

Original Article

Survival of Avulsed Permanent Incisors in Children Following Delayed Replantation

P Demir, C Guler¹, E Kizilci², G Keskin³

Department of Pediatric Dentistry, Faculty of Dentistry, Inonu University, Malatya, ¹Department of Pediatric Dentistry, Faculty of Dentistry, Ordu University, Ordu, ²Department of Pediatric Dentistry, Faculty of Dentistry, Erciyes University, Kayseri, ³Department of Pediatric Dentistry, Faculty of Dentistry, Gaziantep University, Gaziantep, Turkey

Received:
16-Sep-2019;
Revision:
25-Oct-2019;
Accepted:
17-Dec-2019;
Published:
04-May-2020.

ABSTRACT

Background: Replantation of avulsed teeth is an invasive treatment approach where patient cooperation is required after the risks are explained to the patient or family. Although replantation of an avulsed permanent teeth is an accepted treatment approach, the long-term prognosis of the replanted teeth is still controversial. This report describes the survival of delayed replanted 15 incisors that was stored in unfavorable conditions after avulsion. **Materials and Methods:** Nine patients, aged 8–12 years, were referred to the Inonu University, Pediatric Dentistry Department with traumatically avulsed incisors. The parents were informed about the possible complications of a delayed replantation. **Results:** Forty percent of the teeth were splinted with flexible orthodontic wire and composite. The follow-up periods were varied from 24 to 48 months. The mean follow-up periods were 33.3 ± 8 months. 40% of the teeth were retained in the mouth for at least 3 years and contributed to alveolar bone development. In these cases, the most common complication (9 teeth, 60%) was replacement root resorption. Two of the 15 teeth which had wide open apices, continued to the root development. **Conclusion:** In this study, replanted teeth were retained in the mouth for at least 2 years and contributed to the patient's development. Therefore, this study has shown that delayed replantation of an avulsed tooth for a child is still worthwhile, even in cases of poor prognosis where the tooth had extended extra-alveolar dry storage. We believe that delayed replantation should be done because of its importance for the child's jaw and facial development.

KEYWORDS: *Dentoalveolar ankylosis, root resorption, tooth avulsion, tooth replantation*

INTRODUCTION

Traumatic dental injuries are commonly observed problems in young individuals. An avulsion is a type of serious injury that causes damage to dental and supportive tissues; it is defined as a total displacement of the tooth from its socket. An avulsion commonly involves the central maxillary teeth,^[1,2] which make a major esthetic contribution to the smile. In children who are still growing, it also damages the alveolar bone volume. The most preferable treatment for an avulsed tooth is an immediate replantation. Avulsed teeth can be preserved for a short time in appropriate media such as milk, saline, saliva or Hank's solution,^[3-5] however, this may not always be possible. Prognosis

depends on various factors, but the duration of extraoral storage and the storage medium have been identified as critical factors for functional healing.^[1,6,7] The aim of replantation, even when delayed, is to give back an esthetic look and keep the tooth functionally in place for normal growth of the alveolar ridge.


The long-term prognosis of a replanted tooth is still controversial. Prolonged extraoral time will promote damage to the periodontal ligament and there may be ankylosis-related root resorption (replacement

Address for correspondence: Dr. E Kizilci, Erciyes University, Pediatric Dentistry Department 38000/Melikgazi, Kayseri, Turkey. E-mail: esra_ayhan85@hotmail.com

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Demir P, Guler C, Kizilci E, Keskin G. Survival of avulsed permanent incisors in children following delayed replantation. *Niger J Clin Pract* 2020;23:631-7.

Access this article online	
Quick Response Code: 	Website: www.njcponline.com
	DOI: 10.4103/njcp.njcp_496_19

resorption).^[5,8] Ankylosis following replantation of avulsed permanent incisors may affect the growth of the alveolar ridge, which can cause facial asymmetry. Ankylosis may also affect the eruption and position of the adjacent teeth.^[9-11] However, there are more advantages in replanting an avulsed tooth than disadvantages and complications in young patients. Esthetic and masticatory functions, occlusal development, alveolar ridge preservation, and avoiding malocclusions are some of the advantages.^[12,13]

To avoid the complications of ankylosis, removing the ankylosed tooth before the changes become so pronounced can be a safety precaution in young individuals.^[14] Decoronation and esthetic space maintainers should be used until more definitive treatment is provided. Furthermore, if patients are treated before or during pubertal growth periods, they may have shown healing of vertical bone height and maintenance of the alveolar ridge in the buccopalatal direction.^[15] In recent years, delayed replantation has been recommended because of the excellent long-term results of decoronation, which has been shown to preserve bone volume.^[5,11,14,16-18] The purpose of this case serial study was to report the clinical and radiographic survival of 15 delayed replanted incisors that were stored in unfavorable conditions for at least 24 h before reimplantation.

METHODS

In this case-control study, the population was comprised of 9 patients with 15 avulsed permanent teeth who referred to the Inonu University, Faculty of Dentistry, Department of Pediatric Dentistry, in Malatya, during the period from 2010 to 2014. Standard trauma registration forms were completed for all patients that included social, medical, and dental history. Informed consent was received from all parents. The ethics committee approval was obtained. Clinical data were taken from patient records containing details related to the traumatic dental injury (i.e. type and duration of extraoral storage, splinting duration, and use of systemic antibiotics). Radiographic evaluations were conducted for the diagnosis of concomitant injuries as well as complications such as pulp necrosis, infection-related resorption, and ankylosis-related resorption. Finally, a follow-up period of 24–48 months was an inclusion criterion, unless early complications led to extraction before that time.

Demographic data were comprised age, gender, and apical closure of the root. With respect to etiological factors, the mechanism and cause of injury, the month in which the injury happened, and the injured tooth/

jaw were analyzed. For all replanted teeth, the total extra-alveolar duration and the storage medium were examined [Table 1].

Immediately after the patient's arrival at the clinic, the parents were informed of the possible complications of a delayed replantation and that it was a preferred option to do the replacement. First, the necrotic soft tissue around the teeth was cleaned with gauze and then the necrotic pulps were extracted. The root canal treatment was applied in 5 min extraorally prior to the replantation. These steps were applied to all teeth except two teeth. Two teeth with open apicals were reimplanted directly considering the possibility of pulp vitality.

The teeth were stored in a 2% sodium fluoride (NaF) solution for 20 min after the root canal treatment in accordance with IADT guidelines. Concurrently, clinical and radiographical examinations were conducted and the patient's history was taken including the patient's general health condition, extraoral time for the tooth, and the storage medium of the avulsed tooth. After local anesthesia and before replantation, the socket was irrigated with physiologic saline. There were no fractures in any of the patients and the avulsed teeth were gently replanted. Only two teeth had a wide-open apex and the patient came to our clinic 2 h after the avulsion so the pulp was not extracted and the teeth were directly replanted. All replanted teeth were splinted with flexible orthodontic wire and flowable composite. The splinting period was 4 weeks for all patients. Systemic antibiotic treatment was applied in all cases; the patients were prescribed chlorhexidine gluconate (0.2%) mouth rinse and amoxicillin for 1 week. The patients referred to a physician for an evaluation of the need for a tetanus booster if the avulsed tooth had contacted soil or tetanus coverage was uncertain. Both patients and parents were advised regarding the care of the replanted tooth for optimal healing and prevention of further injury. A soft diet for up to 2 weeks was suggested and they were advised to brush their teeth with a soft toothbrush after each meal.

Patients had weekly follow-up appointments during the first 2 months; monthly during the next 6 months; and once every 3 months thereafter. Every 3 months during the first year, and every 6 months thereafter, periapical radiographs were taken. Clinical examinations were performed for the evaluation of postoperative outcomes.

Factors were analyzed in relation to postoperative outcomes; Chen's classification^[19] was modified and the teeth were divided into the following groups:

Complete success (CS): Vital pulp, no root resorption, no tooth mobility, and no symptoms;

Acceptable success (AS): Necrotic pulp, root canal treatment was performed, mild root resorption without obvious mobility, and the replanted tooth will remain for a relatively long time;

Decoronation or extraction (DC): Necrotic pulp, root canal treatment was performed, root resorption with obvious mobility, decoronation (or extraction) and prosthetics were done.

RESULTS

Patients referred to our clinic in as little as 2 h and up to 3 days (meantime: 35.1 ± 29 h) after their tooth avulsion. The age of patients ranged from 8 to 12 years (mean age: 10.7 ± 1.64 years) and all of the patients were male. Thirteen teeth were stored in dry

gauze after an avulsion, and two were brought in stored in tap water.

The observation periods varied from 24 to 48 months (meantime: 33.3 ± 8 months). Four of the 15 teeth had wide-open apices, but only two of these apices had continued to the root development. The most common complication (9 teeth, 60%) was replacement root resorption. Resorption was found to occur at the latest, 4 years after replantation, but was most frequently observed at the end of 3 years (meantime: 36 ± 10 months). All of the root resorptions related to replacement; infection-related resorption was not seen in any teeth. The coronal discoloration was another complication that was observed in three teeth (20%).

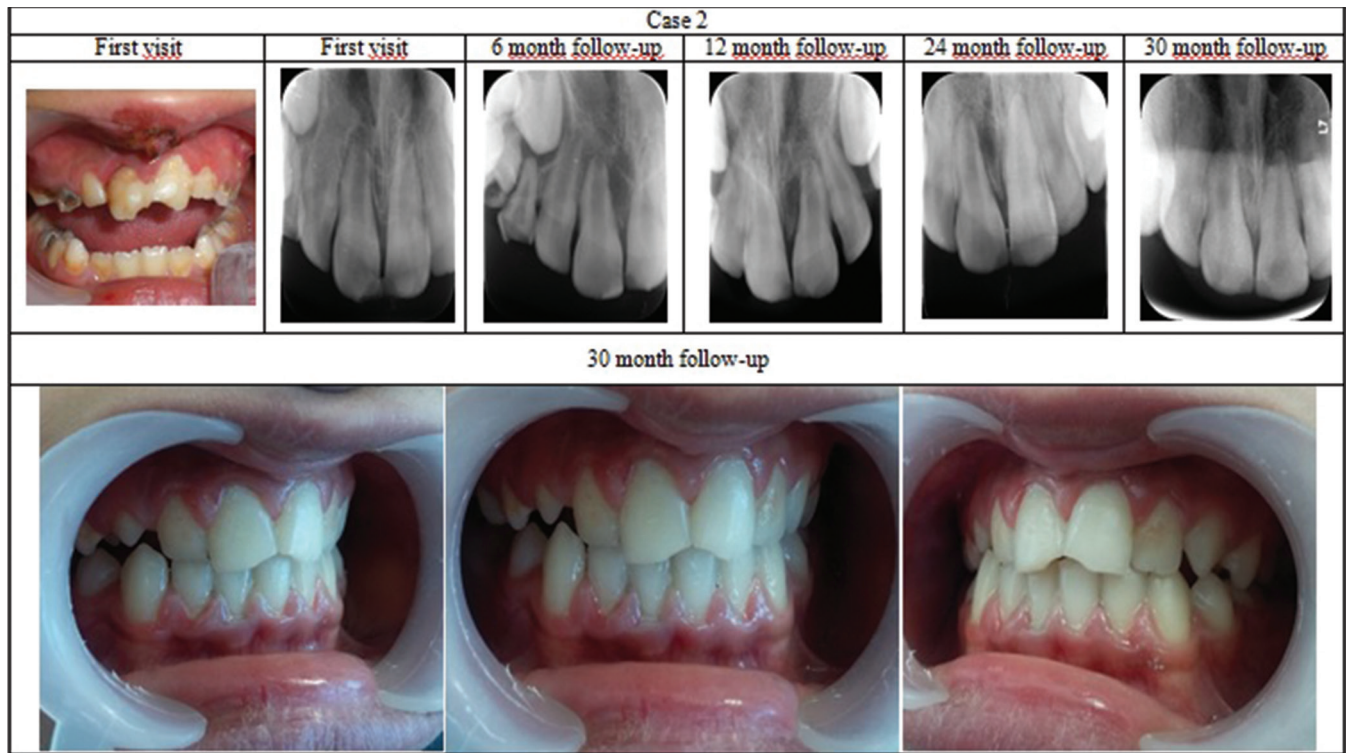


Figure 1: Radiographic and clinical records of case 2

Table 1: Factors that were analyzed

Patient	Age	Tooth	Cause	Month	Extraoral time (hours)	Extraoral storage	Apical closure	Follow-up (months)	Results
1	12	11,21,22	Bicycle	April	72	Dry	Close	18	AS ¹
2	8	11, 21	Collision	December	2	Dry	Open	30	CS ²
3	11	21	Fall	June	2	Dry	Close	24	AS ¹
4	11	11	Fall	January	72	Tap water	Close	36	RR ³ , AS ¹
5	12	11	Bicycle	July	24	Tap water	Close	42	RR ³ , AS ¹
6	12	21	Fall	July	36	Dry	Close	48	RR ³ , DC ⁴
7	8	11, 21	Bicycle	September	24	Dry	Open	36	RR ³ , DC ⁴
8	11	11	Fall	October	24	Dry	Close	36	RR ³ , DC ⁴
9	12	11,21,22	Fall	August	24	Dry	Close	18	RR ³ , DC ⁴

¹AS: Asymptomatic; ²CS: Complete success; ³RR: Replacement Resorption; ⁴DC: Decoronation

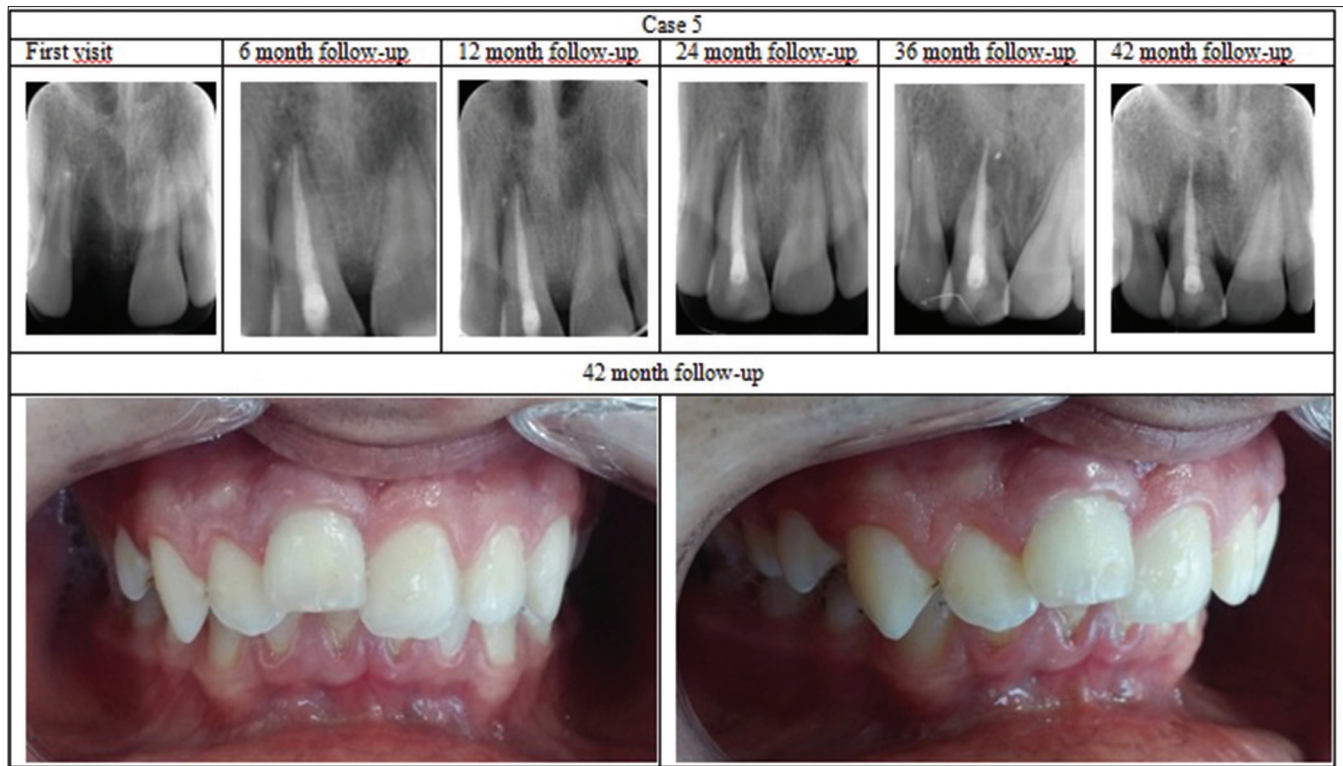


Figure 2: Radiographic and clinical records of case 5

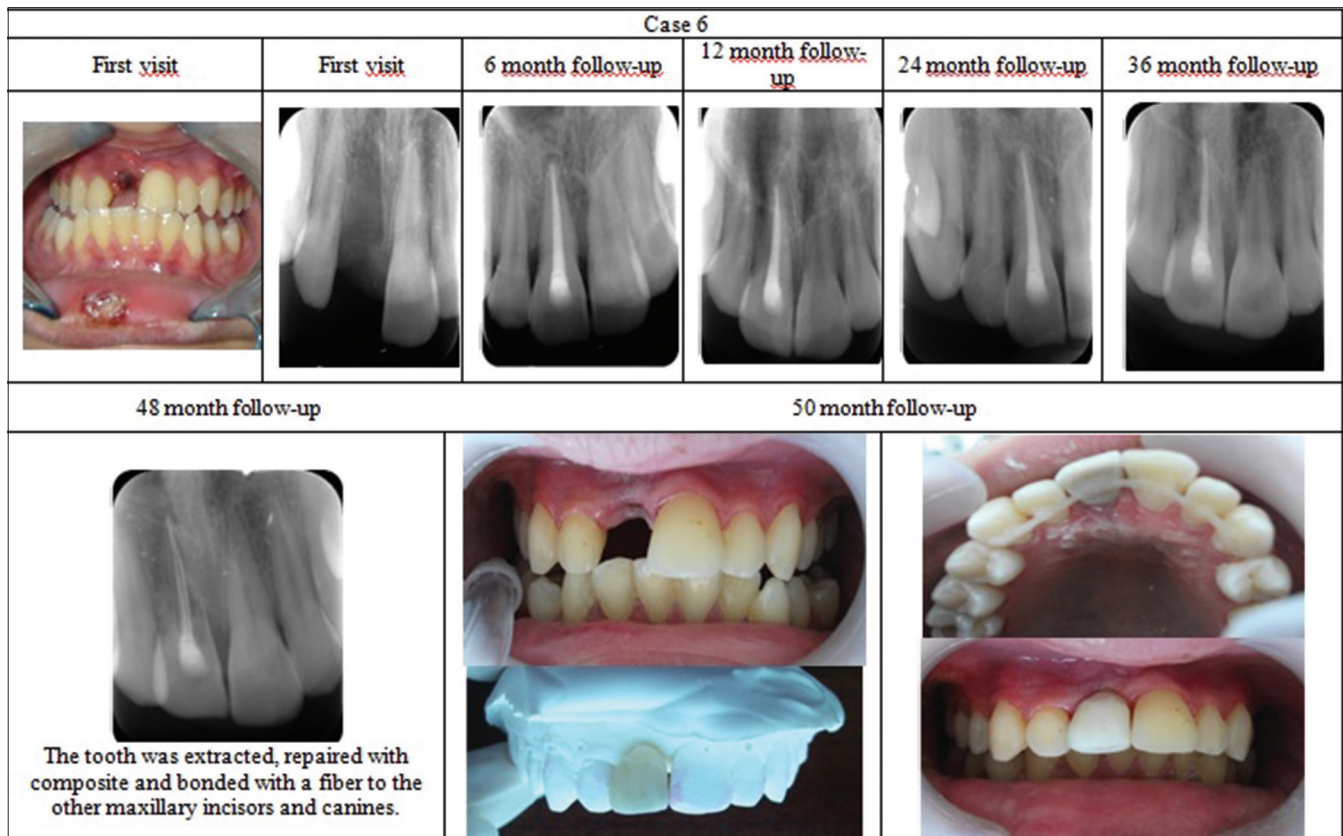


Figure 3: Radiographic and clinical records of case 6

Eight teeth (53.3%) were still in the mouth functionally and their follow-up continued for 24 to 42 months (mean:

31.2 ± 6.9 months). Moreover, two of these (13.3%) were included in the CS group, which indicates they

had a vital pulp and their root development continued for 30 months (Records of case 2 is given in Figure 1). The remaining six teeth (40%) were included in the AS group. Replacement resorption was seen 36 months and 42 months after replantation, but teeth were still clinically asymptomatic and being followed (Records of case 5 is given in Figure 2). In the D group, seven teeth (46.6%) had been decoronated after extreme mobility, which occurred as a result of the replacement root resorption. These teeth maintained functionality for 24–48 months (mean: 36 ± 8.4 months). (Records of case 6 is given in Figure 3). Follow-up procedures were still ongoing every 6 months.

DISCUSSION

The high prevalence of dental injuries and the negative impact on the function and esthetics of affected young patients make dental injuries a severe public health problem.^[20-22] An avulsion is a serious injury that causes damage to the dental pulp and the periodontal ligament,^[23] and the prognosis of the replanted tooth is dependent on the vitality of the periodontal ligament cells.^[24,25] It has been a matter of debate whether an avulsed tooth should be replanted if the extraoral storage conditions of the avulsed tooth were not optimal.^[26] In the absence of the periodontal ligament, and if contamination is under control, the best-predicted outcome would be ankylosis and replacement resorption. This process will progress and lead to a future failure of the replantation. When the periodontal ligament is lost or damaged, the barrier between the root and bone is eliminated, so osteoclasts from the surrounding bone can invade and resorb the root surface.^[27,28] Consistent with other studies, our study also found that delayed replantation causes ankylosis and replacement of the root by the bone.^[5] Tsukiboshi analyzed bone volume with cone-beam computed tomography (CBCT) and reported that the palatal bone volume and shape did not change, even after the root resorption had occurred. Buccal bone is reduced over time, but palatal bone is not reduced to the same extent,^[5] therefore, the replantation has achieved the goal and maintained the alveolar bone volume. In the future, long-term follow-up studies with CBCT should be performed to better understand the alveolar bone morphology and physiology.

Specifically for a delayed replantation, a 2% NaF solution is advised to slow down osseous replacement of the tooth rather than the use of doxycycline.^[23,29] Based on this information, we preferred a 2% NaF solution as described in the IADT guidelines.^[19] This treatment protocol may have contributed to ensuring that replacement resorption did not occur for a long time.

Endodontic treatment was carried out extraorally prior to the replantation in most of the teeth in which revascularization of the pulp could not be expected. Replanted teeth that underwent extended calcium hydroxide treatments had more complications than teeth that had undergone complete root canal treatments. Several studies have reported that delayed endodontic treatment in replanted teeth increases infection-related resorption.^[8,30,31] In the current study, none of the teeth received prolonged calcium hydroxide therapy, thus, this could be related to the finding that all of the teeth were lacking infection-related resorption.

In the IADT guidelines, Andersson *et al.* reported that periodontal and pulpal healing is supported if the replanted tooth is given a chance for slight motion and the splinting time is not too long.^[23] Prolonged use of the splint causes ankylosis. In our study, splints were used for an optimal duration as recommended in the IADT guidelines, therefore, we believe that the IADT directives help to reduce the incidence of ankylosis.

Many types of splinting techniques have been described in the literature, but wire-composite splints and titanium trauma splints are the most recommended types for splinting of traumatized teeth.^[32-34] Filippi *et al.* reported that the titanium trauma splint is more favorable to handling, applying, and removing, with less damage to dental hard tissue than the wire-composite splint.^[33] On the other hand, according to Ebeleseder and Berthold, wire-composite splints are advantageous because the required materials are inexpensive and usually available in dental offices. Wire-composite splints also fulfill most of the properties of the titanium trauma splints for splinting after dental trauma; these properties include flexibility and allowing for dental hygiene and endodontic treatments.^[32,34] In light of these requirements, and according to the IADT guidelines, we prefer the wire-composite splints for splinting avulsed teeth.^[23]

Andreasen *et al.* reported that ankylosis-related resorption is the most frequent complication and predominant resorption type with rates of 71% in teeth with a closed apex. Petrovic *et al.* also found that 84% of delayed replanted teeth had root resorption. Complications are frequent after the replantation of avulsed teeth, with a reported prevalence of 57–84%.^[8,30,31,35,36] In the present study, the complication rate was 60%, which is compatible with previous studies.

The primary goal in the replantation of permanent incisors is to keep the tooth in the alveolar bone until the patient's development is completed and permanent prosthodontic treatment can be made. In this study,

all of the replanted teeth, even the decoronated teeth, were functional for 2–4 years. Tooth survival 2 years following replantation was 80%, and 40% of the teeth were retained for at least 3 years. Therefore, it is important to remember that the replanted teeth help esthetic and masticatory functions, occlusal development, alveolar ridge preservation, and avoiding malocclusions in young individuals.^[12] Considering these advantages, reimplantation seems to be more profitable than other treatment options, even if it is late. Because implant treatment is not suitable for children, we can only keep the area functional with child prostheses and space maintainers. However, these options will only contribute to function and phonation, and will not prevent the reduction of bone volume in that area. When we take into account the fact that children have difficulty in using removable or semi-fixed prostheses, it is more advantageous to perform reimplantation even if it is late.

To conclude;

1. Within the limits of this study, the findings support that delayed replantation after unphysiological storage is inevitably followed by high resorption rates. Replacement resorption was observed in 60% of our cases.
2. In the present study, the tooth survival rate 2 years following replantation was 80%.
3. Following 3 years, 40% of the teeth were still retained, thus, avoiding alveolar bone resorption.

We believe that delayed replantation of a permanent incisor is important for the child's jaw and facial development.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient (s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Sardana D, Goyal A, Gauba K. Delayed replantation of avulsed tooth with 15-hours extra-oral time: 3-year follow-up. *Singapore Dent J* 2014;35:71-6.
2. Bastone EB, Freer TJ, McNamara JR. Epidemiology of dental trauma: A review of the literature. *Aust Dent J* 2000;45:2-9.
3. Patil S, Dumsha TC, Sydiskis RJ. Determining periodontal ligament (PDL) cell vitality from exarticulated teeth stored in saline or milk using fluorescein diacetate. *Int Endod J* 1994;27:1-5.
4. Hiltz J, Trope M. Vitality of human lip fibroblasts in milk, Hank's balanced salt solution and Viaspan storage media. *Endod Dent Traumatol* 1991;7:69-72.
5. Tsukiboshi M, Tsukiboshi T. Bone morphology after delayed tooth replantation-Case series. *Dent Traumatol* 2014;30:477-83.
6. Trope M. Current concepts in the replantation of avulsed teeth. *Alpha Omega* 1997;90:56-63.
7. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors I. Diagnosis of healing complications. *Endod Dent Traumatol* 1995;11:51-8.
8. Andreasen JO, Borum MK, Jacobsen HL, Andreasen FM. Replantation of 400 avulsed permanent incisors. IV Factors related to periodontal ligament healing. *Endod Dent Traumatol* 1995;11:76-89.
9. 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.
10. Kawanami M, Andreasen JO, Borum MK, Schou S, Hjorting-Hansen E, Kato H. Infraposition of ankylosed permanent maxillary incisors after replantation related to age and sex. *Endod Dent Traumatol* 1999;15:50-6.
11. Malmgren O, Malmgren B. Rate of infraposition of reimplanted ankylosed incisors related to age and growth in children and adolescents. *Dent Traumatol* 2002;18:28-36.
12. Malmgren B. Ridge preservation/decoronation. *Pediatr Dent* 2013;35:164-9.
13. 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.
14. Sapir S, Shapira J. Decoronation for the management of an ankylosed young permanent tooth. *Dent Traumatol* 2008;24:131-5.
15. Malmgren B. Decoronation: How, why, and when? *J Calif Assoc* 2000;28:846-54.
16. Filippi A, Pohl Y, Von Arx T. Decoronation of an ankylosed tooth for preservation of alveolar bone prior to implant placement. *Dent Traumatol* 2001;17:93-5.
17. 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.
18. Malmgren B, Cvek M, Lundberg M, Frykholm A. Surgical treatment of ankylosed and infrapositioned reimplanted incisors in adolescents. *Scand J Dent Res* 1984;92:391-9.
19. Chen F, Sun H, Jia B. Clinical studies on the use of hyperbaric oxygen in replantation of young permanent teeth. *Chinese Journal of Stomatology* 2000;35:271-3.
20. Glendor U. Epidemiology of traumatic dental injuries-a 12 year review of the literature. *Dent Traumatol* 2008;24:603-11.
21. Abanto J, Tello G, Bonini GC, Oliveira LB, Murakami C, Bonecker M. Impact of traumatic dental injuries and malocclusions on quality of life of preschool children: A population-based study. *Int J Paediatr Dent* 2015;25:18-28.
22. Bendo CB, Paiva S, Abreu MH, Figueiredo LD, Vale MP. Impact of traumatic dental injuries among adolescents on family's quality of life: A population-based study. *Int J Paediatr Dent* 2014;24:387-96.
23. Andersson L, Andreasen J, 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.
24. Andreasen JO. Periodontal healing after replantation and autotransplantation of incisors in monkeys. *Int J Oral Surg* 1981;10:54-61.
25. 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.
26. Andreasen JO, Malmgren B, Bakland LK. Tooth avulsion in children: To replant or not. *Endod Topics* 2006;14:28-34.
27. Andersson L, Jonsson B, Hammarstrom L, Blomlof L, Andreasen JO, Lindskog S. Evaluation of statistics and desirable experimental design of a histomorphometrical method for studies of root resorption. *Endod Dent Traumatol* 1987;3:288-95.
28. Andreasen JO. Experimental dental traumatology: Development of a model for external root resorption. *Endod Dent Traumatol* 1987;3:269-87.
29. Coccia CT. A clinical investigation of root resorption rates in reimplanted young permanent incisors: A five-year study. *J Endod* 1980;6:413-20.
30. Petrovic B, Markovic D, Peric T, Blagojevic D. Factors related to treatment and outcomes of avulsed teeth. *Dent Traumatol* 2010;26:52-9.
31. Barrett EJ, Kenny DJ. Survival of avulsed permanent maxillary incisors in children following delayed replantation. *Endod Dent Traumatol* 1997;13:269-75.
32. Ebeleseder KA, Glockner K, Pertl C, Stadler P. Splints made of wire and composite: An investigation of lateral tooth mobility *in vivo*. *Endod Dent Traumatol* 1995;11:288-93.
33. Filippi A, Von Arx T, Lussi A. Comfort and discomfort of dental trauma splints-A comparison of a new device (TTS) with three commonly used splinting techniques. *Dent Traumatol* 2002;18:275-80.
34. Berthold C, Thaler A, Petschelt A. Rigidity of commonly used dental trauma splints. *Dent Traumatol* 2009;25:248-55.
35. Pohl Y, Filippi A, Kirschner H. Results after replantation of avulsed permanent teeth I-II. *Dent Traumatol* 2005;21:80-101.
36. Chappuis V, Von Arx T. Replantation of 45 avulsed permanent teeth: A 1-year follow-up study. *Dent Traumatol* 2005;21:289-96.