources/regenerative-endodontics/. Accessed June 2, 2020.
90. Galler KM, Krastl G, Simon S, Van Gorp G, Meschi N, Vahedi B, et al. European Society of Endodontology position statement: revitalization procedures. Int Endod J. 2016;49:717–23.

How to cite this article: Fouad AF, Abbott PV, Tsilingaridis G, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 2. Avulsion of permanent teeth. *Dent Traumatol*. 2020;36:331–342. https://doi.org/10.1111/edt.12573

Received: 19 May 2020 | Accepted: 19 May 2020
DOI: 10.1111/edt.12576

COMPREHENSIVE REVIEW

Dental Traumatology WILEY

International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 3. Injuries in the primary dentition

Peter F. Day[1] | Marie Therese Flores[2] | Anne C. O'Connell[3] | Paul V. Abbott[4] | Georgios Tsilingaridis[5,6] | Ashraf F. Fouad[7] | Nestor Cohenca[8] | Eva Lauridsen[9] | Cecilia Bourguignon[10] | Lamar Hicks[11] | Jens Ove Andreasen[12] | Zafer C. Cehreli[13] | Stephen Harlamb[14] | Bill Kahler[15] | Adeleke Oginni[16] | Marc Semper[17] | Liran Levin[18]

[1]School of Dentistry, University of Leeds and Community Dental Service Bradford District Care NHS Trust, Leeds, UK
[2]Department of Pediatric Dentistry, Faculty of Dentistry, Universidad de Valparaíso, Valparaíso, Chile
[3]Paediatric Dentistry, Dublin Dental University Hospital, Trinity College Dublin, The University of Dublin, Dublin, Ireland
[4]UWA Dental School, University of Western Australia, Nedlands, WA, Australia
[5]Division of Orthodontics and Pediatric Dentistry, Department of Dental Medicine, Karolinska Institutet, Huddinge, Sweden
[6]Center for Pediatric Oral Health Research, Stockholm, Sweden
[7]Adams School of Dentistry, University of North Carolina, Chapel Hill, NC, USA
[8]Department of Pediatric Dentistry, University of Washington and Seattle Children's Hospital, Seattle, WA, USA
[9]Resource Center for Rare Oral Diseases, Copenhagen University Hospital, Copenhagen, Denmark
[10]Specialist Private Practice, Paris, France
[11]Division of Endodontics, University of Maryland School of Dentistry, UMB, Baltimore, MD, USA
[12]Department of Oral and Maxillofacial Surgery, Resource Centre for Rare Oral Diseases, University Hospital in Copenhagen (Rigshospitalet), Copenhagen, Denmark
[13]Department of Pediatric Dentistry, Faculty of Dentistry, Hacettepe University, Ankara, Turkey
[14]Faculty of Medicine and Health, The University of Sydney, Sydney, NSW, Australia
[15]School of Dentistry, The University of Queensland, St Lucia, Qld, Australia
[16]Faculty of Dentistry, College of Health Sciences, Obafemi Awolowo University, Ile-Ife, Nigeria
[17]Specialist Private Practice, Bremen, Germany
[18]Faculty of Medicine and Dentistry, University of Alberta, Edmonton, AB, Canada

Correspondence
Liran Levin, Chair of the IADT Guidelines Committee, Faculty of Medicine & Dentistry, University of Alberta, 5-468 Edmonton Clinic Health Academy, 11405 - 87 Avenue NW, 5th Floor, Edmonton, AB T6G 1C9, Canada.
Email: liran@ualberta.ca

Abstract

Traumatic injuries to the primary dentition present special problems that often require far different management when compared to that used for the permanent dentition. The International Association of Dental Traumatology (IADT) has developed these Guidelines as a consensus statement after a comprehensive review of the dental literature and working group discussions. Experienced researchers and clinicians from various specialties and the general dentistry community were included in the working group. In cases where the published data did not appear conclusive,

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
© 2020 The Authors. *Dental Traumatology* published by John Wiley & Sons Ltd.

recommendations were based on the consensus opinions or majority decisions of the working group. They were then reviewed and approved by the members of the IADT Board of Directors. The primary goal of these Guidelines is to provide clinicians with an approach for the immediate or urgent care of primary teeth injuries based on the best evidence provided by the literature and expert opinions. The IADT cannot, and does not, guarantee favorable outcomes from strict adherence to the Guidelines; however, the IADT believes their application can maximize the probability of favorable outcomes.

KEYWORDS

avulsion, luxation, prevention, tooth fracture, trauma

1 | INTRODUCTION

Injuries to children are a major threat to their health, and they are generally a neglected public health problem.[1] For children, aged 0-6 years, oral injuries account for 18% of all physical injuries and the mouth is the second most common area of the body to be injured.[2] A recent meta-analysis on traumatic dental injuries (TDIs) reveals a world prevalence of 22.7% affecting the primary teeth.[3] Repeated TDIs are also frequently seen in children.[4]

Unintentional falls, collisions, and leisure activities are the most common reasons for TDIs, especially as children learn to crawl, walk, run, and embrace their physical environment.[5] They most commonly occur between 2 and 6 years of age[4–7] with injuries to periodontal tissues occurring most frequently.[6,8] Children with these injuries present to many healthcare settings, including general dental practitioners, emergency medical services, pharmacists, community dental clinics, and specialist dental services. Consequently, each service provider needs to have the appropriate knowledge, skills, and training in how to care for children with TDIs to their primary dentition.

The primary teeth Guidelines contain recommendations for the diagnosis and management of traumatic injuries to the primary dentition, assuming the child is medically healthy with a sound and caries-free primary dentition. Management strategies may change where multiple teeth are injured. Many articles have contributed to the content of these Guidelines and the treatment tables (1-12) and these articles are not mentioned elsewhere in this introductory text.[9–15]

1.1 | Initial presentation and minimizing anxiety to the child and parent

Management of TDIs in children is distressing for both the child and the parents. It can also be challenging for the dental team. A TDI in the primary dentition often may be the reason for the child's first visit to the dentist. Minimizing anxiety for the child and parents, or other caregivers, during the initial visit is essential. At this young age, the child may resist co-operating for an extensive examination, radiographs, and treatment. Knee-to-knee examination can be helpful in examining a young child. Information about how to undertake an examination of a child with a TDI involving their primary dentition can be found in current textbooks[16–18] or can be viewed in the following video (https://tinyurl.com/kneetokneeexamination). Wherever possible, the acute and follow-up dental care should be provided by a child-oriented team that has experience and expertise in the management of pediatric oral injuries. These teams are best placed to access specialist diagnostic and treatment services, including sedation and general anesthesia, and pain management for the prevention or minimization of suffering.[19]

1.2 | A structured approach

It is essential that clinicians adopt a structured approach to managing traumatic dental injuries. This includes history taking, undertaking the clinical examination, collecting test results, and how this information is recorded. The literature shows that the use of a structured history at the initial consultation leads to a significant improvement in the quality of the trauma records involving the permanent dentition[5,20]. There are a variety of structured histories available in current textbooks[16–18] or used at different specialist centers.[21,22] Extra-oral and intra-oral photographs act as a permanent record of the injuries sustained and are strongly recommended.

1.3 | Initial assessment

Elicit a careful medical, social (including those who attend with the child), dental, and accident history. Thoroughly examine the head and neck and intra-orally for both bony and soft tissue injuries.[17,18] Be alert to concomitant injuries including head injury, facial fractures, missing tooth fragments, or lacerations. Seek a medical examination if necessary.

1.4 | Soft tissue injuries

It is essential to identify, record, and diagnose extra-oral and intra-oral soft tissue injuries.[18,23] The lips, oral mucosa, attached and free gingivae, and the frenula should be checked for lacerations and

hematomas. The lips should be examined for possible embedded tooth fragments. The presence of a soft tissue injury is strongly associated with the pursuit of immediate care. Such injuries are most commonly found in the 0- to 3-year age group.[24] Management of soft tissues, beyond just first aid, should be provided by a child-oriented team with experience in pediatric oral injuries. Parental engagement with the homecare for soft tissue injuries to the gingivae is critical and will influence the outcomes for healing of the teeth and soft tissues. Parental homecare instructions for intra-oral soft tissue injuries are described later in these Guidelines.

1.5 | Tests, crown discoloration, and radiographs

Extra-oral and intra-oral photographs are strongly recommended.

Pulp sensibility tests are unreliable in primary teeth and are therefore not recommended.

Tooth mobility, color, tenderness to manual pressure, and the position or displacement should be recorded.

The color of injured and uninjured teeth should be recorded at each clinic visit. Discoloration is a common complication following luxation injuries.[8,25–27] This discoloration may fade, and the tooth may regain its original shade over a period of weeks or months.[8,28–30] Teeth with persistent dark discoloration may remain asymptomatic clinically and radiographically normal, or they may develop apical periodontitis (with or without symptoms).[31,32] Root canal treatment is not indicated for discolored teeth unless there are clinical or radiographic signs of infection of the root canal system.[18,33]

Every effort has been made in these Guidelines to reduce the number of radiographs needed for accurate diagnosis, thus minimizing a child's exposure to radiation. For essential radiographs, radiation protection includes the use of a thyroid collar where the thyroid is in the path of the primary X-ray beam and a lead apron for when parents are holding the child. Radiation-associated risks for children are a concern as they are substantially more susceptible to the effects of radiation exposure for the development of most cancers than adults. This is due to their longer life expectancy and the acute radiosensitivity of some developing organs and tissues.[34,35] Therefore, clinicians should question each radiograph they take and cognitively ask whether additional radiographs will positively affect the diagnosis or treatment provided for the child. Clinicians must work within the ALARA (As Low As Reasonably Achievable) principles to minimize the radiation dose. The use of CBCT following TDI in young children is rarely indicated.[36]

1.6 | Diagnosis

A careful and systematic approach to diagnosis is essential. Clinicians should identify all injuries to each tooth including both hard tissues injuries (eg, fractures) and periodontal injuries (eg, luxations). When concomitant injuries occur in the primary dentition following extrusion and lateral luxation injuries, they have a detrimental impact on pulp survival.[27] The accompanying tables (1-12) and the trauma pathfinder diagram (www.dentaltraumaguide.org) help clinicians identify all possible injuries for each injured tooth.

1.7 | Intentional (non-accidental) injuries

Dental and facial trauma can occur in cases of intentional injuries. Clinicians should check whether the history of the accident and the injuries sustained are consistent or match. In situations where there is suspicion of abuse, prompt referral for a full physical examination and investigation of the incident should be arranged. Referral should follow local protocols, which is beyond the scope of these Guidelines.

1.8 | Impact of orofacial and primary tooth trauma on the permanent dentition

There is a close spatial relationship between the apex of the primary tooth root and the underlying permanent tooth germ. Tooth malformation, impacted teeth, and eruption disturbances in the developing permanent dentition are some of the consequences that can occur following injuries to primary teeth and the alveolar bone.[37–43] Intrusion and avulsion injuries are most commonly associated with the development of anomalies in the permanent dentition.[37–42]

For intrusive and lateral luxation injuries, previous Guidelines have recommended the immediate extraction of the traumatized primary tooth if the direction of displacement of the root is toward the permanent tooth germ. This action is no longer advised due to (a) evidence of spontaneous re-eruption for intruded primary teeth,[8,10,26,43–45] (b) the concern that further damage may be inflicted on the tooth germ during extraction, and (c) the lack of evidence that immediate extraction will minimize further damage to the permanent tooth germ.

It is very important to document that parents have been informed about possible complications to the development of the permanent teeth, especially following intrusion, avulsion, and alveolar fractures.

1.9 | Management strategy for injuries to the primary dentition

In general, there is limited evidence to support many of the treatment options in the primary dentition. Observation is often the most appropriate option in the emergency situation unless there is risk of aspiration, ingestion, or interference with the occlusion. This conservative approach may reduce additional suffering for the child[18] and the risk of further damage to the permanent dentition.[18,46,47]

A summary of the management of TDIs in the primary dentition includes the following:

- A child's maturity and ability to cope with the emergency situation, the time for shedding of the injured tooth, and the occlusion are all important factors that influence treatment.

- It is critical that parents are given appropriate advice on how best to manage the acute symptoms to avoid further distress.[48,49] Luxation injuries, such as intrusion and lateral luxation, and root fractures may cause severe pain. The use of analgesics such as ibuprofen and/or acetaminophen (paracetamol) is recommended when pain is anticipated.
- Minimizing dental anxiety is essential. Provision of dental treatment depends on the child's maturity and ability to cope. Various behavioral approaches are available[50–51]and have been shown to be effective for managing acute procedures in an emergency situation.[52,53] TDIs and their treatment have the potential to lead to both post-traumatic stress disorder and dental anxiety. The development of these conditions in young children is a complex issue[54,55] with little research specifically examining either condition following TDIs in the primary dentition. However, evidence from the wider dental literature suggests that the multi-factorial nature of dental anxiety, its fluctuating nature, and the role of dental extractions are exacerbating factors.[56–58] Where possible, avoidance of dental extractions, especially at the acute or initial visit, is a reasonable strategy.
- Where appropriate and the child's cooperation allows, options that maintain the child's primary dentition should be the priority.[59] Discussions with parents about the different treatment options should include the potential for further treatment visits and consideration for how best to minimize the impact of the injury on the developing permanent dentition.[60]
- For crown and crown-root fractures involving the pulp, root fractures, and luxation injuries, rapid referral within several days to a child-oriented team that has experience and expertise in the management of dental injuries in children is essential.
- Splinting is used for alveolar bone fractures[40,61] and occasionally may be needed in cases of root fractures[62] and lateral luxations.[62]

1.10 | Avulsed primary teeth

An avulsed primary tooth should not be replanted. Reasons include a significant treatment burden (including replantation, splint placement and removal, root canal treatment) for a young child as well as the potential of causing further damage to the permanent tooth or to its eruption.[40,41,63,64] However, the most important reason is to avoid a medical emergency resulting from aspiration of the tooth. Careful follow up is required to monitor the development and eruption of the permanent tooth. Refer to the accompanying table () for specific guidance.

1.11 | Antibiotics and Tetanus

There is no evidence for recommending the use of systemic antibiotics in the management of luxation injuries in the primary dentition. However, antibiotic use does remain at the discretion of the clinician when TDIs are accompanied by soft tissue and other associated injuries or significant surgical intervention is required. Finally, the child´s medical status may warrant antibiotic coverage. The child's pediatrician should be contacted where questions arise in these situations.

A tetanus booster may be required if environmental contamination of the injury has occurred. If in doubt, refer to a medical practitioner within 48 hours.

1.12 | Parental instructions for homecare

Successful healing following an injury to the teeth and oral tissues depends on good oral hygiene. To optimize healing, parents or caregivers should be advised regarding care of the injured tooth/teeth and the prevention of further injury by supervising potentially hazardous activities. Clean the affected area with a soft brush or cotton swab and use alcohol-free chlorhexidine gluconate 0.12% mouth rinse applied topically twice a day for one week to prevent accumulation of plaque and debris and to reduce the bacterial load. Care should be taken when eating not to further traumatize the injured teeth while encouraging a return to normal function as soon as possible.

Parents or caregivers should be advised about possible complications that may occur, such as swelling, increased mobility, or a sinus tract. Children may not complain about pain, but infection may be present. Parents or caregivers should watch for signs of infection such as swelling of the gums. If present, they should take the child to a dentist for treatment. Examples of unfavorable outcomes are found in the table for each injury (Tables 1-12).

1.13 | Training, skills, and experience for teams managing the follow-up care

During the follow-up phase of treatment, dental teams caring for children with complex injuries to the primary dentition should have specialist training, experience, and skills. These attributes enable the members of the team to respond appropriately to the medical, physical, emotional, and developmental needs of children and their families. In addition, skills within the team should also encompass health promotion and access to specialist diagnostic and treatment services including sedation, general anesthesia, and overall pain management for the prevention or minimization of suffering.[19]

1.14 | Prognosis

Factors relating to the injury and subsequent treatment may influence pulp and periodontal outcomes, and they should be carefully recorded. These prognostic factors need to be carefully collected at both the initial consultation and follow-up visits. This is most likely achieved using the structured history form described previously. The dental literature and appropriate websites (eg, www.dentaltraumaguide.org) provide clinicians with useful information on the probable pulp and periodontal prognosis. These sources of information can be invaluable when having conversations with the parents or caregivers and the child.

TABLE 1 Treatment guidelines for primary teeth: Enamel fractures

Enamel fracture	Radiographic recommendations	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcomes	Unfavorable outcomes
 Clinical findings: Fracture involves enamel only	• No radiographs recommended	• Smooth any sharp edges. • Parent/patient education: - Exercise care when eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible. - Encourage gingival healing and prevent plaque accumulation by parents cleaning the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1 to 0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• No clinical or radiographic follow up recommended	• Asymptomatic • Pulp healing with: - Normal color of the remaining crown - No signs of pulp necrosis and infection - Continued root development in immature teeth	• Symptomatic • Crown discoloration • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration with one or more other signs of infection - Radiographic signs of pulp necrosis and infection • No further root development of immature teeth

TABLE 2 Treatment guidelines for primary teeth: Enamel-dentin fractures (with no pulp exposure)

Enamel-dentin fracture (with no pulp exposure)	Radiographic recommendations	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
 Clinical findings: Fracture involves enamel and dentin. The pulp is not exposed • The location of missing tooth fragments should be explored during the trauma history and examination, especially when the accident was not witnessed by an adult or there was a loss of consciousness • Note: While fragments are most often lost out of the mouth, there is a risk that they can be embedded in the soft tissues, ingested, or aspirated	• Baseline radiograph optional • Take a radiograph of the soft tissues if the fractured fragment is suspected to be embedded in the lips, cheeks, or tongue	• Cover all exposed dentin with glass ionomer or composite • Lost tooth structure can be restored using composite immediately or at a later appointment • Parent/patient education: - Exercise care when eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible - Encourage gingival healing and prevent plaque accumulation by parents cleaning the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1 to 0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Clinical examination after 6-8 wk • Radiographic follow up indicated only when clinical findings are suggestive of pathosis (eg, signs of pulp necrosis and infection) • Parents should watch for any unfavorable outcomes. If seen, the child needs to return to the clinic as soon as possible. When unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the remaining crown - No signs of pulp necrosis and infection - Continued root development in immature teeth	• Symptomatic • Crown discoloration • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration with one or more other signs of root canal infection - Radiographic signs of pulp necrosis and infection • No further root development of immature teeth

TABLE 3 Treatment guidelines for primary teeth: Complicated crown fractures (with pulp exposure)

Complicated crown fracture (ie, with exposed pulp)	Radiographic recommendations	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
 Clinical findings: Fracture involves enamel and dentin plus the pulp is exposed. • The location of missing tooth fragments should be explored during the trauma history and examination, especially when the accident was not witnessed by an adult or there was a loss of consciousness • Note: While fragments are most often lost out of the mouth, there is a risk that they can be embedded in the soft tissues, ingested, or aspirated	• A periapical radiograph (using a size 0 sensor/film and the paralleling technique) or an occlusal radiograph (with a size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline • Take a radiograph of the soft tissues if the fractured fragment is suspected to be embedded in the lips, cheeks, or tongue	• Preserve the pulp by partial pulpotomy. Local anesthesia will be required. A non-setting calcium hydroxide paste should be applied over the pulp and cover this with a glass ionomer cement and then a composite resin. Cervical pulpotomy is indicated for teeth with large pulp exposures. The evidence for using other biomaterials such as non-staining calcium silicate-based cements is emerging. Clinicians should focus on appropriate case selection rather than the material used • Treatment depends on the child´s maturity and ability to tolerate procedures. Therefore, discuss different treatment options (including pulpotomy) with the parents. Each option is invasive and has the potential to cause long-term dental anxiety. Treatment is best performed by a child-oriented team with experience and expertise in the management of pediatric dental injuries. Often no treatment may be the most appropriate option in the emergency situation, but only when there is the potential for rapid referral (within several days) to the child-oriented team • Parent/patient education: - Exercise care when eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible. - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1 to 0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Clinical examination after: - 1 wk - 6-8 wk - 1 y • Radiographic follow up at 1 y following pulpotomy or root canal treatment. Other radiographs are only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should watch for any unfavorable outcomes. If seen, the child needs to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required. • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the remaining crown - No signs of pulp necrosis and infection - Continued root development in immature teeth	• Symptomatic • Crown discoloration • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration with one or more signs of root canal infection - Radiographic signs of pulp necrosis and infection • No further root development of immature teeth

TABLE 4 Treatment guidelines for primary teeth: Crown-root fractures

Crown-root fracture	Radiographic recommendations	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
   Clinical findings: Fracture involves enamel, dentin, and root; the pulp may or may not be exposed (ie, complicated or uncomplicated) • Additional findings may include loose, but still attached, fragments of tooth	• A periapical radiograph (using a size 0 sensor/film and the paralleling technique) or an occlusal radiograph (with a size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline	• Often no treatment may be the most appropriate option in the emergency situation, but only when there is the potential for rapid referral (within several days) to a child-oriented team • If treatment is considered at the emergency appointment, local anesthesia will be required • Remove the loose fragment and determine if the crown can be restored • **Option A:** - If restorable and no pulp exposed, cover the exposed dentine with glass ionomer - If restorable and the pulp is exposed, perform a pulpotomy (see crown fracture with exposed pulp) or root canal treatment, depending on the stage of root development and the level of the fracture. • **Option B:** - If unrestorable, extract all loose fragments taking care not to damage the permanent successor tooth and leave any firm root fragment in situ, or extract the entire tooth • Treatment depends on the child´s maturity and ability to tolerate the procedure. Therefore, discuss treatment options (including extraction) with the parents. Each option is invasive and has the potential to cause long-term dental anxiety. Treatment is best performed by a child-oriented team with experience and expertise in the management of pediatric dental injuries• Parent/patient education: - Exercise care when eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1% to 0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Where tooth is retained, clinical examination after: - 1 wk - 6-8 wk - 1 y • Radiographic follow up after 1 y following pulpotomy or root canal treatment. Other radiographs only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should watch for any unfavorable outcomes. If seen, the child needs to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the remaining crown - No signs of pulp necrosis and infection - Continued root development in immature teeth	• Symptomatic • Crown discoloration • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration with one or more signs of root canal infection - Radiographic signs of pulp necrosis and infection • No further root development of immature teeth

TABLE 5 Treatment guidelines for primary teeth: Root fractures

Root fracture	Radiographic recommendations and findings	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
 Clinical findings: Depends on the location of fracture • The coronal fragment may be mobile and may be displaced • Occlusal interference may be present	• A periapical (size 0 sensor/film, paralleling technique) or occlusal radiograph (size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline • The fracture is usually located mid-root or in the apical third	• If the coronal fragment is not displaced, no treatment is required • If the coronal fragment is displaced and is not excessively mobile, leave the coronal fragment to spontaneously reposition even if there is some occlusal interference • If the coronal fragment is displaced, excessively mobile and interfering with occlusion, two options are available, both of which require local anesthesia • **Option A:** - Extract only the loose coronal fragment. The apical fragment should be left in place to be resorbed • **Option B:** - Gently reposition the loose coronal fragment. If the fragment is unstable in its new position, stabilize the fragment with a flexible splint attached to the adjacent uninjured teeth. Leave the splint in place for 4 wk • The treatment depends on the child´s maturity and ability to tolerate the procedure. Therefore, discuss treatment options with the parents. Each option is invasive and has the potential to cause long-term dental anxiety. Treatment is best performed by a child-oriented team with experience and expertise in the management of pediatric dental injuries. Often no treatment may be the most appropriate option in the emergency scenario, but only when there is the potential for rapid referral (within several days) to the child-oriented team • Parent/patient education: - Exercise care when eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1%-0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Where no displacement of coronal fragment, clinical examination after: - 1 wk - 6-8 wk - 1 y and where there are clinical concerns that an unfavorable outcome is likely. - Then continue clinical follow up each year until eruption of permanent teeth • If coronal fragment has been repositioned and splinted, clinical examination after: - 1 wk - 4 wk for splint removal - 8 wk - 1 y • If coronal fragment has been extracted, clinical examination after 1 y • Where there are concerns that an unfavorable outcome is likely, then continue clinical follow up each year until eruption of permanent teeth • Radiographic follow up only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required. • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the crown or transient red/gray or yellow discoloration and pulp canal obliteration - No signs of pulp necrosis and infection - Continued root development in immature teeth • Realignment of the root-fractured tooth • No mobility • Resorption of the apical fragment	• Symptomatic • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration with one or more signs of root canal infection - Radiographic signs of pulp necrosis and infection - Radiographic signs of infection-related (inflammatory) resorption • No further root development of immature teeth • No improvement in the position of the root-fractured tooth

TABLE 6 Treatment guidelines for primary teeth: Alveolar fractures

Alveolar fracture	Radiographic recommendations and findings	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
 Clinical findings: The fracture involves the alveolar bone (labial and palatal/lingual) and may extend to the adjacent bone • Mobility and dislocation of the segment with several teeth moving together are common findings • Occlusal interference is usually present	• A periapical (size 0 sensor/film, paralleling technique) or occlusal radiograph (size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline • A lateral radiograph may give information about the relationship between the maxillary and mandibular dentitions and if the segment is displaced in a labial direction • Fracture lines may be located at any level, from the marginal bone to the root apex or beyond, and they may involve the primary teeth and/or their permanent successors • Further imaging may be needed to visualize the extent of the fracture(s) but only where it is likely to change the treatment provided.	• Reposition (under local anesthesia) any displaced segment which is mobile and/or causing occlusal interference • Stabilize with a flexible splint to the adjacent uninjured teeth for 4 wk • Treatment should be performed by a child-oriented team with experience and expertise in the management of pediatric dental injuries • Parent/patient education: - Exercise care when eating not to further traumatize the injured teeth while encouraging a return to normal function as soon as possible - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1%-0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Clinical examination after: - 1 wk - 4 wk for splint removal - 8 wk - 1 y - Further follow up at 6 y of age is indicated to monitor eruption of the permanent teeth • Radiographic follow up at 4 w and 1 y to assess impact on the primary tooth and the permanent tooth germs in the line of the alveolar fracture. This radiograph may indicate a more frequent follow-up regimen is needed. Other radiographs are indicated only where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • If the fracture line is located at the level of the primary root apex, an abscess can develop. A periapical radiolucency can be seen on the radiograph • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal crown color or transient red/gray or yellow discoloration and pulp canal obliteration - No signs of pulp necrosis and infection - Continued root development in immature teeth • Periodontal healing • Realignment of the alveolar segment with the original occlusion restored • No disturbance to the development and/or eruption of the permanent successor	• Symptomatic • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration plus one or more signs of root canal infection - Radiographic signs of pulp necrosis and infection including infection-related (inflammatory) resorption • No further root development in immature teeth • Limited or no improvement in the position of the displaced segment and the original occlusion is not re-established • Negative impact on the development and/or eruption of the permanent successor

TABLE 7 Treatment guidelines for primary teeth: Concussion

Concussion	Radiographic recommendations	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
 Clinical findings: The tooth is tender to touch but it has not been displaced • It has normal mobility and no sulcular bleeding	• No baseline radiograph recommended	• No treatment is needed. • Observation • Parent/patient education: - Exercise care when eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1%-0,2% mouth rinse chlorhexidine gluconate applied topically twice a day for 1 wk	• Clinical examination after: - 1 wk - 6-8 wk • Radiographic follow up only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the crown or transient red/gray or yellow discoloration and pulp canal obliteration - No signs of pulp necrosis and infection • Continued root development in immature teeth • No disturbance to the development and/or eruption of the permanent successor	• Symptomatic • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration plus one or more other signs of root canal infection • Radiographic signs of pulp necrosis and infection • No further root development of immature teeth • Negative impact on the development and/or eruption of the permanent successor

TABLE 8 Treatment guidelines for primary teeth: Subluxation

Subluxation	Radiographic recommendations and findings	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
 Clinical findings: The tooth is tender to touch and it has increased mobility, but it has not been displaced • Bleeding from gingival crevice may be noted	• A periapical (size 0 sensor/film, paralleling technique) or occlusal radiograph (size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline • Normal to slightly widened periodontal ligament space will be visible	• No treatment is needed. • Observation • Parent/patient education: - Exercise care when eating not to further traumatize the injured teeth while encouraging a return to normal function as soon as possible - To encourage gingival healing. Parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1%-0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Clinical examination after: - 1 wk - 6-8 wk • Where there are concerns that an unfavorable outcome is likely, then continue clinical follow up each year until eruption of the permanent teeth • Radiographic follow up only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the crown or transient red/gray or yellow discoloration and pulp canal obliteration - No signs of pulp necrosis and infection • Continued root development in immature teeth • No disturbance to the development and/or eruption of the permanent successor	• Symptomatic • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration plus one or more signs of root canal infection • Radiographic signs of pulp necrosis and infection • No further root development of immature teeth • Negative impact on the development and/or eruption of the permanent successor

TABLE 9 Treatment guidelines for primary teeth: Extrusive luxation

Extrusive luxation	Radiographic recommendations and findings	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following:	
				Favorable outcome	Unfavorable outcome
 Clinical findings: Partial displacement of the tooth out of its socket • The tooth appears elongated and can be excessively mobile. • Occlusal interference may be present	• A periapical (size 0 sensor/film, paralleling technique) or occlusal radiograph (size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline • Slight increase to substantially widened periodontal ligament space apically	• Treatment decisions are based on the degree of displacement, mobility, interference with the occlusion, root formation, and the ability of the child to tolerate the emergency situation • If the tooth is not interfering with the occlusion—let the tooth spontaneously reposition itself • If the tooth is excessively mobile or extruded > 3 mm, then extract under local anesthesia • Treatment should be performed by a child-oriented team with experience and expertise in the management of pediatric dental injuries. Extractions have the potential to cause long-term dental anxiety • Parent/patient education: - Exercise care when eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible. - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1%-0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Clinical examination after: - 1 wk - 6-8 wk - 1 y • Where there are concerns that an unfavorable outcome is likely, then continue clinical follow up each year until eruption of the permanent teeth • Radiographic follow up only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the crown or transient red/gray or yellow discoloration and pulp canal obliteration - No signs of pulp necrosis and infection • Continued root development in immature teeth • Realignment of the extruded tooth • No interference with the occlusion • No disturbance to the development and/or eruption of the permanent successor	• Symptomatic • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration plus one or more signs of root canal infection • Radiographic signs of pulp necrosis and infection • No further root development of immature teeth • No improvement in the position of the extruded tooth • Negative impact on the development and/or eruption of the permanent successor

TABLE 10 Treatment guidelines for primary teeth: Lateral luxation

Lateral luxation	Radiographic recommendations and findings	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
   Clinical findings: The tooth is displaced, usually in a palatal/lingual or labial direction • The tooth will be immobile • Occlusal interference may be present	• A periapical (size 0 sensor/film, paralleling technique) or occlusal radiograph (size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline • Increased periodontal ligament space apically (most clearly seen on an occlusal radiograph, especially if tooth is displaced labially)	• If there is minimal or no occlusal interference, the tooth should be allowed to spontaneously reposition itself • Spontaneous repositioning usually occurs within 6 mo • In situations of severe displacement, two options are available, both of which require local anesthesia: • **Option A:** - Extraction when there is a risk of ingestion or aspiration of the tooth • **Option B:** - Gently reposition the tooth - If unstable in its new position, splint for 4 wk using a flexible splint attached to the adjacent uninjured teeth • Treatment should be performed by a child-oriented team with experience and expertise in the management of pediatric dental injuries. Extractions have the potential to cause long-term dental anxiety • Parent/patient education: - Exercise care when eating not to further traumatize the injured teeth while encouraging a return to normal function as soon as possible - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free chlorhexidine gluconate 0.1%-0.2% mouth rinse applied topically twice a day for 1 wk	• Clinical examination after: - 1 wk - 6-8 wk - 6 mo - 1 y • If repositioned and splinted, review after: - 1 wk - 4 wk for splint removal - 8 wk - 6 mo - 1 y • Where there are concerns that an unfavorable outcome is likely, then continue clinical follow up each year until eruption of the permanent teeth • Radiographic follow up only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the crown or transient red/gray or yellow discoloration and pulp canal obliteration - No signs of pulp necrosis and infection • Continued root development in immature teeth • Periodontal healing • Realignment of the laterally luxated tooth • Normal occlusion • No disturbance to the development and/or eruption of the permanent successor	• Symptomatic • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration plus one or more signs of root canal infection • Radiographic signs of pulp necrosis and infection • Ankylosis • No further root development of immature teeth • No improvement in position of the laterally luxated tooth • Negative impact on the development and/or eruption of the permanent successor

TABLE 11 Treatment guidelines for primary teeth: Intrusive luxation

Intrusive luxation	Radiographic recommendations and findings	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
   Clinical findings: The tooth is usually displaced through the labial bone plate, or it can impinge on the permanent tooth bud • The tooth has almost or completely disappeared into the socket and can be palpated labially	• A periapical (size 0 sensor/film, paralleling technique) or occlusal radiograph (size 2 sensor/film) should be taken at the time of initial presentation for diagnostic purposes and to establish a baseline • When the apex is displaced toward or through the labial bone plate, the apical tip can be seen and the image of the tooth will appear shorter (foreshortened) than the contralateral tooth • When the apex is displaced toward the permanent tooth germ, the apical tip cannot be visualized and the image of the tooth will appear elongated	• The tooth should be allowed to spontaneously reposition itself, irrespective of the direction of displacement • Spontaneous improvement in the position of the intruded tooth usually occurs within 6 mo • In some cases, it can take up to 1 y • A rapid referral (within a couple of days) to a child-oriented team that has experience and expertise in the management of pediatric dental injuries should be arranged • Parent/patient education: - Exercise care with eating not to further traumatize the injured tooth while encouraging a return to normal function as soon as possible - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1%-0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Clinical examination after: - 1 wk - 6-8 wk - 6 mo - 1 y - Further follow up at 6 y of age is indicated for severe intrusion to monitor eruption of the permanent tooth • Radiographic follow up only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• Asymptomatic • Pulp healing with: - Normal color of the crown or transient red/gray or yellow discoloration and pulp canal obliteration - No signs of pulp necrosis and infection • Continued root development in immature teeth • Periodontal healing • Re-eruption/realignment of the intruded tooth • No disturbance to the development and/or eruption of the permanent successor	• Symptomatic • Signs of pulp necrosis and infection—such as: - Sinus tract, gingival swelling, abscess, or increased mobility - Persistent dark gray discoloration with one or more signs of infection • Radiographic signs of pulp necrosis and infection • No further root development of immature teeth • Ankylosis • Negative impact on the development and/or eruption of the permanent successor

TABLE 12 Treatment guidelines for primary teeth: Avulsion

Avulsion	Radiographic recommendations and findings	Treatment	Follow up	Favorable and unfavorable outcomes include some, but not necessarily all, of the following	
				Favorable outcome	Unfavorable outcome
 Clinical findings: The tooth is completely out of the socket • The location of the missing tooth should be explored during the trauma history and examination, especially when the accident was not witnessed by an adult or there was a loss of consciousness. • While avulsed teeth are most often lost out of the mouth, there is a risk that they can be embedded in soft tissues of the lip, cheek, or tongue, pushed into the nose, ingested or aspirated. • If the avulsed tooth is not found, the child should be referred for medical evaluation to an emergency room for further examination, especially where there are respiratory symptoms	• A periapical (size 0 sensor/film, paralleling technique) or occlusal radiograph (size 2 sensor/film) is essential where the primary tooth is not brought into the clinic to ensure that the missing tooth has not been intruded • The radiograph will also provide a baseline for assessment of the developing permanent tooth and to determine whether it has been displaced	• Avulsed primary teeth should not be replanted • Parent/patient education: - Exercise care when eating not to further traumatize the injured soft tissues - To encourage gingival healing and prevent plaque accumulation, parents should clean the affected area with a soft brush or cotton swab combined with an alcohol-free 0.1%-0.2% chlorhexidine gluconate mouth rinse applied topically twice a day for 1 wk	• Clinical examination after: - 6-8 wk - Further follow up at 6 y of age is indicated to monitor eruption of the permanent tooth • Radiographic follow up only indicated where clinical findings are suggestive of pathosis (eg, an unfavorable outcome) • Parents should be informed to watch for any unfavorable outcomes and the need to return to the clinic as soon as possible. Where unfavorable outcomes are identified, treatment is often required • The follow-up treatment, which frequently requires the expertise of a child-oriented team, is outside the scope of these guidelines	• No signs of disturbance to development and/or eruption of the permanent successor	• Negative impact on the development and/or eruption of the permanent successor

1.15 | Core outcome set

The International Association for Dental Traumatology (IADT) recently developed a core outcome set (COS) for traumatic dental injuries (TDIs) in children and adults.[65] This is one of the first COS developed in dentistry and is underpinned by a systematic review of the outcomes used in the trauma literature and follows a robust consensus methodology.[66] Some outcomes were identified as recurring throughout the different injury types. These outcomes were then identified as "generic" (ie, relevant to all TDIs). Injury-specific outcomes were also determined as those outcomes related only to one or more individual TDIs. Additionally, the study established what, how, when, and by whom these outcomes should be measured. Table 1 in the General Introduction section[67] of the Guidelines shows the generic and injury-specific outcomes to be recorded at the follow-up review appointments recommended for the different traumatic injuries. Further information for each outcome is described in the original article.[65]

CONFLICT OF INTEREST

The authors declare there is no competing interest for the above manuscript. Images courtesy of the Dental Trauma Guide.

ETHICAL STATEMENT

No ethics approval was required for this paper.

ORCID

Peter F. Day https://orcid.org/0000-0001-9711-9638
Marie Therese Flores https://orcid.org/0000-0003-2412-190X
Anne C. O'Connell https://orcid.org/0000-0002-1495-3983
Paul V. Abbott https://orcid.org/0000-0001-5727-4211
Georgios Tsilingaridis https://orcid.org/0000-0001-5361-5840
Ashraf F. Fouad https://orcid.org/0000-0001-6368-1665
Nestor Cohenca https://orcid.org/0000-0002-0603-5437
Eva Lauridsen https://orcid.org/0000-0003-0859-7262
Cecilia Bourguignon https://orcid.org/0000-0003-2753-649X
Bill Kahler https://orcid.org/0000-0002-4181-3871
Liran Levin https://orcid.org/0000-0002-8123-7936

REFERENCES

1. Sleet DA. The global challenge of child injury prevention. Int J Environ Res Public Health. 2018;15(9):1921.
2. Petersson EE, Andersson L, Sorensen S. Traumatic oral vs non-oral injuries. Swed Dent J. 1997;21:55–68.
3. Petti S, Glendor U, Andersson L. World traumatic dental injury prevalence and incidence, a meta-analysis-One billion living people have had traumatic dental injuries. Dent Traumatol. 2018;34:71–86.
4. Glendor U. Epidemiology of traumatic dental injuries - a 12 year review of the literature. Dent Traumatol. 2008;24:603–11.
5. Andersson L, Petti S, Day P, Kenny K, Glendor U, Andreasen JO. Classification, epidemiology and etiology. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth, 5th edn. Copenhagen: Wiley Blackwell; 2019. p. 252–94.
6. Glendor U, Halling A, Andersson L, Eilert-Petersson E. Incidence of traumatic tooth injuries in children and adolescents in the county of Vastmanland, Sweden. Swed Dent J. 1996;20:15–28.
7. Andreasen JO, Ravn JJ. Epidemiology of traumatic dental injuries to primary and permanent teeth in a Danish population sample. Int J Oral Surg. 1972;1:235–9.
8. Borum MK, Andreasen JO. Sequelae of trauma to primary maxillary incisors. I. Complications in the primary dentition. Endod Dent Traumatol. 1998;14:31–44.
9. Kupietzky A, Holan G. Treatment of crown fractures with pulp exposure in primary incisors. Pediatr Dent. 2003;25:241–7.
10. Holan G, Ram D. Sequelae and prognosis of intruded primary incisors: a retrospective study. Pediatr Dent. 1999;21:242–7.
11. Assuncao LR, Ferelle A, Iwakura ML, Nascimento LS, Cunha RF. Luxation injuries in primary teeth: a retrospective study in children assisted at an emergency service. Braz Oral Res. 2011;25:150–6.
12. Qassem A, Martins NM, da Costa VP, Torriani DD, Pappen FG. Long-term clinical and radiographic follow up of subluxated and intruded maxillary primary anterior teeth. Dent Traumatol. 2015;31:57–61.
13. Tannure PN, Fidalgo TK, Barcelos R, Primo LG, Maia LC. Analysis of root canal treated primary incisor after trauma: two year outcomes. J Clin Pediat Dent. 2012;36:257–62.
14. Cardoso M, Rocha MJ. Federal University of Santa Catarina follow-up management routine for traumatized primary teeth - Part 1. Dent Traumatol. 2004;20:307–13.
15. Soporowski NJ, Allred EN, Needleman HL. Luxation injuries of primary anterior teeth–prognosis and related correlates. Pediatr Dent. 1994;16:96–101.
16. Andreasen JOAF, Bakland LK, Flores MT. Traumatic dental injuries, a manual, 3rd edn. Chichester, UK: Wiley-Blackwell; 2011.
17. Andreasen FM, Andreasen JO, Tsukiboshi M, Cohenca N. Examination and diagnosis of dental injuries. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth, 5th edn. Copenhagen, Denmark: Wiley Blackwell; 2019. p. 295–326.
18. Flores MT, Holan G, Andreasen JO, Lauridsen E. Injuries to the primary dentition. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth, 5th edn. Copenhagen, Denmark: Wiley Blackwell; 2019. p. 556–88.
19. World Medical Association. Declaration of Ottawa on Child Health. 2009; https://www.wma.net/policies-post/wma-declaration-of-ottawa-on-child-health/. Accessed June 4, 2020.
20. Day PF, Duggal MS. A multicentre investigation into the role of structured histories for patients with tooth avulsion at their initial visit to a dental hospital. Dent Traumatol. 2003;19:243–7.
21. Day PF, Duggal MS. The role for 'reminders' in dental traumatology: 1. Current practices in the UK and Ireland. Dent Traumatol. 2006;22:247–51.
22. Andreasen JO. Appendix 1 and 2. In: Andreasen JO, Andreasen FM, Andersson L, eds. Textbook and color atlas of traumatic injuries to the teeth, 5th edn. Copenhagen, Denmark: Wiley Blackwell, 2019; p. 1020–3.
23. Andersson L, Andreasen JO. Soft tissue injuries. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth, 5th edn. Copenhagen, Denmark: Wiley Blackwell; 2019. p. 626–44.
24. Soares TR, Barbosa AC, Oliveira SN, Oliveira EM, Risso Pde A, Maia LC. Prevalence of soft tissue injuries in pediatric patients and its relationship with the quest for treatment. Dent Traumatol. 2016;32:48–51.
25. Lauridsen E, Blanche P, Amaloo C, Andreasen JO. The risk of healing complications in primary teeth with concussion or subluxation injury - a retrospective cohort study. Dent Traumatol. 2017;33:337–44.
26. Lauridsen E, Blanche P, Yousaf N, Andreasen JO. The risk of healing complications in primary teeth with intrusive luxation: A retrospective cohort study. Dent Traumatol. 2017;33:329–36.
27. Lauridsen E, Blanche P, Yousaf N, Andreasen JO. The risk of healing complications in primary teeth with extrusive or lateral luxation - A retrospective cohort study. Dent Traumatol. 2017;33:307–16.

28. Auslander WP. Discoloration, a traumatic sequela. NY State Dent J. 1967;33:534–8.
29. Jacobsen I, Sangnes G. Traumatized primary anterior teeth. Prognosis related to calcific reactions in the pulp cavity. Acta Odontol Scand. 1978;36:199–204.
30. Fried I, Erickson P, Schwartz S, Keenan K. Subluxation injuries of maxillary primary anterior teeth: epidemiology and prognosis of 207 traumatized teeth. Pediatr Dent. 1996;18:145–51.
31. Holan G, Fuks AB. The diagnostic value of coronal dark-gray discoloration in primary teeth following traumatic injuries. Pediatr Dent. 1996;18:224–7.
32. Holan G. Development of clinical and radiographic signs associated with dark discolored primary incisors following traumatic injuries: a prospective controlled study. Dent Traumatol. 2004;20:276–87.
33. Holan G. Long-term effect of different treatment modalities for traumatized primary incisors presenting dark coronal discoloration with no other signs of injury. Dent Traumatol. 2006;22:14–7.
34. Law CS, Douglass JM, Farman AG, White SC, Zeller GG, Lurie AG, et al. The image gently in dentistry campaign: partnering with parents to promote the responsible use of x-rays in pediatric dentistry. Pediatr Dent. 2014;36:458–9.
35. White SC, Scarfe WC, Schulze RK, Lurie AG, Douglass JM, Farman AG. The Image Gently in Dentistry campaign: promotion of responsible use of maxillofacial radiology in dentistry for children. Oral Surg Oral Med Oral Pathol Oral Radiol. 2014;118:257–61.
36. Sodhi KS, Krishna S, Saxena AK, Sinha A, Khandelwal N, Lee EY. Clinical application of 'Justification' and 'Optimization' principle of ALARA in pediatric CT imaging: "How many children can be protected from unnecessary radiation?". Eur J Radiol. 2015;84:1752–7.
37. Andreasen JO, Flores MT, Lauridsen E. Injuries to developing teeth. In: Andreasen JO, Andreasen FM, Andersson L, editors. Textbook and color atlas of traumatic injuries to the teeth, 5th edn. Copenhagen, Denmark: Wiley Blackwell; 2019. p. 589–625.
38. Andreasen JO, Ravn JJ. The effect of traumatic injuries to primary teeth on their permanent successors. II. A clinical and radiographic follow-up study of 213 teeth. Scand J Dent Res. 1971;79:284–94.
39. Da Silva Assuncao LR, Ferelle A, Iwakura ML, Cunha RF. Effects on permanent teeth after luxation injuries to the primary predecessors: a study in children assisted at an emergency service. Dent Traumatol. 2009;25:165–70.
40. Flores MT, Onetto JE. How does orofacial trauma in children affect the developing dentition? Long-term treatment and associated complications. Dent Traumatol. 2019;35:312–23.
41. Lenzi MM, da Silva Fidalgo TK, Luiz RR, Maia LC. Trauma in primary teeth and its effect on the development of permanent successors: a controlled study. Acta Odontol Scand. 2018;22:1–6.
42. Lenzi MM, Alexandria AK, Ferreira DM, Maia LC. Does trauma in the primary dentition cause sequelae in permanent successors? A systematic review. Dent Traumatol. 2015;31:79–88.
43. Altun C, Cehreli ZC, Güven G, Acikel C. Traumatic intrusion of primary teeth and its effects on the permanent successors: a clinical follow-up study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009;107:493–8.
44. Spinas E, Melis A, Savasta A. Therapeutic approach to intrusive luxation injuries in primary dentition. A clinical follow-up study. Eur J Paed Dent. 2006;7:179–86.
45. Colak I, Markovic D, Petrovic B, Peric T, Milenkovic A. A retrospective study of intrusive injuries in primary dentition. Dent Traumatol. 2009;25:605–10.
46. Flores MT. Traumatic injuries in the primary dentition. Dent Traumatol. 2002;18:287–98.
47. Cunha RF, Pugliesi DM, Percinoto C. Treatment of traumatized primary teeth: a conservative approach. Dent Traumatol. 2007;23:360–3.
48. Martens LC, Rajasekharan S, Jacquet W, Vandenbulcke JD, Van Acker JWG, Cauwels RGEC. Paediatric dental emergencies: a retrospective study and a proposal for definition and guidelines including pain management. Eur Arch Paediat Dent. 2018;19:245–53.
49. Whiston C, Ali S, Wright B, Wonnacott D, Stang AS, Thompson GC, et al. Is caregiver refusal of analgesics a barrier to pediatric emergency pain management? A cross-sectional study in two Canadian centres. CJEM. 2018;20:892–902.
50. Roberts JF, Curzon ME, Koch G, Martens LC. Review: behaviour management techniques in paediatric dentistry. Eur Arch Paediat Dent. 2010;11:166–74.
51. American Academy of Pediatric Dentistry. Behaviour guidance for the pediatric dental patient. Pediatr Dent. 2015;40:254–67.
52. Ali S, McGrath T, Drendel AL. An evidence-based approach to minimizing acute procedural pain in the emergency department and beyond. Pediatr Emerg Care. 2016;32:36–42.
53. Pancekauskaite G, Jankauskaite L. Paediatric pain medicine: pain differences, recognition and coping acute procedural pain in paediatric emergency room. Medicina. 2018;54(6):94.
54. De Young AC, Kenardy JA, Cobham VE. Trauma in early childhood: a neglected population. Clin Child Fam Psychol Rev. 2011;14:231–50.
55. Stoddard FJ Jr. Outcomes of traumatic exposure. Child Adolesc Psychiatr Clin N Am. 2014;23:243–56.
56. Tickle M, Jones C, Buchannan K, Milsom KM, Blinkhorn AS, Humphris GM. A prospective study of dental anxiety in a cohort of children followed from 5 to 9 years of age. Int J Paediatr Dent. 2009;19:225–32.
57. Milsom KM, Tickle M, Humphris GM, Blinkhorn AS. The relationship between anxiety and dental treatment experience in 5-year-old children. Br Dent J. 2003;194:503–6.
58. Soares FC, Lima RA, de Barros MVG, Dahllöf G, Colares V. Development of dental anxiety in schoolchildren: a 2-year prospective study. Community Dent Oral Epidemiol. 2017;45:281–8.
59. Holan G, Needleman HL. Premature loss of primary anterior teeth due to trauma–potential short- and long-term sequelae. Dent Traumatol. 2014;30:100–6.
60. Holan G, Topf J, Fuks AB. Effect of root canal infection and treatment of traumatized primary incisors on their permanent successors. Dent Traumatol. 1992;8:12–5.
61. Akin A, Uysal S, Cehreli ZC. Segmental alveolar process fracture involving primary incisors: treatment and 24-month follow up. Dent Traumatol. 2011;27:63–6.
62. Cho WC, Nam OH, Kim MS, Lee HS, Choi SC. A retrospective study of traumatic dental injuries in primary dentition: treatment outcomes of splinting. Acta Odontol Scand. 2018;76:253–6.
63. Tewari N, Mathur VP, Singh N, Singh S, Pandey RK. Long-term effects of traumatic dental injuries of primary dentition on permanent successors: a retrospective study of 596 teeth. Dent Traumatol. 2018;34:129–34.
64. de Amorim LF, da Costa LR, Estrela C. Retrospective study of traumatic dental injuries in primary teeth in a Brazilian specialized pediatric practice. Dent Traumatol. 2011;27:368–73.
65. Kenny KP, Day PF, Sharif MO, Parashos P, Lauridsen E, Feldens CA. What are the important outcomes in traumatic dental injuries? An international approach to the development of a core outcome set. Dent Traumatol. 2018;34:4–11.
66. Sharif MO, Tejani-Sharif A, Kenny K, Day PF. A systematic review of outcome measures used in clinical trials of treatment interventions following traumatic dental injuries. Dent Traumatol. 2015;31:422–8.
67. Levin L, Day PF, Hicks L, O'Connell AC, Fouad AF, Bourguigon C, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: General Introduction. Dent Traumatol. 2020;36:309–13.

How to cite this article: Day P, Flores MT, O'Connell A, et al. International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 3. Injuries in the primary dentition. *Dent Traumatol.* 2020;36:343–359. https://doi.org/10.1111/edt.12576