Treatment outcome of 42 replanted permanent incisors with a median follow-up of 2.8 years

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Summary *Aim:* To evaluate the treatment outcome of avulsed and replanted permanent incisors. *Material and Methods:* 42 avulsed and replanted permanent incisors in 37 individuals were followed over a median observation period of 2.8 years (range: one year to five years). The mean age was 16.3 years at the time of replantation, with 81% of patients being younger than 20 years. *Results:* The tooth survival rate after replantation was 83.3% (35/42 teeth). Periodontal healing was observed in 20 teeth. External root resorption was the most frequent complication and was found in 22 of the 42 avulsed teeth: 21 teeth had replacement resorption. Of these 21 teeth, 14 teeth were still in situ at time of recall examination, seven teeth had to be extracted during the follow-up period due to progressive replacement resorption. One tooth had surface resorption. In contrast, infection-related resorption could not be observed in this sample. With regard to periodontal healing, no differences were found between teeth with short (less than 14 days) versus prolonged duration of splinting. Higher incidence of replacement resorption correlated with the extended duration of non-physiologic extraoral storage. *Conclusion:* Use of a strict endodontic treatment protocol after replantation minimized the risk of infection-related root resorption. The occurrence of replacement resorption was mainly influenced by the duration of the non-physiologic extraoral storage time and storage medium.

Introduction

Avulsion of permanent teeth occurs in 0.5–16% of traumatic tooth injuries in the permanent dentition (Andreasen & Andreasen 1994, Glendor et al. 1996). Avulsion is a serious injury and affects several tissues: the pulp, the periodontal ligament and the alveolar bone. The neurovascular bundle of the pulp ruptures at the apical foramen and the pulp tissue becomes necrotic (Andreasen & Andreasen 1994). Following an avulsion injury, the loss of numerous periodontal ligament cells and the damage to the root cementum appears to be associated with the occurrence of ankylosis and post-traumatic external root resorption (Filippi et al. 2002, Pohl et al. 2005, Schjott & Andreasen 2005). In addition, ankylosis may have an impact on the growth of the alveolar ridge and may also impair the position of an unharmed adjacent tooth (Ebeleseder et al. 1998, Malmgren & Malmgren 2002). Reestablishing esthetics after loss of a permanent incisor in young patients continues to be a challenge.

Correct initial care is of high importance, and timely scheduled follow-up is recommended by the International Association of Dental Traumatology 2007 (Flores et al. 2007). It is commonly accepted that periodontal healing depends on the duration and conditions of extraoral storage. Periodontal healing is mainly influenced by the extent of damage to the periodontal ligament cells and the condition of the pulp (Andersson & Bodin 1990, Andreasen et al. 1995c, Chappuis & von Arx 2005, Pohl et al. 2005). Several chemotherapeutic agents have been discussed in the literature to pharmacologically manipulate the processes resulting in external root resorption. a) Systemic treatment with tetracycline after avulsion can be used due to the drug's antiresorptive properties, and its antimicro-

bial effect (Hinckfuss & Messer 2009c). b) Topical steroids and tetracycline reduce the initial inflammatory response due to the trauma (Sae-Lim et al. 1998c). c) Enamel matrix derivative (EMD) may favor stimulation of a functional periodontium (Iqbal & Bamaas 2001). d) In cases where no periodontal healing can be anticipated, removal of the periodontal ligament and treatment of the root surface with sodium fluoride is recommended in order to slow down the resorption process (Yang et al. 1989).

The objective of the present survey was to evaluate the treatment outcome and prognosis of avulsed and replanted permanent incisors. Examination focused on periodontal healing, influence of the storage medium, duration of extraoral storage, influence of EMD, and initiation of endodontic treatment after injury.

Materials and Methods

Patient enrollment

The material comprised 37 patients presenting with 42 avulsed permanent teeth at the Department of Oral Surgery and Stomatology, University of Bern, Switzerland. Patients were enrolled over a period of five years, from January 2004 to June 2009. The follow-up period ranged from one year to five years (median recall period 2.8 years). Exclusion criteria were injured teeth with pre-existing root canal treatment, teeth with accompanying root or root–crown fractures, and cases in which avulsed teeth could not be replanted or could not be found.

Treatment methods

Immediately after arrival of the patient in the department, the avulsed teeth were stored for at least 20 minutes in a special cell culture medium (Dentosafe; Medice GmbH, Iserlohn, Germany), to which 60 µg ml^{-1} of dexamethasone was added. In the meantime, clinical and radiographic examinations were performed. A patient history was taken, which included duration and conditions of extraoral storage. Before replantation, the socket was rinsed with saline. Under local anesthesia, soft tissue lacerations were re-approximated with sutures. Three different treatment options were performed according to the following parameters: a) Under ideal extraoral storage conditions (maximum of 10 min of dry storage), the tooth was manually repositioned and stabilized with a non-rigid splint (TTS; Medartis AG, Basel, Switzerland) for 7–14 days (Fig. 1–3). b) In cases with a dry extraoral storage of 10 to 60 minutes, EMD (Enamel Matrix Derivative; Emdogain®; Straumann Biologics, Basel, Switzerland) was additionally applied into the socket and onto the root surface.

c) In cases with an extended dry storage longer than 60 minutes, the root surface was mechanically debrided of necrotic periodontal ligament and cementum by scraping with a scaler. Additionally, the tooth was soaked in 6% citric acid solution for five minutes, followed by saline irrigation and application of 2% sodium fluoride for five minutes. The aim of such treatment was to slow down the resorption process (Yang et al. 1989).

After replantation and splinting, root canal treatment was performed in all of the cases either immediately or within two days in the Department of Operative Dentistry or by a private dentist in 31 of 42 teeth. In 11 of 42 teeth, pulp extirpation was carried out later than 48 hours after avulsion but within two weeks.

Initial canal medication included the placement of Ledermix® (Demeclocyclinum calcicum, Triamcinoloni acetonidum; Ledermix®; Lederle, Zug, Switzerland). After two to three weeks, calcium hydroxide dressing (Calxyl®; Ca $[OH]_2$) was administered in most of the cases for three weeks prior to root canal filling (Gutta percha with root canal sealer AH plus®). With the eight teeth that had apical canal orifices of an apparent diameter of equal to or greater than 1 mm, apexification was either obtained with a long-term calcium hydroxide medication (five teeth) or Pro-root MTA placement (three teeth) prior to final

Fig. 1 Avulsion of both central maxillary incisors due to a bicycle accident in a 17-year-old girl.

Fig. 2 Avulsed teeth 11 and 21 with a dentin-enamel fracture of tooth 21. Extraoral dry storage time was 5 minutes, followed by 60 minutes storage in saline.

Fig. 3 Replantation of 11 and 21 after storing the teeth for 20 minutes in the Dentosafe® Box, to which 60 µg ml^{-1} of dexamethasone had been added. Splinting of the repositioned teeth with a TTS® splint for ten days.

root canal filling. Only under conditions with a diameter of the apical foramen ⩾1mm and ideal duration and conditions of extraoral storage (adequate physiologic storage medium, and short extraoral dry storage period of less than 5 minutes), replantation without endodontic treatment was considered (Andreasen et al. 1995b). None of the 42 teeth was considered suitable for such treatment.

For postoperative medication patients were prescribed analgesics, 0.1% chlorhexidine-digluconate mouthwash for rinsing twice a day and systemic tetracycline for ten days (Doxyclin; Spirig, Egerkingen, Switzerland). The dosage was applied according to body weight: patients <50 kg received 100 mg on the first day and 50 mg from the 2nd to the 10th day. Patients >50 kg received double this dosage.

Follow-up examination

Follow-up examinations were performed after one, three, six, and twelve months in the first year and subsequently once a year. The cases were recalled from October 2008 to August 2009. The clinical examination included inspection, palpation, percussion, Periotest® measurements (Periotest; Siemens, Behnsheim, Germany), pulp sensitivity using CO_2 snow, intraoral photographs and radiographic examination (Fig. 4–5).

Statistical analysis

Since the survey comprised only 42 teeth in 37 patients with three different treatment methods, a comparative statistical analysis was considered unfeasible. Therefore a descriptive analysis was performed using a frequency analysis, which is adequate for a survey sample of this size.

Results

The mean age of the patients was 16.3 years (range 6 to 62 years). 81% of patients were younger than 20 years. Out of 42 teeth, 35 could be re-examined in 30 patients (13 females and 17 males), seven teeth were lost during the follow-up period. 10 teeth of the initially replanted teeth presented with an additional injury to the dental hard substance (two enamel fractures and eight uncomplicated dentin–enamel fractures of the crown).

Survival rate

The survival rate of the teeth in this survey was 83.3% (35/42 teeth) with a median follow-up period of 2.8 years (range 1 year to 5 years) after replantation. Seven teeth were lost during the follow-up period. All of these teeth had developed progressive replacement resorption (ankylosis) with ultimately crown mobility when total replacement root resorption had occurred leaving the residual crown poorly attached to the gingival tissue, or fracture of the tooth.

Periodontal observations

Periodontal healing could be observed in 20 teeth. It was found more often in teeth with a closed apex (17/33 teeth) than in teeth with an open apex (3/9 teeth) (Tab. I). One tooth developed a surface resorption. Infection-related resorption could not be observed in this survey. Replacement resorption was found in 21 teeth: 14 teeth showed signs of replacement resorption but were still in situ, and seven teeth had to be extracted due to progressive replacement resorption. Replacement resorption was seen more frequently in teeth with an open apex (four out of nine teeth) and less frequently in teeth with a closed apex (10/33 teeth) (Tab. I).

Fig. 4 Clinical aspect at the 1-year follow-up. Both teeth demonstrated good periodontal condition, normal percussion sound, and physiological Periotest® measurements.

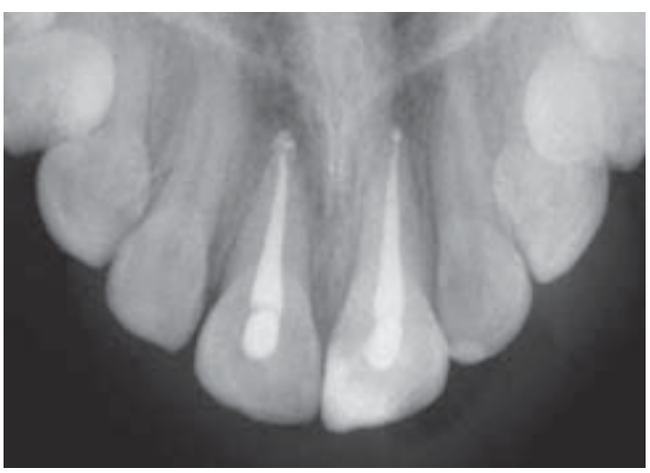

Fig. 5 No radiographic signs of external root resorption were present at the 1-year follow-up.

Tab. I Periodontal healing related to stage of apical closure (n = 42)

	Apex open[1]	Apex closed[2]	Total
Periodontal healing	3	17	20
Surface resorption		1	1
Replacement resorption	4	10	14
Extraction due to replacement resorption	2	5	7
Total	9	33	42

[1] diameter of apical foramen ⩾ 1 mm
[2] diameter of apical foramen < 1 mm

Emdogain® was used in seven replanted teeth. None of these teeth developed normal periodontal healing. Replacement resorption occurred in all seven teeth: six teeth were still in situ, and one tooth had to be removed (Tab. II). 32 of 42 teeth were replanted without application of Emdogain®. 20 of these 32 teeth showed normal periodontal healing and one tooth had a surface resorption. Six teeth showed signs of replacement resorption but were still in situ, and five teeth had to be extracted due to progressive replacement resorption (Tab. II).

Three teeth were replanted after more than 60 minutes. They were treated with 6% citric acid and 2% sodium fluoride. They

Tab. II Periodontal healing related to use of EMD[1] (n = 42)

	EMD[1]	No EMD	Removal of PDL tissue[2]	Total
Periodontal healing		20		20
Surface resorption		1		1
Replacement resorption	6	6	2	14
Extraction due to replacement resorption	1	5	1	7
Total	7	32	3	42

[1] EMD = enamel matrix derivative
[2] Replantation after removal of PDL tissue on root surface with 6% citric acid and 2% sodium fluoride

all showed signs of replacement resorption: two teeth were still in situ, one tooth had to be extracted (Tab. II).

Pulpal observations

All replanted teeth of the survey sample had been root-canal treated, because none of the 42 teeth was considered suitable for replantation without endodontic treatment.

Immediate root-canal treatment was performed in 31 of 42 teeth. 25 teeth in this group showed a closed apex and six showed an open apex. A delayed root-canal treatment (later than 48 hours after avulsion) was performed in eleven teeth. Nine teeth in this group showed a closed and two teeth an open apex. Periodontal healing was observed more common in teeth with immediate root-canal treatment (16/31 teeth) compared to teeth with delayed root-canal treatment (4/11 teeth). The percentage of root resorption was lower in the immediate root-canal treatment group (15/31 teeth) than in the delayed root-canal treatment group (7/11 teeth) (Tab. III).

Tab. IV Periodontal healing related to period of extraoral dry storage (n = 42)

	<15 min	15–60 min	>60 min	Total
Periodontal healing	15	5		20
Surface resorption		1		1
Replacement resorption	3	9	2	14
Extraction due to replacement resorption	2	4	1	7
Total	20	19	3	42

Extraoral dry storage

The relationship between periodontal healing and extraoral dry storage is shown in Tab. IV. In teeth with an extraoral dry storage period of less than 15 minutes, periodontal healing was observed in 15 of 20 teeth. Out of 19 teeth with a dry time of between 15 and 60 minutes, five teeth showed periodontal healing. In teeth with an extended dry storage period (longer than 60 min.), periodontal healing was never observed. The occurrence of replacement resorption or extractions due to progressive replacement resorption increased with an extended period of dry storage.

Storage medium

The correlation between periodontal healing and storage medium is summarized in Tab. V: Eight teeth were stored in a Dentosafe Box®, 16 teeth in milk, nine teeth in saline, and nine teeth under non-physiologic dry conditions. The highest percentage of periodontal healing was achieved with the Dentosafe Box® (6/8 teeth), followed by milk (9/16 teeth) and saline (5/9 teeth). In the group of patients whose teeth were stored under non-physiologic dry conditions, normal periodontal healing was never observed.

Tab. III Periodontal healing related to endodontic treatment (n = 42)

	Immediate root canal treatment[1]			Delayed root canal treatment[2]			
	Apex open[3]	Apex closed[4]		Apex open[3]	Apex closed[4]		Total
Periodontal healing	3	13	16		4	4	20
Surface resorption		1	1				1
Replacement resorption	1	9	10	2	2	4	14
Extraction due to replacement resorption	2	2	4		3	3	7
Total		31			11		42

[1] within 48 hours
[2] within 3–14 days
[3] diameter of apical foramen ⩾ 1 mm
[4] diameter of apical foramen < 1 mm

Tab. V Periodontal healing related to storage medium (n = 42)

	Dentosafe® Box	Milk	Saline	Other (dry)	Total
Periodontal healing	6	9	5		20
Surface resorption				1	1
Replacement resorption	1	5	3	5	14
Extraction due to replacement resorption	1	2	1	3	7
Total	8	16	9	9	42

Tab. VI Periodontal healing related to duration of splinting (n = 42)

	⩽ 14 days	⩾ 15 days	Total
Periodontal healing	10	10	20
Surface resorption	1		1
Replacement resorption	10	4	14
Extraction due to replacement resorption	1	6	7
Total	22	20	42

Duration of the splinting period

Periodontal healing occurred in 10 of 22 teeth with a splinting period shorter than 14 days and in 10 of 20 teeth with a longer splinting duration (Tab. VI).

Discussion

The present retrospective survey evaluated the treatment outcome of 42 avulsed and replanted permanent incisors after a median follow-up period of 2.8 years.

As already mentioned above, a comparative statistical analysis was unfeasible due to the small sample size of 42 teeth. Therefore, it has to be noticed, that the interpretation of the data was of descriptive value and no statistically significant conclusions could be drawn. A larger sample size would be needed to provide more conclusive data.

Pulpal considerations

Post-traumatic infection of pulpal tissues after replantation is very frequent. It plays an important role in the development of infection-related external root resorption, which can lead to tooth loss within a few weeks or months (Trope 1998, Filippi et al. 2000, Andreasen 2007). A study by Andreasen & Hjorting-Hansen (1966) reported extractions of teeth with infection-related resorption in more than 50% of the cases within the first year. A recent meta-analysis by Hinckfuss & Messer (2009a) including six papers with a total of 236 teeth demonstrated a significant correlation between delayed pulp extirpation (>14 days) and occurrence of infection-related resorption. Therefore, timely and proper endodontic treatment has been recommended in order to prevent infection-related root resorption (Andreasen et al. 1995c, Filippi et al. 2000). This observation could be confirmed by the present survey, in which none of 42 teeth showed infection-related resorption. In all of the teeth of the present survey, the root canal treatment was performed within two weeks after avulsion. None of these teeth developed infection-related root resorption. If the root canal treatment was performed immediately, the rate of periodontal healing appeared to be slightly higher and the risk of the development of root resorption seemed to be lower (Tab. III).

Endodontic treatment allowed local administration of tetracycline into the root canal. In the endodontically treated teeth in the present survey, initial canal medication included the placement of Ledermix® paste, which also contains a corticosteroid. The possible synergistic effect of antibiotics and corticosteroids was discussed in an animal study by Bryson et al. (2002). They showed significantly less root resorption in teeth with immediate placement of Ledermix® paste compared to teeth with $Ca(OH_2)$ dressing. Prevention or reduction of external root resorption could be observed in several studies (Hammarström et al. 1986, Sae-Lim et al. 1998a/b, Yanpiset & Trope 2000, Chen et al. 2008).

Periodontal considerations

Numerous studies have reported replacement resorption as the predominant type of post-traumatic external root resorption, but the occurrence of root resorption varies: Andreasen et al. (1995a) reported 76% of external root resorption in 400 avulsed teeth, Soares et al. (2008) in 63% of 100 teeth and Petrovic et al. (2010) found signs of external root resorption in 84%. A study by Chappuis & von Arx (2005) demonstrated the same periodontal healing pattern of external root resorption in 42.3% of 45 teeth and Majorana et al. (2003) in 17.24% of 45 teeth (only 28% of those had avulsions, 72% were partial luxations). In the present survey external root resorption was also the main complication (in 22/42 of the replanted teeth) (Fig. 6–9).

Donaldson & Kinirons (2001) reported more frequent external root resorption when duration of extraoral dry storage exceeded 15 minutes. Similar data were described in an animal study by Hammarström et al. (1989). The findings in the present survey are in concordance with other publications (Pohl et al. 1999, Donaldson & Kinirons 2001, Chappuis & von Arx 2005) and emphasize the importance of a short extraoral dry storage period.

Fig. 6 Bicycle accident of a 10-year-old female patient, with avulsion of teeth 11, 12 and 21.

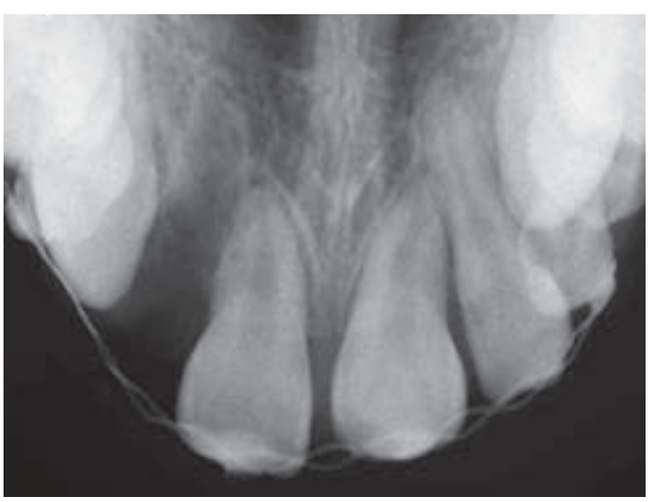

Fig. 7 Teeth 11 and 21 were replanted and stabilized with a TTS® splint after 40 minutes of extraoral dry storage. The right lateral incisor could not be found.

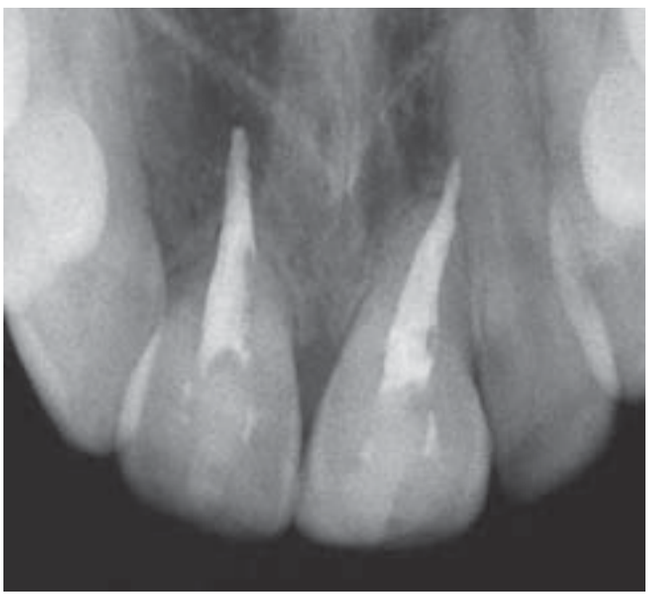

Fig. 8 After 3 years and 7 months, the radiograph shows advanced replacement root resorption in the apical half of root 11.

Fig. 9 The gap of the missing tooth 12 was closed by orthodontic treatment. A slight greyish discoloration of tooth 21 was observed, as well as a vertical gingival and incisal step of tooth 11.

In the present survey, periodontal healing was found in 20 of 42 teeth presenting without clinical or radiographic symptoms of external root resorption (Fig. 4–5). These favorable findings might be explained by appropriate initial care:

1. Short extraoral dry storage: 20 of the 42 teeth were exposed to a dry storage period shorter than 15 minutes (Tab. IV). 15 of 20 teeth with less than 15 min of dry storage showed normal periodontal healing. Therefore a short dry storage period resulted in a higher percentage of periodontal healing.
2. Physiologic storage medium: 33 of 42 teeth were stored in a physiologic wet medium (Tab. V). Six of eight avulsed teeth stored in a Dentosafe Box® immediately after avulsion showed proper periodontal healing, whereas two teeth presented with replacement resorption. The Dentosafe Box® not only conserves vitality but also washes out bacteria and toxic breakdown products after cell death (Cvek et al. 1974, Pohl & Kirschner 1994). Therefore, all avulsed teeth in this survey were soaked in the tooth rescue box for 20 minutes irrespective of the former storage medium prior to replantation. Of the 42 teeth, 16 were stored in milk: nine teeth showed regular periodontal healing and seven teeth had replacement resorption. Milk is a common and readily available storage medium, and thanks to its physiological osmolarity, neutral pH, and nutritive substances it can be considered as a medium of choice when a tooth rescue box is not available (Flores et al. 2007). In this survey, five of nine teeth stored in saline presented with normal periodontal healing and four teeth with replacement resorption. Saline can preserve periodontal ligament cells for up to two hours (Blomlöf 1981, Lekic et al. 1998). In contrast, complications could be observed more often in teeth with non-physiologic dry storage: none of the teeth showed normal periodontal healing. One tooth had surface resorption, whereas the majority of teeth (eight of nine teeth) presented with replacement resorption (Tab. V).
3. Topical application of a glucocorticoid decreased the resorptive activity and enhanced periodontal healing in three studies (Sae-Lim et al. 1998c, Trope 1998, Pohl et al. 2005). For this reason, 60 µg ml^{-1} dexamethasone was added to the Dentosafe Box®.

Splinting period

Non-rigid splinting stabilizes a replanted tooth and retains it in position. Current guidelines (Pavek & Radtke 2000, American Academy of Pediatric Dentistry 2004, Flores et al. 2007) recommend splinting periods ranging from seven to ten days for teeth with short extraoral dry storage time and longer splinting periods for teeth with extended extraoral dry storage and/or teeth with concomitant alveolar fractures (Trope 2002). A short splinting period appears to be associated with a low prevalence of external root resorption (Andreasen et al. 1995c, Kinirons et al. 1999, Kinirons et al. 2000). However, a recent systematic review of 138 replanted teeth pooled from four papers concluded that periodontal healing after replantation is not associated with the duration of the splinting period (Hinckfuss & Messer 2009b). Similar data were found in the present survey: periodontal healing occurred in 10 of 22 teeth with a splinting period shorter than 14 days and in 10 of 20 teeth with a longer splinting duration (Tab. VI). It appears that the effect of extraoral storage time and storage conditions with loss of periodontal ligament cells might be more decisive for functional healing than the splinting period.

Application of EMD

The use of enamel matrix derivative (EMD) to avoid root resorption and enhance healing of vital periodontal ligament cells has been discussed in various studies. It was speculated that the application of EMD onto the root surface before replantation might stimulate surviving periodontal cells to proliferate and cover the root surface, hopefully resulting in repair of the periodontal ligament (Gestrelius et al. 1997, Hammarström 1997). Despite the mentioned favorable effects, re-establishment of a functional periodontium in situations with non-vital periodontal ligament cells has not been achieved to date. Less resorption and better periodontal healing in replanted animal teeth compared to teeth without EMD treatment were found in two animal studies (Iqbal & Bamaas 2001, Hamamoto et al. 2002).

In contrast, a monkey study by Lam & Sae-Lim (2004) could not demonstrate lower occurrence of replacement resorption in teeth treated with EMD. These findings were confirmed by another experimental dog study (Araujo et al. 2003), in which no additional benefit of EMD for periodontal healing could be observed. A clinical study by Schjott et al. (2005) investigated

the effect of Emdogain® on replanted, endodontically treated teeth as well as on replanted teeth that already had established ankylosis. All of the replanted teeth developed ankylosis after a few months, and an established ankylosis could not be reverted. Therefore, the authors concluded that EMD was not able to prevent or treat ankylosis. A follow-up study by Chappuis & von Arx (2005) reported similar data. Efficacy of EMD in animal studies was also evaluated in a recently published meta-analysis by Wiegand & Attin (2008). The evidence for an association between application of Emdogain® and improved periodontal healing or prevention of ankylosis remains inconclusive. In the present survey, EMD was applied in 7 of 42 teeth. All of them showed replacement resorption and normal periodontal healing could not be observed in teeth treated with EMD. But it should be noted that all of these teeth had been stored in non-physiologic conditions for a prolonged period of time. This might explain the high percentage of replacement resorption in teeth with EMD treatment. Use of EMD in this survey seemed not to prevent ankylosis.

Conclusions

1. The present retrospective survey showed a tooth survival rate of 83.3% after a median follow-up period of 2.8 years after replantation of avulsed permanent teeth.
2. Periodontal healing was seen in 20 of 42 teeth.
3. The most prevalent complication was replacement-related root resorption (21/42 teeth). Of those 21 teeth, 7 had to be extracted during the follow-up period.
4. The occurrence of replacement-related root resorption seemed to be related to the duration of the dry storage period and to the storage medium.
5. Infection-related root resorption was not found in this survey. The strict protocol of immediate or early root canal treatment appears to reduce the occurrence of infection-related root resorption and may enhance periodontal healing.
6. Within the limits of the present survey, no beneficial effect of EMD was observed in terms of avoiding replacement root resorption.

Résumé

L'avulsion d'une dent permanente représente un traumatisme sérieux pour la pulpe, le desmodonte et l'alvéole. La vascularisation et l'innervation pulpaire sont rompues au niveau du foramen apical, et de nombreuses cellules parodontales ne survivent pas à une conservation extraorale non physiologique. Une ankylose et des résorptions radiculaires externes après réimplantation apparaissent à la suite de dégâts des cellules vitales de la surface radiculaire.

C'est la proportion des dommages causés aux cellules vitales du ligament parodontal et l'état de la pulpe qui vont influencer le plus la phase de régénération parodontale après une avulsion. Selon la littérature actuelle, on considère que différents agents chimiothérapeutiques peuvent influencer le processus de l'ankylose ou de la résorption radiculaire externe: un traitement antibiotique systémique avec tétracyclines, des applications topiques de stéroïdes ou tétracycline, des dérivés de la matrice amélaire (Emdogain) et fluorures.

Le but de cette étude était de comparer les résultats de trois stratégies différentes de traitement lors de l'avulsion de dents antérieures. Les options de traitement étaient exécutées selon les paramètres suivants: a) dent réimplantée et stabilisée à l'aide d'une contention TTS sans autre traitement après une conservation extraorale idéale (<10 minutes); b) dent réimplantée et stabilisée en procédant auparavant à un traitement topique de la racine et de l'alvéole par des dérivés de la matrice amélaire (Emdogain) lors d'une exposition extraorale à sec entre 10–60 minutes; c) lors d'une exposition extraorale dépassant 60 min – une régénération parodontale étant très peu probable lors d'une réimplantation – les restes du ligament parodontal étaient éliminés de la surface radiculaire au moyen d'un détartreur, et la surface radiculaire traitée avec de l'acide citrique (6%) et une solution de fluorure de sodium (2%) afin de ralentir le processus de résorption radiculaire externe.

Résultats: Le succès du traitement de 42 dents permanentes antérieures avulsées et repositionnées a été évalué cliniquement et radiologiquement après une période d'observation moyenne de 2,8 années (allant de un à cinq ans). Au moment de la réimplantation, les patients (entre 6 et 62 ans) avaient un âge moyen de 16,3 ans, dont 81% des patients étaient âgés de moins de 20 ans. 35 des 42 dents de l'étude étaient encore en bouche au moment de la réévaluation effectuée dans le cadre de cette étude (83,3%). 20 des dents avulsées présentaient une régénération parodontale sans complication. Une résorption radiculaire externe, complication la plus courante, fut diagnostiquée dans 22 des 42 dents examinées: 21 des dents présentaient des signes cliniques et radiologiques d'ankylose. Parmi ces 21 dents, 14 étaient encore en bouche lors du contrôle de cette étude, mais 7 avaient dû être éliminées auparavant pour cause de résorption radiculaire trop avancée ou d'ankylose. Une dent montrait des signes de résorption de surface. Aucun signe radiologique ni clinique d'une résorption d'origine inflammatoire n'a été remarqué.

Aucune différence dans la guérison parodontale n'a été constatée entre une contention de courte durée (moins de 14 jours) et une contention prolongée. L'augmentation de l'ankylose radiculaire corrélait par contre avec la durée de la conservation extraorale non physiologique.

Un traitement radiculaire rapide de dents avulsées et réimplantées a minimisé le risque de résorption radiculaire d'origine inflammatoire. Une extirpation pulpaire (moins de 48 heures après avulsion) a influençé positivement la régénération parodontale, montré moins d'ankylose et moins de résorptions radiculaires d'origine inflammatoire que lors de traitements de racine retardés. Le traitement avec un complexe protéinique amélaire n'a semblé apporter aucun avantage au niveau de la régénération parodontale.

Résumé: Le suivi strict d'un protocole de traitement radiculaire rapide minimise le risque de résorption radiculaire d'origine inflammatoire. L'apparition d'une ankylose est principalement influencée par une durée de l'exposition extraorale non physiologique et par la solution de conservation.

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Zusammenfassung

Die Avulsion eines bleibenden Zahnes ist eine schwerwiegende Verletzung, welche zur Schädigung der Pulpa, des parodontalen Ligaments und des Alveolarknochens führt. Das neurovaskuläre Bündel der Pulpa reisst am apikalen Foramen und es kommt zum Verlust zahlreicher Zellen des parodontalen Ligaments, welche unter nicht physiologischen extraoralen Lagerungsbedingungen absterben. Weiter scheint das Auftreten von Ankylose und externer Wurzelresorption mit der Beschädigung des Wurzelzementes assoziiert zu sein. Die anschliessende pa-

rodontale Heilungsphase eines avulsierten Zahnes wird hauptsächlich durch das Ausmass der Schädigung des parodontalen Ligaments und den Zustand der Pulpa beeinflusst. Mehrere chemotherapeutische Agentien werden in der Literatur diskutiert, welche die Prozesse der externen Wurzelresorption und der Ankylose pharmakologisch beeinflussen können: Systemische Antibiose mit Tetrazyklinen, topisch applizierte Steroide und Tetrazykline, Schmelzmatrixproteine und Fluoride.

Das Ziel dieser Studie war es, die Behandlungsergebnisse avulsierter Frontzähne mit unterschiedlichen Behandlungsstrategien zu evaluieren. Drei verschiedene Behandlungsoptionen wurden entsprechend folgender Parameter durchgeführt: a) Unter idealen extraoralen Lagerungsbedingungen (<10 Min.) wurde der Zahn ohne zusätzliche Therapien manuell replantiert und mit einer TTS-Schiene stabilisiert. b) Betrug die extraorale trockene Lagerungszeit 10–60 Minuten, wurden auf die Wurzeloberfläche und in die Alveole zusätzlich Schmelzmatrixproteine appliziert. c) Bei einer extraoralen trockenen Lagerungszeit über 60 Minuten, galt eine parodontale Heilung als sehr unwahrscheinlich. In diesen Fällen, wurde das parodontale Ligament mittels eines Scalers entfernt und der Zahn mit 6% Zitronensäure und 2% Natriumfluorid behandelt, um die nachfolgenden Wurzelresorptionsprozesse zu verlangsamen.

Resultate: 42 avulsierte und replantierte bleibende Frontzähne wurden mit diesen unterschiedlichen Behandlungsmethoden nach einer medianen Beobachtungszeit von 2,8 Jahren (ein Jahr bis fünf Jahre) klinisch und radiologisch ausgewertet. Zum Zeitpunkt der Replantation betrug das Durchschnittsalter der 6–62 jährigen Patienten 16,3 Jahre, wobei 81% der Patienten jünger als 20 Jahre alt waren. 35 der 42 replantierten Zähne waren zum Zeitpunkt des Kontrolluntersuchs in situ (83,3%). Unauffällige parodontale Heilung wurde bei 20 Zähnen beobachtet. Die häufigste Komplikation war die externe Wurzelresorption, die bei 22 von 42 avulsierten Zähnen festgestellt wurde: 21 Zähne zeigten klinische und röntgenologische Zeichen einer Ersatzresorption. Von diesen 21 Zähnen waren zum Zeitpunkt des Kontrolluntersuchs 14 noch in situ, sieben Zähne mussten während der Nachsorgephase aufgrund fortgeschrittener Ersatzresorption/Ankylose entfernt werden. Ein Zahn zeigte Oberflächenresorption. Klinische oder röntgenologische Zeichen einer entzündlich bedingten Resorption konnten in keinem Fall festgestellt werden. Bezüglich parodontaler Heilung konnten zwischen replantierten Zähnen mit einer kurzen Schienungsdauer (weniger als 14 Tage) und Zähnen mit verlängerten Schienungszeiten keine Unterschiede festgestellt werden. Das häufigere Auftreten von Ersatzresorptionen korrelierte mit der nicht physiologischen extraoralen Lagerungsdauer des avulsierten Zahnes.

Die strikte frühe endodontische Behandlung avulsierter und replantierter Zähne minimierte das Risiko entzündlich bedingter Wurzelresorptionen. Die unmittelbare Pulpaextirpation nach Avulsion (innerhalb von 48 Stunden) schien den Heilungsverlauf zusätzlich positiv zu beeinflussen: Es wurden im Vergleich zu verspäteter endodontischer Behandlung häufiger eine parodontale Heilung, weniger Ersatzresorptionen und keine entzündlich bedingten Wurzelresorption beobachtet. Die Applikation von Schmelzmatrixproteinen schien keine zusätzliche Verbesserung der parodontalen Heilung zu bewirken.

Schlussfolgerung: Das strikte endodontische Behandlungsprotokoll nach der Replantation minimierte das Risiko entzündungsbedingter Wurzelresorptionen. Das Auftreten einer Ankylose wurde hauptsächlich durch die nicht physiologische Lagerungsdauer und das Lagerungsmedium bestimmt.

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