ORIGINAL RESEARCH

Immediate Autotransplantation of Molars with Closed Apex

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Abstract

Aim: The aim of this study was to evaluate clinical features that might be related to success rates of autotransplantation of molars with complete root formation.

Materials and methods: A group of 60 patients with completely formed third molars autotransplanted to a different molar socket was followed for a medium period of 5 years and 5 months. Extreme care was used in order to preserve the vitality of the periodontal ligament cells. The same technique was applied for all teeth despite different anatomies. Descriptive statistics was performed. The association of the various factors with failures was assessed by using the Fisher's exact test and a *p*-value of 0.05 was considered as significance threshold.

Results: Autotransplantation was found to be a reliable method to replace extracted molar teeth with closed apices. The two major factors that positively influenced the outcomes were fixation with splint and a periodontal probing pocket depth less than 4 mm after the initial healing period. The technique resulted in a suitable well-conserved socket and donor tooth, after the extraction.

Conclusion: An accurate case evaluation was critically important in order to identify the risks prior to surgery and to select the right patients for this procedure. Autotransplantation of third molar teeth is a feasible approach to replace compromised mature molars. Proper stabilization of the transplanted tooth is strategical for the success of this procedure. A conservative approach to unerupted wisdom teeth is also recommended.

Clinical significance: Dental implants and fixed prostheses have been utilized to replace missing teeth, and orthodontic space closure can be sometimes an effective treatment option. Tooth autotransplantation can be a reliable and less invasive clinical alternative when an appropriate donor site is available.

Keywords: Autotransplantation, Balanced occlusion, Bioceramic sealer, Missing teeth, Orthodontic space closure, Tooth extraction.

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Introduction

Common treatment of edentulous sites is replacement with osseointegrated implants and fixed prostheses. Periodontitis, endodontic failures, dental traumas and fractures due to occlusal overload are among the most frequent causes of tooth extractions.[1–7] Orthodontic space closure is an evidence-based, effective treatment option for the intervention in a single tooth edentulous area, but often it is not a viable solution.[8–10]

The common treatment for symptomatic retained third molars is extraction. Tooth transfer to a different socket in the same patient is a viable and fascinating therapeutical option to replace missing teeth in order to restore normal functions for transplanted ones in a relatively short time span.

A large number of clinical studies on autotransplanted teeth have been held in the past, but only few of them were conducted on teeth with completely closed apices which is frequently encountered in adult patients. Most of studies about the autotransplantation of teeth with incomplete roots centered their attention on success factors of treatment like pulpal healing, eruption stage of the donor tooth, root resorption, and root development of the transplanted tooth.[11–16]

Furthermore, it must be considered that the final root length of an autotransplanted immature tooth depends on the development stage of the root at autotransplantation time. In mature teeth, such factors should have minor importance for the success of the treatment.[10]

Autotransplantation in adult patients having complete root formation presents many advantages compared to alternative clinical strategies even if it requires endodontic treatment within 3–4 weeks in order to remove necrotic pulp and avoid subsequent complications like periradicular inflammation and inflammatory root resorption.[17,18] The transplanted teeth can be moved subsequently to the ideal position with orthodontic treatment if necessary.[15] However, several factors should be considered with this surgical intervention, such as surgeons' skill and knowledge, patient selections, local inflammatory status, endodontically treated teeth, and availability of periodontal ligament in both donor and recipient sites.[13]

Consequently, the best practices for teeth with immature apices should be different from those with complete root formation. The aim of this study was to evaluate clinical features that might be related to long-term outcome and success rates for autotransplantation of molars with complete root formation.

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This study was planned to investigate the outcomes of the autotransplantation of third molars into the sockets of extracted molar teeth after a 5-year follow-up period.

Materials and Methods

This retrospective cohort study was conducted on patients treated with the support of a multidisciplinary team from December 2011 to December 2014. The sample under investigation consisted of 60 patients who underwent autotransplantation of completely formed molars. One patient had two upper first molars transplanted.

The informed consent was obtained from all patients. All interventions were performed at the Dental School of the University of Milano-Bicocca, Italy. All the patients were followed up until December 2019. The study was approved by the internal ethical committee as a retrospective study.

The clinical practice followed the principles of Helsinki for human experimentation and the clinical research was approved.

The patients examined treatment options together with the medical team selecting whether the autotransplantation should be performed. The mean duration of the follow-up period for all transplanted teeth was 5 years and 5 months. The patients selected for this treatment protocol had complete radiographic documentation, consisting of at least one digital preoperative orthopantomogram (OPT), and subsequent OPTs obtained immediately after autotransplantation at 6 months, 1 year, and 5 years.

Exclusion criteria: patients with a periapical lesion affecting the recipient socket greater than 5 mm diameter, or with the impossibility to show at every scheduled appointment, or with poor oral hygiene conditions were not included in this study. If the surgical extraction caused a damage of the root or its fracture, the patient was excluded from the study as well.

Outcome Variables

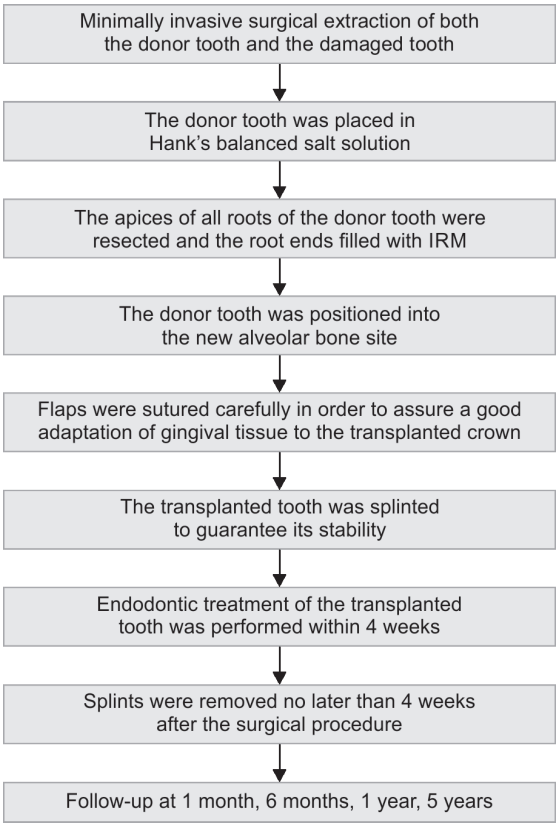
The outcome of the procedure was assessed by considering different parameters. During the first visit, a complete anamnestic record was performed and patients received detailed explanation about the procedure of tooth transplantation and intraoral photographs were obtained. At control appointments, clinical evaluation of the root length, occlusion, tooth stability, comfort in chewing, endodontic, and periodontal complications were also performed. Survival time and the reason for the failure were determined for each extracted tooth.

Surgical Procedures

The surgical protocol was scheduled with a simultaneous insertion of the third molar tooth into the socket of the extracted tooth. Antibiotic prophylaxis (amoxicillin 875 mg added to clavulanic acid 125 mg every 12 hours) began 2 days before the surgery and ended 6 days after the procedure. Mouthwash with chlorhexidine 0.20% was also prescribed.

Surgery was performed under local anesthesia (Articaine® 2% with epinephrine 1:100.000 Pierrel S.p.A., Milano, Italy). Cowhorn forceps were used to minimize damages to the root surface. The periodontal ligament (PDL) surrounding the root surfaces of the donor tooth and the recipient socket were properly preserved using only physiological saline solution in order to clean the bone socket. Atraumatic extraction technique was undertaken in all cases, and when the extraction caused a damage or fracture of the root, the patient was excluded from the study. The teeth were placed in Hank's balanced salt solution when present outside the recipient site. The apices of all roots were resected and the root ends filled with IRM (IRM®, Dentsply Sirona, Charlotte, North Carolina, USA) before tooth were replanted. Sterile and cooled saline isotonic solution was utilized to prevent excess heating of periodontal ligament during the roots resection phase. The donor tooth was positioned into the new alveolar bone site and flaps sutured carefully in order to assure a good adaptation of gingival tissue to the transplanted crown. After that, endodontic treatment was performed by a skilled endodontist within 4 weeks postoperatively. Debridement and decontamination of the root canal system with 5.25% sodium hypoclorite was made, followed by gross sealing of the canals using IRM, with attention to avoid displacing the apical seal previously placed. Transplanted teeth were usually placed slightly below (0.5/1 mm) the occlusal plane to avoid early contact of the donor tooth, which can cause tooth mobilization. The transplanted teeth were usually splinted to guarantee the stability of the grafted tooth. Orthodontic twisted wire, which is used for orthodontic retention, and resin were preferred as a stabilization material; occasionally, the anatomy, bleeding, or patient cooperation were unfit for placing a wire splint in these cases; 4-0 silk sutures were used for stabilization of these donor teeth. Splints were removed no later than 4 weeks after the surgical procedure. No prosthetic treatment was initiated until the completion of the healing phase. No treatment, except for saline solution irrigation, was performed on the socket, in order to avoid the risk of damaging the residual PDL (Flowchart 1).

Flowchart 1: Operative flow diagram



Success Criteria

Three basic criteria were used to categorize autotransplantation as successful:

- The transplanted teeth had to be in a normal occlusal function, and the degree of mobility had to be less than 2 according to Miller scale.
- Patients should not detect any discomfort during periodontal probing and the pocket depth should not exceed 3 mm.
- The radiograph of the transplanted tooth should not show any resorption of the roots and the periodontal tissue should demonstrate normal characteristics.

All transplanted teeth were evaluated clinically and radiographically by two independent operators with more than 10 years of experience in oral surgery and the cases were classified into two groups: unsuccessful and successful.

Group I included failed cases in which the transplanted teeth had severe problems. The cause of failure was recorded (progressive root resorption, failure of healing of pre-existing periapical lesions, periodontal inflammation, or spontaneous root fracture after a successful surgical procedure). The group II included successful cases in which the transplant healed well at the recipient site with only minor problems that did not compromise chewing function and did not cause discomfort to the patient.

Statistical Analysis

Descriptive statistics was performed. Sample size (53) was calculated. The association of the various factors with failures was assessed by using the Fisher's exact test. The analysis was performed with the software GraphPad Prism version 5.03 (GraphPad, La Jolla, California, USA). A *p*-value of 0.05 was considered as the significance threshold.

Results

The sample size was initially composed of 62 patients, of which 37 were females and 25 males, ranging in age from 17 to 76 years (mean age 45.58 years) at the surgery time. Two male patients were excluded from the study due to root fracture during the extraction procedure. Table 1 summarizes the main features of the sample and the distribution of the various factors among the autotransplanted teeth (Table 1). Sixty-one third molars

Table 1: Characteristics of the donor teeth and the patients undergoing surgery

	Upper first molar	*Lower first molar*	*Lower second molar*	*p value*
n. teeth	15 (2)	32 (1)	14 (1)	
Success/failure	13/2	31/1	13/1	
Male/female	7/7* (2)	20/12 (1)	10 (1)/14	0.29
Smoker				
Yes	2	12	7	0.29
No	13 (2)	20 (1)	7 (1)	
Previous RCT				
Yes	2	2	0	1.00
No	13 (2)	30 (1)	14 (1)	
Lack of buccal cortical bone				
No	12	27	13	
Limited	2 (1)	3	0	0.0002
Yes	1 (1)	2 (1)	1 (1)	
Caries in donor tooth				
Yes	2	3	1 (1)	0.35
No	13 (2)	29 (1)	13	
Donor tooth atypical root anatomy for recipient socket				
Imperfect adaptation but good stability	2 (1)	3 (1)	1 (1)	0.002
Good adaptation	13 (1)	29	13	
Bone coverage				
More than 2/3 of the roots	13	28	12	0.0001
Less than 2/3	2 (2)	4 (1)	2 (1)	
Mobility of the extracted tooth				
0	11 (2)	18	9	0.63
1	4	12 (1)	4	
2	0	2	1 (1)	

(Contd...)

Table 1: *(Contd...)*

	Upper first molar	*Lower first molar*	*Lower second molar*	*p value*
Apical osteolytic lesion in the recipient site				
Yes	5	14	6	0.14
No	10 (2)	18 (1)	8 (1)	
Type of fixation				
Wire splint	13 (1)	29	11	0.006
Suture	2 (1)	3 (1)	3 (1)	
Sound of anchylosis				
Normal	15 (2)	30 (1)	13 (1)	1.00
Anchylotic	0	2	1	
Time out of bone socket				
Less than 15 minutes	15 (2)	27	14 (1)	
20 minutes	0	2 (1)	0	0.30
22 minutes	0	2	0	
25 minutes	0	1	0	
Contact with opposing teeth in a week after transplant				
Yes	13 (1)	26 (1)	11 (1)	0.56
No	2 (1)	6	3	
Probing pocket depth of donor tooth				
More than 4 mm	2 (2)	12 (1)	7 (1)	0.01
Less than 4 mm	13	20	7	

Failures are indicated between brackets. *One female patient had two upper first molars replaced. RCT, root canal treatment

were autotransplanted in 60 patients. In 32 cases (52.46%), a lower third molar was transferred to the first molar position; in 14 cases (22.95%), a lower third molar tooth was transferred to the lower second molar position. Forty-six cases (75.41%) were in the lower jaw. Fifteen upper third molars (24.59%) were transplanted to upper first molar position. Four teeth (6.56%) were lost for periodontal reasons related to infection or external root resorption during the 5-year period of observation resulting in a success rate of 90.32%. Seven cases showed a certain degree of mobility which was tolerated by patients (degree 1 or 2) with no signs of infection or resorption. None of the patients showed internal root resorption. All teeth were perceived as normal by patients during the follow-up. Ankylosed sound on percussion was detected in three teeth even if there were not any signs or evidence of root resorption. Nevertheless, these three teeth had reduced mobility (0 in all the cases).

Failure Rates

Twisted wires were used for stabilization in 53 cases. In eight cases, when the autotransplanted tooth stability was sufficiently stable according to operator experience, isolated cross-coronal sutures were used to stabilize the donor teeth. However, three of the four failed teeth were stabilized with only sutures ($p = 0.006$).

Six donor teeth had more than 4 mm of probing pocket depth and four of them failed in the midterm ($p = 0.01$). Four of nine teeth with lack of buccal cortical bone failed, while all 52 teeth without lack of buccal cortical bone were successful ($p = 0.0002$).

The results were found to be statistically significant when the donor tooth root anatomy showed good adaptation to the recipient socket ($p = 0.002$). Four of the eight teeth having less than 2/3 of the roots covered with bone were failed and all 53 teeth having more than 2/3 of the roots covered with bone were successful ($p = 0.0001$).

The failure rate in the maxilla was four times greater than in the lower jaw (Table 1).

Discussion

Previous literature about autotransplantation reported that selection criteria such as preservation of the PDL, age of patients, extraoral time of autotransplanted teeth, stage of donor tooth root development, fixation methods, adaptation of the autotransplanted teeth to the recipient sockets, and the quality of root canal treatment were all factors influencing prognostic factors.[19–28]

The authors evaluated the prognosis for autotransplantation of teeth with complete root formation using analysis of different factors that may affect the outcome of this procedure.

The criteria we used to evaluate the success of the treatment have been widely used in the literature.[10–14] When we compare the previous studies with our study, our success rate was higher than those reported in literature by Akkocaoglu et al. (84%—retrospective study on 96 teeth), Bae et al. (84%—case series on 19 teeth), Watanabe et al. (63.1%—retrospective study on 32 teeth), Huth et al. (74%—retrospective study on 57 teeth), Czochrowska et al. (79%—retrospective study on 33 teeth), Kvint et al. (81%—follow up study on 269 teeth), Mejàre et al. (81.4%—prospective study on

50 teeth), Kallu et al. (68%—descriptive study on 273 teeth), and Tsukiboshi et al. (82%—case series on 319 teeth).[19–27]

In our study, we did not report any cases of upper third molar transplanted to second upper molar position, because when this situation arises, we preferred to wait and let third molar erupt spontaneously in the second molar position. The upper third molar transplantation to second upper molar socket is less affordable in the outcomes and has more complications rather than the physiological eruption which is reasonably fast (approximately 8–12 months). Nevertheless, there is no need to modify root anatomy and the tooth vitality can be preserved.

According to the literature, the probability of pulp healing increases in autotransplantation cases when immature roots are present. Pulp of a completely mature tooth, conversely, is not able to regenerate.[29–31]

All of our cases had mature root formation. For this reason, all the transplanted teeth received root canal treatment within 2 months after surgery or a retrograde filling was placed at the time of surgery. The advantages of using completely formed root are the knowledge of the root length, preservation of the thickness of root wall, which is useful for preventing root fractures during occlusal motion and setting with precision the amount of root resection if needed for adaption of root to the recipient alveolar socket.

Similar to our research, Mejare et al. evaluated risk factors influencing the prognosis of 49 transplanted third molars. They represented three risk factors regarding the transplantation procedure: caries, atypical root anatomy, and bone coverage of less than two-thirds of the buccal root surface. In their study, the lack of the buccal bone plate was the only significant predictor of transplantation failure.[25]

Among these risk factors, caries was of no concern in our study because most of the third molars were partially or completely retained in bone and they were positioned under the gingiva. Hence, only a few of them (n = 6) were affected by caries. Only one tooth failed as a result of decay, but the main cause of failure was increased mobility caused by periodontal problems prior to extraction procedure.

Different extensive reports about completely developed roots undergoing transplantation were published in the last 20 years. Altonen et al. reported that the outcomes of 28 upper cuspids with completely formed roots were different among three age groups: 12–20, 21–30, and 31–47 years.[32] Postoperative results were significantly better in the youngest group than in the older ones. Age of the patient seems to affect the outcome of the transplanted teeth as also mentioned in another study.

In our paper, the age of patients did not affect the outcome of the procedures unlike previously reported studies, but our findings were consistent with other studies about preservation of vitality and regeneration of the periodontal tissue.[28,33]

Gender did not show any influence on the outcomes (p = 0.29).

Analysis of the Failures

Mejare et al. noted that the absence of the buccal bone plate was the only significant predictor of transplantation failure by using a Cox regression analysis.[25]

Akiyama et al. reporting 25 autotransplantation procedures of third molars with completely formed roots, also mentioned this risk factor.[34]

Sugai et al. concluded that the lack of cortical plate was not a risk factor for this procedure. They claimed that the cause of failure was the lack of buccal bone plate.[35] Sugai et al. explained the reason for considering the lack of buccal bone plate as a nonsignificant factor in their study, because the donor teeth were not only third molars, and samples consisted of other tooth types.

In the present study, the importance of intact bone around transplanted teeth is confirmed by the observation that all failed teeth had less than 2/3 of the roots covered with bone (p = 0.0001).

In our study, the failure rate in the maxilla was 4 times greater than in the mandible, which might suggest that site selection of the donor tooth can influence the success of the procedure. This could also be attributed to the increased frequency of maxillary buccal bone wall fracture during extraction of teeth at the recipient site (p = 0.0002), or due to more complex anatomy of the maxillary molars, thus reducing the adaptability of donor roots to recipient alveolar sockets (p = 0.002).

Intact bone means healthy periodontal tissues with the absence of periodontal pockets. The importance of having a healthy condition of periodontium for the donor teeth is consistent in our data set since all failed cases had probing pocket depth more than 4 mm at surgery time (p = 0.01).

Kim et al. analyzed the impact of the extraoral time of the donor tooth during the surgical procedure and the outcomes indicated that extraoral time was not significantly different among the ankylosed cases, the cases with root resorption and the cases without complications.[28] For this reason, they hypothesize that ankylosis and root resorption are the result of local factors.

The present study found that extraoral time was not an important factor for the prognosis of donor teeth (p = 0.30). However, it should be taken into account that extraoral time (outside of the alveolar ridge) for donor teeth was mostly less than 15 minutes, very rarely did it reach 20–25 minutes, and during this period, irrigation with saline solution was continued in order to protect the periodontal ligament from dehydration.

Previous root canal treatment of the donor tooth did not influence the outcomes of teeth in our study (p = 1.00). Two reasons are considered to explain this situation. First, all donor teeth had their apices resected and root end fillings placed at the time of surgery in order to reduce the importance of apical curvatures in adapting root shape to bone sockets, and furthermore, all donor teeth received root canal treatment within 8 weeks after surgery.

Kim et al.[28] noted that good initial stability, adaptation to recipient socket, and stabilization using wires and composite were the important variables that significantly increased the rate of complete healing. In our study, teeth fixed with twisted wire from the beginning showed a better success rate than those fixed only with crossed sutures (p = 0.006) (Figs 1 to 4).

Of the eight donor teeth fixed only with sutures, three failed (37.5%); it suggested that this was a poor stabilizing technique resulting in a poor prognosis. Only one tooth fixed with wire failed (1.89%) and 52 teeth were successful (98.11%). In cases of autotransplantation of teeth with completely formed roots, a primary factor affecting the successful prognosis is the stability after grafting, which is in agreement with Tang et al.[36]

Incomplete adaptation of donor teeth with completely formed roots into the recipient socket could result in reduced stability and less resistance to lateral dislodging forces during chewing. Buccal or lingual wire fixation greatly helps to achieve proper stability. Furthermore, some degree of mobility provided by wire can

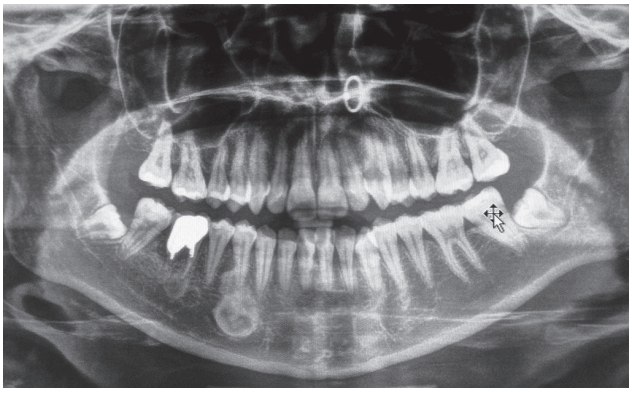


Fig. 1: Panoramic radiograph of the patient with an excessive restoration and old endodontic treatment in the right mandibular first molar

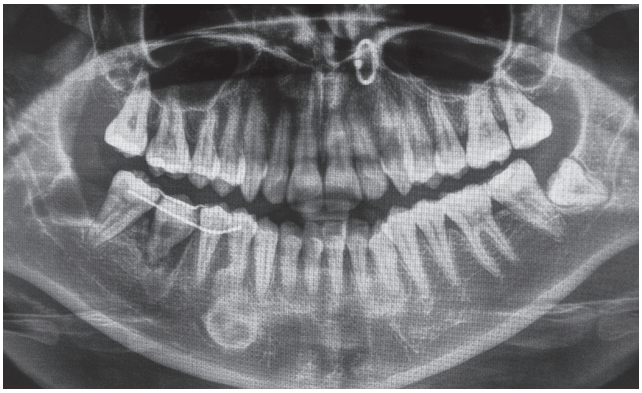


Fig. 2: Panoramic radiograph of the patient after autotransplantation of right mandibular third molar. The tooth was stabilized with a wire splint to optimize reattachment

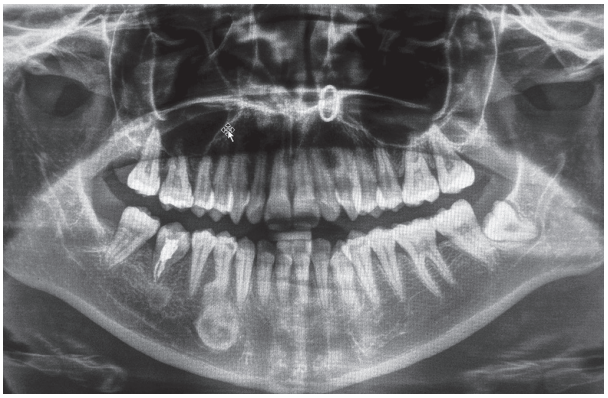


Fig. 3: Panoramic radiograph of the patient after endodontic treatment

Figs 4A and B: (A) Clinical view of the autotransplanted tooth, taken after endodontic treatment. The tooth was placed in a deep position to prevent occlusal trauma. Some spaces remained at mesial aspect because the mesiodistal width of the crown of the donor tooth was smaller than the extracted tooth. (B) An occlusal view of the cavity after endodontic treatment and composite restoration of the autotransplanted tooth

help to achieve maturation of the PDL, rather than a completely rigid fixation. Occlusal reduction of donor tooth until a newly formed PDL achieves maturation is also important for a similar reason. Some authors identified that ankylosed teeth as perfectly functional but these teeth often present with visible replacement resorption on radiographs, combined with a metallic sound when percussed.[30,31,37] These teeth show no signs of pain or other symptoms though gradually progressive replacement resorption of the tooth can be expected with ankyloses, and this process is very aggressive in children. In our study, only three teeth showed an anchylotic sound on percussion even if there was no sign of root resorption. This low incidence might be related to the routinely performed root canal treatment.

Finally, smoking habits did not affect the outcome of the procedure in this study ($p = 0.29$). Despite its physiological advantages, autotransplantation may be seen as an unpredictable and largely operator sensitive rehabilitation alternative by clinicians unfamiliar with the procedure. A recent systematic review noted inflammatory root resorption and ankylosis as the main post-transplantation disadvantages, both found to be relatively low at 4%.[38]

Conclusion

Autotransplantation is a reliable clinical opportunity with a good prognosis for molars with a closed apex. Prediction of the outcomes for autotransplantation is an important tool for clinicians identifying major risks before surgery and selecting the right patients for this procedure. Two major factors may negatively influence the outcomes: fixation only with sutures and periodontal probing pockets depth greater than 4 mm after the initial healing phase. This technique is applicable when the anatomy of the donor teeth is suitable and well preserved after extraction. For these reasons, a conservative approach to unerupted wisdom molar teeth is recommended when these teeth are clinically asymptomatic.

Limitations of This Study and Future Directions

Pros and cons of the autotransplantation of molars with closed apex should be evaluated in detail. To understand which is the best fitting technique for each case, larger trials are required, according to the Consolidated Standards of Reporting Trials (CONSORT) guidelines (www.consort-statement.org/). More prolonged studies over time are as well necessary, to assess in detail the failure rates over time.

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