Canine autotransplantation: Effect of extraction site preservation with a titanium prosthesis and a bioresorbable membrane

Nan Ru and Yuxing Bai
Beijing, China

The permanent canine is the most frequently displaced or impacted tooth. The standard treatment for an impacted canine includes surgical exposure and orthodontic alignment. Autotransplantation is a treatment alternative for canines with complete root formation. The purpose of this article is to report a canine autotransplantation where the extraction site was preserved with a titanium prosthesis and a bioresorbable membrane. The autotransplanted canine had minimal root resorption and no ankylosis. (Am J Orthod Dentofacial Orthop 2013;143:724-34)

Permanent canines are important both functionally and esthetically. However, they are also the most frequently displaced and impacted teeth in the dentition.1 The standard method to manage an impacted canine includes surgical exposure and orthodontic alignment, but such treatment is often impractical.

Autotransplantation of teeth with completed root formation is an alternative to orthodontic treatment, and this process refers to the autogenous repositioning of a tooth in a surgically formed socket to replace a tooth that might be congenitally missing or have severe caries.

Autogenous transplantation of impacted canines was tried by Widman in 1915.1 Root resorption is often found after autotransplantation surgery. The prevalence of external root resorption is high, and it is the most common cause of the eventual failure of the autotransplanted teeth.2 Periodontal healing is responsible for root resorption after autotransplantation. Periodontal cells located at the surface of the transplanted roots are known to facilitate ankylosis and root resorption. Preparing a suitable recipient site and protecting the periodontal cells from damage should increase the success rate of autotransplantation.

In this case report, we describe extraction site preservation by fixation with a titanium prosthesis and a bioresorbable membrane, and their effects on the autotransplanted canine during and after orthodontic treatment.

DIAGNOSIS AND ETIOLOGY

The patient was a 14-year-old adolescent boy who was referred by his dentist for an orthodontic consultation with the chief complaint of a missing canine. He was healthy with no remarkable medical history and had no contraindication for dental treatment. No signs or symptoms of temporomandibular disorders according to the guidelines of the American Academy of Orofacial Pain were reported.

The pretreatment records showed that the patient had normal vertical facial proportions, a straight profile, and good facial symmetry. The pretreatment intraoral photographs showed that the maxillary left deciduous canine was retained and decayed (Fig 1). Analysis of the dental casts disclosed a Class II molar relationship tendency on both sides and several mildly rotated teeth. The maxillary overjet was 3.5 mm, and the patient had a normal overbite and no crossbites. The maxillary and mandibular midlines were coincident (Fig 2).

The panoramic radiograph showed that the maxillary left canine was impacted at the apex of the maxillary left lateral incisor, and this incisor had obvious root resorption because of the impacted canine. No radiographic signs of the third molars were visible at the beginning of the treatment (Fig 3).
The cephalometric evaluation confirmed a Class I skeletal relationship with an average growth pattern. The maxillary dentition was placed normally on its base, but the mandibular dentition was retracted. The vertical relationships appeared to be within normal limits (Table).

**TREATMENT OBJECTIVES**

Autotransplantation of a tooth can obviously shorten the treatment time when a suitable donor tooth is available and the anatomic circumstances permit this procedure. The treatment objectives included extracting the retained deciduous canine, transplanting the impacted canine into the extraction site, and establishing a Class I molar relationship on both sides along with normal overjet and overbite.

**TREATMENT ALTERNATIVES**

One treatment alternative for this patient was to extract the deciduous canine and move the permanent canine into position orthodontically. This option would take 2 to 3 years and could jeopardize the root of the maxillary left lateral incisor.

The second option was to extract both the deciduous canine and the impacted permanent canine, adjust the canine space orthodontically, keep the space until adulthood, and place an implant in the canine space. However, from the esthetic point of view, the patient would not tolerate the missing canine throughout adolescence. Furthermore, after removal of the tooth, the alveolar processes would begin to atrophy, affecting the maintenance of the alveolar bone and the attached gingiva.

The other option was extraction of the left lateral incisor and the deciduous canine with canine

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Fig 1. Pretreatment photographs.
transposition into the lateral incisor site orthodontically. After orthodontic treatment, a veneer could be placed on the canine to match the morphology of the contralateral incisor, and a future implant would be placed in the left canine position. However, the success of this treatment option depends on the success of the extrusion of the impacted canine, the future cost of an implant, and the appearance of the incisor’s gingiva.

**TREATMENT PROGRESS**

After discussion with the oral surgeon, who performed the autotransplant surgery, we decided to treat with full fixed appliances, incorporating extraction of the deciduous canine and autotransplantation of the impacted canine into the extraction site.
Before the orthodontic treatment, we could not accurately identify the position of the impacted tooth on the pretreatment panoramic radiograph. A medical computerized tomography scan was planned to assess the position of the canine relative to the root of the lateral incisor.

The composite image showed complete transposition, with the crown of the canine mesial to the root of the lateral incisor and palatal to the root of the left incisor (Fig 4). Degeneration of alveolar bone would most likely occur after extraction; thus, to maintain the height of the alveolar ridge, a pure titanium canine prothesis was planned for the extraction site. With the computerized tomography images, 2 acrylic teeth were made, and the sizes were the same as the impacted tooth. One was for the autotransplantation surgery to prepare the recipient site, and the other was invested, cast, and soldered with special equipment in an oxygen-free environment to produce a pure titanium canine prothesis.

Fixed appliances (Mini Uni-Twin, 0.022-in slot; 3M Unitek, Monrovia, Calif) were placed on the maxillary and mandibular teeth in February 2009. A nickel-titanium open-coil spring was used to gain more space for the donor tooth (0.019 × 0.025 in); B, the deciduous canine was extracted, and the extraction site was kept for the titanium tooth; C, the impacted canine was extracted and transplanted into the extraction site; D, the impacted canine was brought into the arch with light 0.012-in nickel-titanium wire.

Fig 4. Computerized tomography scan showed a complete transposition, with the crown of the canine mesial to the root of the lateral incisor and palatal to the root of the left incisor, and the maxillary left incisor had obvious root resorption.

Fig 5. A, Nickel-titanium open-coil spring was used to gain more space for the donor tooth (0.019 × 0.025 in); B, the deciduous canine was extracted, and the extraction site was kept for the titanium tooth; C, the impacted canine was extracted and transplanted into the extraction site; D, the impacted canine was brought into the arch with light 0.012-in nickel-titanium wire.
At this time, the molar and canine relationships were Class I on the right side, with a Class II tendency on the left side because the impacted canine was smaller than the right canine.

The deciduous canine was extracted, and the extraction site was maintained to implant the titanium canine prosthesis (Fig 5, B). After a month of recovery, the titanium prosthesis was removed, and the extraction site was the same as the titanium prosthesis, with no inflammation. The impacted canine was extracted and transplanted into the extraction site. Because there was not enough bone on the buccal alveolar process, we placed a xenograft of deproteinized bovine bone mineral (Bio-Oss; Geistlich, Wolhusen, Switzerland) between the root and the gingival flap. We also placed a bioresorbable membrane between the bone substitute and the gingival flap (Fig 6). We removed the donor tooth's occlusal contact for early stability in the first 2 weeks and used a 0.012-in nickel-titanium segment wire to level and align the autotransplanted tooth into its normal position (Fig 5, C and D). One month after the transplantation surgery, root canal treatment was performed (Fig 7, B). During the final stages, Class II elastics and anterior box elastics were used to idealize the occlusion.

After 18 months of treatment, the appliances were removed, and a Hawley retainer was delivered with instructions to wear it for 24 hours each day for the first year and at night in the second year. We also asked the patient not to chew hard food with the maxillary left lateral incisor because of its short root.
TREATMENT RESULTS

After 18 months of treatment, the autotransplanted canine was in a good position in the arch. Clinically, there was no evidence of attachment loss of the tooth. The gingival margin of the canine was not ideal but could be idealized with a gingivectomy. Ideal overjet and overbite were achieved with adequate canine disclusion and protrusive guidance. Ideal Class I molar and canine relationships were achieved as well (Figs 8 and 9).

On the panoramic radiograph, no signs of ankylosis, mobility, increased pocket depth, or inflammation in the recipient site were detected. There was a little apical root resorption and a small notching of the root on the distal aspect near the alveolar crest of the canine. The root resorption of the maxillary left central incisor had stabilized (Fig 10).

The pretreatment and posttreatment cephalometric analyses were outlined. The mandibular incisors were ideal in their posttreatment relationships to the nasion-supramentale line. The protrusion of the maxillary incisors and the lip to E-plane distance were maintained (Fig 11). The posttreatment facial esthetics were excellent, and the patient was satisfied with the results of the treatment.

The treatment results were maintained after 2 years of retention, and the occlusion had improved (Fig 12). The periapical radiograph of the transplanted canine taken 2 years posttreatment showed no obvious root resorption, and the notching of the root on the distal aspect near the alveolar crest of the canine had repaired (Fig 13). The panoramic radiograph after 2 years of retention showed that all other teeth were in good condition, without root resorption (Fig 14).
Superimposition of the posttreatment and the 2-years posttreatment tracings showed that facial growth had continued during the 2 years (Fig 15).

DISCUSSION

This patient had an impacted canine and severe incisor root resorption. Both the crown and the root of the canine were mesial to the crown and the root of the lateral incisor. The case was further complicated because the canine was unerupted, and the conventional radiographs offered conflicting evidence of its relative position to the lateral incisor. The panoramic and periapical films could not provide accurate assessments of the relative position of the impacted tooth or of the root resorption of the lateral incisor because of the 2-dimensional images. However, the ultimate success of the treatment plan hinged on accurate assessment of the relative position of the impacted tooth. There have been reports of successful use of computerized tomography in the localization of impacted canines.3,4 Computerized tomography can provide buccolingual, axial, coronal, sagittal, and panoramic views to identify root resorption of a lateral incisor. Furthermore, with the software, the computerized tomography images can be accurately converted into 3-dimensional images, which are helpful for the extraction procedure and the creation of a tooth prototype.

Fig 9. Posttreatment dental casts.

Fig 10. Posttreatment lateral cephalogram and panoramic radiograph.
Autotransplantation of teeth has evolved as an accepted treatment option in orthodontics over the last 3 or 4 decades. Andreasen et al reported survival rates of 95% and 98% for teeth transplanted with incomplete and complete roots, respectively. Pogrel reported a success rate of 72%. The most relevant complications in autotransplantation of teeth that affect the success rate are inflammatory or replacement resorption. Inflammatory resorption could lead to tooth loss without proper endodontic treatment. Tooth ankylosis can be visible on radiographic examinations as the disappearance of the periodontal ligament space, with or without resorption of the root, and, clinically, as a high metallic sound with the percussion test. This complication, although considered untreatable, can be symptomless, and the tooth can function normally for 10 to 15 years.

The prognosis of autotransplantation has been greatly improved with the prevention of infection in medical science, but some unfavorable results such as root resorption and ankylosis still remain. It was reported that the successful prognosis of transplanted teeth depends on the following factors: the condition of the remaining periodontal ligament attached to the extracted donor tooth, the adaptation of the donor tooth to the socket, the duration and the method of splinting after transplantation, and the timing of endodontic treatment of the transplanted teeth.

Based on those findings, an attempt to reduce the damage to the periodontal ligament was an acceptable solution for us. We created a prototype acrylic tooth made of pure titanium and transplanted it into the extraction site for healing. Titanium is a biologically compatible metal and widely used in medicine and dentistry. After it was placed in the socket for 1 month, the socket healed quite well around the prosthesis without inflammation, and the alveolar process of the extraction site remained at a constant height. This method avoided removing much bone during preparation of the extraction site and allowed for stable insertion of the transplanted tooth in the extraction site.

We also used some methods to prevent root resorption or ankylosis. During the autotransplantation procedure, the buccal alveolar process needed grafting. To fix the donor tooth and sustain the height of the alveolar process, we placed the bone substitute between the root and the gingival flap, and then applied a bioresorbable membrane between the bone substitute.

Fig 11. Pretreatment and posttreatment superimposed cephalometric tracings: A, superimposed on the sella-nasion plane at sella; B, superimposed on the posterior portion of the hard palate; C, superimposed on the mandibular plane at menton.
and the gingival flap. This treatment is derived from the concept of guided tissue regeneration. While improving the osseous conditions of the recipient site, the use of a membrane permitted recolonization of the periodontal cells into the extraction site and optimized the periodontal healing.28

Some reports have focused on the prevention of ankylosis. Mine et al29 reported that an occlusal stimulus after transplantation might promote regeneration of the periodontal ligament. Some clinical studies have suggested that the preapplication of mechanical stimuli to the donor teeth might stimulate the periodontal ligament, prevent ankylosis, reduce the damage to the periodontal ligament, and prevent root resorption after replantation.30,31 Nevertheless, the jiggling forces used in those experiments were also reported to cause greater destruction of the periodontium, including root resorption.32,33 During the first 2 weeks after the autotransplantation procedure, we removed the donor tooth’s occlusal contact to prevent any jiggling forces on it. Then we applied a light force to the donor tooth to stimulate the periodontal ligament to reduce root resorption or ankylosis. It was apparently helpful in our patient to prevent ankylosis.

The final result demonstrated mild apical root resorption of the maxillary left canine and severe root resorption on the maxillary left lateral incisor. Compared with the incisor root before treatment, the root length did not change much. Several authors have looked at the long-term consequences of apical root resorption. Falahat et al34 demonstrated favorable long-term prognoses in a long-term follow-up of resorbed maxillary incisors, and no incisors lost vitality or exhibited ankylosis. Remington et al35 suggested that orthodontically induced root resorption does not progress once the appliances are

![Fig 12. Two years posttreatment.](image-url)
Fig 13. Periapical radiograph of the canine taken 2 years posttreatment showed no obvious root resorption.

Fig 14. Lateral cephalogram and panoramic radiograph at 2 years posttreatment.

Fig 15. Posttreatment and 2-years posttreatment superimposed cephalometric tracings: A, superimposed on sella-nasion plane at sella; B, superimposed on the posterior portion of the hard palate; C, superimposed on the mandibular plane at menton.
removed. The patient and his family were satisfied with the results.

CONCLUSIONS

Autotransplantation with orthodontic treatment could be considered as a treatment alternative for an impacted tooth. Computerized tomography imaging is necessary to develop a successful treatment plan. Extraction site preservation and fixation with titanium prosthetic and a bioresorbable membrane on the autotransplanted canine during orthodontic treatment were helpful to prevent root resorption and ankylosis.

REFERENCES