



Case report

Tooth autotransplantation gives teeth a second chance at life: A case series

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ABSTRACT

Traditional transplantation, surgical extrusion and intentional replantation procedures are important treatment options that clinicians may consider performing in their daily clinical practice. There should be a well-constructed treatment plan for teeth with problems. In this paper, we present a series of case reports on three treatment methods used in autologous tooth transplantation and a literature review on the prevention of postoperative complications and the advantages of autologous tooth transplantation compared to dental implantation. The purpose of this study was to improve the understanding of autologous tooth transplantation.

1. Introduction

Autologous tooth transplantation can be divided into three categories: traditional transplantation, surgical extrusion and intentional replantation [1,2]. Traditional transplantation replaces teeth that cannot be preserved by transferring impacted or developing teeth from the donor site to the surgically prepared recipient site [3]. In 1965, Hale was the first to systematically describe the technique for transplanting the third molar into the first molar area. In 1974, Slagvold introduced the concept of transplanting premolars with immature roots by means of a spare hole. In 1988, Nethander proposed a two-step method for tooth transplantation, in which the number of surviving periodontal cells on the root surface is the key to successful tooth transplantation [1,4,5]. Tooth transplantation is mainly used for the replantation of impacted or ectopic teeth into normal positions or the replacement of teeth missing due to trauma, congenitally missing teeth or teeth that cannot be retained [6]. Surgical extrusion is the purposeful coronal displacement of the remaining tooth roots in the tooth socket to restore irreparable teeth [7]. Intentional replantation is used to treat intractable apical or resorptive lesions by deliberate nontraumatic tooth extraction and reimplantation of teeth into the extraction socket after in vitro restoration [8]. In 1966, Crossman et al. proposed the indication for intentional replanting, which was later modified by Mainkar et al., in 2017: failure of nonoperative root canal therapy and apical microsurgery, failure of apical surgery to remove periapical irritants (cysts, etc.), perforation and extracorporeal resorption, crown root fracture, periodontal defects, and

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inability of patients to afford longer and more expensive treatments [9,10]. Intentional replantation gained renewed interest when it was used in combination with apical biomaterials and periodontal regeneration agents, and its clinical efficacy may be improved when combined with contemporary guidelines for replantation and apical microsurgery. A recent systematic analysis by scholars showed that the success rate of intentional replantation was as high as 90% [11]. The main advantages of the operation are that the surface of the tooth is directly observed and that the repair does not damage adjacent periodontal tissue. In the clinical setting, replantation is intentionally performed for lateral incisors with deformed deep root surface ditches or mandibular second molars with refractory root infections. In these cases, the main goal of intentional replantation is to retain teeth. The secondary goal is to cure periapical disease [12].

Some scholars have reported that immature teeth are the best donor teeth because the chance of revascularization is greater in teeth with wide cusps. Standardized nontraumatic surgery was performed for 370 autologous grafts, and follow-up over 1–13 years showed that the survival rates of immature and mature grafts were 98% and 95%, respectively [13]. In the clinical setting, autologous tooth transplantation requires complete root development. While the focus of most studies has been using the root of an incomplete tooth in autologous tooth transplantation, clinicians must consider using the root of a complete tooth to expand the indications for autologous tooth transplantation, despite the root being fully developed. However, there is a lack of evidence regarding the clinical outcome of this approach [14,15].

Three methods for autologous tooth transplantation have been reported. The treatment options are traditional tooth transplantation, intra-alveolar tooth transplantation and intentional tooth replantation. Clinicians should focus on teeth in poor condition and on providing more treatment options. Dentists should be equipped with the knowledge to recommend and perform procedures to the appropriate patients. With developments in science and technology, autologous tooth transplantation will improve the satisfaction and smile of patients. With further developments in diagnostic and surgical technologies, such as cone-beam computed tomography (CBCT), computer-aided rapid prototyping (CARP) and 3D printing surgical template technology, the success rate of autologous tooth transplantation has gradually increased. Nevertheless, autologous tooth transplantation definitely requires further development [16].

2. Case reports

2.1. Case 1

A 25-year-old female presented to our hospital with pain in her lower left posterior teeth. The patient reported that a lower left posterior tooth had been repaired with a post-core crown at another hospital five years prior and that she had recently begun suffering from pain on biting. Intraoral examination showed that the post-core-crown prosthesis on tooth #37 was not closed, and caries, pain on percussion, mild redness and swelling of the gingival margin were observed; there was no redness or swelling of the apical area and no sinus opening on the labial side. Tooth #38 had a vertical eruption and an intact crown, with no pain on percussion, loosening or pericrown discharge. X-ray examination showed that tooth #37 had a low-density shadow below the porcelain crown, imperfect filling of the root canal to the root tip, and a low-density shadow around the root tip (1 mm × 0.5 mm); however, tooth #38 had a crown without impaction or root abnormalities, and the periodontal membrane was complete (Fig. 1, Fig. 2a).

After evaluation, tooth #37 had no remaining value, so extraction was recommended. Two plans were presented to the patient. The first plan consisted of transplanting tooth #38 after the extraction of tooth #37. The second plan consisted of implanting a prosthesis after the extraction of tooth #37. The patient was informed of the treatment plans, costs and risks and allowed to choose the best option.

Routine disinfection was performed under a mandibular block with local 2% lidocaine and infiltration anaesthesia. The gingiva of tooth #37 was separated, and then the tooth was completely extracted. Inflammatory tissue in the alveolar fossa was removed, and then the area was rinsed with normal saline. Dental forceps were used in a minimally invasive manner to completely extract tooth #38. Since the shape of the root was basically consistent with the shape of the alveolar fossa in the recipient area, no extra alveolar fossa preparation was performed, and tooth #38 was immediately implanted into the alveolar fossa in the recipient area. The in vitro isolation time was 1 min, and the wound was fixed and closed with a needle suture after complete positioning [Fig. 2b-f]. One week



Fig. 1. Preoperative panoramic: tooth #37 - low-density shadow below the porcelain crown, imperfect filling of the root canal to the root tip, and low-density shadow around the root tip (1 mm × 0.5 mm); tooth #38 - crown without impaction or root abnormalities and with a continuous periodontal membrane.

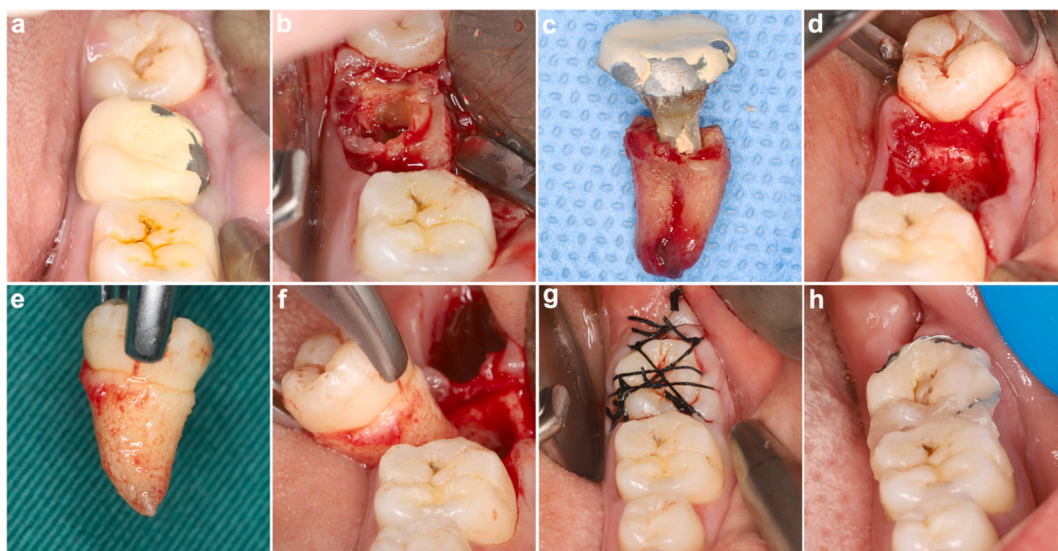


Fig. 2. a: Preoperative intraoral photograph. b: Removal of tooth #37. c: Complete removal of crown and root of tooth #37. d: Cleaning of the alveolar socket. e: Minimally invasive extraction of donor tooth #38 with intact root and periodontal membrane. f: Implantation of tooth #38 into alveolar socket of tooth #37. g: Wound fixation and closure with needle suture. h: Elastic fixation after suture removal.

later, the suture was removed [17]; the wound had healed well and loosened from I° to II°. After removing the suture, elastic fixation was performed. Two weeks later, the transplanted tooth underwent complete endodontic treatment. The patient was followed up after 3 months, 6 months, 1 year, and 2 years. The graft healed well without loosening, the average depth of buccal and lingual periodontal exploration was 3 mm, and X-ray examination showed gradual disappearance of the apical low-density shadow [Fig. 3(a-f)].

2.2. Case 2

A 43-year-old male presented to our hospital for the treatment of anterior tooth trauma caused by a fall on his bicycle. The patient had no symptoms of dizziness, nausea, vomiting, loss of consciousness, etc. Intraoral examination showed complete dislocation of tooth #21, an empty alveolar fossa, and blood clots. Tooth #22 showed an embedded dislocation and I° loosening. Tooth #11 showed a slight inclination, pain on percussion, gingival swelling, and II° loosening. X-ray examination showed very little periodontal space

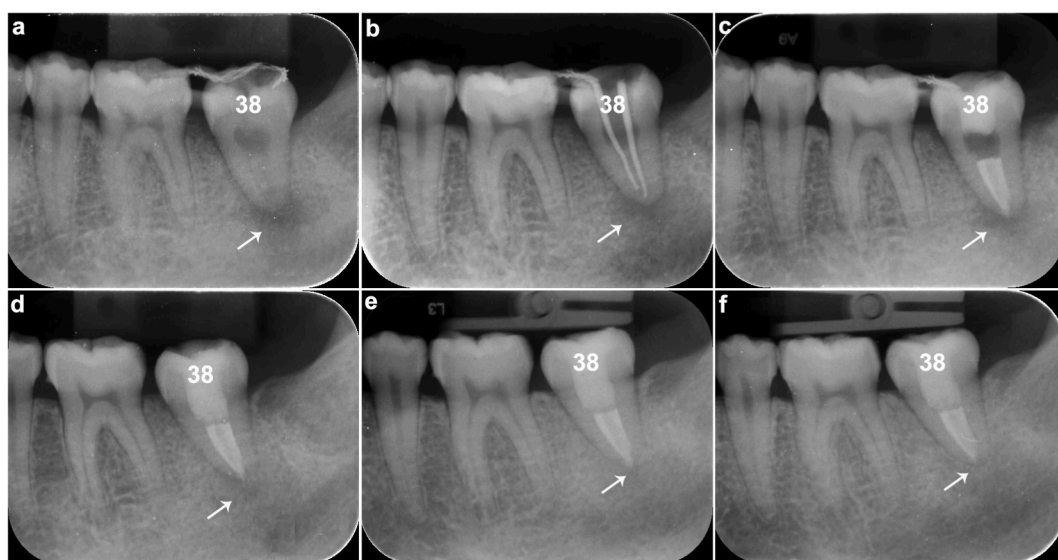


Fig. 3. a: No significant changes were observed in apical low-density images at 1 week after the operation. b and c: Complete root canal treatment 2 weeks after surgery. d: Apical hypodensity was significantly reduced at 6 months after the operation. e: The apical hypodense shadow disappeared 1 year after the operation. f: Continuous periodontal membrane 2 years after the operation, indicating good recovery.

around tooth #22 and wider periodontal space around tooth #11 (Fig. 4a, Fig. 5a).

Due to gingival swelling and alveolar bleeding, the patient was asked to undergo 3 days of local anti-inflammatory treatment. The following treatment plan was provided for the patient: elastic fixation of the anterior teeth after intra-alveolar transplantation and fixed bridge repair of tooth #22 with complete healing of the periodontal membrane. The patient was informed of the treatment plan, costs, risks and prognosis, and the patient provided informed consent to undergo treatment.

After routine disinfection was performed under local 4% tetracaine infiltration anaesthesia, tooth #22 was prepared for alveolar transplantation, tooth #11 underwent manual reduction, and adequate haemostasis was achieved. Elastic fixation of the anterior teeth was performed, tooth #21 was temporarily repaired, and the occlusion was adjusted. Two weeks after the operation, complete root canal treatment was performed for teeth #11 and #22, and the wound healed well. At 1 month after the operation, the elastic fixation was removed, and no loosening of tooth #11 or #22, pain on percussion, gingival swelling, periodontal membrane discontinuity or widening of the periodontal space were observed on the apical film. Subsequently, fixed bridge repair was performed from tooth #11 to tooth #22 [Fig. 4b-f]. Due to the impact of COVID-19, the patient could not complete the follow-up visits while living at another location; thus, the follow-up data from 3 to 6 months after surgery are missing. One year after the operation, the fixed bridge was functioning well, the oral function and appearance of the patient were restored, and the periodontal membrane of teeth #11 and #22 was continuous and normal on the apical film [Fig. 5b-d].

2.3. Case 3

A 26-year-old woman presented with a 3-month history of swelling, pain and discomfort in a lower left posterior tooth. Six months prior, the patient had been treated at another hospital for pain in the lower left posterior tooth. In the past 3 months, the affected tooth was often swollen, painful and uncomfortable. Intraoral examination of tooth #36 showed filling material on the tooth surface, no response to thermal testing, discomfort on percussion, no loosening, and no sinus tract on the buccal or lingual side. X-ray examination showed that tooth #36 had a continuous high-density shadow in the apical 1/3 of the mesial root canal, a low-density shadow around the apical root canal, and a large low-density shadow around the distal root canal, with a clear and continuous boundary. CT examination showed that tooth #36 had a continuous high-density shadow located in the curvature of the apical 1/3 of the proximal buccal root and a distal periapical circular low-density shadow (1.5 mm × 2.0 mm × 1.5 mm) with clear and continuous edges (Fig. 7a).

The possibility of device separation for the proximal root canal and distal apical cyst was considered by clinical and auxiliary examination. If the affected tooth was completely cured, complete removal of the cyst and complete root canal retreatment would be needed. The patient was offered two options: intentional replantation or apical surgery for tooth #36. The patient was informed of the treatment plan, costs and risks and finally chose the first option.

After routine disinfection, local anaesthesia was established via a mandibular block with 2% lidocaine along with infiltration anaesthesia using 4% articaine. Then, the gingiva of tooth #36 was separated and removed using dental forceps in a minimally invasive manner, and the tooth was transferred to the oral physician for reimplantation. The root of the crown was wrapped with wet gauze and soaked in normal saline for apical resection, and the separation instruments were removed. Apicectomy was performed for 3 mm, and no root breakage was found on methylene blue staining. The root canal was prepared with ultrasonic instruments, rinsed with 0.9% normal saline, and dried with paper tips, and inverted root canal filling was performed for 3 mm using iRoot BP. At the same time, the surgeon processed the alveolar fossa, completely removed the cyst, and removed the inflammatory tissue. After rinsing with normal saline, the treated tooth was replanted back into the alveolar fossa. The *in vitro* separation time was 10 min, and after placement was completed, the wound was fixed and closed with a needle suture [Fig. 6(a-h)]. One week later, the suture was removed; the wound had healed well and loosened from I° to II°. After removing the suture, elastic fixation was performed. Two weeks later, the replanted tooth

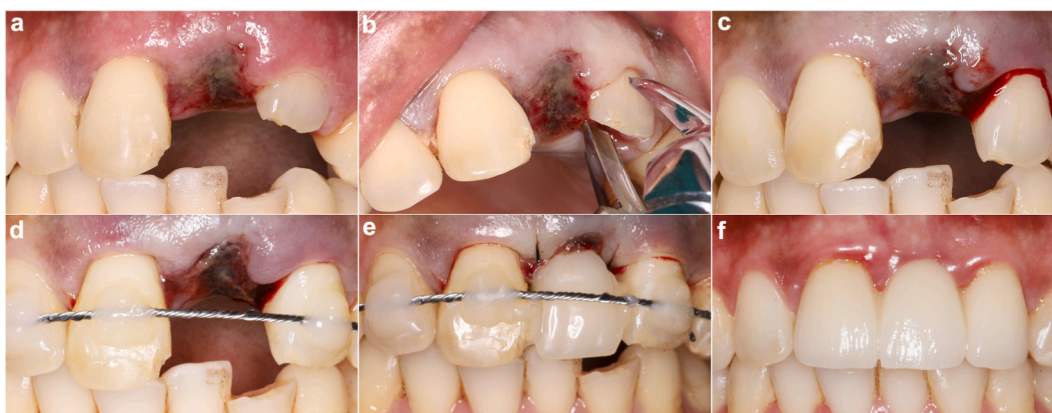


Fig. 4. a: Preoperative intraoral images showing complete dislocation of tooth #21 and embedded dislocation of tooth #22. b: Preparation of tooth #22 for alveolar transplantation. c: Return to the normal occlusal position. d: Elastic fixation of upper anterior teeth. e: Temporary restoration of tooth #21. f: Acceptable function of the fixed bridge after one year.

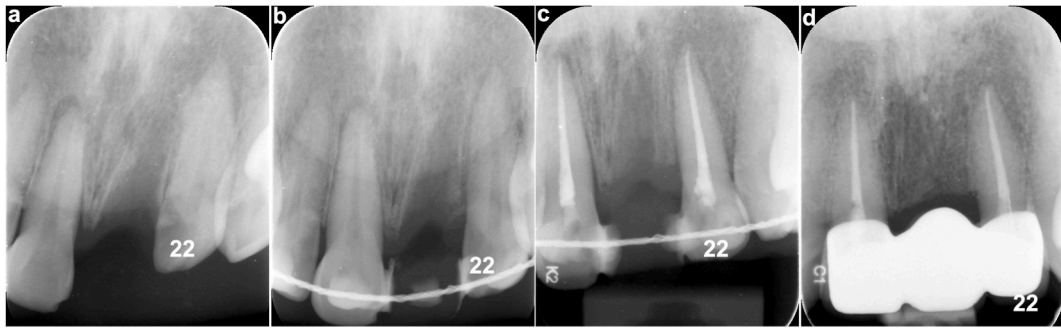


Fig. 5. a: Disappearance of periodontal space around tooth #22 and widening of periodontal space around tooth #11 before surgery. b: Image of periodontal membrane widening immediately after surgery. c: Root canal treatment for teeth #11 and #22 two weeks after surgery, with a continuous periodontal membrane. d: Continuous periodontal membrane 1 year after surgery.

underwent complete endodontic treatment. The patient underwent follow-up examinations after 3 months, 6 months and 1 year. The replanted tooth healed well without loosening. The average depth of buccal and lingual periodontal exploration was 3–4 mm, and X-ray examination showed gradual disappearance of the apical low-density shadow [Fig. 7a-e].

3. Discussion

The most common complications of autologous tooth transplantation are inflammatory root resorption and root rigidity [18]. Timely and complete root canal treatment and fixation of transplanted teeth are particularly important for controlling postoperative complications. Early root canal treatment can also stop the process of root resorption. In a study by Andreason et al., 28 premolars with fully developed roots underwent root canal treatment within 4 weeks after transplantation, and the 5-year survival rate was 98% [19]. Some scholars have also reported that it is very important to perform root canal treatment within 2 weeks. When an avulsed tooth is immediately reimplanted into the alveolar socket, optimal healing of the periodontal ligament can be achieved, and “reattachment” of the connective tissue on the root surface to the recipient socket wall will occur within 2 weeks [20]. Therefore, premature root canal treatment after surgery may cause additional periodontal ligament damage, and if delayed for more than 2 weeks, root canal system infection may result in root resorption [15]. All grafts in this case series underwent endodontic treatment 2 weeks after the operation and recovered well. Rapid healing of the periodontal ligament is of great significance to promote root survival in autologous tooth grafts. Kristerson and Andreason believed that the physiological micromovement of autologous teeth is conducive to periodontal revascularization [21]. Small movements of teeth after transplantation can promote the regeneration of periodontal blood vessels, while rigid fixation can inhibit this movement, which is not conducive to periodontal revascularization and even increases the risk of plaque accumulation. Therefore, it is recommended to use flexible wire for elastic fixation, which can not only keep the tooth stably in the alveolar socket but also provide sufficient flexibility to allow the donor tooth to receive appropriate periodontal stimulation.

In the process of autologous tooth transplantation, whether it is traditional transplantation, intra-alveolar transplantation or

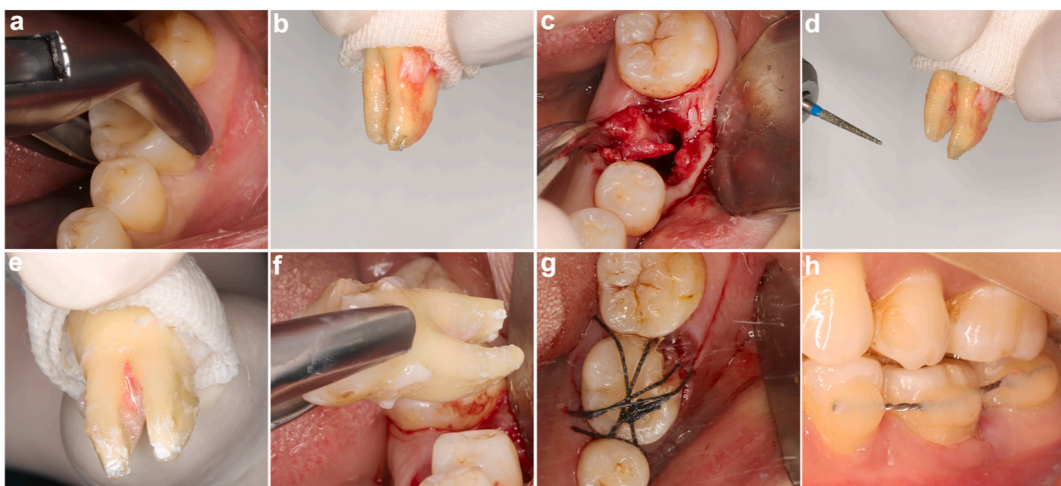


Fig. 6. a: Extraction of tooth #36. b: Placement of tooth #36 in proximal apical metal disconnection device. c: Cleaning of the alveolar fossa and distal periapical cyst of tooth #36. d: Apical resection. e: Root canal backfilling with mineral trioxide aggregate. f: Reimplantation of tooth #36 into the alveolar socket. g: Wound closure and fixation with needle suture. h: Elastic fixation after suture removal.

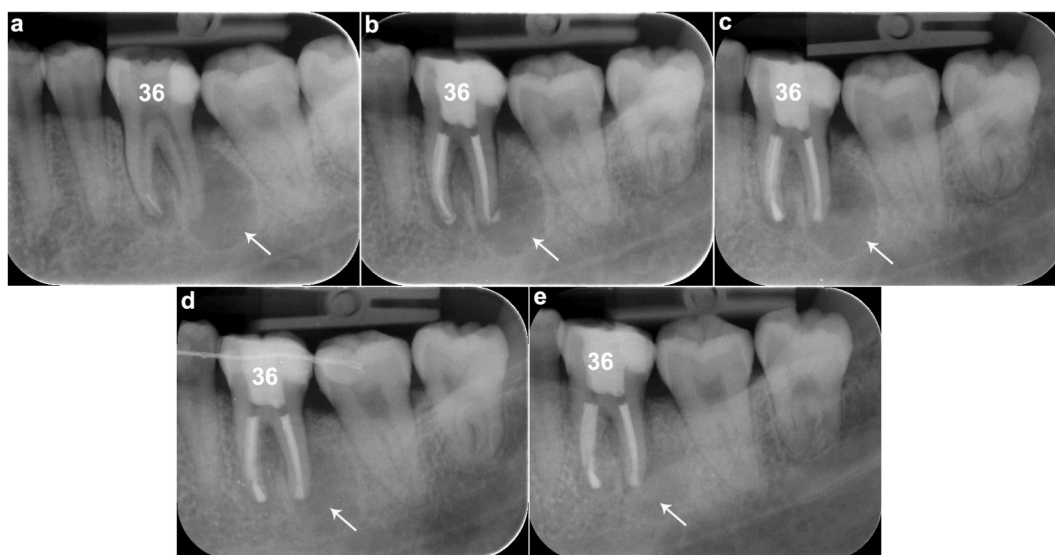


Fig. 7. a: Preoperative examination of tooth #36 showing a continuous high-density shadow at the apical 1/3 of the mesial root canal, a low-density shadow around the apical tip, and a large round low-density shadow around the distal apical root canal with a clear and continuous boundary. b: Complete endodontic treatment 2 weeks after surgery. c: Slight reduction of apical hypodensity 3 months after surgery. d: Disappearance of the low-density shadow in the proximal apical area and significant reduction of the shadow in the distal area 6 months after surgery. e: Continued shrinkage of the apical low-density shadow, with satisfactory healing one year after surgery.

intentional replantation, tooth extraction is considered to be the most sensitive step, and the trauma to both the tooth and periodontal tissue during tooth extraction must be minimized. It is recommended that special dental extraction forceps or minimally invasive dental extraction forceps be selected in clinical practice. The dental forceps should be placed on the crown, not touching the cementum surface, and then the tooth should be gently and slowly moved in the buccal and lingual directions with appropriate rotation to gradually tear the periodontal membrane and allow the donor or affected tooth to be pulled out.

At present, in traditional treatment, missing teeth are often replaced with implants to restore oral function. In 2017, Mainkar et al. conducted a systematic literature review and compared the survival rates of autologous tooth transplants and dental implants. The average 5-year survival rates of autologous tooth transplants and dental implants were relatively similar, at 89.1% and 96.3%, respectively. In fact, autologous tooth transplantation is a cost-effective alternative treatment [10]. The advantage of autologous tooth transplantation is that maintains the proprioception of natural teeth such that the periodontal ligament that can adapt to the biting force in the process of chewing; additionally, it is easier to maintain the anatomical morphology of the gingiva and achieve satisfactory aesthetic results [22]. Successful autologous tooth transplantation preserves the periodontal tissue and maintains the height of alveolar bone and adjacent gingival papilla; furthermore, tooth transplants can be moved to normal occlusal positions by orthodontic traction [23]. In autologous tooth transplantation, the periodontal ligament can induce osteogenesis, and periodontal ligament cells differentiate into three types of cells: fibroblasts, cementocytes and osteoblasts. Bone induction is characterized by rapid bone regeneration and the appearance of hard bone plates around the graft. Even though the gap between the bone wall and the root of the graft is very wide, bone grafting materials are not needed. Compared with the use of implants, bone induction around the graft is a significant advantage of this type of surgery [24].

The three types of autologous tooth transplantation play a role in different scenarios (Table 1). Traditional transplantation is more suitable when the affected tooth cannot be preserved due to caries and other factors and when there is a suitable autologous donor tooth (e.g., orthotopic eruption of the third molar). Intentional replantation is suitable when the tooth tissue is intact or can be used after repair but apical or periodontal lesions cannot be cured by apical or periodontal surgery. When the length of the crown of the tooth cannot be repaired due to trauma or caries, attempts can be made to improve the repairable condition of the tooth by surgical extrusion. All three methods have their own application scenarios, and clinicians can consider each method when appropriate.

4. Conclusion

Autogenous tooth transplantation is a better treatment method for replacing teeth than the application of fixed or movable dentures. However, there are corresponding risks (loss of attachment, root resorption, etc.), and eventually, the grafts may fail. Careful preoperative evaluation and effective long-term follow-up are key to the success of autologous tooth transplantation.

Author contribution statement

All authors listed have significantly contributed to the investigation, development and writing of this article.

Table 1
Comparison of three methods of autologous tooth transplantation.

	Indications	Key technologies	Timing of root canal treatment	Elastic fixed time	Main factors affecting recovery
Traditional transplant	1.Tooth cannot be preserved 2.Suitable autologous tooth donor	1.Tooth extraction 2.Perfect root canal therapy 3.Assessment of the third molars	≤2 weeks	Maxillary: 1 month Jaw: 1.5 month	1.Tooth in vitro time [25] 2.Root morphology [26] 3.Period of root development [27] 4.Hard and soft tissue [28]
Surgical extrusion	1.Length of the crown is insufficient	1.Tooth extraction 2.Perfect root canal therapy 3.Evaluation of pull out length	≤2 weeks	Maxillary: 1 month Jaw: 1.5 month	ditto
Intentional replantation	1.Serious apical lesions 2.Tooth can be preserved	1.Tooth extraction 2.apical resection 3.root canal backfilling 4.Perfect root canal therapy	≤2 weeks	Maxillary: 1 month Jaw: 1.5 month	ditto

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Data availability statement

Data included in article/supp. material/referenced in article.

Declaration of interest's statement

The authors declare no competing interests.

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