

Survival and complication analyses of avulsed and replanted permanent teeth –A Clinico-Radiographic Study

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Abstract

This prospective clinical study investigated the survival probability of avulsed and replanted permanent teeth in relation to functional healing, replacement and inflammatory resorption. This study included 40 patients and 48 replanted permanent teeth. The patients were generally treated according to the current guidelines of the International Association of Dental Traumatology at the oral and maxillofacial surgery department of King Khalid hospital and Najran University. The mean observation period was 3 years. Functional healing was observed in 23.5% (N=11/48) of the included avulsion cases. In comparison, replacement resorption affected 55.0% (N=26/48) of the replanted teeth, of which 27.0% (N=7/26) were lost over the course of years (mean, 4 years). In contrast, inflammatory resorption resulted in the early loss of all replanted teeth (mean, 1.4 years) and affected 21.5% (N=10/48) of all the monitored teeth. Therefore, it can be concluded that tooth avulsion remains a severe dental injury with an unpredictable prognosis. This topic demands further fundamental research aiming to maintain and/or regenerate the periodontal ligament after tooth avulsion, particularly in association with non-physiological tooth rescue.

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I. Introduction

Avulsion of permanent teeth is seen in 0.5%–16% of all dental injuries [1,2]. Tooth avulsion is defined as the complete loss of a tooth out of the alveolar bone socket as a result of an accident and represents a severe traumatic dental injury (TDI). Tooth avulsion mostly affects incisors in children and adolescents and is often associated with an unpredictable outcome and long-term treatment burden [3]. After replantation of the tooth, the prognosis commonly remains uncertain. Replacement resorption or inflammatory resorption are probable adverse outcomes in comparison to the more favourable functional healing [4]. In certain areas bone gets directly attached to the root surface. This is called replacement resorption or osseous replacement [5]. This process is usually progressive and irreversible in nature concluding in ankylosis. In favourable cases, this effect will appear in only smaller demarcated areas for a limited period, leading to an acceptable prognosis, even if ankylosis and/or infraposition occur (“functional healing”). The bacteria from the necrotic pulp evoke an inflammatory reaction in the PDL causing bone and root substance destruction. This whole chain of events is called inflammatory root resorption [6]. Tooth resorption appears to be most likely in cases when connective tissue between the root cementum surface and the alveolar bone – the periodontal ligament (PDL) – is severely damaged. By mechanical destruction either during or after TDI, the cells on the root surface can be considerably impaired during the extra-oral dry time of the avulsed tooth. Therefore, immediate rescue of the avulsed tooth, without inducing further mechanical stress or contamination, by placement in a tooth rescue box with a physiological storage medium before the PDL cells dry out is of the utmost importance [7-8]. These cellular processes are influenced by several other factors, such as the individual’s medical and dental characteristics and the quality of on-site primary (emergency) and sequential dental treatment, and therefore affect the overall prognosis of tooth survival. The best practice recommendations include storage, replantation and splinting of the tooth. While these guidelines are constantly revised by experts [9-11], the long-term consequences of dental trauma can adversely affect the long-term prognosis of the traumatized teeth and can even lead to tooth loss and its consequent adverse functional and esthetic sequel

II. Materials and Methods

After obtaining approval from the institutional ethical committee, the study was undertaken in the postgraduate department of oral and maxillofacial surgery, government dental college and hospital Srinagar and informed consent was obtained from each participant included in the study and/or their legal guardians. Study comprised of 40 patients (26 males and 14 females) with 48 replanted avulsed permanent teeth (40 upper incisors, 4 lower incisors, 4 upper canines).

III. Methodology

The treatment principles were followed as per the International Association of Dental Traumatology (IADT) guidelines at the emergency department of oral and maxillofacial surgery followed the current best practice recommendations and some of the recommendations for treatment options based on consensus opinions. Even prior to obtaining the medical and accident-related history, all the avulsed teeth were instantly placed in a tooth rescue box (HBSS) by the first responding dental professional if these teeth were not already stored in a physiological medium or replanted before presentation. A tooth rescue box contains a physiological medium that preserves the vitality and proliferative capacity of PDL cells of isolated teeth. This physiological medium is pH-balanced, contains inorganic salts, amino acids and further ingredients such as glucose, buffering agents, vitamins and a preservative. The emergency protocol included an initial medical examination to exclude central neurological damage and other severe bodily injuries, collection of the full medical and specific trauma history, instructions for tetanus protection, clinical and radiographic diagnostics, and treatment planning,

aiming for replantation of the avulsed teeth as soon and as accurately as possible. In addition, the patients and/or guardians were educated on the treatment options, risks, follow-up procedures and possible outcomes as well as the related preparations and the actual replantation process. The avulsed permanent teeth were replanted according to the following procedure after the administration of local anaesthesia: The root surface and alveolar socket were examined and cleaned with saline. If required, repositioning and adaptation of the socket and adjacent tissues was performed. Then, individualization and fixation of a semi-rigid splint to adjacent teeth was performed prior to replantation of the affected teeth. Subsequently, the emergency procedure was completed by careful replantation, manual repositioning with slight digital pressure and fixation of the avulsed teeth to the splint with a flowable composite, followed by clinical and radiographic verification of adequate positioning. Suturing of the soft tissue was provided, if necessary. Antibiotics were prescribed on an individual basis. No extra-oral root canal treatment was performed, as the primary goal was the fastest possible and most gentle replantation in order to preserve PDL cell vitality. All the patients were offered to be admitted according to the follow-up procedure of the hospital for further dental treatment and long-term evaluation of the replanted teeth, including radiographic monitoring after 3, 6 and 12 months followed by a yearly recall thereafter. In recall sessions, the teeth and their surroundings were inspected visually as well as manually, and their mobility, percussion and sensitivity were tested. In all mature teeth with closed apices, preparation of an access cavity to the pulp chamber (trepanation) was executed, followed by intracanal medication via an aqueous calcium hydroxide solution (hycal) in a timely manner after replantation. In replanted teeth with immature root development, apexification was performed when consistent negative sensitivity testing for approximately 3 months indicated that no spontaneous revascularization of the traumatized pulp had occurred. Generally, the trauma splint was removed after endodontic treatment had been initiated. A definitive root canal filling with gutta-percha was performed in a timely manner.

Statistics.

All data analysis was performed in Excel and SPSS (SPSS Statistics for Windows, IBM Company, Armonk, NY, USA, version 21.0.1).

IV. Results

A total of 40 patients were included. Places of trauma included outdoor activities (N=8 patients, 20%), at school (N=7, 17.5%), in public places and on public transportation (N=5, 12.5%), at home (N=8, 20%), or at an unspecified location (N=17, 42.5%). Most of the avulsions of this study population occurred due to falls (N=1, 42.5%), while injuries inflicted by violence (N=4, 10%), traffic accidents (N=5, 12.5%), syncope (N=3, 7.5%) and stone pelting (N=10, 25%) seemed to play only a major role in this part of the world. The mean observation period for all the included 48 avulsed and replanted teeth amounted to 3.6 years. According to the patient recordings, the avulsed teeth remained in a non-physiological environment until storage in a physiological medium for a mean of 93 min and were replanted after an average time period of 187 min after the initial accident. No spontaneous pulp revascularization could be observed. The details regarding the time intervals in relation to the dental measures and the setting of primary dental care can be found in Table 1. The loss of replanted teeth occurred in 18 cases (N = 18/48, 37.5%; inflammatory resorption: N = 12/18, 66.7%; replacement resorption: N=6/18, 33.3%); thus, 30 teeth (N=30/48, 62.5%) were preserved (replacement resorption: N=21/30, 70%; functional healing: N=9/30, 30%). Tooth loss occurred on average after 3.2 years. On closer examination of the individual categories, it becomes apparent that there is a high probability of tooth survival for replanted teeth that healed without complication or ankylosis (Fig. 2b). For teeth with replacement resorption but no inflammation (Fig. 2c), tooth loss was a probable outcome but was more likely to occur many years after the detection of resorption. In contrast, inflammatory resorption was likely to cause rapid tooth loss (Fig. 2d).

V. Discussion

The present retrospective clinical study reports key variables that are closely linked to TDI and its dental management (Tables 1–3) and, more importantly, investigates the long-term outcome of 49 avulsed and replanted permanent teeth (Fig. 2). The first noticeable aspect is that the observed outcomes are very heterogeneous; they range from symptom-free healing to inflammation and rapid tooth loss. This study found an overall tooth survival rate of 65.3% within a mean observation period of 3.5 years for replanted avulsed teeth. This is considerably inferior to the success rates of most other treatment procedures in modern dentistry, including dental traumatology, but it is in line with other reports on replanted avulsed teeth, showing survival rates between 50.0% and 83.3% [16–18, 20, 27, 28] and emphasizing the severity of this specific type of TDI. The most desirable outcome after avulsion is functional healing, which was observed in 26.5% (N=13/49) of all monitored cases and did not lead to the loss of a single tooth during the observation period (Fig. 2b). In contrast, all the teeth showing inflammatory resorption (N=11/49, 22.5%) were lost within the first 4 years after the accident, with the highest probability of loss within the first two years post-trauma (Fig. 2d). In comparison, the teeth showing replacement resorption (N=25/49, 51.0%) may remain clinically asymptomatic for many years, resulting in a lower probability of tooth loss in the first three years after trauma (Fig. 2c). Tooth loss related to replacement resorption (N=6/24, 25.0%) may occur as a long-term consequence mostly due to crown fractures following extensive root resorption. It can be concluded that replanted avulsed teeth that do not show any signs of resorption within the first three years after the accident are likely to remain symptom-free, but for teeth affected by resorption, tooth loss, possibly years after the accident, is a likely outcome. As most cases of avulsion occur in juvenile patients [3, 29], it is of clinical importance to preserve the tooth and surrounding bone tissue to provide optimal, definitive, prosthodontic rehabilitation under the possibility of later treatment with dental implants. In this study no conclusive association between the stage of root development and potential complications in avulsed and replanted teeth was registered (supplementary information). This finding may support the initially mentioned hypothesis that the PDL protects the tooth against active osteoclastic cells. Thus, the severity of PDL damage may have a greater influence on the occurrence of resorptions and/or tooth loss than the stage of root development. Nevertheless, this assumption needs verification in future

and larger cohort studies. It is common knowledge that the prompt rescue and replantation of an avulsed tooth will enhance the probability of achieving a favourable outcome after trauma¹⁵. Based on the data of the included cases, optimal tooth rescue is a rare and exceptional occurrence in real-life settings, which is illustrated by the documented average dry storage time of 82min and mean of 173min until replantation (Table 1). Only two teeth, in the same patient, were replanted immediately on the accident site, and only three more were placed in a tooth rescue box within 15min after the accident. This supports the recommendation that tooth rescue, often provided by non-professionals, is of the utmost importance for the fate of avulsed teeth. The widespread and sustainable availability of special physiological storage media and, more importantly, knowledge of how to manage the replantation of avulsed teeth on-site need a major boost in awareness in terms of medical first aid guidance. Considering that such proposals have already been made in the past, the uncertain coverage of costs and the unpredictability of the location and timing of TDI complicate the establishment of a close and ubiquitous tooth rescue service³⁰. Furthermore, deviations in the treatment intervals were noticed (Table 2), despite all efforts to adhere to international guidelines¹⁵. In particular, in some cases, the splinting time was exceeded, which also resulted in delayed endodontic treatment (Table 1). This might be partially because of the lack of patient compliance. Even less encouraging for clinicians is the low long-term survival probability of avulsed and replanted teeth and limited treatment options to control complications at a later stage. One reason for these issues is the early and unpredictable appearance of inflammatory resorption. Even if endodontic treatment is provided in a timely manner, inflammation and/or resorption can lead to the rapid destruction of dental hard and/or bone tissue, possibly leading to gutta-percha being integrated into the bone tissue. Experiencing the possibility of early destructive resorption led to modification of the endodontic treatment procedure in the present study population. After ~2010, definitive endodontic treatment was no longer carried out earlier than one year after TDI and was carried out only under the condition that no resorption was diagnosed to avoid the challenging removal of definite root canal filling material from the partially resorbed tooth and replacing bone.

To treat avulsed teeth after unfavourable tooth rescue, most techniques, until now, have aimed at delaying the onset and/or limiting the extent of replacement resorption. Panzarini et al.³¹ reviewed strategies for treating the root surface or PDL prior to replantation with a variety of agents, e.g., antibiotics, enamel matrix proteins, acid etching solutions, fluoride, corticosteroids, or bisphosphonates, but concluded that none of the reviewed reports offered a treatment that could prevent or heal ankylosis or replacement resorption in teeth with severely damaged PDL cells. New approaches for research activities based on the underlying cell biology are urgently needed, with the aim of finding a way to restore or rebuild the PDL to prevent tooth loss in replanted teeth after unfavourable tooth rescue³². This longitudinal, retrospective clinical study has strengths and limitations. Mainly, the study was based on a longitudinal recall over several years of caring for patients who received dental care due to avulsion between 2004 and 2017. Long-term and detailed data for TDI cases, especially the avulsion of permanent teeth, have been rare in the last decade^{16,17,20}; therefore, current information is required to reflect the present state of clinical practice. Although a practice-based, retrospective study design is often considered less optimal, particularly due to the possibility of missing information (Tables 1–3), this design might still be the most feasible approach to study the outcome of replanted permanent teeth in humans under real-life circumstances. The use of a randomized, prospective study design would have been more appropriate to collect data systematically, but it is difficult to subject patients, most of whom are underage and in an acute emergency situation, to the necessary preliminary procedure. One limitation of this study was that several patients with replanted teeth decided not to receive follow-up treatment at the university hospital, which resulted in a smaller sample size. Furthermore, only those cases with a minimum observation time of 60 days were included, which not only further reduced the sample size but also helped to limit the heterogeneity of the study population. However, several patients who did not receive immediate dental care at the university hospital after TDI but had been referred to the university hospital at a later time due to associated complications were included. This may have led to an overrepresentation of undesirable events in this case series. The small sample size limits the possible use of regression analyses. Therefore, solely descriptive statistical data are provided (Tables 1–3), presenting an overview of the current findings instead of detailed explorative analyses. To include larger numbers of cases, the urgent need for a well-standardized, multi-centre clinical study or specialist network aiming to investigate possible outcome scenarios after tooth avulsion should be emphasized.

VI. Conclusions

One-third of replanted avulsed teeth were lost during the mean observation period of 3.5 years, and only one out of four replanted teeth showed functional healing. Teeth were lost earlier in cases linked to inflammatory resorption (mean, 1.7 years) than in cases linked to replacement resorption (mean, 6.1 years). Therefore, it can be concluded that tooth avulsion remains a severe dental injury with an unpredictable prognosis, which demands new fundamental research aiming to maintain and/or regenerate the PDL after tooth avulsion.

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