Autotransplantation of impacted maxillary canines into surgically modified sockets and orthodontic treatment: a 4-year follow-up case report

Juan Zufía, DDS, MSc
Private Practice, Madrid, Spain

Francesc Abella, DDS, PhD
Department of Endodontics and Restorative Dentistry, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Barcelona, Spain

Ramon Gómez-Meda, DDS, MSc
Private Practice, Ponferrada, Spain

Helena Blanco, DDS, MSc
Private Practice, Madrid, Spain

Miguel Roig, DDS, PhD
Department of Aesthetic and Restorative Dentistry, Universitat Internacional de Catalunya, Sant Cugat del Vallès, Barcelona, Spain

Correspondence to: Dr Francesc Abella
Universitat Internacional de Catalunya, Dentistry Faculty, C/ Josep Trueta s/n, 08195 Sant Cugat del Vallès, Spain; Tel: +34 504 2000, Fax: +34 504 2031; Email: e-mail: franabella@uic.es
Abstract

The permanent maxillary canine is the second most frequently impacted or displaced tooth. The standard treatment for an impacted canine includes, among other things, surgical exposure and orthodontic alignment. Surgical techniques for this procedure vary depending on whether the tooth is labially or palatally impacted, while orthodontic techniques vary according to clinical judgment and experience. Autotransplantation is a treatment alternative for impacted canines with complete root formation. The success of tooth transplantation depends on the vitality of the periodontal ligament (PDL) attached to the donor tooth, and its viability decreases when it is exposed extraorally. This article reports on maxillary canine autotransplantations combined with connective tissue grafts (CTGs) and orthodontics. The recipient mesiodistal space was created orthodontically and the recipient socket was prepared using dental implant drills. Following transplantation, bone defects were grafted using guided bone regeneration (GBR). At 4 years post-transplantation, the soft tissue level was stable and periapical radiographs showed a practically normal contour of the alveolar crest around teeth 13 and 23. The two permanent canines presented no root resorption and ankylosis, and no signs of inflammation or bleeding were observed. The procedure used in this case report demonstrates that canine transplantation combined with GBR, plastic surgery procedures, and orthodontic treatment may yield acceptable and predictable esthetic results.

Introduction

According to clinical and radiographic assessment, impacted teeth are described as those that either erupt late or are not predicted to erupt completely. The incidence of tooth impaction has been reported to vary from 5.6% to 18.8% of the population. After the third molar, the second most frequently impacted tooth is the permanent maxillary canine, the impaction of which has a prevalence of some 2% in the general population. Of these, 85% are palatally impacted, and 15% are labially impacted. The maxillary canine performs a vital role in facial appearance, dental esthetics, lip support, arch development, functional occlusion, and phonetics. In contrast, the incidence of impacted mandibular canines does not exceed 0.5%.

The main treatment options available for impacted canines include the wait-and-see approach, interception, surgical exposure (with or without orthodontic alignment), autotransplantation, and extraction. The two most common methods used to bring palatally impacted canines into occlusion consist of: 1) surgically exposing the teeth and allowing them to erupt naturally during early or late mixed dentition; and 2) surgically exposing the teeth and bonding an attachment to move the tooth using orthodontic forces.

Orthodontic appliance treatment is sometimes hazardous or impractical, especially when impacted maxillary canines are in oblique/horizontal positions. Moreover, orthodontic treatment is not always accepted by patients due to the 2- to 3-year treatment time, and factors such as the position of the canines as well as aesthetic and economic considerations. In such cases, if there is sufficient space for the transplanted tooth, autotransplantation might provide a treatment alternative. This process entails atraumatic surgical removal of a tooth from its impacted or ectopic site and the creation or modification of a socket at the recipient site. This is followed by reimplantation of the tooth in the ideal three-dimensional (3D) position within the alveolus.

The prognosis of autotransplanted teeth is determined by several conditions including patient age and gender, developmental stage and root anatomy of the donor tooth, adequate alveolar bone support, atraumatic surgical technique, adaptation of the donor tooth to the recipient site, method of fixation/stabilization, and postoperative care. It goes without saying that the clinician’s experience is equally essential. However, the most critical factor for long-term success is to maintain healthy and viable periodontal ligament (PDL) cells on the root surface. Implants and removable or fixed partial dentures can also offer good alternatives, but unlike natural teeth that have a normal PDL and a natural esthetic, the use of artificial material is a drawback. Autotransplants not only maintain alveolar bone, they also trump implants in that they allow proprioception during function, and can be performed in growing patients.

The present case report presents a 40-year-old female. Teeth 53 and 63 have mobility type II and impacted maxillary canines. The treatment plan called for a series of periodontal surgeries combined with orthodontics and autotransplantation of teeth 13 and 23. The treatment lasted 1 year and 8 months, with the last clinical and radiographic control carried out 4 years post-treatment. The procedure described in this article aimed to demonstrate that autotransplantation is also a reliable alternative in cases of impacted canines.

Case presentation

A 40-year-old female presented at the clinic complaining of increased mobility in the maxillary primary canines and of the un-
sightly aspect of her anterior teeth. At the first appointment, the patient’s medical and dental records showed no history of systemic disease or drug allergies, and that she was taking no medication. Clinical and radiological testing to exclude pathological processes revealed no contraindications for dental treatment.

The pretreatment records showed normal vertical facial proportions, a straight profile, and good facial symmetry. The initial intraoral photograph confirmed that the maxillary left and right primary canines were retained and restored with composite resin (Fig 1). Teeth 12 and 22 presented Miller Class III gingival recessions, although another clinician had previously attempted to correct them by performing two free epithelial grafts. As seen in Figure 1, the result was unsuccessful and unsightly. Analysis of the dental casts disclosed a Class III molar relationship tendency on both sides. The maxillary overjet was 2.0 mm and the overbite 4.0 mm, and the patient had no crossbites. In addition, the upper midline shifted to the left by 1 mm.

The panoramic radiograph showed that both maxillary canines were impacted without producing any apparent root resorption in the adjacent teeth (Fig 2a). It was decided to perform cone beam computed tomography (CBCT) to find out the exact position of the permanent canines and to ascertain whether autotransplantation of these teeth was viable for replacing the primary canines. After evaluating the different CBCT slices (sagittal, coronal, and axial views), both canines were observed to be palatally placed, making an autotransplantation technique perfectly possible (Fig 2b to d). Due to the patient’s age, and because orthodontic treatment is prolonged, the surgical exposure technique followed by orthodontic traction was ruled out. The patient was fully informed that in the event of autotransplantation failure, the definitive treatment would consist of either an implant or a fixed dental prosthesis.

Fig 1  Preoperative view showing the presence of axillary primary canines and Miller Class III gingival recessions in teeth 12 and 22.

Fig 2  Pretreatment radiographic study. (a) Panoramic radiograph. (b) Coronal view of the cone beam computed tomography (CBCT) image. (c and d) Axial and sagittal views revealing the palatal position of both maxillary permanent canines.
**Fig 3** Root coverage surgery on teeth 12 and 22. (a) Connective tissue graft on tooth 12 by means of a coronally advanced tunnel flap (CATF) technique. (b) Same surgical procedure performed on tooth 22. (c) Final situation immediately after the two connective tissue grafts. (d) Clinical appearance at 3 weeks post periodontal surgery.

**Fig 4** (a) Multibracket orthodontic treatment started at 3 months postsurgery. (b) Careful extraction of the maxillary right primary canine. (c) The recipient site postextraction. (d) Surgical exposure of the maxillary right permanent canine.
**Treatment objectives**

The objectives were to obtain root coverage of teeth 12 and 22 and replace the primary canines with the permanent ones by means of autotransplant surgery. At the same time, the esthetics of the anterior teeth would be improved and the soft tissue profile maintained.

**Treatment progress**

The first phase consisted of performing root coverage surgery on teeth 12 and 22 through two connective tissue grafts (CTGs) by means of a coronally advanced tunnel flap (CA1T) technique (Fig 5). After 3 months of healing, multibracket orthodontic treatment was started (Dolphin Aesthetic SLB MBT 022; Ortolan) to align and level all the teeth and to open up the space in the primary canine area (previously measured in the CBCT) where the permanent canines would be seated in an ideal 3D position (Fig 4a). The DICOM (Digital Imaging and Communications in Medicine) files obtained from the CBCT were used to measure the length, height, and width of the permanent canines. The distance between the transplanted canines and the neighboring teeth was digitally calculated at about 2 mm to provide sufficient space for the biologic width and to achieve an optimum esthetic outcome. The first phase of the orthodontic treatment lasted 12 months.

After completing the first phase of the treatment, autotransplantation surgery was performed. First, the primary canines were extracted carefully so as not to damage the buccal cortical plate at any time (Fig 4b and c). Bone covering the impacted teeth was gradually demarcated using a piezoelectric handpiece under abundant water-cooling irrigation until a thin layer of bone was left close to the cementum and enamel. Final elevation of the bone as a block was performed gently with an excavator with the aim of avoiding damage to the healthy PDL remnants on the root (Fig 4d). When sufficient bone was removed, the impacted canines were delicately elevated from their sockets. Once the extractions had been completed, the previously calculated digital measurements (root length, total tooth length, and diameter) were checked quickly with a periodontal probe, and the teeth were placed in saline solution until they were transplanted. The curvature of the root of the permanent canines meant that both roots had to be shortened to better accommodate them in the recipient sites.

At this point, the work was divided into two parts: one clinician prepared the new sockets so that the teeth could be placed in their correct anatomical position (Fig 5), while another performed the endodontic treatments and sealed the root-end cavities with an apical plug using white root repair material (ProRoot MTA; Dentsply Sirona) (Fig 6). Endodontic treatments and apical retrofillings were performed to avoid contamination of the bone substitute used to regenerate the cavities resulting from the extraction of the canines. These cavities were sufficiently large to facilitate the atraumatic extraction of the impacted canines.

The recipient sites were modified by a surgical implantology set (Camlog Biotechnologies). The entire milling sequence was used up to the 6-mm-diameter drill, which was moved from palatine to buccal with an oscillating movement to form an ovoid recipient capable of harboring the root of both permanent canines. Care was taken to preserve the entire buccal cortical plate. The height of the palatal cortical plate was preserved only in the area 2 mm coronal to the right maxillary canine, and disappeared completely during the site preparation to house tooth 23. Given the amount of bone removed in the palatal alveolar process, an allograft human bone (Barcelona Tissue...
**Fig 5** Preparation of the alveolar bed to receive the donor tooth. (a) Initial dimensions of the recipient socket. (b) Modification of the recipient socket using dental implant drills. (c) The recipient site after the surgical preparation.

**Fig 6** Apical preparation of the permanent canine. (a) Comparison of dimensions between the permanent maxillary canine and the primary canine. (b) Enlargement and resection of the apical 3 mm. (c) Endodontic treatment completed extraorally. (d) Apical plug with white P-oRoot MTA. (e) Donor tooth coated with enamel matrix proteins before placement in the recipient socket.
Bank) between the root and the palatine mucosa was placed. Then, a bioresorbable membrane (OsteoBiol Evolution membrane; Tecnoss) was inserted between the bone substitute and the flap (Figs 7 and 8).

Before placing the permanent canines on the modified recipient sites, they were coated with enamel matrix proteins (Emdogain; Straumann), which facilitate the regeneration of possible injured periodontal tissue. At the same time, two new CTGs were placed to stabilize the gingival margin before the final suture. The upper archwire system was maintained in order to passively hold the permanent canines, which were anchored to the arch by two brackets. The canines were also splinted in the palatal surface with a segment wire (0.012 nickel-titanium) and composite resin for 30 days (Fig 9a). In both canines, the time between removal and placement of the impacted tooth in the new socket did not exceed 25 min. In addition, to avoid canine-guided occlusion during healing, occlusal lifts were temporary placed on the maxillary incisors, second premolars, and first molars (Fig 9b and c).

After 1 month, new CTGs were performed in both canine areas to finish removing the epithelial remains from previous surgeries (Figs 10 and 11). Advantage was taken of these grafts to improve the biotypes, stabilize the margins, and treat the postsurgical residual recessions. The ortho-

Fig 7 Placement procedure of the right maxillary canine. (a) New connective tissue graft placed to stabilize the gingival margin. (b) Try-in of the donor tooth. (c and d) Allograft human bone inserted between the root and the palatine mucosa. (e) Bioresorbable membrane placed between the bone substitute and the flap. (f) Final position of the donor tooth and suture.
Fig 8  Placement procedure of the left maxillary canine. (a) Palatal flap elevated from left canine region. (b) Surgical exposure of the donor tooth. (c) Modification of the socket to allow the permanent canine to be replanted. (d) Try-in of the donor tooth. (e) Allograft at the donor site. (f) Adjustment of the membrane to the bone defect.

Fig 9  Final position of the autotransplanted teeth anchored to the arch by two brackets. (a) Buccal view. (b) Palatal view. (c) Aspect of healing at 30 days.
odontic appliances were completely removed 6 months after autotransplant surgery. After the healing of these third connective grafts, the case was terminated by performing an external bleaching as well as direct composite restorations on teeth 12 and 22 to correct the wear and to shape the anatomy of the teeth (Fig 12). The occlusion was stabilized using a lingual bonded retainer (from teeth 33 to 43) and an upper Essix retainer. The total treatment time was 1 year and 8 months.

Four years after the transplantation, the soft tissue level was stable, and periapical radiographs showed a practically normal contour of the alveolar crest around teeth 13 and 23 (Fig 13). No signs of inflammation or bleeding were observed.
Fig 11  Connective tissue graft performed in the left maxillary canine area. (a) Final size of the connective tissue graft. (b) Stabilization of the connective tissue graft. (c) Buccal aspect of the anterior teeth immediately after the connective tissue grafts.

Fig 12  External bleaching and direct composite restorations on teeth 12 and 22. (a and b) Occlusal adjustment in eccentric movements. (c) Palatal view of the transplanted canines (d and e) Radiographic views.
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Discussion

The management of impacted canines is important in terms of esthetics and function. Clinicians should plan treatments that are in the best interests of the patient; therefore, they need to be knowledgeable about the range of treatment options. Although transplantation is not usually first-line treatment for patients with impacted canines, this procedure presents a mean survival of 14.5 years for 83% of transplants, making it a viable option.

Clinicians should take into account two main factors when considering autotransplantation for impacted maxillary canines: 1) the anatomical complexity involved in accommodating the canine with orthodontic traction; and 2) the patient’s willingness to wear orthodontic appliances or undergo long-term treatment. Other factors to consider include the available space in the arch for autotransplantation, the prognosis of the primary canines, the possibility of performing an atraumatic extraction while maintaining the viability of the PDL, and the clinician’s experience.

The longevity and prognosis of tooth autotransplantation, particularly donor teeth with an open apex, are similar to those of dental implants. When a donor tooth has incompletely formed roots, pulp revascularization allows for pulp healing and continual root development. Thus, in most cases, no endodonic treatment is required, allowing for short treatment times, few pulpoperiapical problems, and almost no root fractures. These advantages partly account for the high success rates of autotransplants of immature teeth, a procedure particularly indicated in growing patients.

Recent studies have also reported high success rates in donor teeth with a closed apex. In their meta-analysis of autotransplantation of maxillary canines, Grisar et al showed an 87.5% outcome rate at 2 to 5 years follow-up, and 88.2% at over 5 years follow-up. The pulp of a completely mature tooth cannot generally regenerate. Hence, if the tooth to be transplanted is accessible, endodontic treatment should be completed before transplantation; otherwise, the endodontic treatment should be initiated 2 weeks after transplantation to avoid an inflammatory resorption from the infected root canal. Endodontic treatment can also be performed during the same surgical procedure (but was not done in this case) when

Fig 13 Follow-up at 4-years posttreatment.
longer splinting periods are estimated. As initial primary stability is crucial to the success of autotransplantation, additional damage to the PDL was avoided by performing premature endodontic treatment. The treatment was not postponed, which would have jeopardized the success of the guided bone regeneration (GBR) in an infected root canal.

To increase the success rate of tooth autotransplantation and make it more predictable, it is necessary to be meticulous regarding the selection criteria, and to assess in detail the viability of the donor tooth. In this sense, low-dose CBCT is the more suitable technology for planning the surgical feasibility and the optimal 3D position of the donor tooth in the new socket. From the CBCT files, computer-aided designed 3D-printed replicas of the donor tooth can be obtained, although they were not used in this case. Tooth replica acts as a surgical guide; provides individualized bone adaptability; and reduces extra-alveolar time for the donor tooth, thus lowering the risk of ankylosis.

On the other hand, the treatment of gingival recessions through plastic surgery procedures is both functionally and esthetically essential, particularly in anterior teeth. The main objective of these procedures is to achieve complete root coverage, while improving esthetics, hypersensitivity, and prevention of caries and noncarious cervical lesions. In this case, a series of periodontal surgeries were performed, combined at different times with orthodontic treatment. Various systematic reviews, including Cairo et al. and Sanz and Simion, have confirmed that the gold standard for root coverage consists of a coronally advanced flap combined with a CTG. It has been shown that the use of a CTG allows for a more stable coronal advance and less soft tissue shrinkage. It also leads to increases in keratinized tissue.

Despite the successful result of this case, the autotransplantation technique may present complications, such as root resorption and attachment loss, which could even result in tooth loss, making the treatment outcome difficult to predict.

**Conclusions**

Autotransplantation combined with orthodontic treatment provides a viable treatment alternative for impacted canines. The most important factor for success is that a vital (and functional) PDL must be attached to the autotransplanted tooth. Necrosis or mechanical loss of the PDL leads to root resorption (ankylosis or inflammatory resorption) or epithelial downgrowth. Even in cases with extensive buccal or palatal/lingual alveolar bone atrophy, promising and optimally functional outcomes can be obtained with the use of GBR. In this case, modified surgical techniques allowed for a minimally traumatic removal of the donor teeth. Finally, it should be noted that CBCT imaging is mandatory to develop a successful treatment plan.

**Disclaimer**

The authors declare that there are no conflicts of interest.
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