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SHORT COMMUNICATION

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# A step-by step guide for autotransplantation of teeth

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## Abstract

Tooth loss is an adverse consequence of oral diseases and traumatic dental injuries. Although several treatment options exist to treat a missing or hopeless tooth, especially in young individuals, most of the existing alternatives (such as orthodontic treatment, removable or fixed partial dentures, and dental implants) impose a challenge in children due to the nature of the developing jaw bones. Tooth autotransplantation is the replacement of a tooth with another functional tooth within the patient's dentition. Autotransplantation can serve as a promising treatment alternative in cases of tooth loss not only in children and adolescents but also in adult patients. Autotransplantation is a technique-sensitive procedure, that requires proper and thorough planning as well as careful and knowledgeable execution in order to improve the chances for long-term success and survival of the transplanted tooth. Thus, the aim of this article was to provide a step-by-step clinical guide, emphasizing key points and highlights for planning and performing a successful autotransplantation procedure. Autotransplantation is a very predictable treatment modality that can serve as a viable option to replace a missing tooth, especially in young patients. Proper planning and careful execution of the procedure are important to achieve optimal long-term results.

**KEYWORDS**
alveolar bone, ankylosis, bone loss, success, survival

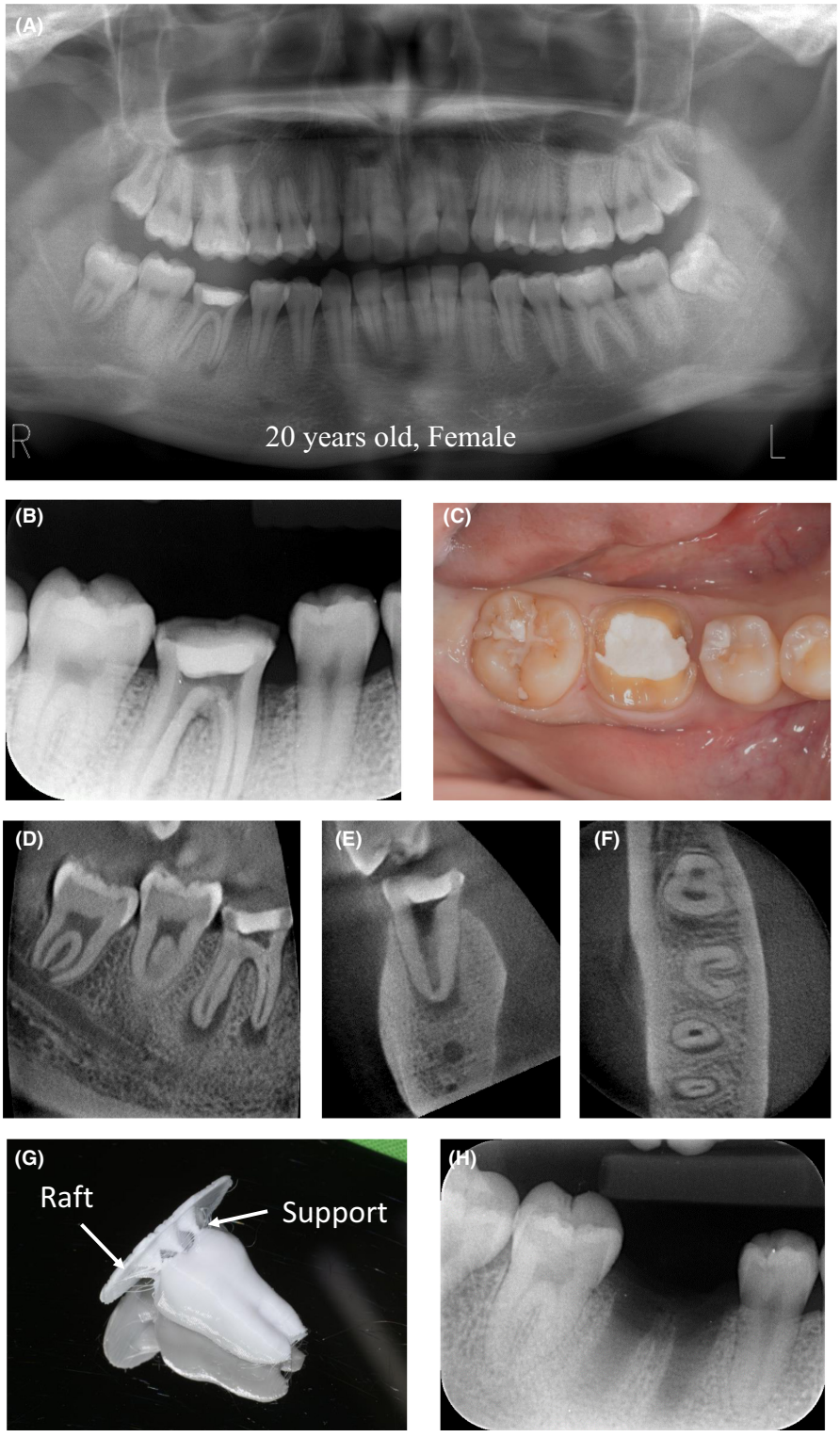
## 1 | INTRODUCTION

Tooth loss is an adverse consequence of oral diseases and traumatic dental injuries.[1–3] Although several treatment options exist to treat a missing or hopeless tooth, especially in young individuals, most of the existing alternatives (such as orthodontic treatment, removable or fixed partial dentures, and dental implants) impose a challenge in children due to the nature of the developing jaw bones.[4,5] Tooth autotransplantation is the replacement of a tooth with another functional tooth within the patient's dentition.[6] Autotransplantation can serve as a promising treatment alternative in cases of tooth loss not only in children and adolescents but also in adult patients.[6] Very high success and survival rates were reported with the use of autotransplantations in various patient populations.[6,7] The ability of transplanted teeth to remain harmonious with the adjacent teeth allows for natural space closure, higher esthetics, and reduced cost and treatment time in comparison to dental implants.[3,6] This will also enable soft and hard tissue preservation and further development. Even if the tooth has been missing for a long time and bone loss has occurred, bone regeneration was observed in the recipient socket, as well as presence of lamina dura in the transplant site.[6] The capability of autotransplanted teeth to erupt with the adjacent dentition is an additional asset in comparison to "ankylosed," osseointegrated dental implants that have no ability to erupt which could lead to infraocclusion in younger patients.[4–6] Most patients were satisfied with the esthetic outcome of their transplanted teeth.[7] It is recommended

that the donor tooth be between Morrees stages 4 and 6 (between full root formation with open apical foramen and full root formation with closed apical foramen) in order to achieve highest chances of good pulp healing.[8] Failures of autotransplantation of teeth were mostly seen due to replacement resorption and ankylosis.[6,7]

Autotransplanted teeth allow preservation of the alveolar bone in the area of the missing tooth (compared to an empty extraction site), which can be used for a future implant in case of a failure.[4,5]

Autotransplantation of teeth had its first breakthrough in the early 1950s. Replacing a first molar with severe dental caries with a third molar (donor tooth) with an immature root formation fascinated many dentists.[9] However, low success rates have discouraged dentists from using this dental treatment option. The failure at that time might be attributed to the lack of proper comprehension of the biology related to autotransplantation. Nevertheless, with the subsequent development of basic, animal, and clinical research,



autotransplantation has eventually established itself as an evidence-based treatment modality.[8,10–13] It is important to realize, though, that autotransplantation is a technique-sensitive procedure, that requires proper and thorough planning as well as careful and knowledgeable execution in order to improve the chances for long-term success and survival of the transplanted tooth.

Thus, the aim of this article was to provide a step-by-step clinical guide, emphasizing key points, and highlights for planning and performing a successful autotransplantation procedure.

## 2 | INDICATIONS FOR AUTOTRANSPLANTATION

In order for autotransplantation to be successful, it is first necessary to have clear criteria for judging whether autotransplantation is indicated. The following points can be used as indication criteria for conventional autotransplantation.

- There are hopeless or missing teeth and available, suitable and spare-able donor teeth such as premolars or third molars in the same mouth.
- It is preferable that the donor tooth has a simple, easy-to-extract form (single root, conical, bullet-shaped, etc.), and that the bone width of the recipient site is wide enough to accommodate the donor tooth.
- In the transplantation of immature root teeth, the optimal stage of development of the root of the donor tooth is Morrees stage 4 to stage 5. However, revascularization can be expected even in stage 6 (if the diameter of the apical foramen is 1 mm or more).
- If the donor tooth is completely developed, it is preferable that the patient is no older than 30 years of age.
- Autotransplantation should have more advantages than other treatments (implants, bridges, removable dentures, etc.). Criteria of advantages include treatment duration, cost, aesthetics, preservability, and biological acceptability.

## 3 | EXAMINATION AND DIAGNOSIS

A recipient tooth and a donor tooth are examined with panoramic radiograph (Figure 1A), periapical radiograph (Figure 1B), clinical photograph (Figure 1C), Cone Beam CT (Figure 1D–F), probing depts, and clinical parameters in order to judge whether or not the recipient tooth can be preserved, the condition of the socket (bone width, bone level, etc.), the morphology, and the stage of root development of the donor tooth. Autotransplantation is determined as a suitable treatment modality when the case has matched the indications cited

**FIGURE 1** A transplantation of a third mandibular molar to a hopeless first mandibular molar site. (A) A panoramic view of a 20 -year-old female, who was referred for the treatment of the right first mandibular molar. A vertical fracture on the mesial aspect of the mesial root was suspected. (B) A periapical radiograph of the right first molar. The lamina dura is unclear on the mesial aspect. (C) An occlusal view of the right first molar. (D) A sagittal view of a CBCT of the right third molar (the donor tooth) and the right first molar (recipient site). The prognosis of the right first molar seems poor. The impacted third molar seems to be a good candidate as a donor to replace the right first molar. The stage of root development is stage 6 and a little late for optimal stages as a donor tooth but still pulp healing might be expected. (E) A coronal view around the distal root of the right first molar. (F) A axial view of around the molars. The bone width of the recipient site is wide enough to accommodate the narrower donor tooth. (G) A plastic replica of the donor tooth which was made from the DICOM data of the CBCT images. The replica is sterilized by cold sterilization system. Raft and supports have been attached to the replica to ease the try-in procedure. (H) A radiograph after the extraction of the right first molar. In immediate transplantation, the first step of the surgery is a tooth extraction of the recipient site after anesthesia. (I) To visualize the alveolar ridge, envelope-type flaps were raised to reveal the ridge by 2 to 3 mm. (J, K) Preparation of the recipient socket. Using a surgical round bur and an implant bur, the recipient socket is prepared under saline cooling. In the first molar site, the main purpose is to remove the alveolar septum of the furcation area. (L) The prepared socket. (M) Try-in of the replica which has been attached to a raft to facilitate carrying. Fitness between the prepared socket and the replica is checked. If the replica is not placed into the socket sufficiently, the recipient site should be further prepared. (N) Interfering portions would be found by moving the replica buccolingually or mesiodistally. (O) The try-in of the replica has been detached the raft. Make sure the replica tooth should be placed deep enough to make occlusal adjustment unnecessary. (P) Incision over the donor tooth. (Q) Revealing the crown of the donor tooth. (R) Removing the bone over the crown with piezotome. (S) Incision into the sulcus around the donor tooth. (T) Extraction of the donor tooth. Note, dental papilla are attached at the root apices. (U) Try-in of the donor tooth into the socket to make sure it fits. (V) Checking with a radiograph. (W) Suturing flaps after removing the donor tooth which is placed back into the original socket or kept in saline temporarily. (X) The donor tooth is placed into the socket after suturing the mesial flap with one knot. (Y) Cross-suture over the occlusal surface of the transplant is performed to fix the transplanted tooth for 1 week. (Z) Suturing the donor site. (AA) Bonding lingual buttons for the retention of surgical dressing. (BB) Surgical dressing to protect the wound from bacterial contamination. Dressing and suture strings are removed 1 week after the surgery. (CC) If the tooth mobility is increased after removing the suture, the transplant is splinted to the adjacent tooth with wire and bonding resin for 1 month. This is an example using a model. Actually, the transplant was splinted to the adjacent premolar in this case. (DD) One month after transplantation just before the removal of the wire-resin splint. (EE) Two months postop. (FF) Three months postop. In transplantation of an immature tooth, the healing should be followed up every month for the first 3 months because inflammatory resorption may take place if the pulp is infected. Once inflammatory resorption is found, pulp canal treatment should be started. This case seems to have no complication. (GG) Six months postop. PDL healing is observed since lamina dura has formed around the root. (HH) An occlusal view after 6 months. (II, JJ) One year postop. Pulp canal obliteration is progressing. The tooth responded positively to EPT. (KK, LL) Two years and six months postop. The PDL healing is nicely maintained and the pulp canal is almost completely obliterated with positive EPT. The occlusion of the transplant to the antagonist tooth is tight.

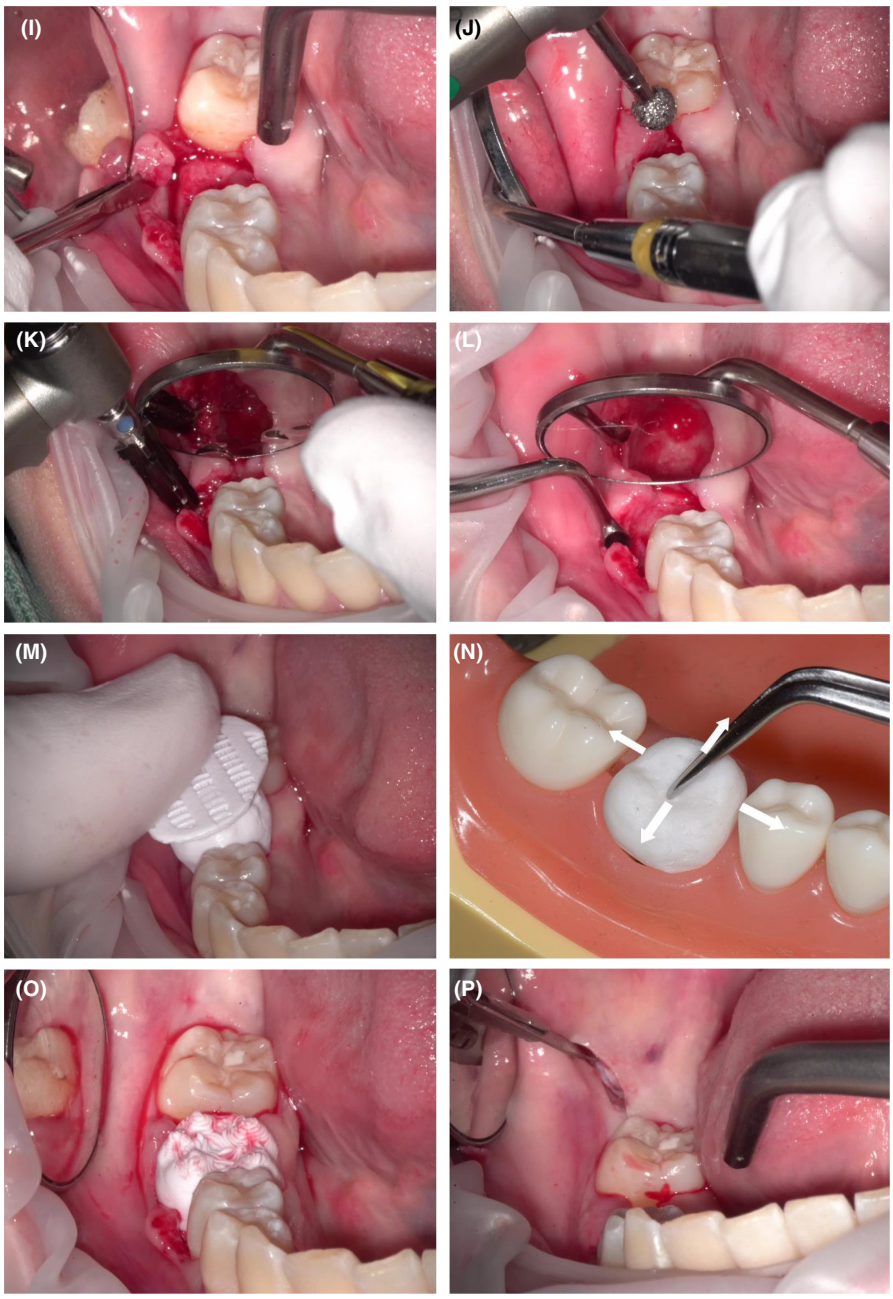



FIGURE 1 (Continued)

above. Thorough explanations should be given to the patient (and parents when applicable) including the possible complications and the need for a frequent and adequate follow-up regimen. Informed consent should be then obtained.

## 4 | A STEP-BY-STEP GUIDE FOR THE SURGICAL PROCEDURE

1. Creating a replica

In recent years, it has become possible to minimize mechanical damage to the periodontal ligament of the donor tooth at the time of try-in by creating a replica[14,15] of the donor tooth based on DICOM data obtained from CBCT (Figure 1G).

2. Anesthesia of the recipient and donor site

After cleaning the oral cavity and disinfecting the surgical field, local anesthesia is applied to the recipient site and the donor site.

3. Extraction of the recipient tooth and preparation of the recipient socket

In the case of an immediate autotransplantation, the hopeless tooth in the recipient site is extracted first (Figure 1H). When the

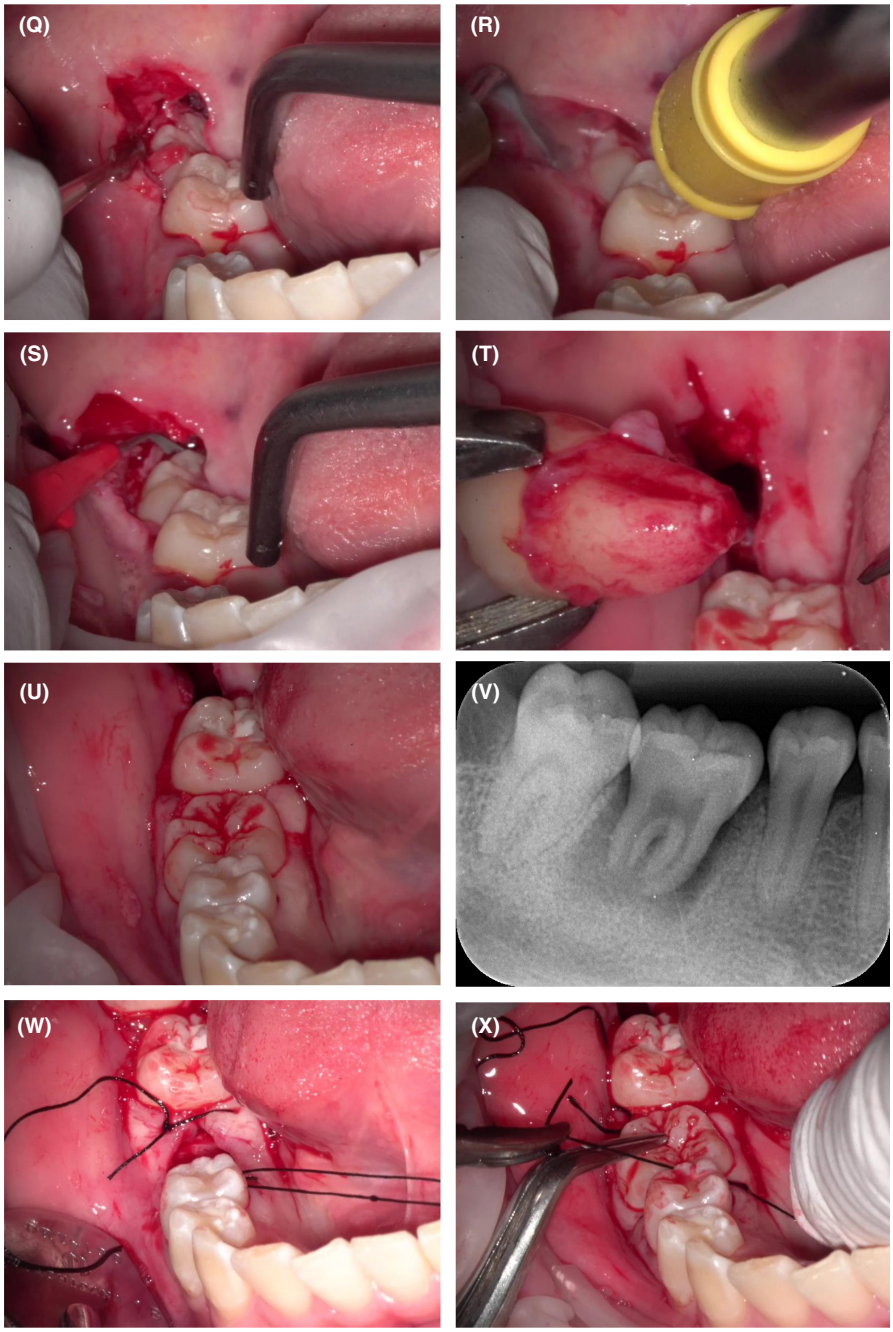



FIGURE 1 (Continued)

recipient tooth has periapical lesion, the granulation tissue should be thoroughly removed, but care should be taken not to curettage the periodontal ligament of the extraction socket if unnecessary. In the case of delayed autotransplantation, the tooth on the recipient site should be extracted 3 to 4 weeks before transplantation. Avoid further delay to perform autotransplantation for more than 2 months after the extraction since the recipient socket might be reduced in dimensions.

After making a gingival sulcus incision to the corner of the adjacent tooth, open the flap so that the alveolar ridge of the recipient site is exposed by 2 to 3 mm (Figure 1I). A recipient socket of approximate size is prepared using a surgical round bur (Figure 1J) and an implant drill (Figure 1K). The recommended rotation speed of the drill should be around 2000 rpm, and the drilling should be performed under cooling with saline.

4. Try-in of the replica and adjustment of the socket

After preparing the recipient socket of an approximate size (Figure 1L), the replica of the same type as the donor tooth is tried in the socket (Figure 1M). If the replica cannot be planted to the proper position, it is necessary to identify and reshape the socket

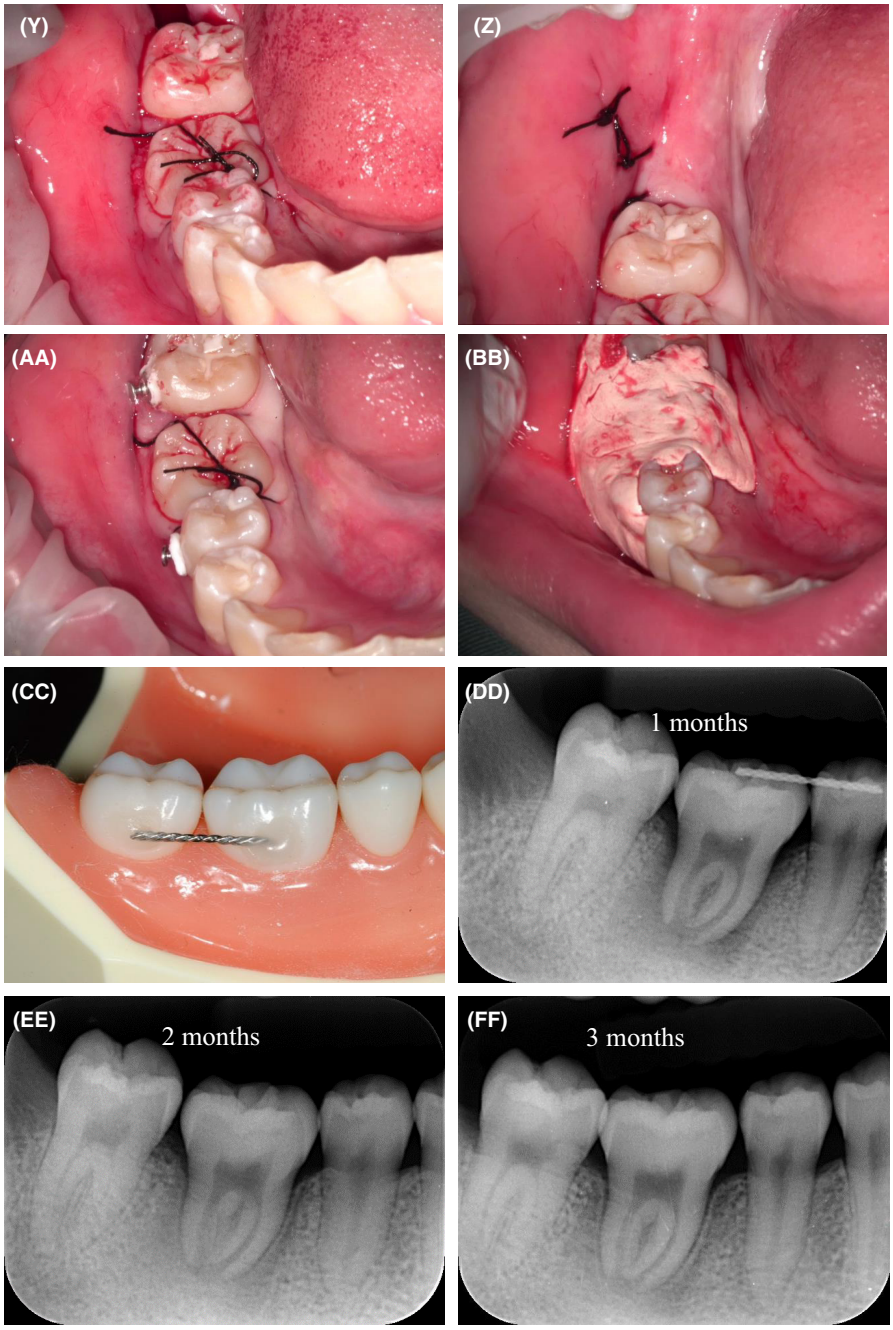



FIGURE 1 (Continued)

where the preparation is insufficient. The place to be adjusted can be roughly identified by placing the replica in the socket and moving it mesiodistally or buccolingually (Figure 1N). If it rocks buccolingually but not mesiodistally, enlarge the socket buccolingually. If it sways buccolingually but not mesiodistally, remove the bone on the mesiodistal aspect. If the replica moves in both directions, enlarge the apical aspect. Care should be taken not to damage the mandibular canal, the maxillary sinus, or other adjacent anatomical structures. If there is no replica available, it is necessary to perform the extraction of the donor tooth as described in the next section, and complete the abovementioned try-in and regrinding with the actual tooth.

5. Occlusal adjustment

Occlusal adjustment is preferably not performed in the transplantation of immature teeth. If dentinal tubules are exposed by grinding beyond the enamel, pulp infection might occur, and ideal pulp healing cannot be expected. Therefore, it is recommended that transplanted teeth should be placed as deeply as possible so that

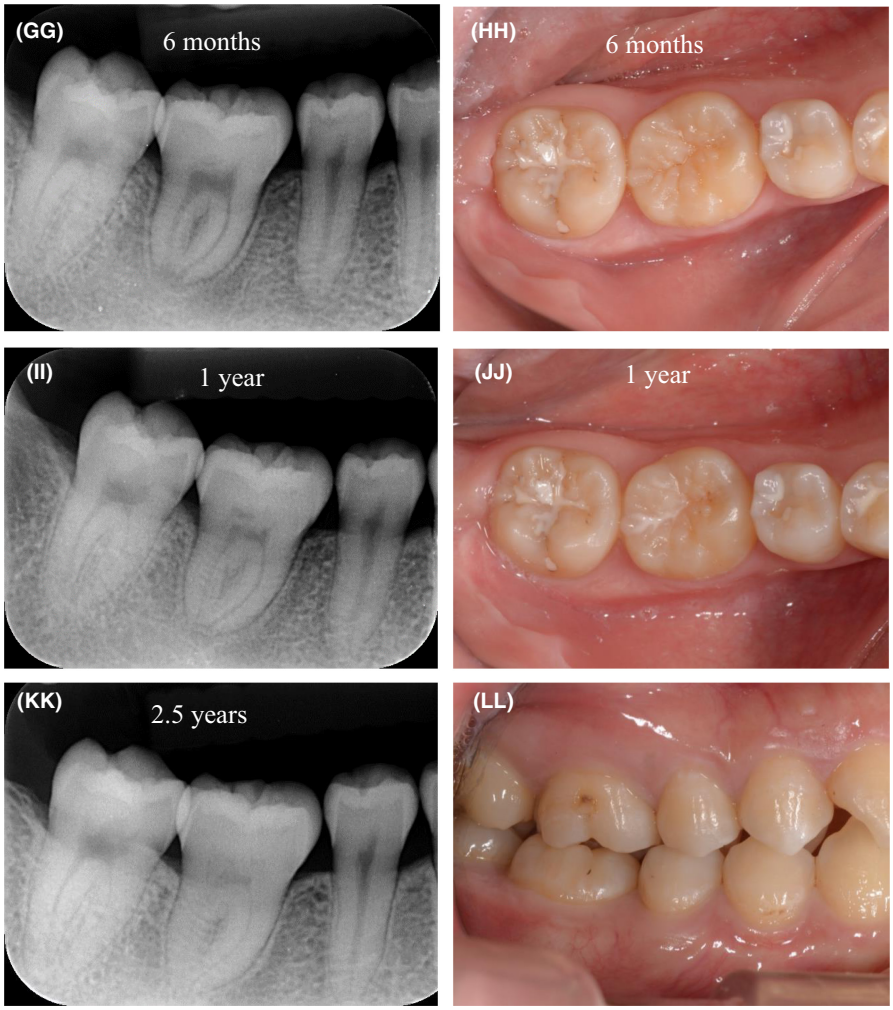



FIGURE 1 (Continued)

occlusal adjustment is unnecessary (Figure 1O). This confirmation work is carried out at the trial fitting stage of the replica.

6. Extraction of the donor tooth

After the preparation of the recipient socket, the extraction of the donor tooth is performed. If the donor tooth is impacted, a gingival flap is raised (Figure 1P, Q), and if necessary, the bone covering the crown is carefully removed using a surgical round bur or piezotome (Figure 1R). After the crown is exposed (even if it is exposed from the beginning), insert a thin blade into the gingival sulcus (Figure 1S) and care is taken to attach the periodontal ligament to the donor tooth as much as possible. The donor tooth was extracted gently using forceps (Figure 1T).

7. Try-in of the donor tooth

The extracted donor tooth is placed directly into the recipient socket to check the fitness between the donor and the recipient (Figure 1U). In this state, fitness is confirmed with a radiograph (Figure 1V).

8. Suturing the flaps

The donor tooth (hereinafter referred to as the transplant) is removed from the socket once and is preserved in the original socket or saline temporarily if further adjustments are necessary. The gingival flaps are then sutured (Figure 1W). By suturing the flaps without placing the transplant, a tighter adaptation between the transplant and the flaps can be obtained.

First, the distal flap is sutured and the knot is placed on the bucco-distal aspect. One of the suture strings is left by about 4 cm (Figure 1W). The mesial flap is then sutured, but stopped at the surgical single knot stage (Figure 1W), at which stage the donor tooth is replaced into the socket (Figure 1X). The double knot is then tied to ensure a tight seal around the transplant with the flap but leave the sutures uncut (Figure 1X).

9. Fixing the transplant with suture

The transplant is usually fixed with suture strings on the day of surgery, as long as there is not too high mobility of the placed transplant, it is convenient to fix the transplant with sutures, to shorten

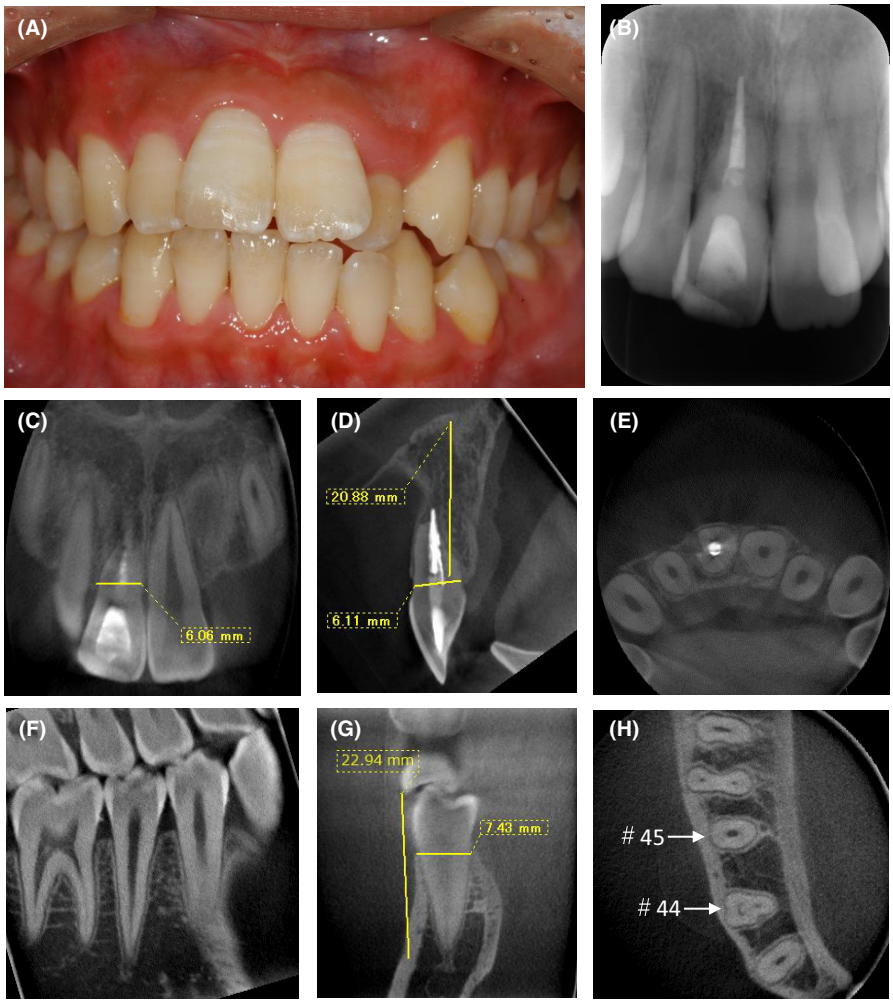



**FIGURE 2** A transplantation of a premolar to an anterior region following traumatic dental injury. (A, B) A frontal view and a radiograph of a 16 years and 11 months old male before treatment who suffered avulsion of the right maxillary central incisor 2 years and 3 months prior. He is to have orthodontic treatment for maxillary protrusion, open bite and ectopic eruption of the left lateral maxillary incisor, but the right maxillary central incisor is ankylosed. The diagnosis and treatment plan have suggested to extract four premolars for the orthodontic treatment and the ankylosed tooth is to be replaced with one of the extracted teeth. (C–E) CBCT images of the recipient site. Root resorption of the right maxillary central incisor seems to be progressing. The alveolar ridge as the recipient site seems to be wide and high enough to accommodate a donor tooth (the right mandibular second premolar). (F–H) CBCT images of the donor tooth. From the orthodontic strategic point of view, the first premolars were to be extracted. However, considering the size and form of the root as a donor tooth, the second mandibular premolars were better candidates. The upper premolars are too wide buccolingually and the lower first molars have complicated root form as seen in the axial image (H). Hence, the right second mandibular premolar was chosen as the donor (F, G). (I, J) Two months after the initiation of orthodontic treatment and just before the autotransplantation. The upper first premolars were extracted and the left lateral maxillary incisor has been aligned to normal position. (K, L) Extraction of the tooth of the recipient site. The root has been absorbed more on the apical, lingual, and distal aspects. (M, N) #45 was extracted as the donor tooth. (O, P) Immediately following transplantation. (Q) A radiograph 7 weeks after transplantation and following placement of calcium hydroxide up to the apex. The transplant is mature and no pulp healing is expected. The pulp canal treatment was initiated 2 weeks after transplantation and calcium hydroxide preparation was placed temporarily in this case because the apex was slightly open. The final obturation with sealer and gutta-percha was performed after 6 months. (R) A clinical view 10 weeks after transplantation and before restoration of the crown with composite resin. (S) After temporary restoration of the crown. The orthodontic tooth movement of the transplant started 3 months after the surgery. (T) A CBCT sagittal image of the transplant 7 months after transplantation. PDL healing and bone healing around the transplant are observed. (U, V) A radiograph and a CBCT sagittal image 3 years and 6 months after transplantation following the completion of the orthodontic treatment. The apex seems to have been absorbed slightly due to the orthodontic tooth movement, but no ankylosis is observed. (W) A clinical view 1 year after orthodontics. The crown of the transplant has been re-restored with composite and a fiber post. (X–Z) Eight years and 4 months following autotransplantation. PDL and bone healing is maintained.

the operation time, and to reduce the burden on both the operator and the patient. Cross suture or crisscross suture is performed using the mesial suture and the remaining distal suture (Figure 1Y). Then, the flaps on the donor site are sutured (Figure 1Z).

10. Surgical dressings and medications

Postoperative healing will depend on preventing infection around the transplant for the first several days. Therefore,

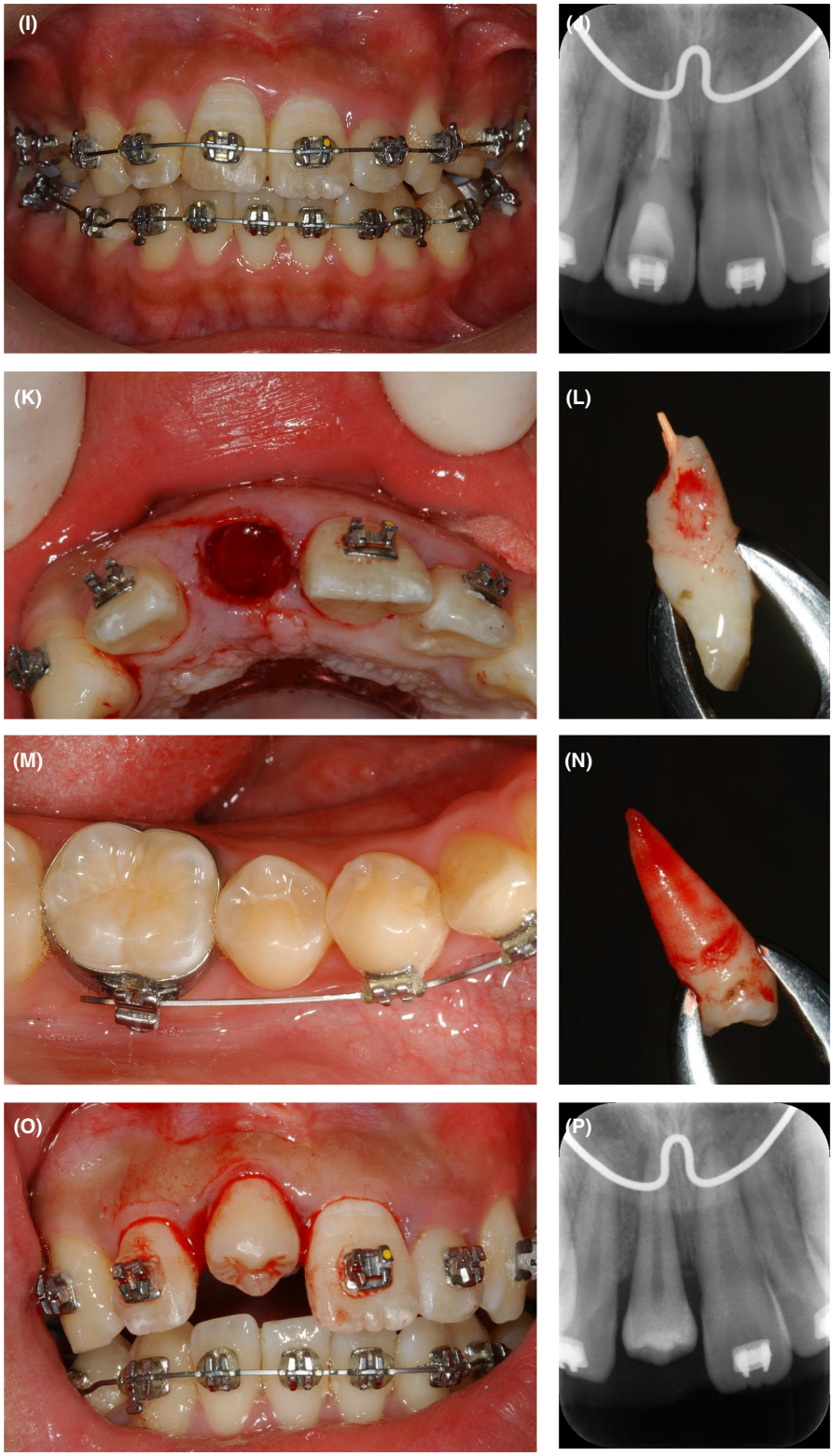



FIGURE 2 (Continued)

covering the wound with dressing or keeping the area as clean as possible are considered important during the initial healing phase (Figure 1AA, BB). Appropriate antibiotics are administered for 3 days to prevent infection in conjunction with chlorhexidine rinses.

11. Dressing and suture removal, and wire fixation

The surgical dressing and sutures are usually removed 7 days after surgery. If the mobility of the transplant is high, another fixation with wire and adhesive resin is applied on this day (Figure 1CC). This

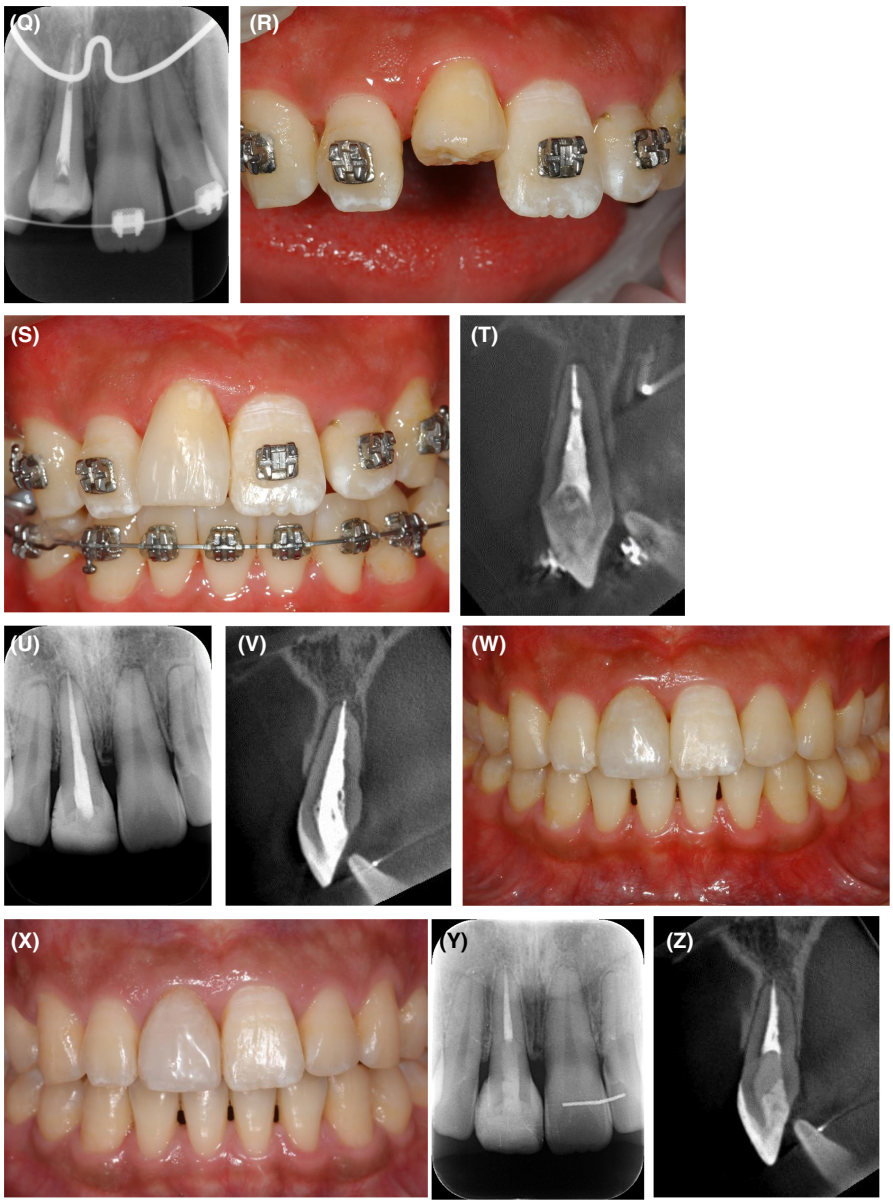



FIGURE 2 (Continued)

type of fixation is usually removed after about 1 month (Figure 1T). However, if the bony defect in the recipient site is large and the mobility of the transplant is still high, the fixation may be extended for several more months.

12. Follow up

In transplantation of immature teeth, pulp healing and root development can be expected. However, in order not to overlook inflammatory resorption, radiographs should be taken every month for the first 3 months after the surgery (Figure 1DD–FF), and careful observation should be made for any problems. If no problem is observed for the 3 months, the next recall is after 6 months (Figure 1GG, HH) and 1 year (Figure 1II, JJ). The transplant usually shows positive response to EPT in 6–12 months postoperatively. Pulp canal obliteration and root development becomes obvious after 1 year (Figure 1II, JJ). Thereafter, the transplant is followed up every year (Figure 1KK, LL).

## 4.1 | Root canal treatment

In transplantation of mature teeth, it is necessary to perform root canal treatment (RCT) of the transplanted tooth. In addition, root canal treatment is necessary even for immature teeth if pulp healing does not occur after transplantation.

When donor teeth are mature, RCT may be completed before transplantation or performed after transplantation. For impacted teeth, RCT must be performed after transplantation and can be started 2 weeks after transplantation and is limited to removal of the coronal pulp (due to the high degree of tooth mobility, a rubber dam cannot be performed). Four weeks after the transplantation, RCT is

finalized to the apex. If the apical foramen is open, calcium hydroxide is applied for several months (about 6 months) until the apical foramen is closed with hard tissue. Then, the final root canal filling with sealer and gutta-percha or MTA is performed.

In transplantation of immature teeth, it is necessary to follow up several healing processes simultaneously, such as periodontal ligament healing, pulp healing, and root development. Although the biological principles for achieving healing have been widely studied, it is difficult to achieve 100% healing in actual clinical practice settings. Nonetheless, if correct indications are chosen and correct techniques are performed, the success rate of the transplant can be extremely high, which will bring many benefits to patients. An additional case of anterior autotransplantation following traumatic dental injury is presented in Figure 2.

## 5 | CONCLUSIONS

Autotransplantation is a very predictable treatment modality that can serve as a viable option to replace a missing tooth, especially in young patients. Proper planning and careful execution of the procedure are important to achieve optimal long-term results.

### AUTHOR CONTRIBUTIONS

All authors contrituted to the the preprataion of the paper and approved the final version of the manuscript

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None.

### CONFLICT OF INTEREST STATEMENT

None.

### DATA AVAILABILITY STATEMENT

Data is avaialbe as presented in the paper. there is not other data to provide.

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