

Autotransplantation of Premolars to the Position of Central Maxillary Incisors: Evaluation After 10-Year Follow-up

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Summary

Autotransplantation of premolars to replace lost maxillary incisors in young patients can ensure restoration of normal function and aesthetics. However, there is a need to evaluate the function and aesthetic appearance of the transplanted teeth after a long period. The purpose of this study was to evaluate the success of treatment and aesthetic appearance of transplanted premolars after follow-up of 9 to 13 years. The intention was also to assess whether the transplantation procedure can give predictable functional and aesthetic results after long-term intraoral use. The study was performed on 10 patients with teeth transplanted to the position of the upper central incisors. At the time of transplantation the patients were aged between 9 and 14 years (mean 12 years). They were all treated in the Department of Paediatric Dentistry, School of Dental Medicine. After transplantation all the teeth were immobilised with a wire-composite splint for two weeks, and reshaped with composite after three months. The reshaped teeth were compared with the contralateral incisors with regard to morphology, colour and overall aesthetics. Follow-up of the treatment ranged from 9 to 13 years (average 10.5 years). Transplantation outcome was assessed on the basis of clinical, radiographic and aesthetic criteria. Patients were given a visual analogous scale to assess their overall satisfaction with the treatment outcome. Aesthetic outcome was classified in three categories: 1. Match (difference less than 0.5 mm), 2. Deviation (difference from 0.5 to 1.5 mm) and 3. Mismatch (difference greater than 1.5 mm). The results showed that all the teeth survived without signs of root resorption and ankylosis, although endodontic treatment was performed in 70% of the teeth. Aesthetic appearance after the initial reshaping was classified as matched in all cases and in 80% of cases after 9 to 12.5 years. The study showed that the overall satisfaction of patients with the outcome of treatment was very high (VAS = 87.1). Transplantation of premolars to the position of incisors represents a safe method of treatment which gives highly predictable functional and aesthetic results.

Key words: tooth transplantation, success of transplantation, dental trauma.

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Introduction

Dental traumas in children are very frequent, and epidemiological data show that up to the age of 10 years almost every other child experiences some form of dental injury (1, 2). The most severe form of dental trauma involves tooth avulsion, which accounts for 0.5 to 16% of total dental injuries. The central maxillary incisors are most frequently involved in children aged between 7 and 9 years (2). If prompt replantation of the lost tooth is not carried out such a tooth is lost and thus the possibility of prosthetic replacement can be considered, orthodontic closure of the space or tooth transplantation.

By the method of autotransplantation or homologous transplantation another tooth from the same person is transplanted to the position of the lost tooth (e.g. second lower or second upper premolar). The transplantation procedure enables successful solution to the loss of a central upper incisor, with regard to aesthetics and function. Numerous studies have confirmed the high rate of success of the method, with five-year survival of the transplant of 98 to 99%. Ten-year survival of transplanted teeth is only slightly less and amounts to around 87 to 95% (1, 3, 4).

Autotransplantation of the second lower premolars to replace lost central maxillary incisors has proved a reliable method with predictable outcome (1, 3-10). Long-term prognosis (20-40 years) has proved to be better for teeth with a partially developed root (4, 10-15). The following are key factors for successful transplantation of a tooth: correct choice of tooth for transplantation, non-traumatic technique and correct postoperative treatment (1,7,16). Teeth with unfinished root growth have optimal prognosis, and thus patients aged between 10 and 13 years are most suitable for successful transplantation. At this age growth of the alveolar bone is unfinished and consequently insertion of an implant and fixed prosthetic treatment are contraindicated (1).

The second lower premolars from the contralateral side of the jaw are considered most suitable for replacement of an upper central incisor. Their roots are morphologically and with regard to size most similar to the roots of the central incisors. Particularly suitable are teeth with unfinished root growth

and open apex, as they are easily taken from the jaw, and their pulpal and periodontal healing is very good (2, 3, 17).

After the treatment and aesthetic reshaping the transplanted tooth should have a highly aesthetic appearance and in relation to the neighbouring central incisors be of the same shape and colour. The level of the gingival edge and position of the tooth after successful treatment should be identical for both central incisors: the transplanted and the natural tooth. Treatment is considered successful if the root of the transplanted tooth is not affected by pathological changes/lesions, and if a highly aesthetic effect is achieved after reconstruction and a follow-up period.

Transplantation of premolars to the position of maxillary incisors is mainly indicated in younger patients, usually between the ages of 10 and 13 years (1, 7, 18).

When assessing the overall success of the treatment it is also necessary to take into account satisfaction of the patient with the outcome of treatment and appearance of the teeth (12). Thus the patient's perception of the aesthetic appearance of the teeth after reconstruction is important.

The aim of this study was to evaluate the success and possible predictability of the outcome of treatment by autotransplantation of premolars to the position of the maxillary incisors in children, with regard to the physiological-pathological and aesthetic aspect. The object was to compare the aesthetic appearance of the transplanted teeth with the natural neighbouring incisors and to determine the degree of patient satisfaction with the aesthetic effect achieved. The intention was also to evaluate to what extent the transplanted tooth represents a long-term reliable method of treatment and also factors important for treatment planning.

Subjects and methods

1. Patients

Homologous transplantation of teeth into the position of the upper central incisors was carried out in 10 patients. All patients had experienced trauma of the maxillary incisors, as a result of which a

tooth was lost or its extraction indicated. The age of the patient at the time of transplantation ranged from 9 to 14 years, mean 12 years. In 7 cases the teeth were transplanted into the prepared alveoli of a central incisor immediately after its extraction, and in 3 cases a new alveolar socket was formed in the bone by means of a burr with internal cooling. The transplanted teeth were analysed after a follow-up period, which ranged from 9 to 12.5 years, mean 10.5 years (Table 1).

2. Method of transplantation and reshaping the teeth

Autotransplantation of a tooth to the position of the upper central incisors was performed in 10 patients. The reasons for transplantation were traumatic loss of the tooth or its indication for extraction because of the impossibility of further treatment and reconstruction (Figure 1). Second lower premolars from the contralateral side were transplanted to the position of the upper central incisor, and in one case the second premolar from the same side of the jaw. Widely open apex and unfinished root growth offer the possibility of revascularisation of the tooth pulp (Figure 2). In one case the tooth graft was the upper canine from the same side, for which extraction was indicated due to orthodontic reasons.

Preparation for transplantation included a radiograph of the tooth or position to which the premolar was to be transplanted, a radiograph of the premolar graft and preoperative administration of medication for the control of infection. To prevent infection antibiotic doxycycline and chemotherapeutic metronidazol were administered. Each patient was given one doxycycline the day before the operation, amounting to 200 mg (2 capsules of 100 mg), and thereafter one capsule of 100 mg daily for four days. Metronidazol was administered perorally, amounting to 250 mg every 8 hours for five days.

The method of taking the graft, preparation of the alveoli and transplantation of the tooth was carried out according to the method suggested by Andreasen et al (1, 3, 19). After local anaesthesia a circular incision of the cervical part of the periodontal ligament was made around the tooth for extraction. The tooth was then usually extracted by forceps. After which a circular incision was made around the tooth graft (of the lower premolar) which was extracted and

tried in the alveoli. When necessary the alveoli was deepened or widened to enable the lower premolar to be brought into the required position. The tooth was placed laterally into the alveoli of the incisor, with the labial surface turned mesially. The transplanted tooth was immobilised with a wire composite splint (Figure 3). For all patients immobilisation was removed after 7 to 10 days (Figure 4).

Aesthetic reshaping of the crown of the transplanted tooth with composite material was carried out three months after transplantation. During the procedure care was taken to minimise trauma to the dentin and pulp of the tooth as well as the surrounding gingiva. Composite reshaping of the crown of the transplanted premolar into the shape of the incisor was preceded by prior grinding of the crown and tapering in the labio-palatinal direction. The approximal surfaces of the premolar after reconstruction become the labial and palatinal surface of the reshaped incisor. After etching the enamel and application of adhesive the tooth crown was reshaped with composite into a celluloid crown. Particular care was taken to ensure that the shape and colour resembled as much as possible the adjacent natural tooth (Figure 5).

3. Method of evaluation of the transplanted teeth

Evaluation of the transplanted teeth included functional and aesthetic aspects. From the functional aspect the condition of the tooth root was evaluated, the occurrence of eventual ankylosis and its functional value.

Aesthetic evaluation of the transplanted teeth included two aspects: 1. Assessment of the appearance of the tooth crown and surrounding tissue, and 2. Patient evaluation of the achieved level of aesthetics by the application of a visual analogous scale (VAS). The appearance of the restored tooth crown immediately after reconstruction and after the follow-up period, was carried out by application of an objective evaluation according to the method proposed by Espeland & Stenvik (20). The tooth after reconstruction is compared with the contralateral tooth and marked as: 1) Match (score 1) - difference between the teeth less than 0.5 mm; 2) Deviation (score 2) - difference of 0.5 - 1.5 mm; and 3) Mismatch (score 3) - difference between the teeth greater than 1.5 mm.

The appearance of the surrounding tissue was assessed according to the criteria proposed by Begazi et al (21). According to this criteria the appearance of the surrounding gingiva is calculated as: 1) The same as around the contralateral healthy tooth (score 1), 2) Deviates from the appearance around the adjacent tooth (score 2), 3) Does not match (score 3) - greatly changed colour with bleeding.

Results

The results of this study show the successful survival of all transplanted teeth after monitoring for a period of 10 years. Not one pathological occurrence was registered which could have endangered the remaining teeth in the jaw. Root resorption was not observed on any root of the 10 transplanted teeth, and periodontal healing without ankylosis was determined for all teeth (Table 2). Revascularisation of the pulp and preservation of its vitality occurred in three cases. In the remaining seven cases pulpal necrosis occurred and endodontic treatment was carried out. The teeth involved had a narrow apical opening during transplantation, in which revascularisation of the pulp could not occur. Root canals of all those teeth were filled with calcium hydroxide paste (Calaseptom).

The crowns of all the transplanted teeth were reshaped in the shape of the central incisors with composite material three months after transplantation (Figure 5). The attained level of aesthetics was very high in 9 cases (score 1), while in one case mild deviation occurred in relation to the adjacent contralateral tooth (score 2). The overall satisfaction of patients with the achieved level of aesthetics at the end of treatment was assessed by the patients as high. Mean VAS score amounted to 87.1 (Table 2).

Analysis of the gingiva around the transplanted tooth after the period of monitoring revealed that it was identical to the gingiva around the contralateral tooth. By monitoring the aesthetics of the reshaped transplanted tooth for a period of 10 years it was found that with time some deviation occurred in the shape and size of the tooth crown (Figure 6). The aesthetic level of the reconstruction remained unchanged in 6 cases, while in four mismatch with

the neighbouring tooth occurred with regard to shape and size. This indicates that in some cases, after a long period, there is a need for correction of the reconstruction of the transplanted teeth crowns.

After monitoring for 10 years radiographic check-up showed normal finding of the root and closure of the apex, with no signs of external resorption (Figure 7). The site from which the graft was taken (second lower premolar) closed spontaneously in the majority of cases, so that orthodontic closure of the site was unnecessary (Figure 8).

Discussion

The results of this study show that all the transplanted teeth survived a period of 9 years and that not one case of pathological changes was registered which could have endangered the remaining teeth in the jaw. However, survival of the pulp did not occur in the majority of cases and it was necessary to carry out endodontic treatment and filling of the root canals. Radiographic analysis and follow-up revealed transitory resorptive changes/lesions on the teeth roots with partial loss of PDL in some cases. Prevention of infection in the presented patients by administration of doxycycline and metronidasol avoided postoperative inflammatory changes in the area of the transplanted tooth in all subjects.

Numerous clinical and experimental studies have shown that traumatically lost central maxillary incisors can successfully be replaced by transplantation of mandibular premolars. Thus, in cases of young patients in whom extraction of a central incisor is unavoidable or it has been traumatically lost, the possibility of homologous transplantation of a tooth should be considered (22). In 1965 Amšel demonstrated the success of the method of autotransplantation in young patients with impacted canines and the possibility of attaining an aesthetic and functionally satisfactory result (23).

For the success of transplantation the procedure must be carried out carefully and non-traumatically (1, 24). The optimal time for tooth transplantation is when the patient has unfinished root growth and open apex of the donor tooth (graft). For the second lower premolar this is between the ages of 10 and 12 years. The transplanted tooth ensures preservation

of alveolar bone and its further growth, due to the fact that PDL cells have osteogenous potential (1, 5, 19, 25). Success is much greater in persons with unfinished root growth and thus transplantation of the tooth should be planned and carried out whenever possible at that time. For maximum success of the procedure a combination of optimal surgical technique and endodontic treatment when necessary is essential. The method and duration of immobilisation of the transplanted tooth has an important role in the success of the transplantation. In all patients in the present investigation immobilisation by flexible splints lasted from 7-10 days. Very thin orthodontic wire (0.1-0.2 mm thick) was used for immobilisation, so that slight movement of the transplanted teeth was possible. Such movement induces cellular activity of PDL and prevents bone resorption (11, 27).

Survival of the teeth 5 years after transplantation ranges from 74% to 100%, and after 10 years from 87% to 95% (1, 5, 7, 9, 13, 14, 18). In a comprehensive study performed on 370 transplanted premolars Andreasen et al (4) demonstrated that teeth with unfinished root growth show long-term survival in 95-98% of cases. Teeth with finished root growth show greater success if the method of preparing the alveoli is performed by a burr with internal cooling and if the extraoral time of the transplanted tooth is short (4). Experimental studies show that trauma of PDL during transplantation causes resorption of the tooth root (5, 20, 21). It has also been determined that transplanted teeth in older patients show a smaller degree of root resorption than in younger patients (28).

Experiments on animal models showed that PDL damage significantly influences periodontal healing after autotransplantation of a tooth (5, 7-9). Preserved PDL on the root surface is the most important factor for healing without root resorption. Also, the length of the extraoral time of the tooth during the transplantation procedure is particularly important (7, 9). After transplantation and reconstruction of the tooth it is often necessary to reduce the maxillary bite by orthodontic therapy. Recent clinical studies have shown that orthodontic treatment is possible as early as 3 to 6 months after transplantation, without greater risk of resorptive changes/lesions on the root of the tooth (2).

Resorption of the root of a traumatised tooth is the most important complication that can occur after transplantation and threaten long-term prognosis for the tooth. Replacement resorption in transplanted teeth is very rare and mild. Eight weeks after transplantation the tooth usually heals with the formation of a significant amount of normal PDL (5,20,129).

Vital and undamaged periodontal ligament is essential for periodontal healing. Its removal leads to extensive root resorption (2, 5, 7-9). Teeth with vital PDL have significant osteogenous potential. Investigations have shown that after autotransplantation of a tooth in people with an incompletely developed root, formation of alveolar bone occurs (2, 5, 6). The technique of preserving the tooth during transplantation is also important for eventual resorptive changes/lesions on the root (2, 8, 10).

Healing of the periodontal ligament after transplantation is the most critical factor for evaluating the success of the procedure (7). The process of healing of the periodontal ligament after transplantation is connected with a positive phenomena in the form of induction of the osteogenesis of the alveolar bone. Successful healing of PDL depends on the preservation of vital cells on the surface of the root of the transplanted tooth (19, 20, 30-36). During the transplantation procedure PDL cells can be damaged mechanically or biochemically, depending on the extraoral conditions of the tooth (7, 37-41). It is particularly important that the donor tooth is removed with as little damage to PDL cells as possible, and kept in optimal extraoral conditions during the preparation of the alveoli prior to transplantation.

Excellent success can be anticipated in cases when the donor tooth is immediately placed in the alveoli of the extracted tooth (19, 20). Damaged cells on a large surface of the root will lead to replacement resorption. The bone will coalesce with the surface of the root and lead to ankylosis (32, 33, 38).

PDL cells can be differentiated in fibroblasts, cementoblasts and osteoblasts. Differentiated osteoblasts can further form bone around the transplanted tooth, which is an important advantage of the transplantation procedure compared to the use of implants (7, 25, 26, 42).

In optimal conditions of tooth transplantation with unfinished root growth revascularisation and regeneration of pulp can occur (4, 43). The transplanted tooth will show positive sensitivity test for 6 months (7). The most important factors for healing of the pulp after transplantation are the diameter of the apical opening of the tooth and the control of infection (4, 11, 12). Revascularisation of the pulp will most probably occur in the tooth with the diameter of the apical opening greater than 2 mm (2, 4). If the transplanted tooth has a closed apex, revascularisation will not occur and it is necessary to carry out its endodontal treatment after 6 to 8 weeks, and filling of the root canal (13).

Clinical and radiographic check-ups are necessary after 4 and 8 weeks in order to promptly detect eventual complications such as pulpal necrosis or external root resorption (inflammatory or replacement resorption). Radiographic check-up of the transplanted tooth is necessary after 6 months, and subsequently after one, two and five years, in order to monitor pulpal and periodontal healing and continued root development (2, 4-6).

Analysis of transplanted teeth demonstrated that the degree of development and length of the root prior to transplantation is significantly connected with the final length after transplantation. Teeth transplanted in the early phases of root development show greater decrease in the final length of the root (2, 6). In the case of homologous transplantation of premolars it has been determined that 14% of the teeth show discontinuation of root growth, 65% partial discontinuation, while 21% resume normal root growth (6).

The aesthetic appearance of the reconstruction after the observation period was satisfactory in all cases. However, in several cases it was necessary to perform corrections in order to improve the aesthetic effect. Czochrowska et al (12) investigated the long-term result of transplanted teeth, and particularly the state of the gingiva, periodont and patient attitude to the outcome of treatment. They determined survival of transplanted teeth in 90% after monitoring for 26.4 years. Patient satisfaction with the treatment outcome was assessed as very satisfactory.

The method of autotransplantation of a tooth enables restoration of a defect occurring through loss of a tooth and continued growth of the alveo-

lar ridge, which was discontinued at the moment of tooth loss. In all cases of tooth transplantation long-term monitoring is necessary, with frequent check-ups twice a year during the first five years, and later at least once a year. Normal periodontal healing and preservation of the periodontal ligament without the occurrence of ankylosis is most important for the success of tooth transplantation.

Tooth transplantation has been a routine procedure in the Department of Paediatric Dentistry since the beginning of 1992. By monitoring patients with transplanted teeth during that period ten-year survival of the teeth was determined in 100% of cases. Apart from success with regard to long-term survival, the attained aesthetic effect and psychological reasons, homologous transplantation of teeth also has an advantage with regard to financial feasibility, compared with other methods of treatment. In addition, the functional value of the tooth and relevant part of the alveolar (process) are completely preserved.

Conclusions

Based on the results of this study it can be concluded that transplantation of a tooth to the position of the upper incisors can be considered a reliable procedure with predictable outcome if the procedure is performed with care and correctly. Reconstruction of the crown with composite gives an aesthetic result which is highly rated by the patient. However, in some cases after a long period (longer than 5 years) there is a need for corrective reconstruction. Depending on the state of the root development and width of the apex of the tooth to be transplanted it is possible to predict the possibility of revascularisation of the pulp, or need for endodontic treatment with filling of the root canal. Transplantation of premolars to the position of lost central incisors offers long-term, predictable and reliable treatment outcome. Reshaping the crown of the premolar with composite into the shape of the incisor gives a highly aesthetic appearance, and patients assess the attained result as highly satisfactory.