



Splinting of Traumatized Teeth with Focus on Adhesive Techniques

Thomas von Arx, DMD, PD, DrMedDent

Abstract

Splinting of traumatized teeth is an important step in the treatment of periodontally injured teeth and a precondition of healing of the periodontal tissues. Although it has been shown in animal experiments that replanted teeth without splinting showed analogous healing outcomes compared to splinted teeth, the placement of a splint in dental trauma situations is warranted for medico-legal reasons, for the comfort of the patient, and for the avoidance of additional trauma during periodontal healing. Ideally, the splinting of traumatized teeth should be an easy and fast procedure for the dentist. Trauma splints should be comfortable and easy to keep clean for the patient. The splint should allow some physiologic mobility to promote healing of the periodontal tissues. The widely used and recommended wire-composite splint, with material variations, meets the ideal requirements of current splinting concepts in dental traumatology. Times of using destructive tissue-coverage splints are definitely gone. They are too rigid, compromise periodontal and gingival healing, and are uncomfortable to the patient. The objective of this article is to present the current concepts in splinting of traumatized teeth. The given recommendations about splinting techniques and splinting periods are based on experimental and clinical studies.

Dental trauma represents one of the few situations where dentists are called upon to make unscheduled diagnostic and treatment decisions in an area that is outside their routine experience.¹ Dental trauma includes injuries to the dental hard tissues, injuries to the periodontal tissues, or combinations of such injuries. While injuries to the dental hard tissues normally do not require tooth stabilization during treatment, tooth fixation is often indispensable in cases with injuries to the periodontal tissues.

Clinically, injuries to the periodontal tissues may be characterized by altered tooth mobility, tooth displacement, and bleeding from the sulcus. The current classification of injuries to the periodontal tissues includes concussion, subluxation (“traumatic loosening”), extrusive luxation, lateral luxation, intrusive luxation, and avulsion.²

Histologically, injuries to the periodontal tissues involve the root cementum, the periodontal ligament, and the alveolar bone. With regard to the periodontal ligament, stabilization is required whenever the tooth or the



Author / Thomas von Arx, DMD, PD, DrMedDent, is with the Department of Oral Surgery and Stomatology School of Dental Medicine, University of Berne, Switzerland.

tooth fragment (in root fractures) has been traumatically displaced. An avulsed and replanted tooth is also subject for stabilization using trauma splints. In addition, traumatically loosened teeth may be stabilized when they are highly mobile, or for the comfort of the patient.

A dental trauma splint is defined as a device or compound used to support, protect, or immobilize teeth that have been loosened, replanted, or fractured.

Objective and Rationale of Splinting

The main objective of splinting a traumatically loosened or displaced tooth is to protect the attachment apparatus in order to allow repair or regeneration of the periodontal fibers.³ Although it has been shown in animal experiments that nonstabilized teeth healed equally well or better compared to splinted teeth, the application of a splint is reasoned as follows:⁴⁻⁶

Medico-legal aspects. A severely loosened tooth without stabilization may be swallowed, aspirated, or knocked out accidentally.

PDL protection. Additional damage to the injured periodontal tissues must be avoided under all circumstances during the healing period; therefore, splint placement is warranted to reduce the risk of further damage to the periodontal ligament.

Patient comfort. Immediate masticatory function is readily achieved following splinting, and patients feel safer than without tooth stabilization.

The current requirements of dental trauma splints include the following:

Intraoral application. In order to speed up tooth stabilization and treatment time, the splint should be applied directly intraorally without additional impression taking for laboratory procedures.

Placement and removal. The splinting technique should not be a complex procedure in view of the emergency situation and the young trauma



Figure 1a. A rigid arch-bar splint that destroys the gingival tissues by direct pressure and accumulation of bacteriae.



Figure 1b. The arch-bar splint was removed and exchanged for a correctly placed titanium trauma splint.



Figure 1c. Three days later, the tissues have markedly recovered.



Figure 1d. The healed tissues eight months after replantation of the left central incisor.

patient. In addition, the working field is often compromised with bleeding and lacerated tissues.

Tooth stabilization. The tooth must be adequately stabilized throughout the required splinting period, and untimely splint loss should be avoided.

Tooth physiology. Physiologic tooth mobility should be preserved following splint placement to allow for functional repair or regeneration of the periodontal fibers; semi-rigid or flexible splints are preferred to rigid splints to avoid dentoalveolar ankylosis.⁷

Occlusion. The splint should not interfere with jaw movements and occlusion.

Oral hygiene. The splint should allow proper oral hygiene. The splint should not be placed too close to the gingival tissues, thereby avoiding accumulation of debris and plaque in the sulcus^{8,9} (Figure 1).

Endodontic access. The splint must allow access to the pulpal tissues once an endodontic treatment is indicated.

Splinting Techniques

Many different splinting techniques have been described in dental trauma articles. Since the introduction of enamel etching with phosphoric acid in 1955 by Buonocore, the majority of published studies have recommended the use of this adhesive technique in combination with resin and/or composite materials.¹⁰ In general, this is a simple and fast procedure with materials readily available in the dental office. However, the acid-etch technique cannot be used in teeth having large restorations or artificial crowns. Yet, this is a rare finding in anterior maxillary teeth, particularly in children and adolescents. At the time of splint removal, residual composite resin is removed with a fluted, carbide finishing bur or with a fine diamond bur. Composite remnants are removed with abrasive or polishing disks. In some situations, this procedure may be postponed in order to avoid disturbance of healing of the gingival and periodontal tissues.

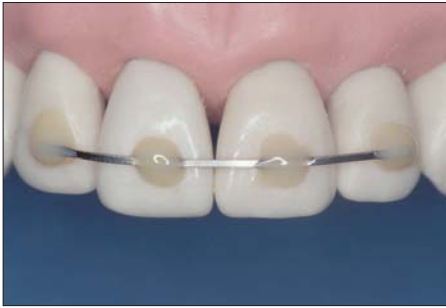


Figure 2a. A wire-composite splint bonded and fixed with the acid-etch technique.



Figure 2b. The occlusal view shows the low profile of this splint.



Figure 3a. This orthodontic splint was made with button brackets. A braided wire was slung around the button brackets, which were reinforced with composite.



Figure 3b. The occlusal view depicts the more voluminous configuration of such a splint.

Wire-composite splint

This technique includes the application of a soft wire that is adapted to the curvature of the dental arch. The wire is fixed to the teeth with adhesive composite¹¹ (Figure 2). Depending on the thickness and the memory effect of the wire, it is important to obtain a fully passive fit in order to avoid any orthodontic forces exerted by the splint. A slight modification is the use of orthodontic ligation wire that can be twisted together in multiple strands to provide a thicker wire.¹² Yet, another variation described the application of a thin flexible wire that was twisted around the teeth by means of a palatal loop.⁷ After polymerization, the distal ends of the wire were cut and the palatal part of the loop was removed.

Orthodontic splint

A similar approach comprises the placement of brackets with the adhesive technique¹³ (Figure 3). An orthodontic wire is subsequently bent and ligated to the brackets, or the wire is passed in figure-eight-loops from bracket to bracket.¹⁴ However, this splinting method resulted in more irritation of the lips and increased speech impairment compared to other splinting techniques.¹⁵ With this technique, caution must be exercised not to apply any orthodontic forces to the splinted teeth.¹⁶

TTS splint

A new splinting technique that offers improved comfort and handling to the patient and dentist alike, utilizes a specifically designed trauma splint



Figure 4a. The titanium trauma splint with only small fixation areas defined by the rhombic openings of the splint.



Figure 4b. The occlusal view demonstrates that this splint has a very smooth and low profile.



Figure 5a. In the resin splint, the composite material is used for connecting the teeth as well as for the proper splint fixation.



Figure 5b. The occlusal view depicts the voluminous aspect of the resin splint.

made of titanium (TTS, Medartis AG, Basel, Switzerland)¹⁷ (Figure 4). The splint is fully adaptable by hand and preserves physiologic tooth mobility, but still allows adequate tooth fixation throughout the splinting period. Splint placement and removal is simple due to the small amount of composite required for fixation (spot etching and bonding), and it is particularly effective and easy to use.^{18,19}

Resin splint

A different method of using the adhesive technique is the placement of a full resin splint to the tooth surfaces (Figure 5). This splint fully bridges the interdental spaces, and resulted in less comfort to the patient compared to other splinting techniques.¹⁵ In addition, this method showed markedly decreased tooth mobility compared to a wire-composite splint in an experimental study.²⁰

Kevlar/fiberglass splint

Yet another method using the adhesive technique involves nylon fibers, Kevlar bands or fiberglass to stabilize an injured tooth to noninjured teeth.²¹ The fibers or bands are soaked in resin and placed to the etched tooth surfaces with subsequent polymerization. These splints are esthetically pleasing, and although of light construction, appear to have a low fracture frequency.²¹

Self-etching and bonding material

In contrast to the standard adhesive technique, a method using self-etching bonding material was recently presented.²² Subsequently, a soft stainless-steel ligature wire that was twisted upon itself to make a double strand was fixed with small increments of a light-curing compomer material. The use of a self-etching adhesive bonding agent appeared to make splint application easier and faster elimi-

nating the separate etching and rinsing steps. The authors also claimed that the compomer material is cut away more easily compared to resin-based composites.

Suture splint

Suture splints may be useful as temporary fixations, and in cases in which there are retention problems due to lack of adjacent teeth, such as in primary or mixed dentitions (Figure 6). However, the maximum life of a suture splint is only a few days.⁷ The suture is passed from the labial to the lingual tissues with the thread crossing the incisal edge, thereby preventing the tooth moving from its socket. In addition, a small amount of resin may be placed to assure the retention of the suture.²³

Splinting Times

Clinical healing of the periodontium takes place within the first seven days, and consequently cases with minor supporting tissue injuries should not be immobilized for a period of more than one week.⁷ While it has been shown that prolonged and rigid splinting may lead to adverse effects, such as ankylosis and replacement resorption, there is current agreement in the dental trauma literature that splinting periods should be in accordance to the clinical and radiographic findings.^{24,25} Since the periodontal ligament reaches its normal strength seven to 14 days following trauma, there are only few situations that merit longer splinting periods. Such situations include damage to the den-toalveolar bone, as may be present in intrusive or lateral luxation injuries with crushing of alveolar bone, and in cases with a fractured labial bone plate.

The International Association of Dental Traumatology has presented a series of articles about guidelines for the evaluation and management of traumatic dental injuries.^{26,27} The suggested splinting times for luxated permanent teeth are as follows:



Figure 6a. The left central maxillary incisor was traumatically displaced in a lateral direction.



Figure 6b. A temporary splint suture was placed for tooth fixation since no adjacent teeth were present.



Figure 6c. After impression taking, a vacuum-formed removable splint was inserted.

Concussion/subluxation. A flexible splint — optional — can be used for the comfort of the patient for seven to 10 days, or according to trauma diagnoses of adjacent teeth.

Extrusion. Stabilize the tooth with a splint for up to three weeks.

Lateral luxation. Stabilize the tooth with a splint for up to three weeks. In case of marginal bone breakdown, usually observed radiographically after three weeks, add three to four weeks extra splinting time.

Intrusion. No splinting times were given following orthodontic or surgical repositioning; the author suggests at least three to four weeks of splinting time following surgical repositioning.

Avulsion. Apply a flexible splint for one week.

Experimental Studies on Splinting

Two *in vitro* studies analyzed the flexibility of various splinting methods.^{28,29} The flexible wire-composite splint proved to allow greater vertical flexibility than the other splints tested and providing adequate horizontal support. In contrast, Kevlar and fiber splints might not give sufficient lateral support, whereas a rigid wire-composite splint (with the composite extended along the entire length of the wire) exhibited the lowest horizontal and vertical mobility measurements.

Another study measured the forces

originating from orthodontic appliances for splinting of teeth.¹⁶ The results demonstrated that square or round stainless-steel or cobalt-chromium wires exerted lower forces compared to rectangular or nickel-titanium wires. The study also showed that the construction of a truly neutral arch was difficult, and therefore the authors concluded that only dentists experienced in the handling of orthodontic appliances should use such materials for dental trauma splints.

Several experimental studies evaluating the effect of splinting upon periodontal healing following extraction and replantation were conducted in animals.^{4,6,25,30} A consistent histologic finding was that teeth without splinting or with a short splinting period of only one week demonstrated normal periodontal healing to a higher degree compared to teeth with extended splinting periods.

Four different splinting methods were evaluated in an experimental study in 10 volunteers comparing a new dental trauma splint to a wire-composite splint, bracket splint and resin splint.^{15,20} All tested splints appeared to maintain physiologic vertical and horizontal tooth mobility. However, the latter was critically reduced in resin splints. Bracket splints lead to a significantly higher irritation of the lips and the gingiva, and greater impairment of speech compared to the other tested splints.

Clinical Studies on Splinting

Oikarinen and coworkers evaluated 172 periodontally injured teeth with a mean follow up of 22 months.³¹ They reported that the duration of immobilization was a more decisive factor for the occurrence of external replacement resorption than the stage of root formation or the type of injury.

In a large sample of 637 luxated teeth, the placement of orthodontic band and acrylic splints significantly increased the occurrence of pulp canal obliteration compared to acid-etch and composite fixation.³²

Ebeleseder and coworkers demonstrated that a semi-rigid splint did not reduce lateral tooth mobility to a level below the mobility of the firmest tooth within the splint, thereby decreasing mobility of a traumatized, splinted tooth to within normal ranges, and that there was no benefit in extending the splint to more than one adjacent firm tooth.³³

In a study comprising 84 reimplanted teeth with a minimum follow-up period of two years, significantly more replacement resorption was observed when teeth were splinted for periods longer than 10 days.³⁴ It was concluded that ankylosis might be minimized by limiting splinting to 10 days or less.

In a much larger study sample of 400 reimplanted avulsed permanent incisors, splinting periods of six weeks or longer resulted in a lower frequency

of periodontal healing compared to shorter splinting periods.³⁵

Clair and coworkers analyzed the reliability of a wire-mesh splinting technique in combination with enamel etching and bonding in 207 patients.³⁶ A complete, premature loss of the splint was only observed in 2.2 percent of the treated cases, while a partial loosening of the splint was seen in 6.1 percent. In all instances, splint refixation was accomplished without interruption of the splinting treatment period.

In a retrospective study evaluating 400 intra-alveolar root fractures, Andreasen and coworkers reported that a certain flexibility of the splint and possibly also a nontraumatogenic splint application favored healing following intra-alveolar root fractures.³⁷ No beneficial effect of splinting periods greater than four weeks could be demonstrated.

A similar conclusion was drawn in another retrospective study about the outcomes for root fractured permanent incisors.³⁸ The authors suggested the use of a functional splint for two to three weeks that allowed physiological movement as an option for root fractured teeth. This would also simplify trauma teaching because the only scenario that would then require a rigid splint would be the dentoalveolar fracture.

Conclusions

When applying a dental splint to stabilize traumatized, repositioned or replanted teeth, three important aspects must be kept in mind by the practitioner:³⁷

- Avoid additional trauma during splint application.

- Prevent bacterial invasion into the healing periodontal ligament by correctly placing the splint and allowing oral hygiene.

- Avoid complete immobilization of the splinted teeth.

The presented acid-etch techniques appear to fulfil the current requirements

of dental trauma splints, and can be recommended for stabilization of traumatized teeth.

CDA

References / 1. Barrett EJ, Kenny DJ, Avulsed permanent teeth: a review of the literature and treatment guidelines. *Endod Dent Traumatol* 13:153-63, 1997.

2. Andreasen JO, Andreasen FM, Classification, etiology and epidemiology of traumatic dental injuries. In: Andreasen JO, Andreasen FM. *Textbook and Color Atlas of Traumatic Injuries to the Teeth*. 3rd ed Copenhagen: Munksgaard Publishers, pp 151-77, 1993.

3. Kehoe JC, Splinting and replantation after traumatic avulsion. *J Am Dent Assoc* 112:224-30, 1986.

4. Andreasen JO, The effect of splinting upon periodontal healing after replantation of permanent incisors in monkeys. *Acta Odont Scand* 33:313-23, 1975.

5. Kristerson L, Andreasen JO, The effect of splinting upon periodontal and pulpal healing after autotransplantation of mature and immature permanent incisors in monkeys. *Int J Oral Surg* 12:239-49, 1983.

6. Mandel U, Viidik A, Effect of splinting on the mechanical and histological properties of the healing periodontal ligament in the vervet monkey. *Archs Oral Biol* 34:209-17, 1989.

7. Oikarinen KS, Tooth splinting: a review of the literature and consideration of the versatility of a wire-composite splint. *Endod Dent Traumatol* 6:237-50, 1990.

8. Lello JL, Lello GE, The effect of interdental continuous loop wire splinting and intermaxillary fixation on the marginal gingiva. *Int J Oral Maxillofac Surg* 17:249-52, 1988.

9. Oikarinen KS, Nieminen TM, Influence of arch bar splinting on periodontium and mobility of fixed teeth. *Acta Odontol Scand* 52:203-8, 1994.

10. Buonocore MG, Simple method of increasing the adhesion of acrylic filling materials to enamel surface. *J Dent Res* 34:849-51, 1955.

11. Brown CL, Mackie IC, Splinting of traumatized teeth in children. *Dent Update* 30:78-82, 2003.

12. Croll TP, Bonded composite resin/ligature wire splint for stabilization of traumatically displaced teeth. *Quintessence Int* 22:17-21, 1991.

13. Dawoodbhoy I, Valiathan A, et al, Splinting of avulsed central incisors with orthodontic wires: a case report. *Endod Dent Traumatol* 10:149-52, 1995.

14. Gigon S, Peron JM, Semi-rigid bracket splinting of teeth after traumatic luxation (in French). *Rev Stomatol Chir Maxillofac* 101:272-5, 2000.

15. Filippi A, von Arx T, et al, Comfort and discomfort of dental trauma splints – a comparison of a new device (TTS) with three commonly used splinting techniques. *Dent Traumatol* 18:275-80, 2002.

16. Prevost J, Louis JP, et al, A study of forces originating from orthodontic appliances for splinting of teeth. *Endod Dent Traumatol* 10:179-84, 1994.

17. von Arx T, Filippi A et al, Splinting of traumatized teeth with a new device: TTS (titanium trauma splint). *Dent Traumatol* 17:180-4, 2001.

18. Ingimarsson S, von Arx T, A new splinting technique in dental traumatology (in German). *Schweiz Monatsschr Zahnmed* 112:1263-70, 2002.

19. Trope M, Clinical management of the avulsed tooth: present strategies and future direc-

tions. *Dent Traumatol* 18:1-11, 2002.

20. von Arx T, Filippi A, et al, Comparison of a new dental trauma splint device (TTS) with three commonly used splinting techniques. *Dent Traumatol* 17:266-74, 2001.

21. Andersson L, Friskopp J, et al, Fiber-glass splinting of traumatized teeth. *J Dent Child* 50:21-4, 1983.

22. Croll TP, Helpin ML, Use of self-etching adhesive system and compomer for splinting traumatized incisors. *Pediatr Dent* 24:53-6, 2002.

23. Gupta S, Sharma A, et al, Suture splint: an alternative for luxation injuries of teeth in pediatric patients - a case report. *J Clin Pediatr Dent* 22:19-21, 1997.

24. Andreasen JO, A time-related study of periodontal healing and root resorption activity after replantation of mature permanent incisors in monkeys. *Swed Dent J* 4:101-10, 1980.

25. Nasjleti CE, Castelli WA, et al, The effects of different splinting times on replantation of teeth in monkeys. *Oral Surg* 53:557-66, 1982.

26. Flores MT, Andreasen JO, et al, Guidelines for the evaluation and management of traumatic dental injuries. *Dent Traumatol* 17:145-8, 2001.

27. Flores MT, Andreasen JO, et al, Guidelines for the evaluation and management of traumatic dental injuries. *Dent Traumatol* 17:193-8, 2001.

28. Oikarinen KS, Comparison of the flexibility of various splinting methods for tooth fixation. *Int J Oral Maxillofac Surg* 17:125-7, 1988.

29. Oikarinen KS, Andreasen JO, et al, Rigidity of various fixation methods used as dental splints. *Endod Dent Traumatol* 8:113-9, 1992.

30. Berude JA, Hicks L, et al, Resorption after physiological and rigid splinting of replanted permanent incisors in monkeys. *J Endod* 14:592-600, 1988.

31. Oikarinen KS, Gundlach KKH, et al, Late complications of luxation injuries to teeth. *Endod Dent Traumatol* 3:296-303, 1987.

32. Andreasen FM, Pulpal healing after luxation injuries and root fracture in the permanent dentition. *Endod Dent Traumatol* 5:111-31, 1989.

33. Ebeleseder KA, Glockner K, et al, Splints made of wire and composite: an investigation of lateral tooth mobility in vivo. *Endod Dent Traumatol* 11:288-93, 1995.

34. Kinirons MJ, Boyd DH, et al, Inflammatory and replacement resorption in replanted permanent incisor teeth: a study of the characteristics of 84 teeth. *Endod Dent Traumatol* 15:269-72, 1999.

35. Andreasen JO, Borum MK, et al, Replantation of 400 avulsed permanent incisors. 4. Factors related to periodontal ligament healing. *Endod Dent Traumatol* 11:76-89, 1995.

36. Clair M, Schwarze T, et al, Wire-mesh-technique in urgent treatment of dentoalveolar trauma – a prospective examination (in German). *Deutsch Zahnärztl Zeitschr* 57:697-700, 2002.

37. Andreasen JO, Andreasen FM, et al, Healing of 400 intra-alveolar root fractures. 2. Effect of treatment factors such as treatment delay, repositioning, splinting type and period and antibiotics. *Dent Traumatol* 20:203-11, 2004.

38. Welbury RR, Kinirons MJ, et al, Outcomes for root-fractured permanent incisors: a retrospective study. *Pediatr Dent* 24:98-102, 2002.

To request a printed copy of this article, please contact / Thomas von Arx, DMD, PD, DrMedDent, Freiburgstrasse 7, CH-3010 Berne, Switzerland or via e-mail: thomas.vonarx@zmk.unibe.ch