

# International Association of Dental Traumatology Guidelines for the Management of Traumatic Dental Injuries: 2. Avulsion of Permanent Teeth

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## 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 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. (Dental Traumatology 2020;36(4):331-342; doi: 10.1111/edt.12573) Received May 19, 2020 | Accepted May 19 2020.*

KEYWORDS: AVULSION, LUXATION, PREVENTION, TOOTH FRACTURE, TRAUMA

## 1 | INTRODUCTION

Avulsion of permanent teeth is seen in 0.5%–16% of all dental injuries.<sup>1,2</sup> 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.<sup>3-17</sup> 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.<sup>18</sup>

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

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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 longterm 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.<sup>19-21</sup>

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.<sup>21,22-27</sup> 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.<sup>28,29</sup>
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.<sup>28,29</sup>

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-dental-trauma.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.<sup>30,31</sup> 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 vaso-constrictor.
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<sup>32</sup> 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

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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.<sup>33</sup> 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.<sup>34,35</sup> (see: "Antibiotics")
10. Check tetanus status.<sup>36</sup> (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.<sup>37</sup>
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.<sup>32</sup> 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").<sup>38,39</sup>
13. Administer systemic antibiotics.<sup>34,35</sup> (see: "Antibiotics")
14. Check tetanus status.<sup>36</sup> (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<sup>40</sup> using a passive flexible wire of a diameter up to 0.016" or 0.4 mm.<sup>32</sup> 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.<sup>34,35</sup> (see: "Antibiotics")
11. Check tetanus status.<sup>36</sup> (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.<sup>41</sup> 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<sup>41-46</sup> 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.<sup>32</sup> Short immature teeth may require a longer splinting time.<sup>47</sup> 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

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children. If spontaneous revascularization does not occur, apexification, pulp revitalization/ revascularization,<sup>48,49</sup> or root canal treatment should be initiated as soon as pulp necrosis and infection is identified (refer to Endodontic Considerations).

9. Administer systemic antibiotics.<sup>34,35</sup> (see: "Antibiotics")
10. Check tetanus status.<sup>36</sup> (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.<sup>32</sup> 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,<sup>48,49</sup> or root canal treatment should be initiated as soon as pulp necrosis and infection is identified (refer to Endodontic Considerations).
11. Administer systemic antibiotics.<sup>34,35</sup> (see: "Antibiotics")
12. Check tetanus status.<sup>36</sup> (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.<sup>32</sup> 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.<sup>34,35</sup> (see: "Antibiotics")
12. Check tetanus status.<sup>36</sup> (see: "Tetanus")
13. Provide post-operative instructions. (see: "Post-operative instructions")
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Delayed replantation has a poor long-term prognosis.<sup>41</sup> 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 extraoral 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<sup>41-46</sup> 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.<sup>50-55</sup> 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, infra-orbital 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.<sup>51,52</sup>

## 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

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root resorption.<sup>34,35</sup> 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.<sup>35</sup> 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.<sup>36</sup>

## 6 | TOPICAL ANTIBIOTICS

The effect of topical antibiotics placed on the root surface prior to replantation with respect to pulp revascularization remains controversial.<sup>8,57,58</sup> While animal studies have shown great potential,<sup>59-61</sup> human studies have failed to demonstrate improved pulp revascularization when teeth are soaked in topical antibiotics.<sup>62</sup> 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.<sup>36,63,64</sup> 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.<sup>32,47,65-72</sup> 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,<sup>66</sup> achieved with stainless steel wire up to a diameter of 0.016" or 0.4 mm<sup>32</sup> 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.<sup>69</sup> However, the likelihood of successful periodontal healing after replantation is not likely to be affected by splinting duration.<sup>47</sup>

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.<sup>72</sup> 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.<sup>2,24,25,27,29</sup> 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.<sup>65</sup>
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),<sup>17,73-81</sup> treatments should be initiated within 2 weeks postreplantation. 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.<sup>82,83</sup> 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.<sup>76,78,84</sup> 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.<sup>77</sup>

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.<sup>2,6-9,25,26,85</sup> 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.<sup>2,6-9,25,26,85</sup>

### 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.

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### 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.<sup>86</sup>

### 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.<sup>41,45</sup> 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.<sup>87</sup> 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.<sup>88</sup> 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.<sup>87</sup>

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)<sup>89</sup> and the European Society of Endodontology (ESE).<sup>90</sup>
- 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.

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