

Long-term outcomes 1–20 years after autotransplantation of teeth: clinical and radiographic evaluation of 66 premolars and 8 molars

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Abstract

In this retrospective study we investigated the long-term survival of autotransplanted premolars and molars with incompletely developed roots. The presence of the transplanted teeth and their outcome after autotransplantation was ascertained from clinical and radiographic evaluation by a maxillofacial surgeon or dentist. Kaplan Meier survival curves were estimated for the total population and for the two groups (premolars and molars).

Fifty-one patients with 74 transplanted teeth were included, and the median duration of follow-up was 10 (range 1–20) years. Four of 66 premolars and one of 8 molars were removed and the cumulative survival was 95.4% (95% CI 90.3 to 100). The difference in survival between the premolars and molars was not significant. These results show that the long-term survival of autotransplanted teeth is good. Replacement of a single tooth by autotransplantation should therefore always be considered and is preferred when a suitable donor tooth is available.

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Introduction

Autotransplantation is a common procedure in which teeth (donor site) are transplanted to another site in the upper or

lower jaw (recipient site) in the same patient. In most cases in our clinic the procedure is done for agenesis of the mandibular premolars. In patients with reduced width of the arch of the maxilla, and agenesis of the premolars of the mandible, autotransplantation of maxillary premolars to replace mandibular ones can prevent increasing disto-occlusion because of missing teeth. Another common indication is premature loss of teeth, after which autotransplantation of premolars or third molars can be considered. Nevertheless, autotransplantation

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Fig. 1. Radiograph of an upper premolar that was transplanted to the location of the lower left second premolar more than 15 years earlier. The autotransplanted premolar functioned as a normal tooth.

is often not considered as a treatment for the replacement of a single tooth when it has been lost.^{1,2}

There are several preoperative requirements for autotransplantation of teeth, in particular the availability and suitability of a donor tooth. The most commonly available donor teeth are premolars (particularly in the case of plans for orthodontic extraction) (Fig. 1). Suitability is mainly governed by the development of the roots of the donor tooth. However, several other factors can be important, including the morphology of the root of the donor tooth, the possibility of extracting the donor tooth without iatrogenic damage, and the presence of adequate alveolar bone at the recipient site.³

The time for autotransplantation is optimal when the developmental stage of the donor tooth shows about 50%–75% of its expected total development (the apical foramen should be at least 2 mm wide on radiographic images).^{1,3,4} It is nevertheless also possible to use autotransplantation in fully developed teeth as long as the patient has endodontic treatment before (or shortly after) autotransplantation.^{5,6} If it is done when the donor tooth still has an open apex, it is normally indicated in patients of about 12 (premolars) or 18 years (third molars) of age. Maxillofacial growth is still progressing in these relatively young patients and placement of titanium dental implants is contraindicated.⁷

Autotransplantation can be a beneficial option to replace an absent tooth or at least bridge the time until placement of a dental implant is possible.¹ If the long-term prognosis is good, however, autotransplantation might even avoid the need for dental implants. The long-term prognosis of transplanted teeth is therefore vital to the decision on whether autotransplantation is the best option for the patient. We know of relatively few reliable papers on this important topic,^{5,8–11} and it would therefore be helpful to investigate the long-term outcome after the procedure in a large homogeneous group of patients with transplanted premolars and molars.

Our aim was to analyse the long-term survival after autotransplantation of premolars and molars and calculate the cumulative survival.

Material and methods

We retrospectively reviewed the medical records of consecutive patients who had had autotransplantation of (pre)molars at the Leiden University Medical Centre between December 1996 and January 2015. Patients were included if they had had one or more autotransplantation of a premolar or molar with an incompletely developed root. Traumatic avulsion, or procedures involving completely-formed teeth, or both, were not included.

Patients who met the inclusion criteria were sent a questionnaire to inquire about their evaluation of the procedure(s) and the presence of the transplant(s). Postoperative clinical follow-up by the oral and maxillofacial surgeon at the Leiden University Medical Centre had consisted of clinical evaluations and panoramic radiographs at 1 week, 6 months, and 1 year postoperatively. If patients gave informed consent, additional information was gathered from clinical or radiographic examinations, or both (either dental or panoramic radiographs), of the transplant(s) by a qualified maxillofacial surgeon or dentist. The following factors were evaluated: the presence or absence of the transplanted tooth and the possible reason for removal; additional treatment(s) after autotransplantation; endodontic treatment; resorption of the root; ankylosis, and mobility. The date of the last clinical and radiographic examination was noted.

Autotransplantation was planned when development of the root of the donor tooth was 50%–75% of its total expected development. All patients were treated according to the same treatment protocol, except for the use of antibiotic treatment.^{1,12} Preoperative antibiotics, in the form of amoxicillin/clavulanic acid (500/125 mg for seven days), were prescribed until December 2013. Patients treated after this date were not given prophylactic antibiotics.

Surgical technique

The procedures were done under local anaesthesia. First, the (deciduous) tooth at the acceptor site was removed (if present). Then, the donor tooth was carefully extracted with forceps and preserved in saline. At all times care was taken to prevent damage to the donor tooth and its cementum and periodontal ligaments. After inspection of the donor tooth, a neoalveolus was prepared at the acceptor site, and the donor tooth was subsequently fitted. If necessary, the donor tooth was placed in a rotated position to achieve a better fit. When a good fit had been obtained, the donor tooth was gently placed in the neoalveolus and fixed with sutures. Autotransplanted teeth were fixed in a slight infraposition to prevent occlusal forces during the healing phase (Fig. 2).



Fig. 2. Photograph of an autotransplanted premolar fixed with a suture splint.

This study was done in accordance with the guidelines of our institution and followed the Declaration of Helsinki on medical protocol and ethics. The study protocol was reviewed by the Leiden University Centre institutional ethical review board, and it was granted an exemption in writing (P15.002).

Statistical methods

For statistical analyses we used IBM SPSS Statistics for Windows (version 25.0, IBM Corp). Descriptive statistics were used. Kaplan Meier survival curves were estimated for the total group of patients and for the two groups (premolar and molar). To assess the effects of possible risk factors on the outcome, univariate Cox regression models were estimated. The hazard ratio (HR) and 95% CI were reported. To estimate the median duration of follow-up we used the reverse Kaplan Meier method.¹³ Statistical comparisons were considered significant if the probability was less than 0.05.

Results

Of the 97 consecutive patients who were treated by autotransplantation of (pre)molars, one patient died; the remaining 96 were sent questionnaires by mail. Of this group, a complete evaluation, including the response to the questionnaire and clinical/radiographic examinations, was obtained in 51 patients. There were no significant differences in personal characteristics among the groups of patients who did and did not respond to our questionnaires.

The total study group therefore included 51 patients who were treated by autotransplantation of 66 premolars and 8 third molars (74 procedures). The median duration of follow-up was 9.7 years (95% CI: 7.5 to 12.0), ranging from 1–20 years postoperatively. The patients' personal characteristics are shown in Table 1.

Endodontic treatment after autotransplantation was required for 7 teeth. This was necessary within 6 months

Table 1
Characteristics of patients.

| | Premolar group | Molar group | Total |
|-------------------|----------------|-------------|----------|
| No. of patients | 44 | 7 | 51 |
| No. of procedures | 66 | 8 | 74 |
| Sex: | | | |
| Male | 20 | 4 | 24 |
| Female | 24 | 3 | 27 |
| Mean age (years): | 12.2 | 18.7 | 12.9 |
| SD | 1.2 | 2.7 | 2.5 |
| Range | 9.3–14.6 | 16.0–23.9 | 9.3–23.9 |

Data are the number of patients unless otherwise stated.

Table 2
Survival of (pre)molars after autotransplantation.

| | Total number of teeth | Number of teeth removed | Cumulative 10-year survival (%) |
|----------------|-----------------------|-------------------------|---------------------------------|
| Premolars | 66 | 4 | 96.7 |
| Molars | 8 | 1 | 85.7 |
| All procedures | 74 | 5 | 95.4 |

of autotransplantation in one premolar, and after more than 6 months in 1 premolar and 2 molars (2.5–5.1 years after the procedure). The timing of endodontic treatment was unknown in 3 premolars. Ankylosis was present in two premolars that both functioned well for more than 15 years after autotransplantation. Resorption of the root that was not progressive was visible on the radiographs of 7 transplanted teeth.

Five of the 74 transplanted teeth were removed at the end of follow-up (Table 2) after 1.4–15.4 years. Four premolars were removed after 1.4, 4.1, 9.9, and 15.4 years, and 1 molar was removed after 5.5 years. The reasons for removal were: endodontic problems (including resorption of the root) in four, and unknown in one. To investigate the effect of risk factors on the final outcome, a Cox proportional hazard regression model was used. The HR for age (continuous) was equal to 0.999 (95% CI 0.74 to 1.35).

Four of 66 premolars and one of 8 molars were removed. The cumulative long-term survival after autotransplantation of premolars was 96.7% (95% CI 92.2 to 100) and of molars was 85.7% (95% CI 60 to 100). The survival curves for the two groups are shown in Fig. 3. Comparison between the two groups based on the log-rank test showed no significant difference between premolars and molars ($p=0.950$). The overall survival for all 74 transplanted teeth (Fig. 4) was 95.4% (95% CI 90.3 to 100).

Of the patients who reported additional information about the satisfaction of the procedure in the questionnaire, most were very satisfied with both the procedure and the outcome of autotransplantation.

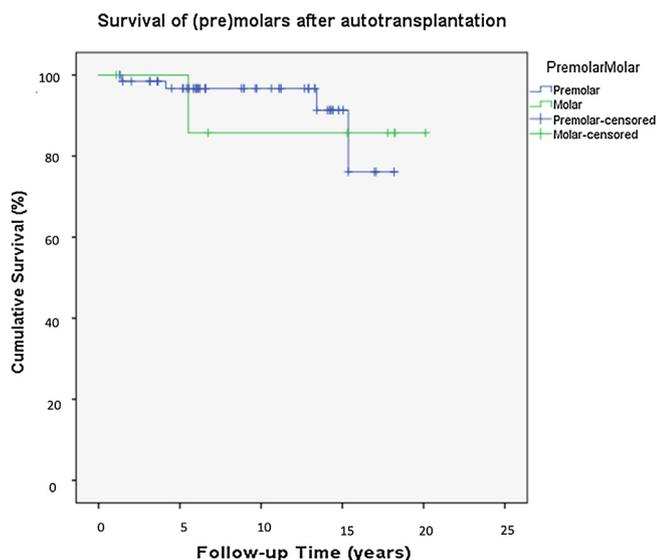


Fig. 3. Kaplan-Meier curve of the long-term survival of premolars and molars after autotransplantation.

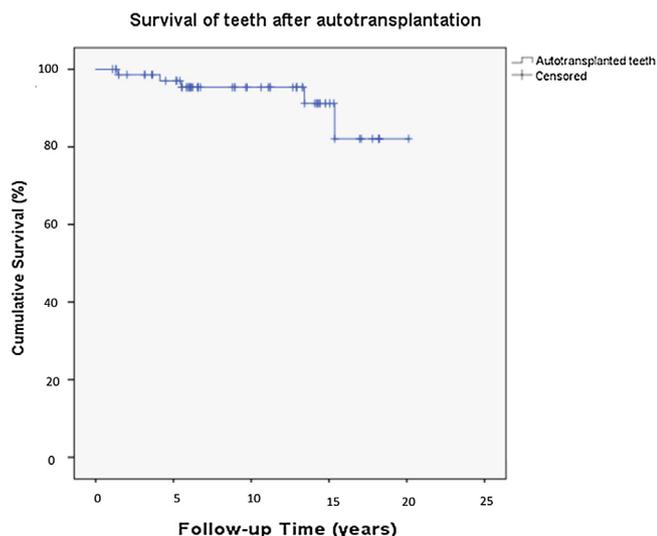


Fig. 4. Kaplan-Meier curve of the long-term survival of autotransplanted teeth.

Discussion

Our aim was to evaluate long-term survival of transplanted premolars and molars through questionnaires to patients and clinical/radiographic examination.

The reported short-term survival of teeth after autotransplantation ranges from 88.4%–100%.^{1,3,12,14–18} The success rates are similarly high, and successful autotransplantation can be ascertained by the absence of endodontic disease or resorption, adequate bony height without pockets, and progressive development of the root after autotransplantation.^{1,2}

We know of few studies that have reported on the long-term prognosis of autotransplanted teeth, but some are available. In a paper from 1990, Andreasen et al⁵ reported on 370 autotransplanted premolars with a follow-up of 1–13

years. They calculated a long-term survival of 95% of teeth with incomplete formation of roots. Czochrowska et al¹⁰ investigated the survival and success of 33 transplanted teeth after 17–41 years and found a survival of 90%. Jonsson and Sigurdsson⁹ reported 40 transplanted premolars with a follow-up of 2–22 years and found 97.5% survival. These reported findings are in accordance with the survival that we found in this study, even though the transplantation protocols that were used in those studies (for example - operation, postoperative treatment, and differences in criteria of success) differed slightly from ours.

We found that the overall cumulative survival for all transplanted teeth was 95.4%, and the difference in the cumulative survival for molars (85.7%) and for premolars (96.7%) was not significant. Nevertheless, different rates of survival based on the type of tooth can be present as reported in the above-mentioned studies.^{8,19,20} These differences can be caused, for example, by the morphology of the root or difficulty of extracting the donor tooth without iatrogenic damage to the periodontium.

Yoshino et al⁸ found a 10-year survival for transplanted third molars of 59.1% in men and 81.9% in women. Gonnissen et al²⁰ found an 11-year survival of 75% for canine autotransplantation. We found no significant difference between premolars and molars in this study, but our group of transplanted molars was relatively small.

The long-term outcome is important when choosing between autotransplantation and other possible options for treatment, one of the most popular of which for replacement of a single tooth is a dental implant. The 10-year survival of titanium implants for replacement of a single tooth is reported to be 95.2%, which is similar to the long-term survival of autotransplanted teeth.²¹ Dental implants are nevertheless associated with their own biological and technical complications, such as peri-implantitis or mechanical failure.

In addition, dental implants are not compatible with progressive craniofacial development.⁷ Major changes in the jawbone as a result of maxillofacial growth occur during puberty, and can progress until 18 years of age.²² Coincidentally, the likelihood that a suitable donor tooth may be available for autotransplantation is high in these young patients. Auto-transplantation should therefore always be considered for them, and is probably preferred in most cases.

Autotransplantation offers several important advantages over dental implants. For example, the transplanted tooth will form a physiological connection, which is accompanied by proprioception and bony regeneration as a result of stimulation of the periodontal ligament. The possibility of postoperative orthodontic treatment also remains, and the cost of autotransplantation is relatively low.

Several aspects of the operation are important to achieve successful results from autotransplantation.² The surgeon should always strive to cause as little trauma as possible during the extraction of possible deciduous teeth at the recipient site, and when extracting the donor tooth. Care should be taken not to damage the surface of the root and the peri-

odontal ligament of the donor tooth, either mechanically or chemically. Extra-alveolar time should be as limited as possible - some authors propose leaving the extracted donor tooth in its socket.⁹ However, we prefer to preserve the donor tooth in saline solution during preparation of the neoalveolus.

After autotransplantation, the transplanted tooth should initially be placed in an infraposition to prevent occlusal forces on the tooth during the healing phase. The tooth should be fixed with a suture because a more rigid fixation with a wire-composite splint can lead to ankylosis.²³ The need for antibiotic prophylaxis is uncertain, and we know of little published evidence to support it, so we have not used prophylactic antibiotics in our clinic since January 2014.

Because of the retrospective design of this study there are some limitations that should be mentioned. No calculation of sample size and no randomisation of patients were possible because of the retrospective nature of the study. Loss of patients during follow-up and the difficulty of following patients up over a period of years were also important limitations.

We obtained a complete evaluation for over half the transplantations. If all or more transplants among the non-responders were lost, the reported survival would have been lower. However, patients were instructed to return to our clinic if they experienced problems with the transplanted tooth and we therefore do not think that many transplants among the non-responders were lost. What is more likely is that the youth of many patients at the time of operation (about 12 years of age) and a long period of follow-up, meant that patients had moved away to a different city or country, for example. We therefore think that our current study group was a reliable representation of patients treated by autotransplantation in our clinic. Nevertheless, the results of this retrospective study should be interpreted with caution.

The outcome of classic autotransplantation techniques are good, with high long-term survival currently reported.¹ Further increase in the success and survival after autotransplantation can be obtained with 3-dimensional techniques.¹⁸ For example, the use of these techniques combined with rapid prototyping to fabricate a replica of the donor tooth enables preparation of the neoalveolus at the recipient site before extraction of the donor tooth.²⁴ A 3-dimensional replica of the donor tooth can reduce the risk of iatrogenic damage to the tooth itself, minimise extra-alveolar time spent on the transplant, and facilitate an easy, predictable procedure.²⁵ Future research should therefore focus on further improving techniques of autotransplantation, and aiming to provide biological tooth replacement with transplants that function as normal teeth in all cases.

Conclusions

Autotransplantation is useful in growing patients with a high chance of long-term survival. In particular, in patients with missing teeth and incompletely-formed premolars or molars,

autotransplantation should always be considered, as it has been shown to be a successful treatment for replacement of permanent teeth.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients' permission

The protocol was reviewed by the Leiden University Medical Centre who granted exemption for writing (P15.002). Permission was acquired from the patients, and no identifiable information was included.

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