

# Research Progress on the Prognosis Influencing Factors of Autogenous Tooth Transplantation

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**Abstract:** This paper summarizes the factors affecting the prognosis of autologous dental transplantation and improvement measures, so as to provide theoretical guidance for the further application of autogenous tooth transplantation in dental clinic, and thus improve the success rates and survival rates of autogenous tooth transplantation in the clinic.

**Keywords:** tooth autotransplantation; influencing factors; measure

## 1. Introduction

The report of autogenous tooth transplantation(ATT) has begun in the 1970s and was first introduced by Fuchard in 1728 in his work *Le Chirurgien Dentiste* [1], which was defined as the planned transplantation of healthy non-functional teeth from one location within the same individual mouth into another fresh or artificial alveolar socket[2], thus achieving the restoration of masticatory function and the normal proprioception of the teeth[3]. Autologous tooth transplantation has been studied in depth by many scholars over the centuries for its theoretical and clinical practice operations, and the autologous tooth transplantation has gradually matured, but there are many prognosis influencing factors, which still affect the success of autologous tooth transplantation. In this article, we will discuss four aspects, including the general condition of the patient, the condition of the donor tooth, the condition of the recipient area, and the condition of the surgery.

## 2. General conditions

### 2.1. Gender

The previous studies showed no significant difference between male and female in autologous dental transplantation [4,5]. However, it has recently been suggested that the survival rates of females in autologous dental transplantation are greater than that of males[6,7], which may be related to the fact that males have stronger occlusal forces than females and that females have better treatment reliance than males. Therefore, we should pay more attention to the preoperative evaluation and postoperative maintenance of male patients in autologous dental transplantation.

### 2.2. Age

The regeneration capacity of periodontal ligament (PDL) cells decreases with age [8], mineralization of the mandible increases [9], and surgical trauma may be increased in older patients during donor tooth extraction. Some studies have demonstrated that the success rate of transplantation is significantly higher in those younger than 45 years than in those older than 45 years [10], i.e., the success rate is higher in younger patients with incompletely formed roots [11]. Tsukiboshi et al [12], after long-term follow-up, concluded that the success rate was about 90% in patients younger than 30 years and about 80% in patients older than 30 years. However, some studies have also shown no significant effect of age for autogenous tooth transplantation with fully developed roots [13].

### **2.3. Smoking**

Li Yongqing et al [4] showed that smoking can lead to the failure of autologous dental transplantation; therefore, it is important to ask detailed smoking history before autologous dental transplantation, and to provide necessary dental hygiene education to smoking patients as well as to inform them that smoking may lead to the failure of dental transplantation.

## **3. Donor tooth**

### **3.1. Periodontal ligament damage**

The complete and surviving periodontal ligament cells are considered to be a key factor in the long-term healing of autologous dental transplantation [15]. The periodontal ligament is torn to varying degrees during excessively invasive extraction of the donor tooth using dental forceps or jaws [15], and root resorption after autologous tooth transplantation is significantly increased when the periodontal ligament is damaged by more than 25% [10]. An intact periodontal ligament can prevent root resorption or root-bone adhesions after autologous tooth transplantation and can induce bone formation to promote healing of the recipient area [16]. In addition, it has been shown that donor teeth left in vitro for longer than 15 min can impair periodontal ligament cellular activity [10], and more than 50% of periodontal ligament activity is lost when donor teeth are left in vitro under dry conditions for longer than 30 min under the influence of changes in pH and osmotic pressure.

Therefore, in order to protect the integrity of the periodontal ligament of the donor teeth, minimally invasive extraction [17,18] and aseptic operation should be required during surgery, or the donor teeth that are quite loose or clamped loose can be temporarily stored in the donor area without extraction [3] or minimally invasive extraction can be performed by ultrasonic bone knife; 3D model teeth can be used instead of donor teeth for trial implantation during the preparation of the alveolar socket stage, and the donor teeth can be extracted after the 3D model teeth are matched with the alveolar sockets in the recipient area for further matching with the alveolar sockets; the donor teeth can be stored in saline during surgery to preserve the periodontal ligament cell activity.

### **3.2. Dental root morphology**

Anterior teeth are mostly single-rooted and minimally invasive extractions cause minimal damage to the periodontal ligament; therefore, the survival rate of anterior teeth is higher than that of molars [19]. Aoyama et al [11] showed that atypical root morphology such as hypertrophy, curved roots, and large root bifurcations are more likely to result in root resorption after autologous tooth transplantation. The success rates of transplanted teeth are affected when the donor teeth are multi-rooted. Therefore, the success rates of single-rooted teeth with conical and simple root morphology used for autologous tooth transplantation are higher [18].

### **3.3. Root integrity**

Vasiliki et al [15, 20] showed that autologous tooth transplantation in children and adolescents has a high success and survival rates and that the stage of root development influences the healing of the pulp and periodontal ligament of the transplanted tooth. The success rate at 1, 5, and 10 years after transplantation is high (>90%) when the root development is incomplete, and complications such as root-bone adhesions, root resorption, and pulpal necrosis are low [22]. Root bone adhesions are more than twice as likely to occur in teeth with fully developed roots than in incompletely developed teeth [23], and the pulp of incompletely developed teeth can heal and repair after transplantation without root canal therapy (RCT), which is preferred for autologous tooth transplantation [24], whereas teeth with fully formed roots require 2-4 weeks postoperatively [3,13], which can avoid the occurrence of root-bone adhesions and extra-root resorption and improve the survival rate. Therefore, for immature teeth, it is recommended to use stage 2 to stage 4 (i.e., 1/2 to 3/4 of the root formation) for transplantation [21], when the crown-to-root ratio is appropriate and better initial stability can be obtained. RCT of mature teeth should be performed within 2-4 weeks after the procedure.

### **3.4. Donor tooth location**

It was shown that the survival rates of maxillary teeth were significantly higher than those of

mandibular teeth, and there were differences in bone density between maxillary and mandibular bones at different sites, with the average bone density in the mandible being greater than that in the maxilla, while the bone density in the anterior part of the maxilla was greater than that in the posterior part [9,25]. Therefore, it is recommended to design a minimally invasive extraction plan before autologous tooth transplantation, operate aseptically during surgery, and extract the donor tooth minimally or non-invasively.

### **3.5. Donor tooth storage**

There is a relationship between post-operative bony adhesions or root resorption and the properties and temperature of the donor tooth storage medium. Proper storage of donor teeth is particularly important for periodontal ligament cells activity as well as for the success rates of transplanted teeth. Solutions for storing donor teeth include balanced salt solution, milk [27], and saline, etc. Studies have shown that although saline has physiological osmotic pressure and pH, it does not contain substances required by cells, and compared to milk, saline is slightly inferior for storing teeth, but it is recommended for short-term storage of teeth [28].

## **4. Recipient area**

### **4.1. Alveolar bone situation**

After tooth extraction, the alveolar ridge shows varying degrees of resorption, and the mandibular alveolar ridge is more rapidly resorbed than the maxillary alveolar ridge [25], and the lack of bone volume in the alveolar bone has an impact on the success rates of autogenous tooth transplantation [15]. Generally, when there is more bone loss than is sufficient for dental transplantation, bone implants are needed at the missing tooth site to maintain the width and vertical height of the buccolingual (palatal) bone in the missing tooth area [15] so that an alveolar socket can be prepared to accommodate the donor tooth.

### **4.2. Recipient area locatio**

Aoyama et al [11] showed that there was no significant correlation between the location of the recipient area and the success rates after autogenous tooth transplantation. Singh et al [19] showed that the success rates of maxillary dental implants were higher than mandibular ones, which may be due to the lax porosity of the upper alveolar bone, the abundant blood supply, and the lower direct occlusal load on the maxillary teeth compared to the mandibular ones.

## **5. Surgery**

### **5.1. Surgery type**

Jang et al [10] studied that the extraction of donor teeth is considered as "surgical extraction" when flap surgery and osteotomy are required for the extraction of donor teeth and "simple extraction" for the rest, and the timing of donor implantation is considered as "immediate surgery" when the extraction of donor teeth and donor implantation are performed on the same day, and "delayed surgery" when manual preparation is required after a period of alveolar socket healing.

### **5.2. Alveolar socket preparation**

Alveolar socket preparation: Raisha et al [29] showed that transplantation of teeth with fully developed roots into fresh, early, and artificially prepared alveolar sockets resulted in high success rates and had similar efficacy, but immediate transplantation in fresh alveolar sockets and early transplantation within 4-8 weeks after extraction were mostly periodontal ligament healing with no significant difference in healing, whereas periodontal ligament healing was not as good as the first two for grafts requiring surgical preparation of the socket after 3 months of extraction. In contrast, Yao Dongsheng [30] et al. investigated and reported that the results of blood flow reconstruction in fresh and artificial alveolar sockets were similar, and there was no significant difference in postoperative periodontal ligament healing. Ashkenazi [31] showed that the alveolar socket prepared in the recipient area should be slightly larger than the donor tooth by 1-2 mm, which reduces the test implantation

number and provides an effective blood supply. When inflammation exists in the affected tooth in the recipient area, 4-8 weeks after extraction is chosen for dental grafting, in which the inflammation has been eliminated, periodontal tissue has healed, and osteoblasts are active, which facilitates bone healing and post-transplant aesthetics [29]. And whether it is a fresh socket or an artificial socket, the depth of the socket preparation should be less than 1 mm above the enamel bone boundary or 1 mm wide periodontal ligament left above the top of the alveolar ridge, and for root incompletely developed donor teeth, the depth should be appropriately greater than the root length when performing socket preparation [3].

### **5.3. Operator's ability**

As studies have shown, experienced surgeons with some clinical competence have an impact on the success rate of autologous dental transplantation [15, 32]. In the study by Kafourou [15], most of the unfavorable outcomes were caused by immaturity of autotransplantation technique early in the transplantation program, and after a period of improvement in autotransplantation technique, handling the tissue (pulp and periodontium) by an experienced surgeon with some surgical skills would improve the survival rates of the transplanted teeth. However, it has also been shown that there is no significant difference in outcomes during autologous tooth transplantation with either experienced or inexperienced primary surgeons [33].

### **5.4. Donor tooth dissociation time**

Jang [10] demonstrated that excessive dissociation time has a detrimental effect on the survival of PDL cells and that donor tooth dissociation time less than 15 minutes was associated with dental transplant success, i.e., patients with dissociation time less than 15 minutes had significantly higher tooth survival compared to the same age group. Kim and Lee [34, 35] suggested the application of the computer-assisted rapid prototyping (CARP) model to minimize the departure time of autologous dental transplantation and that the CARP model is effective in reducing the departure time of donor teeth.

### **5.5. The use of 3D printing technology**

Keightley et al [36] first used 3D model teeth designed by CBCT instead of autologous teeth for trial implantation and achieved good results. Ashkenazi [31] and Tang [37] studied that the use of CBCT, computer 3D simulation and 3D model teeth combined with digital guides can accurately prepare the alveolar sockets position, thus shortening the operative time, reducing the risk of intraoperative infection, and increasing the success rates of dental transplants.

### **5.6. Use of biomaterials**

Studies have shown [29] that bone healing is more likely to develop after artificial socket preparation, possibly because of failure of hematologic reconstruction caused by surgical trauma during socket preparation. Therefore, it has been shown that the placement of biomaterials such as platelet-rich fibrin (PRF), concentrated growth factor (CGF), and artificial bone material (Bio-Oss) in artificially prepared alveolar sockets may reduce root resorption and bony adhesions [39-41].

### **5.7. Fixation method**

Chung [42] studied that fixation after autologous tooth grafting contributes to initial stability, and the likelihood of failure of autologous tooth transplantation using wire splints in this study was less than that using suture fixation, but root bone adhesions after wire splint fixation were three times greater than those with suture fixation. Qiong Li et al [43] used three fixation methods, i.e., using orthodontic archwires, resin wires, and dental arch splints for comparison. The animal experimental study by Yun Yang [44] showed that the orthodontic archwire method used for autogenous tooth transplantation facilitated the healing of the transplanted tooth when it was exercising masticatory function. Therefore, it is recommended to choose elastic fixation, i.e., "8" suture or fiber resin fixation, when the initial stability of the donor tooth is good, and to choose rigid fixation, i.e., resin wire fixation, when the initial stability is poor.

### 5.8. Initial stability

Jang et al [10] stated that horizontal movement less than 2 mm before fixed splinting after autologous tooth transplantation was considered as good initial stability, while horizontal movement greater than 2 mm before fixed splinting was considered as poor initial stability. Kim et al [34] reported that transplanted teeth with good initial stability had better early healing than those with poor initial stability. Oortgiese et al also reported that periodontal ligament cells proliferated more actively in response to mechanical stimulation.

### 5.9. Postoperative root canal treatment situation

Root canal treatment is essential for the success of autogenous dental transplantation with fully formed roots [42]. Undergoing RCT after autotransplantation has a significantly lower failure rate compared to performing RCT outside the dental cavity, as extra-oral root canal treatment increases the time for the autogenous tooth to leave the body and affects the prognosis of healing. Studies have demonstrated that RCT can be performed within 3-4 weeks after autologous tooth transplantation. In contrast, Chung et al [42] concluded that root resorption rate (RR) was twice as high when root canal treatment was performed after 14 days post-transplantation than within 14 days post-operatively.

## 6. Conclusion

With the development of technology and medical techniques, autologous tooth transplantation has gradually become an economical and effective technique for restoring dental defects. In contrast to dental implants, autologous dental transplantation is a periodontal membrane healing procedure that restores the normal proprioception of the tooth. Experts have already reached a consensus on this, which is also reflected in this paper, and the technique can be further improved. The improved autologous tooth grafting technique has shortened the procedure time, is affordable and easily accepted by patients, and thus has more clinical application prospects.

## References

- [1] Pape H D, Heiss R. [History of tooth transplantation]. [Z]. 1976: 20, 121-125.
- [2] Natiella J R, Armitage J E, Greene G W. The replantation and transplantation of teeth: A review [J]. *Oral Surgery, Oral Medicine, Oral Pathology*, 1970, 29(3): 397-419.
- [3] Mi W, Dong Q, Zhang L. Research progress on cognitive impairment and influencing factors in adolescents with depression [J]. *Journal of New Medicine*, 2023, 54(1):13-16.
- [4] Li YQ, Hui SY, Xu GJ, et al. Screening and analysis of prognostic factors for restoring single tooth loss with autogenous dental implants [J]. *Chinese Journal of Stomatology*, 2022, 57(05): 495-502.
- [5] Mendes R A, Rocha G. Mandibular third molar autotransplantation--literature review with clinical cases. [Z]. 2004: 70, 761-766.
- [6] Yoshino K, Ishizuka Y, Sugihara N, et al. Risk factors affecting third molar autotransplantation during 5 and 10 years. [J]. *The Bulletin of Tokyo Dental College*, 2014, 55(2): 111-122.
- [7] Yoshino K, Ishizuka Y, Sugihara N, et al. Gender difference in tooth autotransplantation with complete root formation: a retrospective survey. [J]. *Journal of oral rehabilitation*, 2013, 40(5): 368-374.
- [8] Zhang J, An Y, Gao L N, et al. The effect of aging on the pluripotential capacity and regenerative potential of human periodontal ligament stem cells [J]. *Biomaterials*, 2012, 33(29): 6974-6986.
- [9] Oliveira M R, Gonçalves A, Gabrielli M A C, et al. Radiographic Evaluation in the Diagnosis of Alveolar Bone Quality in Implant Rehabilitation [J]. *The Journal of craniofacial surgery*, 2020, 31(6): 1805-1808.
- [10] Jang Y, Choi Y J, Lee S J, et al. Prognostic Factors for Clinical Outcomes in Autotransplantation of Teeth with Complete Root Formation: Survival Analysis for up to 12 Years [J]. *J Endod*, 2016, 42(2): 198-205.
- [11] Aoyama S D, Yoshizawa M D P, Niimi K D P, et al. Prognostic factors for autotransplantation of teeth with complete root formation [J]. *Oral surgery, oral medicine, oral pathology and oral radiology*, 2012, 114(5): S216-S228.
- [12] Tsukiboshi M, Yamauchi N, Tsukiboshi Y. Long-term Outcomes of Autotransplantation of Teeth: A Case Series [J]. *Journal of Endodontics*, 2019, 45(12, Supplement): S72-S83.
- [13] Nie S.H., Lv Jiao, Wang Z., et al. A retrospective clinical analysis of autologous tooth grafts with

- completed root development [J]. *Chinese Journal of Stomatology*, 2018, 53(11): 736-740.
- [14] Kafourou V, Tong H J, Day P, et al. Outcomes and prognostic factors that influence the success of tooth autotransplantation in children and adolescents [J]. *Dent Traumatol*, 2017, 33(5): 393-399.
- [15] Prato G P, Zuccati G, Clauser C. Commentary: A Translational Medicine Approach to Tooth Transplantation [J]. *Journal of Periodontology*, 2017:519.
- [16] Strbac G D, Giannis K, Mittlböck M, et al. Survival rate of autotransplanted teeth after 5 years - A retrospective cohort study. [J]. *Journal of cranio-maxillo-facial surgery: official publication of the European Association for Cranio-Maxillo-Facial Surgery*, 2017, 45(8): 1143-1149.
- [17] Tang H, Shen Z, Hou M, et al. Autotransplantation of mature and immature third molars in 23 Chinese patients: a clinical and radiological follow-up study. [J]. *BMC oral health*, 2017, 17(1): 163.
- [18] Singh A K, Khanal N, Acharya N, et al. What Are the Complications, Success and Survival Rates for Autotransplanted Teeth? An Overview of Systematic Reviews and Metanalyses [J]. *Healthcare (Basel)*, 2022, 10(5).
- [19] Jang J, Lee S, Kim E. Autotransplantation of Immature Third Molars Using a Computer-aided Rapid Prototyping Model: A Report of 4 Cases [J]. *Journal of Endodontics*, 2013, 39(11): 1461-1466.
- [20] Rohof E, Kerdijk W, Jansma J, et al. Autotransplantation of teeth with incomplete root formation: a systematic review and meta-analysis [J]. *Clin Oral Investig*, 2018, 22(4): 1613-1624.
- [21] Lucas-Taule E, Bofarull-Ballus A, Llaquet M, et al. Does Root Development Status Affect the Outcome of Tooth Autotransplantation? A Systematic Review and Meta-Analysis [J]. *Materials (Basel)*, 2022, 15(9).
- [22] Li J, Pan J. Research progress on tooth autotransplantation combined with orthodontic treatment [J]. *International Journal of Stomatology*, 2018.
- [23] Devlin H, Horner K, Ledgerton D. A comparison of maxillary and mandibular bone mineral densities. [Z]. 1998: 79, 323-327.
- [24] Poi W R, Sonoda C K, Martins C M, et al. Storage media for avulsed teeth: a literature review [J]. *Braz Dent J*, 2013, 24(5): 437-445.
- [25] Schwartz O, Andreasen F M, Andreasen J O. Effects of temperature, storage time and media on periodontal and pulpal healing after replantation of incisors in monkeys [J]. *Dent Traumatol*, 2002, 18(4): 190-195.
- [26] Raisha Abdukim, Jiang Chunyan, Alimeldan Aniwar, et al. Preliminary study of autologous tooth transplantation in three different periodontal sockets [J]. *Oral Medicine Research*, 2021, 37(03): 255-259.
- [27] Yao D S, Gao L, Pei H J, et al. Animal experiment of autologous tooth transplantation into artificial alveolar sockets [J]. *Journal of Practical Dentistry*, 2018, 34(01): 39-42.
- [28] Ashkenazi M, Shashua D, Kegen S, et al. Computerized three-dimensional design for accurate orienting and dimensioning artificial dental socket for tooth autotransplantation [J]. *Quintessence international (Berlin, Germany)*: 1985, 2018, 49(8): 663-671.
- [29] Jonsson T, Sigurdsson T J. Autotransplantation of premolars to premolar sites. A long-term follow-up study of 40 consecutive patients. [J]. *American journal of orthodontics and dentofacial orthopedics: official publication of the American Association of Orthodontists, its constituent societies, and the American Board of Orthodontics*, 2004, 125(6): 668-675.
- [30] Jakobsen C, Stokbro K, Kier-Swiatecka E, et al. Autotransplantation of premolars: does surgeon experience matter? [J]. *Int J Oral Maxillofac Surg*, 2018, 47(12): 1604-1608.
- [31] Kim E, Jung J, Cha I, et al. Evaluation of the prognosis and causes of failure in 182 cases of autogenous tooth transplantation. [Z]. 2005: 100, 112-119.
- [32] Lee S J, Jung I Y, Lee C Y, et al. Clinical application of computer-aided rapid prototyping for tooth transplantation. [Z]. 2001: 17, 114-119.
- [33] Keightley A J, Cross D L, McKerlie R A, et al. Autotransplantation of an immature premolar, with the aid of cone beam CT and computer-aided prototyping: a case report. [Z]. 2010: 26, 195-199.
- [34] Tang H, Shen Z, Hou M, et al. Autotransplantation of mature and immature third molars in 23 Chinese patients: a clinical and radiological follow-up study [J]. *BMC Oral Health*, 2017, 17(1): 163.
- [35] Ez-Eldeen M, Wyatt J, Al-Rimawi A, et al. Use of CBCT Guidance for Tooth Autotransplantation in Children. [J]. *Journal of dental research*, 2019, 98(4): 406-413.
- [36] Zheng Z, Li HF, Zhao YH, et al. Experimental study of enamel matrix protein to promote periodontal healing in autografted teeth [J]. *Chinese Journal of Geriatric Dentistry*, 2012, 10(04): 193-196.
- [37] Gui H M, Du L J, Lei A D, et al. Two-year clinical effect analysis of artificial bone for autologous tooth transplantation [J]. *Chinese Journal of Oral Medicine Research (electronic version)*, 2009, 3(02): 187-192.
- [38] Liu Junping, Chen Fuguang, Kwong See-Ping. Clinical efficacy of platelet-rich fibrin (PRF)

- combined with autologous bone in immediate autologous tooth grafting during tooth extraction [J]. Chinese Journal of Oral and Maxillofacial Surgery, 2016, 14(06): 527-531.*
- [39] Chung W, Tu Y, Lin Y, et al. *Outcomes of autotransplanted teeth with complete root formation: a systematic review and meta-analysis [J]. Journal of clinical periodontology, 2014, 41(4): 412-423.*
- [40] Li Qiong, Wang Shu, Shi Huiqing, et al. *A comparative study of different fixation methods for autogenous dental implants in the posterior region [J]. Beijing Stomatology, 2018, 26(03): 160-163.*
- [41] Yang Y, Bai YX, Li S, et al. *Establishment of an experimental animal model of orthodontic force after autologous dental implantation [J]. Beijing Stomatology, 2014, 22(04): 187-190.*
- [42] Lv Baoping. *Clinical study of autologous dental implants and their combination with orthodontic treatment [J]. World Medical News Digest, 2018, 18(69): 54.*
- [43] Oortgiesen D A W, Yu N, Bronckers A L J J, et al. *A three-dimensional cell culture model to study the mechano-biological behavior in periodontal ligament regeneration. [J]. Tissue engineering. Part C, Methods, 2012, 18(2): 81-89.*
- [44] Lin P Y, Chiang Y C, Hsu L Y, et al. *Endodontic considerations of survival rate for autotransplanted third molars: a nationwide population-based study [J]. Int Endod J, 2020, 53(6): 733-741.*
- [45] Mejàre B, Wannfors K, Jansson L. *A prospective study on transplantation of third molars with complete root formation [J]. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology, 2004, 97(2): 231-238.*