

# Survival Rate of Teeth after Replantation of permanent incisors in Relation to defined Parameters: An Interventional Study

Dr. Heidrun Schaaf<sup>1§</sup>, Dr. Martha Johanna Hoh<sup>2</sup>, Dr. Philipp Streckbein<sup>3</sup>, Dr. Jan-Falco Wilbrand<sup>4</sup>, Dr. Heiko Kerkmann<sup>5</sup> and Dr. Sameh Attia<sup>6</sup>

<sup>1,5</sup>Maxillofacial Surgery, MKG am Theater, Giessen, Germany

<sup>§</sup>Email of Corresponding Author: schAAF@mkg-am-theater.de

<sup>2</sup>Dental Plus, Wiesbaden, Germany

<sup>3,4,6</sup>Department of Maxillofacial Surgery, University Hospital Giessen and Marburg GmbH, Giessen, Germany

**Abstract**—Treatment of severely traumatized teeth is known to be a challenge in oral surgery. In particular, severe tooth trauma in children is difficult to treat, mainly because of damage to the periodontal ligament, unphysiologic storage of the tooth and the growing jaw of these patients.

In this present clinical study, teeth with severe trauma were treated using an extra-oral endodontic method. Auto-alloplastic replantation involves using a titanium post as endodontic filling prior to replantation. Aim of this study was to determine survival rate of such replanted permanent teeth in relation to defined parameters that may influence survival. In this study, 44 patients with 58 replanted teeth were evaluated.

Out of 58 teeth, 28 were avulsed and 30 teeth were dislocated; 24 teeth healed with a functional periodontal ligament (functional healing), 8 teeth healed with ankylosis and a further 8 showed replacement resorption. Infection-related resorptions were present in 2 teeth, which were removed after two months. Other 16 cases could not be assessed. 5-year survival rate according to Kaplan-Meier analysis was 83.9% and estimated time of survival was 88.5 months. Avulsion and storage had no significant effect on tooth loss ( $p=0.178$ ). Mature teeth had a significantly higher 5-year survival rate (92.2%) than immature teeth (72.4%,  $p = 0.041$ , log rank test).

It can be concluded that auto-alloplastic replantation is a reliable method in dental trauma treatment. This method is suitable with a high rate of success for avulsed or severely traumatized teeth.

**Keywords:** Dental Trauma, Avulsion, Replantation, Extra-Oral Endodontic Treatment.

## I. INTRODUCTION

Currently, avulsed permanent teeth can be replanted with an acceptable outcome. Survival of periodontal ligament is important for a successful replantation: formation of a physiological periodontal ligament after replantation and the preservation of cells of root surface is vital.<sup>1</sup> Andreasen and Hjorting-Hansen described resorption of roots after replantation as a possible reaction of periodontal ligament.<sup>2,3</sup> On the basis of radiological and histological studies in humans, healing process is classified into three categories: surface resorption, replacement resorption and infection-related resorption and surface resorption with functional recovery.

Periodontal healing depends on storage of injured tooth, endodontic treatment, management of replantation, splinting and immune response of body. Avulsed and replanted teeth can be lost within first two months or survive for many years.<sup>3,4</sup> In children, loss of permanent teeth has serious long-term consequences. A prosthetic conventional bridge or a dental implant is not indicated because of continuing growth of jaw.

Avulsion or severe trauma of incisors leads to injury of pulp and periodontal ligament. If width of apical foramina is more than two millimeters, pulp may vascularize and stay vital<sup>5</sup> or transform into scar tissue. These teeth can be replanted without endodontic treatment.

In permanent mature teeth with closed apices, there is a high risk of pulp necrosis. Revascularization cannot be expected.<sup>6,7</sup> These teeth must be followed carefully and endodontic treatment must be carried out conventionally or with an extra-oral approach and retrograde insertion of a titanium post.

Auto-alloplastic replantation involves insertion of a tooth with its autologous periodontal ligament and an alloplastic titanium post in root canal.<sup>8,9</sup> Aim of auto-alloplastic replantation is reintegration of injured tooth and functional loading of bone and tooth to preserve physiologic structures of bone and periodontal ligament.

Some studies have focused on survival of replanted teeth, but very few have focused specifically on auto-alloplastic replantation. These have reported a 42.5% 5-year survival rate, based on Kaplan-Meier analysis.<sup>10,11</sup>

Aim of this study was to estimate survival rate and healing results of auto-alloplastic replanted incisors after trauma. Parameters of maturity of teeth, storage and type of healing were also examined separately.

## II. METHODOLOGY

This interventional study was conducted on 44 patients with 58 replanted teeth. Data for this study were collected from patients who were treated between years 2000 and 2005 after dental trauma to incisors. Treatment was performed according to standard protocol using auto-alloplastic replantation.<sup>8,9</sup> Type of dislocation of tooth was classified as avulsion, intrusion, extrusion, lateral luxation, subluxation and concussion.<sup>12,13</sup> Maturity of traumatized tooth root was classified as mature with closed apex and immature with open foramen.<sup>14</sup> Storage of tooth was classified as physiological (<30 min dry and <60 min unphysiological for cells) or unphysiological (>30 min dry and >60 min unphysiological for cell).

During treatment procedure, tooth was stored in a rescue box (e.g., Dentosafe®, Dentosafe GmbH, Iserlohn, Germany). Immediate extra-oral endodontic treatment with preparation of root canal up to 1.6–3 mm has been performed. Then a titanium post was cemented retrogradely.

Root surface was intensively rinsed during treatment with sterile isotonic saline prior to replantation. For anti-resorptive therapy, topical application of doxycycline and glucocorticoid was performed. After endodontic treatment, tooth was stored for about 20 minutes in tissue culture medium in tooth rescue box and dexamethasone was added. Additionally, doxycycline was prescribed for oral systemic use for five days. If avulsed tooth was dry for more than 30 minutes, then Emdogain® (Straumann, Basel, Switzerland) was used on root surface and in socket.

Classification of success or failure of therapy was in accordance with guidelines of International Association of Dental Traumatology (IADT).<sup>15</sup> Criteria for success were clinically asymptomatic, normal mobility, no apical lesion in a radiograph and no resorption or ankylosis of root.

Institute for Medical Statistics of University of Giessen performed statistical analysis. Survival rates were calculated using Kaplan-Meier analysis. Statistical tests were carried out with log-rank test and p-value was defined at a significance level of  $p \leq 0.05$ . To further analyze nature of healing, a multivariate Cox regression was carried out.

### III. RESULTS

From a 5-year time period (2000–2005), a total of 44 patients with dental trauma of upper incisors were included in this retrospective trial. In total, 58 teeth (44 patients) were replanted. average observation time was 58 ( $\pm$  30.7) months for 42 of 58 teeth until 2009 or until tooth was lost. In total, 4 teeth were removed as a result of trauma. A further 5 teeth were removed for other reasons, for example orthodontic reasons. Of 44 patients, 31 were male and 13 were female (male:female ratio of 2.3:1).

Teeth were classified according to type of trauma: avulsion in 28 teeth (48.3%), extrusion in 5 (8.6%), intrusion in 10 (17.2%), contusion in 4 (6.9%), luxation in 6 (10.3%) and subluxation in 5 (8.6%).

Avulsed teeth (n=28) were replanted and 30 traumatized and dislocated teeth were extracted carefully and then intentionally replanted after auto-alloplastic treatment. Of 30 dislocated teeth, 7 had a horizontal root fracture.

Overall, 34.5% (n = 20) of replanted teeth were immature with wide-open apical foramen and 65.5% (n = 38) had fully formed root growth and were diagnosed as mature. Of 28 avulsed teeth, only 28.6% (n = 8) were kept in physiological storage; 71.4% (n = 20) were stored non-physiologically after trauma. Based on all auto-alloplastic replanted teeth (n = 58), 34.5% were stored non-physiologically.

#### 3.1 Healing

Radiographic examination of 58 replanted teeth showed that 41.4% (n = 24) had functional healing, 8 had ankylosis without replacement resorption, 8 had replacement resorption and 2 had infection-related resorption. remaining teeth could not be assessed due to short evaluation time after replantation or teeth could not be distinctively judged. Long-term follow-up of 27 teeth until year 2009 revealed 17 with functional healing, 6 with ankyloses and 4 that were healed with replacement resorption.

#### 3.2 Survival

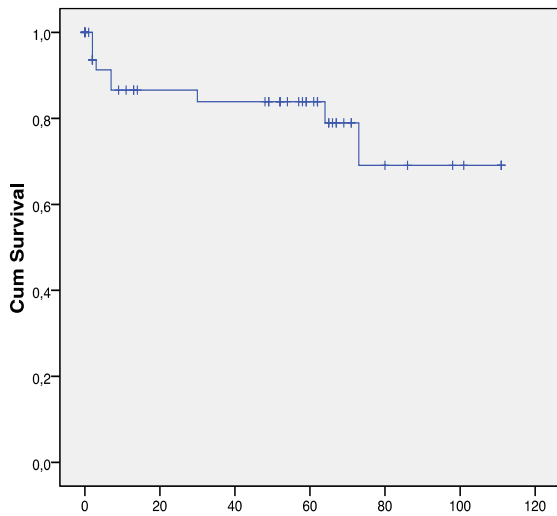
Estimated 5-year-survival rate was 83.9%, according to Kaplan-Meier analysis. expected survival time was 88.4 months (6.7 SD; see Figure 1)

5-year-survival rate was 91.3% for intentional replantation and 75.9% for auto-alloplastic replantation (Fig. 2). log-rank test revealed no statistically significant difference between two therapies (p = 0.178). (Figure 2)

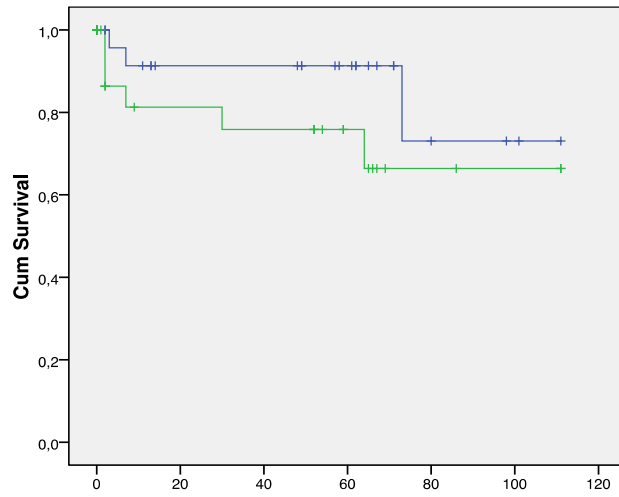
Mature replanted teeth had a 5-year survival rate of 92.2%, whereas rate for immature roots was 72.4% (Figure 3).

5-year survival rate was 87% for teeth with functional healing and 83.3% in cases with ankylosis. Teeth with replacement resorption had a 90% 5-year-survival rate, but after another four months survival rate dropped to 72%. Teeth with infection-related resorption were lost within three months, with a survival rate of 0% (Figure 4).

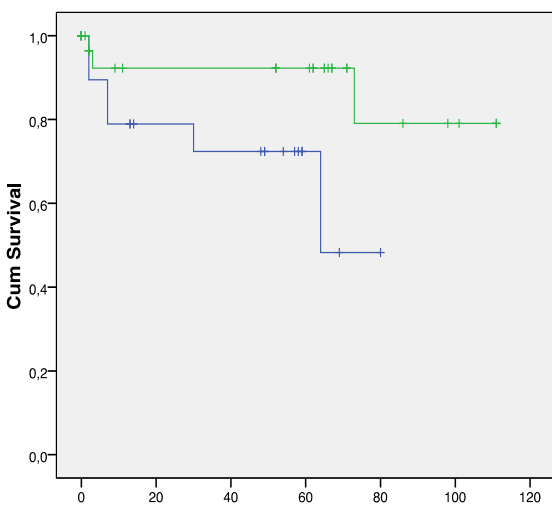
**Figure 1**  
**Survival rates of all teeth following auto-alloplastic replantation (n=58) (in Months)**



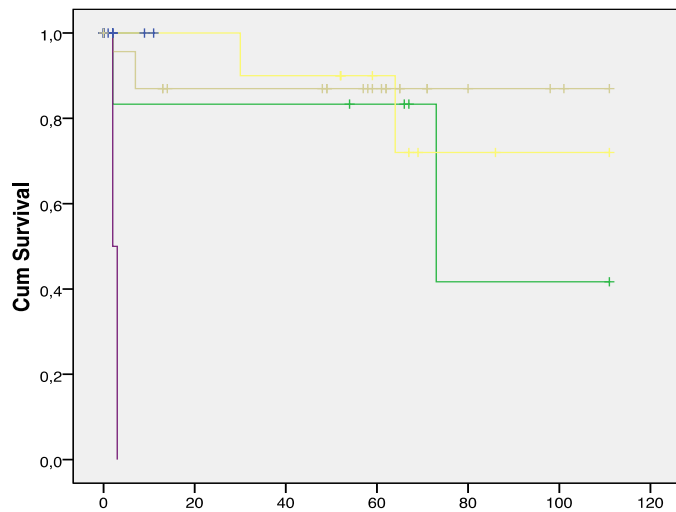
**Figure 2**  
**Survival rates depending on the treatment of intentional replantation (blue) and auto-alloplastic replanted teeth (green)**



**Figure 3**  
**Survival rates according to Kaplan-Meier depending on the maturity state: Immature (blue) and Mature (green)**



**Figure 4**  
**Survival rates according to Kaplan-Meier pending on the type of healing: ankylosis (green), functional healing (brown), infection-related resorption (purple) and replacement resorption (yellow)**



For further analysis, a Cox regression for types of healing was performed. survival rate of teeth with infection-related resorption differed significantly ( $p = 0.009$ ) compared to other groups. Rates for teeth with other types of healing differed only slightly and difference was not significant ( $p > 0.05$ ). Infraposition was measured in 17,2% ( $n=10$ ) of teeth.

#### IV. DISCUSSION

Observations of present are compared with other studies that used only auto-alloplastic replantation. Very few articles have been published about original auto-alloplastic replantation and like this study all had retrospective designs. One reported that based on early follow-up examination, auto-alloplastic replanted incisors of upper jaw showed almost similar periodontal healing compared to healthy neighboring teeth.<sup>16</sup>

Pohl et al.<sup>11</sup> reported a mean lifetime of 59.2 (+/- 42.5) months for 40 intentional replanted teeth. expected survival time was 99.5 months. They found that extra-oral root canal treatment and insertion of a titanium post caused no further damage to periodontal ligament and that infection-related complications could be prevented with this method.

One analysis of 28 avulsed and auto-alloplastic replanted teeth found that survival was dependent on storage, while maturity of root and patient's age had no influence. average survival rate of all teeth was 57.3 months. Teeth with physiological storage were not lost and life expectancy could be long.<sup>10</sup> Compared to present study, estimated survival time was even higher, at 88.4 months. dependency on storage to survival could be found in both studies.

Following table compares 5-year survival rates among different studies and lists success rate for functional healing. 5-year survival rates in studies by Pohl et al.<sup>10</sup> and Boyd et al.<sup>17</sup> were taken from charts of their Kaplan-Meier analyses.

**Table 1**  
**Comparison of 5-year survival and success rates of functional healing of replanted teeth**

	5-year survival	Number of replanted teeth	Success rate of functional healing
Present study	84% in total 72% immature teeth	n=58	58%
Pohl et al. (10, 11)	44% in total	n=28	32%
andreasen et al. (18, 19)	70% in total 60% immature teeth	n=400	34%

Survival rates in present study are similar to (but slightly higher than) rates in studies with largest number of included patients.<sup>18,19</sup> Reason for this might be deduced when comparing 5-year survival rates of avulsed teeth (75.9%) and intentional auto-alloplastic replanted teeth (91.3%). In most cases, intentional replanted teeth have a vital periodontal ligament, no history of extra-oral dry storage and less traumatic mechanical injury. periodontal ligament and its vitality and storage have a great influence on success of replantation. In a prospective study, Boyd et al. found that total extra-oral time and time stored dry are important factors for onset of resorption in replanted avulsed teeth in children.<sup>17</sup> In present study, auto-alloplastic replanted teeth had a higher survival rate in this study (84%) than conventional replanted teeth (70% (20) or 75%.<sup>19</sup> (21)). In present study, 34.5% of replanted teeth were immature. Mature teeth had a significantly higher survival rate (5-year survival probability of 92.2%) than immature teeth (5-year survival probability of 72.4%). In contrast andreasen et al. found better periodontal healing (57%) in immature teeth than in mature teeth (29%), but also higher rates of tooth

loss in immature teeth (40%) than in mature teeth (27%).<sup>20</sup> Reason could be discussed, that immature teeth have a shorter root.

Failure rate after tooth replantation was 4.2-fold higher in immature teeth than in mature ones.<sup>21</sup>

A clinical trial of luxated upper incisors revealed that frequency of cervical root fractures was markedly higher in immature than mature teeth.<sup>14</sup> In that study, frequency of fractures was also related to defects after healing of inflammatory root resorption in cervical area. However, no cervical root fractures were detected in present study, maybe because there was no inspection with a magnifier or microscope.

## V. CONCLUSION

Present study suggest that treatment using auto-alloplastic replantation is a reliable method with a good long-term outcome. It yielded higher survival rates than conventional treatment. Extraoral endodontic preparation of avulsed teeth did not result in further damage to periodontal ligament due to prolonged extra-oral time. With regard to root status, immature teeth healed better than they did in other studies. Auto-alloplastic replanted teeth can function successfully until adolescence.

Influencing factors, such as storage of avulsed teeth or comparison between conventional and auto-alloplastic treatment, need to be studied with a larger number of patients. A multi-center study may be a promising enterprise.

## CONFLICT

None declared till date.

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