EVALUATION OF THE CLINICAL SUCCESS OF 56 AUTOTRANSPLANTED TEETH – A RETROSPECTIVE STUDY

Original article

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Dedicated to MUDr. Ivo Marek, Ph.D., for popularization of dental autotransplantation in the Czech Republic.

SUMMARY

Introduction, aim: At present, tooth autotransplantation is considered one of the therapeutic methods for the replacement of lost teeth. In the last 30 years, the method of tooth autotransplantation has been developed and refined and has become a basic knowledge of dental practitioners. The aim of this clinical retrospective study was to examine children and adult patients with tooth autotransplantation and obtain survival and success rates. Another aim was to determine other specifics of autotransplantation in each group with conclusions relevant for clinical practice.

Methods: The study population consisted of the patients referred consecutively for tooth autotransplantation to a specialist department between years 2016 and 2021. The specialization of the referring dentist, the suitability and feasibility of the transplantation, and the donor and recipient area of the tooth graft were recorded. In 2022, clinical and radiological evaluation of the autotransplanted teeth was performed. Patients were divided into two groups according to age in time of autotransplantation, namely under 18 years and over 18 years.

Results: Overall, 73 patients in the age range of 10–59 years were referred for autotransplantation. The mean age was 21.43 years with a median age of 17 years. Autotransplantation was not recommended in 12 patients. A total of 68 autotransplantations were performed, but at the time of examination, 12 did not meet the minimum 6-month follow up, so they were excluded from the evaluation. A total of 56 autografts were evaluated.

In the group of children, there were 27 patients aged 10–17 years who underwent autotransplantation of at least one permanent tooth. A total of 34 teeth were transplanted. The evaluation of the transplanted teeth was performed 6–50 months after the transplantation with a mean follow-up time of 24 months. The survival rate was 100% and the success rate was 91%.

The adult group consisted of 22 patients aged 18–59 years and a total of 22 teeth were transplanted. The evaluation of the transplanted teeth was performed 6–72 months after transplantation with a mean of 33 months. The survival rate was 95%, the success rate 77%.

Conclusion: The use of autograft to replace an unerupted tooth or tooth loss was most often indicated by orthodontists. In the patients under 18 years of age, the premolars are the predominant donor area and recipient area. In patients over 18 years of age, the third molars are the predominant donor area and the mandibular molars the predominant recipient area. Both age groups have high survival and success rates of autograft and this procedure can be considered as a predictable method of tooth replacement.

Key words: tooth transplantation, tooth autotransplantation, indication, survival rate, success rate, autograft

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INTRODUCTION

Tooth autotransplantation is defined as the surgical repositioning of a tooth from one site to another within the same individual [1]. This therapeutic procedure has many advantages and is often indicated as a replacement for a lost tooth in growing individuals when conventional dental implant treatment is contraindicated. Thus, here we use the body's own biological implant, which is both capable of osteoinduction and does not interfere with any ongoing growth processes in the surrounding area. Autotransplantation as a reliable method of treatment was

most elaborated by Scandinavian authors [2–5] and since the end of the last century this method of treatment has been fully accepted and increasingly used in Europe. Its indications include not only children and adolescents, but also adults [6]. The objective of this retrospective study was (i) to evaluate the accuracy of the indication including recording the expertise of the referring dentist, (ii) to determine the type of tooth transplanted and its recipient site, i.e., the most common types of autotransplantation in the age groups under 18 years and over 18 years, and (iii) to determine the survival and success rates of autografts including their comparison between age groups using Kaplan-Meier analysis.

SAMPLE OF PATIENTS AND METHODOLOGY

The study sample consisted of patients referred for autotransplantation to our specialized department in Olomouc. It was a group of 73 patients, 61 of them underwent the autotransplantation. We have been dealing with tooth autotransplantation since 2000, so it can be assumed that most of the cooperating dentists have sufficient knowledge of this type of procedure and its indications. The group consisted of patients referred for autotransplantation in the period 2016–2021. According to the specialty of the referring dentist, the studied individuals were divided into groups referred by a general dental practitioner, an orthodontist, or the treatment was indicated by the performing dental surgeon in the case of a primarily different request, or the patient himself requested the treatment based on information obtained from his community (internet, experience of friends, etc.).

Selection of patients

The patients (or their legal representatives) provided written informed consent if they agreed to participate in the study. The clinical study was conducted with the approval of the ethics committee (VFN Ref. No. 176/20 S-IV) and in compliance with the provisions of the Helsinki Declaration of 1975, revised in 2013.

The patients of good general health, without medication affecting the immune response, non-smokers, were included in the study. All of them had to maintain a good level of dental hygiene and the donor teeth had periodontal status without pathological findings. If the periodontal treatment was carried out, the periodontal status had to be stable and the depth of the gingival sulcus of the donor tooth had to be less than 3 mm in circumference at the time of the procedure (this applied to a total of seven adult patients).

Performing an autotransplantation

Surgery was performed under local anaesthesia (Supracaine, Zentiva, active components articaine and adrenaline) and a prophylactic dose of antibiotics one hour before surgery (Augmentin, GlaxoSmithKline, active components amoxicillin and clavulanic acid, dosage according to patient weight). The procedure involved gentle extraction of the donor tooth and its subsequent repositioning to the recipient site. The time during which the graft was out of the oral cavity was minimized and the graft was, if possible, left in its original position until the formation of the socket. If this technique was not possible, then the graft was placed in saline solution while adjustments were made in the recipient site. When the graft was placed in its new position, soft tissue suture was performed, and the graft was fixed with cross suture through the occlusion. Monofil 5/0 (Resopren 5-0, Resorba) was used for soft tissue suture and fixation of the autograft in children and monofil 4/0 (Resopren 4-0, Resorba) in adults. After checking the articulation, with the autotransplated tooth placed in mild infraocclusion, the patient was instructed on the postoperative regimen, which consisted of cooling the recipient area with compresses on the day of surgery, no hard food for 14 days, and no mechanical cleaning of the teeth in the grafted site. During this period, the patient only rinsed the site with chlorhexidine solution (Corsodyl 0.1%, GlaxoSmithKline) for one minute, twice a day. In case of pain, conventional analgesics (paracetamol, ibuprofen) were recommended.

Post-operative follow-ups

14 days after the tooth autotransplantation, the first follow-up was performed, which consisted of suture removal, tissue healing examination and intraoral orthoradial radiograph. Subsequent follow-ups were performed at one month, three months, six months after the procedure and at regular intervals of one year thereafter. The follow-up consisted of an evaluation of the soft tissues and clinical status of the periodontium in the grafted tooth. From the

third month onwards, periodontal sulcus probing was performed, supplemented by Periotest examination (Siemens, Bensheim, Germany). Follow-up intraoral radiographs were taken at three and six months after the procedure, and once a year thereafter.

Evaluation of the autograft

The primary criteria used to evaluate the cohort were graft survival and success rates. The autograft survival rate was determined by its presence at the time of follow-up. It was therefore a quantitative indicator. The graft success rate evaluated the quality of the autograft. To determine the quality of the graft, several parameters evaluating the level of tissue healing were monitored. The following parameters were monitored:

1. gingival sulcus depth up to 3 mm (measured using a periodontal probe),
2. the presence of a periodontal space around the visible perimeter of the graft on the radiograph,
3. absence of progressive root resorption,
4. absence of periapical radiolucency,
5. tooth in function (in occlusion without traumatic articulation),
6. Periotest value in the range of -8 to +15.

Other factors that were monitored in terms of clinical evaluation were the number of individual teeth intended for autotransplantation, the number of recipient sites, the stage of root development in individual teeth, the need for subsequent endodontic treatment, and complications.

The classification of the root developmental stage of the autotransplanted tooth was evaluated according to Moorrees et al. [7]: stage I: intial root formation, stage II: root length less than the crown length, stage III: root length equal to the crown length, stage IV: ¾ of the root length developed, apex widely open, stage V: root length completed, walls parallel, stage VI: root length completed, walls convergent, apex closed. Moorrees et al. also mention stage VII, i.e. closed apex with normal width of periodontal space. This condition is insignificant with respect to the possible indication for endodontic treatment [8].

Endodontic treatment

Before autotransplantation (radiologically) and perioperatively, the degree of root development and the condition of the apical orifice were recorded. If the developmental stage was stage VI according to Moorrees et al., the tooth was indicated for subsequent endodontic treatment, which was performed approximately one month after autotransplantation. In only two cases an endodontic treatment was performed before autotransplantation.

RESULTS

Overall, 73 patients in the age range of 10–59 years were referred for autotransplantation. The mean age was 21.4 years with a median age of 17 years. Most patients were female (n = 59; 81%), and 14 (19%) were male. The expertise of the dentists who referred patients for autotransplantation varied, particularly with respect to the age of the individual. All 38 younger individuals (under 18 years of age) were referred by an orthodontist. In adult patients, out of 35 patients, the referring physician was an orthodontist in 21 individuals (60%), a general dental practitioner in four individuals (11.4%), one patient (2.8%) requested autotransplantation based on information from the internet, and the rest of the patients (25.8%) were referred for autotransplantation by the treating dental surgeon, with the primary referral being for dental implant insertion. Considering the whole population, i.e. paediatric and adult patients, orthodontists indicated autotransplantation in 59 patients (81%).

Although 73 patients were initially referred, only 61 of them underwent the autotransplantation. In 12 of the referred patients, the autotransplantation was not performed due to unsuitable conditions. In seven cases, orthodontic treatment (gap closure after a missing tooth) was recommended, in two cases a dental implant was recommended, in one case preservation of the tooth by reendodontic treatment was recommended, in one case it was recommended to wait for a more advanced stage of donor root development and one case was referred for treatment under general anaesthesia due to an unmanageable patient. In 61 patients, 68 autotransplantations were performed. However, some teeth were excluded from evaluation (n = 12) because they did not meet our minimum follow-up period of six months after autotransplantation. Finally, 56 autografts in two age groups were evaluated according to the given criteria.

The age group up to 18 years included 27 patients with 34 autotransplantations, the group over 18 years included 22 patients with one autotransplantation each.

Tab. 1 *Age of the patients (years) in the group ≤ 18 years and > 18 years.*

	min	max	median	mean
Age ≤ 18 years	10	17	14	13,8
Age > 18 years	18	59	28	32,5

Tab. 2 *Gender of the patients in the group ≤ 18 years and > 18 years.*

	≤ 18 years		> 18 years	
	n	%	n	%
Males	5	18	5	23
Females	22	82	17	77

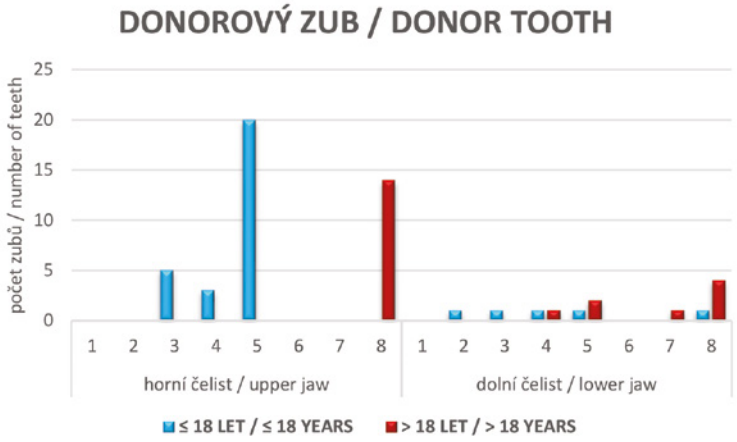
The distribution of patients by age and gender in both groups is shown in **Tables 1** and **2**.

Graphs 1 and **2** present the numbers of individual teeth autotransplanted and the frequency of representation of each recipient site. In the age group up to 18 years, the upper second premolars, upper canines and upper first premolars were the most frequently used for autotransplantation, whereas in the group over 18 years of age, the upper and lower third molars were the most frequently used. In the under 18 age group, the most frequent recipient site was that of the lower second premolars, followed by the upper canines and lower second premolars. In patients over 18 years of age, the most common recipient sites were the lower molars and lower second premolars, followed by the upper first molars.

The root development stage of the autotransplanted teeth is shown in **Graph 3**. In the age group up to 18 years, teeth with a well-developed root were transplanted most frequently (stages V and VI), less frequently teeth with a wide-open apex (stages III and IV) and minimally teeth with a root length less than the crown length (stage II). In patients over 18 years of age, the majority of teeth were those with complete root development (stages V and VI). Minimally, teeth with incomplete root development (stage III and IV).

The period after autotransplantation (follow up) in months is described in **Table 3**. At the time of examination, the autograft was functional and present in the mouth in 34 cases (100% survival rate) in patients from the age group under 18 years and in 21 cases (95% survival rate) in patients from the age group over 18 years. In one case, early loss of the autograft (within 14 days) occurred due to fixation failure. At the same time, 31 teeth (91% success rate) in the age group under 18 years and 16 teeth (73% success rate) in the age group over 18 years met the established success conditions.

All three teeth that did not meet the success criteria in the group of patients under 18 years of age showed partial disappearance of the periodontal space in the vicinity of the root with the finding of ankylosis, which was confirmed by the Periotest examination. In one case it was tooth 45 with stage II root development and in the other two cases there were canines with primary atypical localization. One of them was a lower canine in the VI stage of root development with odontoma finding preventing eruption, and the other case was an atypically placed upper canine in the V stage of root development that could not be repositioned by orthodontic realignment. Both had failed orthodontic treatment for at least one year and it can be assumed that ankylosis was already present in both patients before the surgical procedure. Both canines were endodontically treated after transplantation.



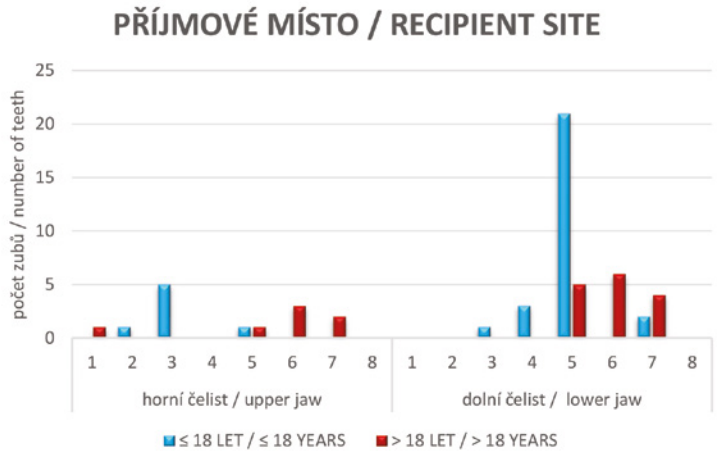
Graph 1 *Donor teeth in both groups.*

Five teeth that did not meet the success criteria in the age group of patients over 18 years were diagnosed with a more advanced gingival sulcus depth (in three cases) or disappearance of the periodontal space (in two cases) visible on the radiograph. Ankylosis was also confirmed by Periotest. The teeth with a gingival sulcus depth exceeding 3 mm were: tooth 28 grafted to site 35 in a 53-years-old female patient, tooth 48 grafted to site 46 in a 51-years-old female patient and tooth 28 grafted to site 27 in a 45-years-old female patient. In all cases, an early form of marginal periodontitis was treated, in all cases the root developmental stage was VI and the teeth were endodontically treated after transplantation. The findings of ankylosis were as follows: tooth 18 grafted to site 36 in a 19-years-old patient, where the root development stage was III, and tooth 18 grafted to site 37 in an 18-years-old patient, where the root development stage was IV. No endodontic treatment was performed on these teeth and radiographs showed ankylosis of the alveolar tissues with the tooth.

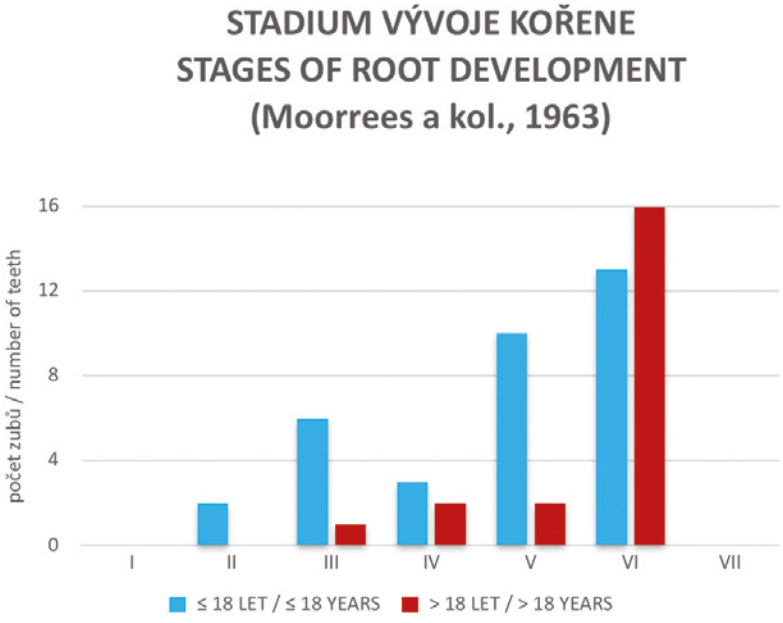
Endodontic treatment was performed in 16 (47%) and 17 (77%) cases in each age group. The need for endodontic treatment correlated with the findings of the degree of root development. Ten teeth with root development grade VI and six teeth with root development grade V were endodontically treated in the group under 18 years of age.

A Kaplan-Meier analysis was used to compare the two groups of patients studied, i.e., under 18 years of age and over 18 years of age, focusing on both survival and success rates.

In the case of the survival evaluation, the presented **Graph 4** corresponds to only one failure, in the group with an age of over 18 years. The difference between the groups is not statistically significant ($p > 0.05$) and it can be concluded that in both age groups this is a treatment with a very high prognosis for autograft survival. The dotted line indicates the confidence interval. The success rate was evaluated in a similar manner and is presented in **Graph 5**. A higher success rate was observed in the group of patients under 18 years of age, but the difference is not statistically significant ($p > 0.05$). The dotted lines indicate the confidence intervals. According to this analysis, the success rate of autotransplantation is similar in both groups and the differences are not statistically significant.



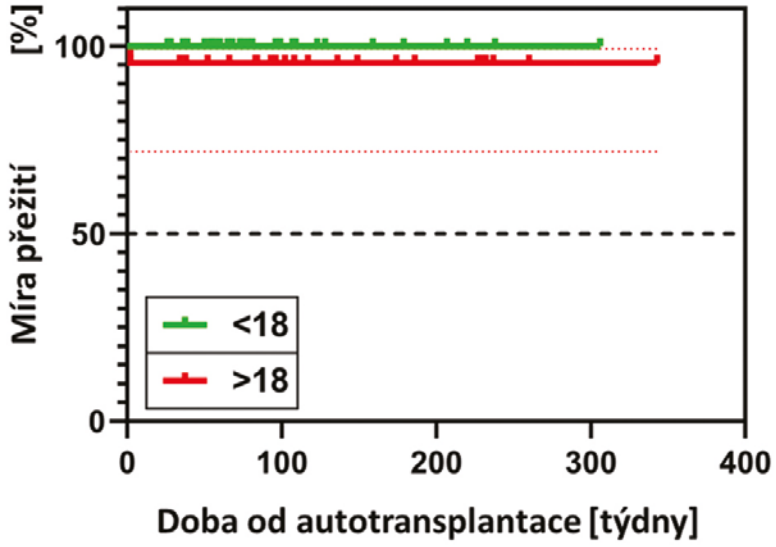
Graph 2 *Recipient site in both groups.*



Graph 3 *Root development stage [7] in both groups.*

Tab. 3 *Follow-up (months) of the patients in the group ≤18 years and >18 years.*

	min	max	median	mean
≤ 18 years	6	70	17	24,2
> 18 years	7	78	26	32,9

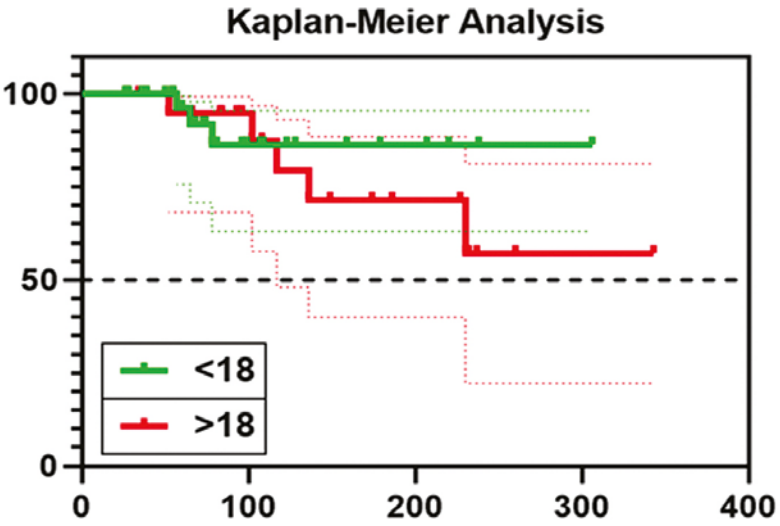


Graph 4 *Survival rate of autotransplanted teeth (weeks after autotransplantation).*

DISCUSSION

The results show that the orthodontists most often indicated the performance of autotransplantation. This finding is not surprising as the orthodontic community is well informed about the possibility of autotransplantation. The prevalence of the use of this treatment option and its increasing trend is evidenced by a questionnaire study published in 2017 [9]. General dental practitioners indicated the use of autotransplantation minimally and it can be assumed that they are not yet informed about this method of treatment more extensively. In some patients, autotransplantation was indicated by the treating dental surgeon instead of the originally requested conventional implant therapy (use of a dental implant).

The criteria for evaluating the success of an autograft are not completely uniform. Mostly, functional periodontium without evidence of ankylosis, root length exceeding the crown length, asymptomatic tooth in function and absence of root resorption are reported [10]. Most of these criteria were used in our study. The absence of periapical burnout was also evaluated in teeth after endodontic treatment and is therefore directly related to the quality of this treatment. This was performed within one month after autotransplantation in the case of stage VI root development. If the root development was stage V, endodontic treatment was performed only if periapical clearance was subsequently found on follow-up radiographs. The success of endodontic treatment was then verified by the disappearance of periapical burnout. In teeth whose root development is not complete, the characteristic sign of pulp revitalization is the gradual obliteration of the pulp chamber without the finding of periapical burnout [3]. In these cases, endodontic treatment is never indicated **(Fig. 1**). Sometimes endodontic treatment may be indicated before autotransplantation, but this is only in those cases where the donor tooth is freely accessible.



Graph 5 *Success rate of autotransplanted teeth (weeks after autotransplantation).*

Age group up to 18 years

In this group, endodontic treatment before autotransplantation was indicated in only two cases. In one case, transplantation of tooth 15 to site 25 was indicated and in the other case, transplantation of tooth 32 to site 12 was indicated (**Fig. 2**). Both teeth were stage VI root development and single-rooted teeth. In the case where ankylosis was confirmed radiologically and clinically, it was an atypically placed premolar with root development stage II. We proceeded to autotransplantation due to the risk of subsequent root development affecting manipulation with the tooth and the possibility of damage to surrounding teeth (**Fig. 3a**). Although autotransplantation was performed without complications, further root development did not continue and ankylosis occurred (**Fig. 3b, c**). Prolonged extra-alveolar time or negligent graft manipulation is considered

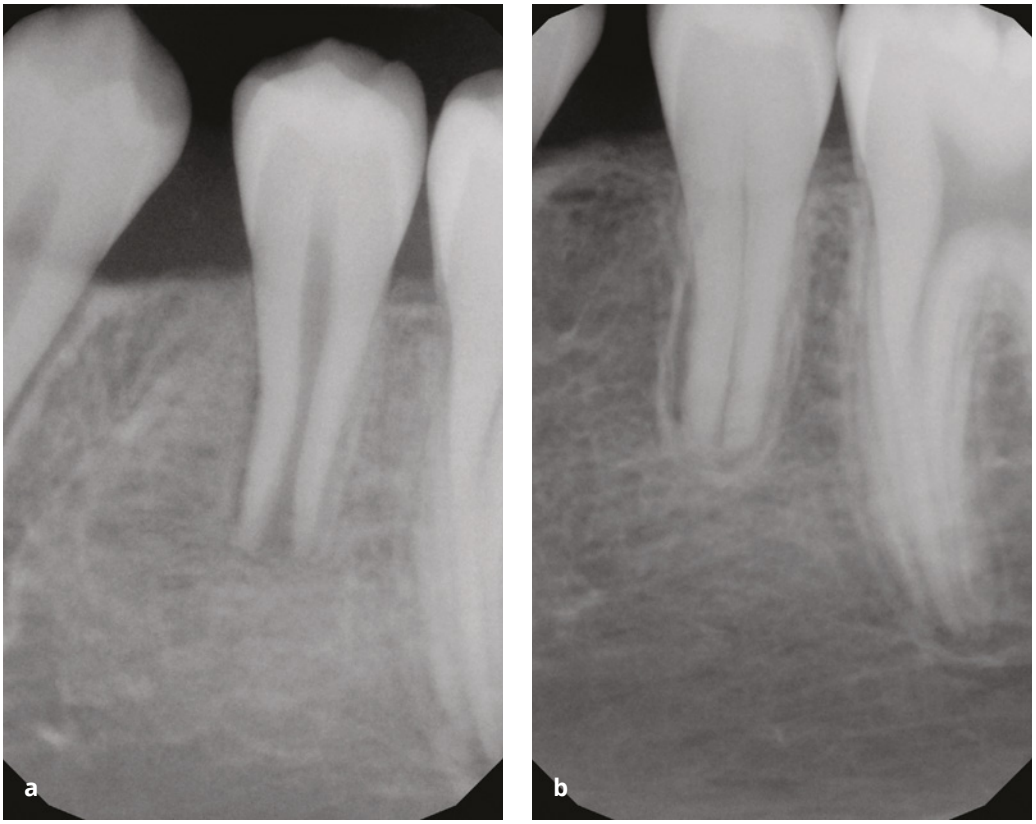
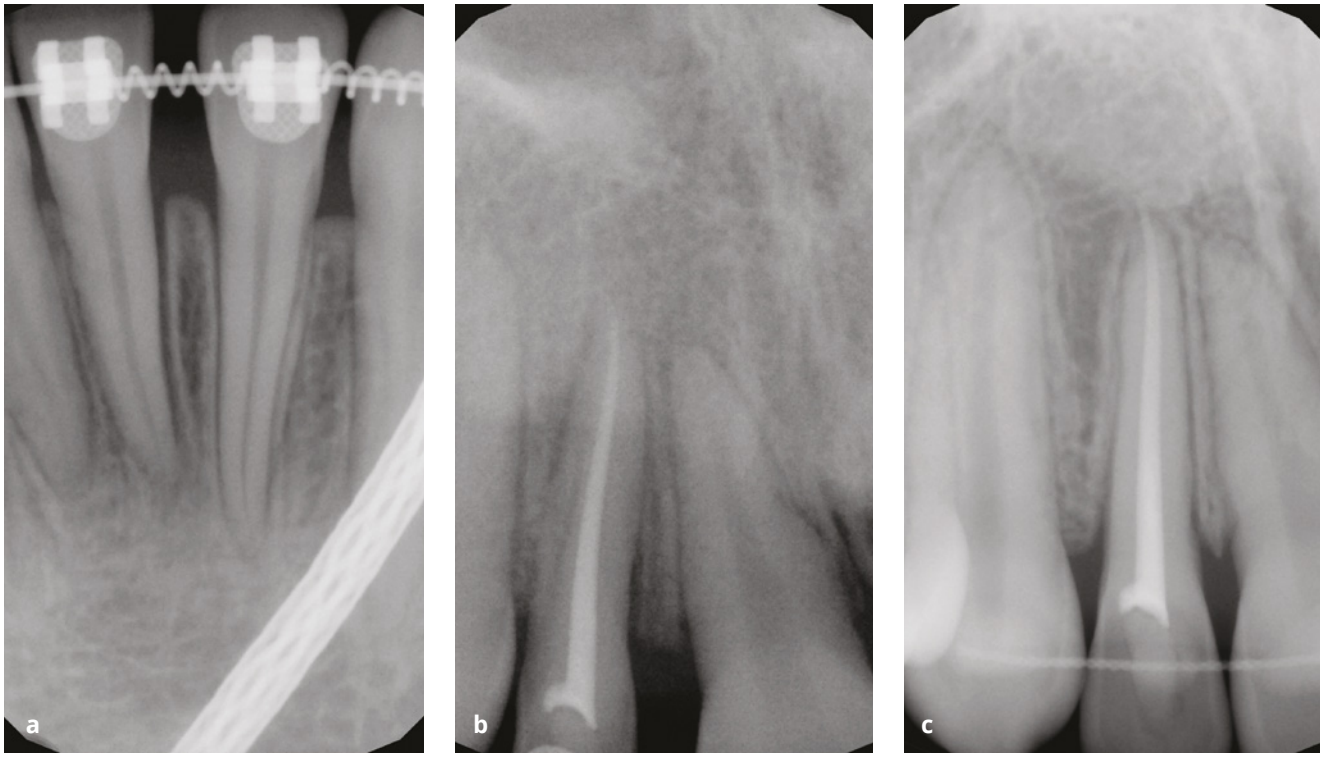
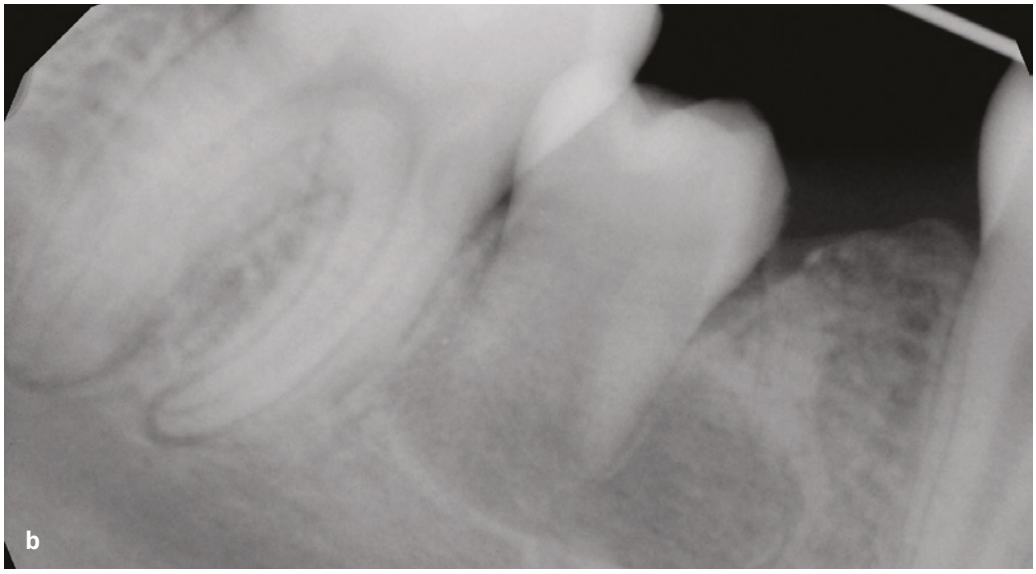


Fig. 1
Autotransplantated tooth reg. 35, three months (a) and one year (b) after autotransplantation.

a risk factor for ankylosis, which may lead to necrosis of vital periodontal fibres on the root surface [11]. In this case, the fact that it was a low developmental stage of the root, when there is higher likelihood of subsequent root developmental failure, may also play a role [12]. If we look at the average age at the time of treatment in the under 18 age group, it is 13.7 years with a median age of 14 years. It is therefore not surprising that root development has already been completed in most teeth.

Fig. 2
The tooth 32 intended for autotransplantation before endodontic treatment (a), after endodontic treatment, two weeks after autotransplantation to the reg. 12 (b), and after finishing of orthodontic treatment (c).





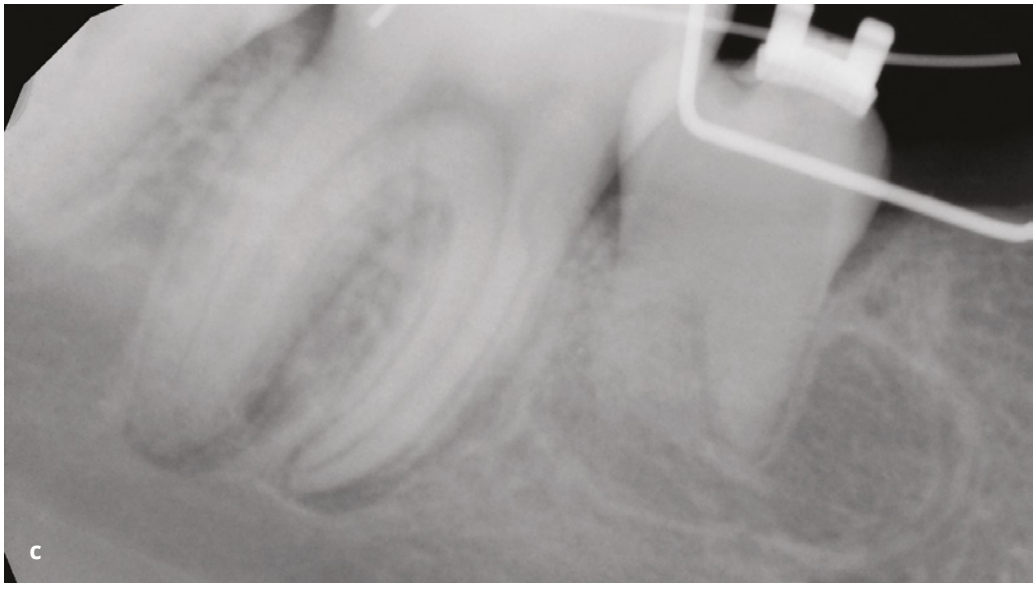
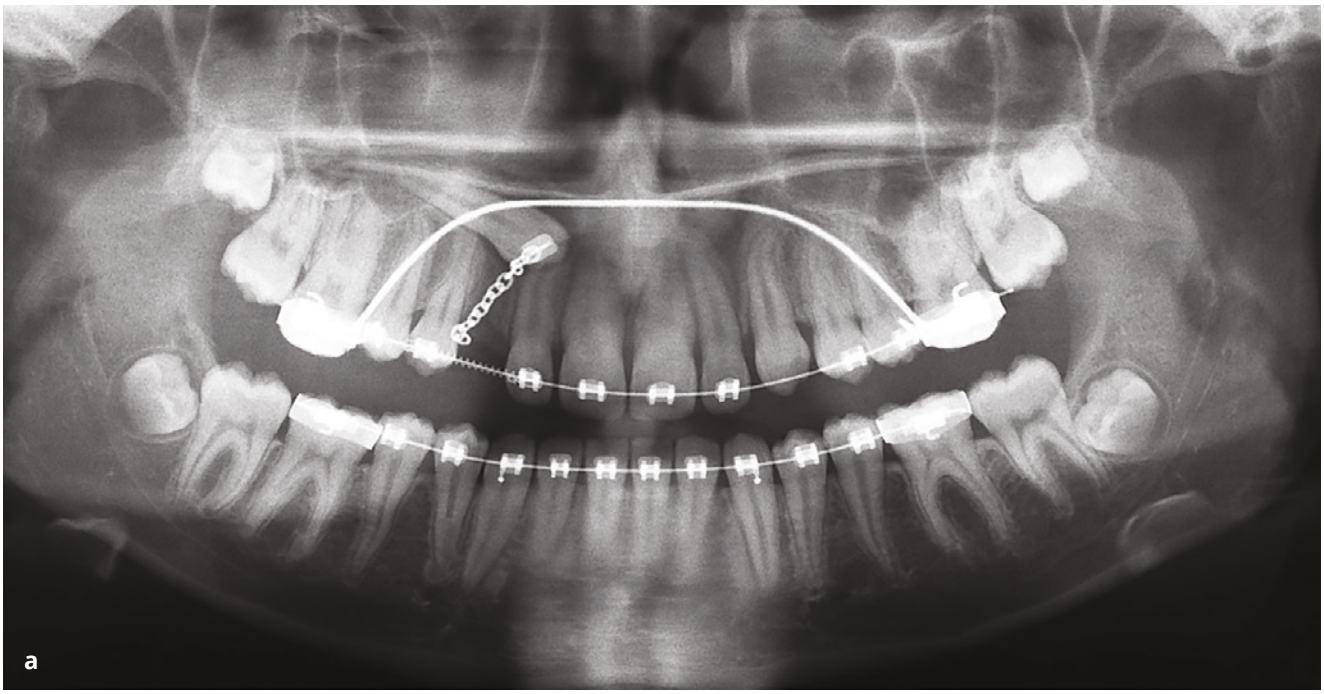


Fig. 3
The tooth 45 intended to autotransplantation in an OPG (a), three months after autotransplantation (b), and one year after autotransplantation (c).



This is also associated with the need for subsequent endodontic treatment. The need for endodontic treatment disappears at lower stages of root development, when at least ¾ of the root length is optimally formed. Therefore, it seems most appropriate to perform autotransplantation when the root developmental stage IV is in progress [5]. This usually corresponds to a patient's age between 11 and 12 years. Autotransplantation of premolars from the maxilla to sites of agenesis in the mandible was also prevalent in this group of patients. Due to the morphological shape of the crown of both types of premolars, we did not need to use shape correction in either case. The second most frequently indicated tooth for autotransplantation in the group was the maxillary canine. In all cases, this was a surgical tooth plantation into position (**Fig. 4**), when primarily the orthodontic alignment of the tooth could not be used (or failed). The survival rate was 100%. This finding is not uncommon in younger patients and a greater capacity for tissue regeneration can be assumed. Studies with similar results can be found in the literature, even after a longer follow-up period [13, 14]. The success rate was 91%, a figure also similar to the results of other studies dealing with autotransplantation in children and adolescents [15, 16]. One of the success criteria considered is the absence of ankylosis, which is considered an important feature of the graft in children due to the necessary further development

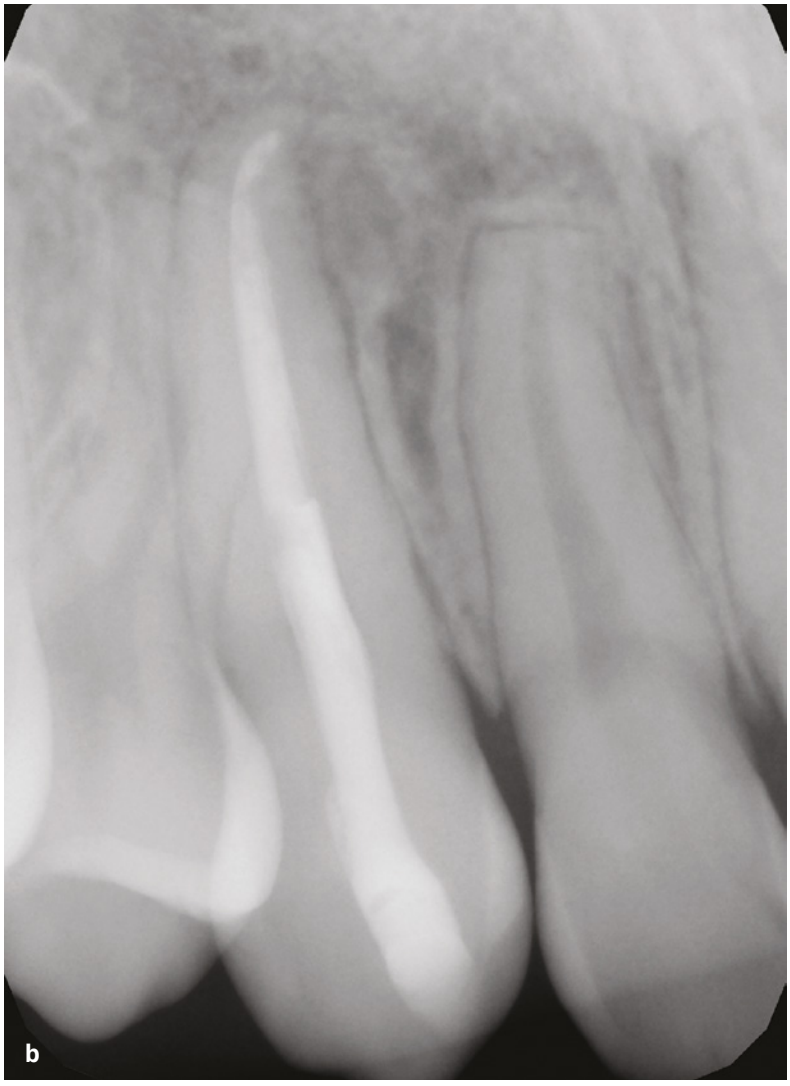


Fig. 4
The tooth 13 intended for autotransplantation in an OPG (a) and one and half year after autotransplantation (b).

Fig. 5
The OPG images of adult patient with agenesis of teeth 35, 45 before (a) and after (b) the treatment. The missing tooth 45 was replaced with the autotransplanted tooth 18, with a subsequent root canal treatment and prosthetic reconstruction (c). The missing tooth 35 was replaced with a dental implant (d).

of surrounding tissues. In all three cases that we evaluated as unsuccessful, this was a major complication.

Age group over 18 years

In contrast to younger patients, several specific variables are encountered in patients over 18 years of age. Adult patients often already have varying degrees of inflammatory periodontal disease. In these cases, periodontal treatment is required first to ensure stabilization of the periodontal condition, and autotransplantation can only be approached subsequently. It can be expected that the periodontal involvement of the donor tooth will not improve after autotransplantation [17]. Donor teeth are already at the stage where they have completed root development. Therefore, endodontic treatment is a necessity. Another factor that greatly affects the prognosis of autograft is the number of roots and their shape [6]. In adult patients, third molars, which have complex root morphology, are most commonly replanted [18].

The position of the third molar also influences the course of the entire surgical procedure. In most cases, endodontic treatment before autotransplantation is not possible, and we also usually cannot keep the donor tooth in the extraction wound after extraction [19]. We keep it in the saline solution until it is placed in the created socket, which increases the possibility of damage to the vital periodontal fibers, and the vitality of the periodontal fibers is considered the most important prognostic factor for tooth autotransplantation [20]. However, the development of ankylosis is not as significant issue in the adult as in the young patient, due to the already completed growth of the surrounding tissues. The risk is the development of inflammatory root resorption. In order to avoid complications associated with repeated handling and keeping the donor tooth out of the mouth, we can advantageously use a 3D model of the donor tooth. This technique is particularly useful for less experienced dental surgeons and for autotransplantation of a multirooted tooth [21].

Since we encountered autograft loss due to failure of the fixation cross suture over the occlusion, we often supplement it with a flow composite to provide greater stability. In cases where even this fixation is inadequate, we use a multifilament wire, which is commonly used in orthodontics for retention. Although this more rigid method of fixation has been described as less advantageous in terms of the vitality of the surrounding tissues [22], it is suitable in some cases to ensure the primary stability of the graft.

Another problem in adult patients is the heterogeneity of the graft occlusal surface with the antagonists. Thus, in most cases, it is not sufficient to perform only articulatory adjustment, but it is necessary to use onlay to reconstruct the antagonist relationships [23]. The morphology of the graft crown may also limit us in the mesiodistal dimension of the recipient site. If this dimension is inadequate, orthodontic treatment should be considered prior to transplantation. In the case of minimal differences, where an enamel drilling is sufficient to modify the crown, we may choose this option. In a single patient, we may choose different methods of tooth replacement depending on the availability of a suitable donor (**Fig. 5**).

CONCLUSION

The use of an autograft to replace an unerupted or lost tooth was most often indicated by orthodontists.

In patients under 18 years of age, premolars predominate as the donor site and recipient site. In patients over 18 years of age, the third molars predominate as the donor site and the mandibular molars as the recipient site.

In both age groups studied, the survival and success rate of the autograft is high, and this procedure can be considered a reliable method of tooth replacement. In adult patients, a more complex treatment can be expected, involving, in addition to the surgical procedure itself, orthodontic treatment, endodontic treatment of the tooth, or prosthetic restoration of the graft.

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