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Case Report

Dentistry Section

3D Printing Assisted Autotransplantation of Impacted Maxillary Canine: A Case Report

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ABSTRACT

This case report highlights successful management of a horizontally impacted maxillary canine by surgical autotransplantation technique using three-dimensional (3D) printed replicas of the donor tooth. An 18-year-old male patient reported for orthodontic treatment with a chief complaint of irregularly placed teeth. On clinical and radiographic examination, he was diagnosed as having skeletal Class I jaw relation, Angle's Class I malocclusion with horizontally impacted 23 causing root resorption of 22, over-retained 63, scissors bite in relation to 15 and 45, reduced overjet and deep bite. Fixed orthodontic treatment was planned for leveling and alignment of teeth followed by autotransplantation of the impacted 23 as it was not favourable for orthodontic alignment. After alignment of all teeth, adequate space was created for accommodating permanent canine using open coil spring. A preoperative Cone-beam Computed Tomography (CBCT) scan was recorded for digital planning of surgical autotransplantation procedure. Based on CBCT data, a surgical template was designed that replicated the exact root dimensions of impacted maxillary canine. This template was subsequently 3D printed in resin and utilised intraoperatively to aid in socket preparation during surgical autotransplantation. Extraction and surgical repositioning was extremely challenging due to the close proximity of canine to the nasal floor, following which grafting was done and splint was placed. Following the initial stabilisation phase, orthodontic traction was applied to align the transplanted tooth in its ideal position. Accurate timing of interventional procedures like endodontic treatment and initiation of orthodontic traction helped in successful alignment of the transplanted canine. A 3D printing assisted autotransplantation procedure in this case successfully replaced the requirement of tooth removal followed by prosthetic restorations.

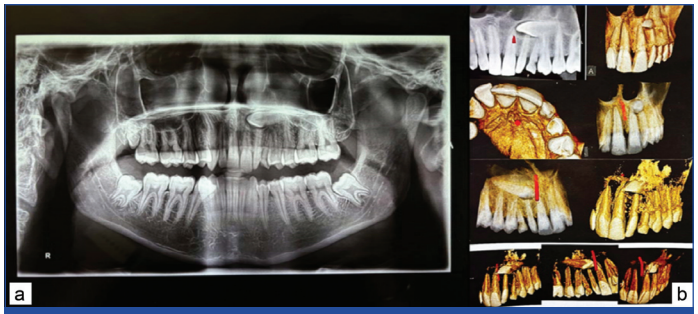
Keywords: Ectopic canine, Interdisciplinary orthodontics, Surgical guiding template, Three-dimensional imaging

CASE REPORT

An 18-year-old male patient reported for treatment with chief complaint of irregularly placed upper front teeth. There was no relevant past medical or dental history or presence of any parafunctional habits. Patient had symmetrical facial pattern with a straight profile, average nasolabial angle and competent lips [Table/Fig-1a]. Intraoral examination revealed Angle's Class I malocclusion with mild crowding, over-retained left deciduous canine, peg shaped 22, missing 23, retroclined maxillary incisors, deep bite, lingually displaced 45 leading to scissor bite in that region and upper midline shift towards left by 3 mm [Table/Fig-1b]. Radiographic investigation using Orthopantomogram (OPG) [Table/Fig-2a] and Cone Beam Computed Tomography (CBCT) revealed horizontally and palatally impacted upper left canine. The crown of the impacted tooth was placed away from incisive foramen and protruding into the labial cortex between apical portion of roots of 21 and 22. Root resorption with shortening of root was seen with 22. The root of canine was placed palatally adjacent to palatal roots of 24, 25 and in close proximity to the floor of nasal cavity. The length of the canine was 28.5 mm with its root having a closed apex and a visible periodontal ligament outline [Table/Fig-2b]. The over-retained deciduous canine presented with proximal caries extending close to the pulp; however, as extraction was planned in subsequent treatment, no restorative treatment was undertaken for the same.

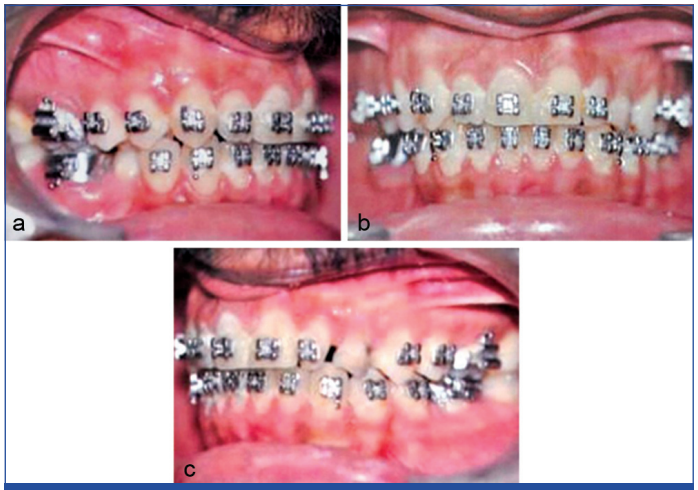
Treatment options included extraction of deciduous canine and impacted canine with prosthetic replacement or surgical exposure of impacted canine followed by orthodontic alignment or surgical repositioning of the impacted canine with autotransplantation. Orthodontic alignment did not seem to be favourable due to its completely horizontal position with canine crown being buccal and mesial to long-axis of lateral incisor. Sacrificing the permanent canine and replacing it with prosthesis option was not considered initially as despite the challenges, there were fair chances of saving the tooth by autotransplantation. After obtaining informed consent from the patient, autotransplantation was considered to be the most viable treatment option in this case.

[Table/Fig-1]: Pretreatment photographs: a) Extraoral photographs; b) Intraoral photographs.



[Table/Fig-2]: Pretreatment radiographs: a) Orthopantomogram (OPG); b) Cone Beam Computed Tomography (CBCT).

Orthodontic treatment objectives were explained to the patient and informed consent was obtained for autotransplantation. MBT 0.022 preadjusted appliance was bonded in maxillary and mandibular arch, except 63. Alignment and leveling of teeth was initiated with 0.012 Nickel-Titanium (NiTi) wires followed by 0.014 NiTi, 0.016 NiTi, 16×22 NiTi, 17×25 NiTi, 17×25 Stainless Steel (ss) and 19×25 ss wire. Anteriorly, composite bite blocks were bonded on 12, 11, 21 for intrusion of incisors and deep bite correction. After six months complete levelling and alignment of upper and lower arches was achieved. Open coil springs were placed to create space for alignment of 45 and autotransplantation of 23 [Table/Fig-3].

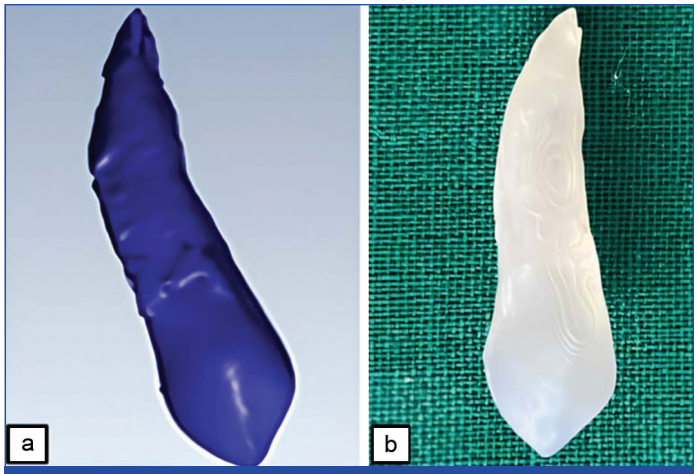


[Table/Fig-3]: Deep bite correction and space creation for alignment of 45 and autotransplantation of 23.

For successful autotransplantation, reducing extraoral time of donor tooth and preparing the recipient site morphology for the best adaptation are critical. Therefore, a 3D printed surgical template of the impacted canine was fabricated based on patient's CBCT data. Using the segmentation mode of Digital Imaging and Communications in Medicine (DICOM), the impacted canine, including its Periodontal Ligament Space (PDL) space, was selected. The ideal position, angulation, and rotation of the canine were predefined and exported as Standard Tessellation Language (STL) file to a 3D printer for fabrication. A 1:1 size replica of the tooth was obtained by Inkjet-based system with photopolymerisable methacrylate resin [Table/Fig-4]. Rapid prototype template thus obtained was sterilised in a steam autoclave for autotransplantation procedure.

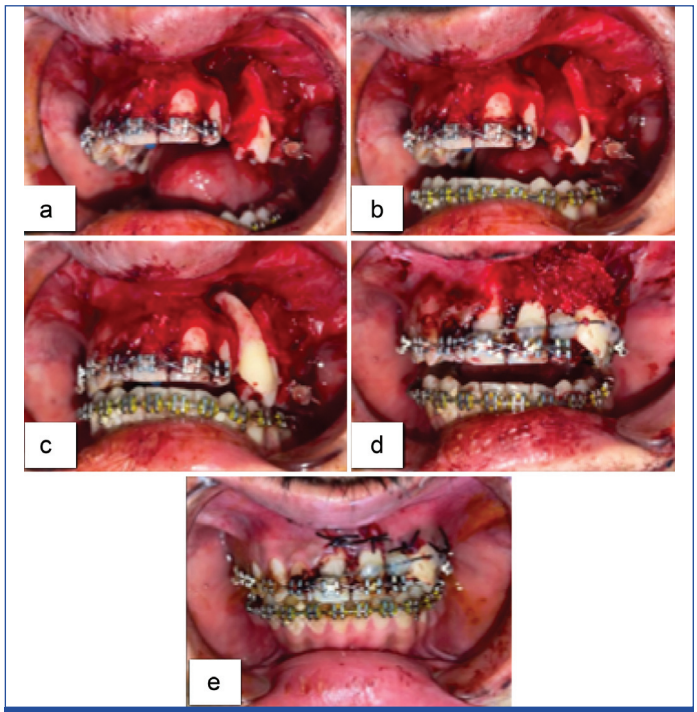
After local anaesthesia, incision was placed to raise a mucogingival flap for surgical exposure of the impacted canine. The deciduous tooth was extracted and the horizontally positioned canine was carefully luxated with great precaution to preserve the maximum possible periodontal ligament fibres on the root surface.

The extracted permanent canine was stored in normal saline during socket preparation for transplantation. Surgical round burs at low speed along with irrigation were used to modify the socket dimensions. The 3D printed template was then used as a surgical guide for socket preparation and trial implantation in order



[Table/Fig-4]: Fabrication of 3D printed surgical template of 23 using CBCT data: a) STL model; b) 3D Printed prototype of 23.

to shorten the extra-alveolar time of the donor tooth, reduce the number of positioning trials and hence avoid injury to the periodontal membrane. Transplanting the canine in an upright position posed significant risk of penetrating into the nasal cavity floor, to avoid which it was placed with a labial inclination. Since the labial cortical plate present in the canine region had to be sacrificed for atraumatic extraction and transplantation of the impacted canine, bovine xenograft (Straumann) was used to cover the buccal root surface of the canine as it gets converted into highly porous osteoconductive scaffold aiding in bone augmentation. The mucoperiosteal flap was then closed and secured with sutures. The transplanted canine was splinted to the adjacent teeth using 0.3 mm round stainless steel wire for three months [Table/Fig-5]. Endodontic treatment was performed on it one week after the autotransplantation procedure.



[Table/Fig-5]: Surgical procedure: a) Extraction of deciduous canine and impacted 23; b) Socket preparation with 3D printed template; c) Reimplantation of 23 in the prepared socket; d) Splinting and bone grafting at the surgical site; e) Suturing and flap closure of the surgical site.

After initial healing period and passive stabilisation, the splint was removed and bracket was bonded to the transplanted canine. Alignment was initiated using light and continuous force to avoid ankylosis. For correction of buccal displacement of 23, lingual force was applied close to its centre of resistance with an e-chain placed from 11 to 26 to achieve controlled tipping [Table/Fig-6]. For final leveling and alignment of 23, continuous 0.016 NiTi, 16×22 NiTi, 17×25 NiTi, 17×25 ss were placed for one month

each. 0.016 ss wire with triangular settling elastics for 23 were given for two months for final finishing and detailing stage.

[Table/Fig-6]: Initiation of alignment of 23 with light orthodontic forces.

Root canal therapy was done with 22 to inhibit further root resorption and composite buildup was done to correct its peg shaped appearance. Six months post autotransplantation, radiographic evaluation revealed no signs of root resorption [Table/Fig-7]. Deep bite correction and alignment of irregularly placed teeth was accomplished with Class I canine relation without any prosthetic intervention.

[Table/Fig-7]: Six months postoperative OPG of the patient.

After completion of orthodontic treatment, the appliance was removed and removable retainers were provided to the patient. Post-treatment extraoral and intraoral photographs revealed enhanced smile aesthetics [Table/Fig-8].

[Table/Fig-8]: Post-treatment photographs: a) Extraoral photographs; b) Intraoral photographs.

On three year follow-up, radiographic evaluation was done [Table/Fig-9]. Clinically, the tooth remained stable in its socket, with no apparent pathologic findings. Radiographically, the lamina dura appeared normal and new bone formation surrounding the periapical area of 23 was evident.

[Table/Fig-9]: Three-year follow-up OPG.

DISCUSSION

Maxillary canines are frequently found to be impacted (0.9-2.2%) next to third molars. Surgical exposure followed by orthodontic alignment is the most preferred line of treatment in such situations. When the position of impacted tooth is not favorable for orthodontic alignment, autotransplantation procedure can offer an interesting alternative to tooth removal and prosthetic solutions [1]. Autotransplantation pertains to the repositioning of an autogenous tooth to either an extraction site or a surgically prepared recipient site. Tooth autotransplantation procedure is advantageous compared to prosthetic management in a growing patient with impacted or missing teeth for various reasons such as it provides an aesthetically superior emergence profile and gingival contour when compared to its prosthetic alternatives, with less of a burden on oral hygiene [2,3].

Successful autotransplantation of a donor tooth primarily relies on its careful surgical management, most essentially, the conservation of an intact periodontal ligament. This is recommended to avert replacement resorption and facilitate orthodontic movement if required in future [2]. More than 90% of survival rates have been reported in literature for autotransplanted teeth with complete root development [4]. The most common cause of failure has been found to be ankylosis of the transplanted tooth and subsequent replacement root resorption [5]. However, even in instances when periodontal integration fails, the autotransplant may still provide an excellent biological space maintainer that conserves both the gingiva and high-quality alveolar bone.

A multidisciplinary team approach involving orthodontists, restorative dentists and oral and maxillofacial surgeons is of paramount importance in the successful planning and execution of autotransplantation procedure. One of the most significant advantages of 3D printing in tooth transplantation procedure is the placement of osteotomy drills that can be customised to the three-dimensional anatomy of the tooth root which is to be transplanted [6]. In the traditional autotransplantation technique, the donor tooth is directly used as a guide to prepare alveolar socket during the process of surgery, due to which the extra-alveolar time of donor tooth increases and inevitably results in mechanical damage to the periodontal membrane of the donor tooth, thus reducing its vitality. The key factor for the success of autotransplantation is the presence of viable periodontal ligament on the surface of donor tooth root [7].

In comparison with the conventional autotransplantation technique, the advent of computer-aided design along with 3D printing of the donor tooth and surgical guides has evidently reduced the preparation time of the alveolar socket, extra-alveolar time of the donor tooth and reduced number of positioning trials with the donor tooth irrespective of the shape deviation between the guiding template and actual teeth [8].

Evidence of successful orthodontic tooth movement of a surgically transplanted tooth from its new recipient site is extremely rare and

scarcely reported in literature. The present case report highlights such accomplishment along with exploring usage of 3D printed surgical template for successful management of an ectopically erupted canine. In recent years, with assistance of guiding replicas of donor tooth based on DICOM data derived from CBCT, it has become possible to minimise mechanical damage to the periodontal ligament of the donor tooth during try-in.

Use of printed three-dimensional (3D) replicas based on radiological examination in the autotransplantation protocol has significantly improved the success rates of autotransplantation procedure. In the conventional technique, the grafted tooth was first extracted and then tested several times at the new site until a good fit was achieved. This led to increased chances of root resorption, injury to PDL fibres and ankylosis of the transplanted tooth. In the present case, CBCT was used to analyse the morphology of the impacted canine and recipient site to assess the feasibility of the surgery intuitively and estimate the possibility of invasion of anatomical structures, such as the maxillary sinus cavity.

Despite the fact that, autotransplantation is now considered a viable solution for tooth replacement, there are several prognostic factors that determine the overall success and survival of these teeth. Stage of root completion, surgical technique, handling of the donor tooth, recipient site preparation and adjunctive procedures such as root surface treatment, ex-vivo Root Canal Treatment (RCT), type and duration of splinting are some of the factors that have been reported to affect the prognosis [9]. The common complications associated with transplantation procedure are root resorption, pulp necrosis, mobility and ankylosis which occurs due to damage to periodontal ligament cells [10].

Accurate timing of RCT and fixation with splinting of transplanted teeth is crucial for controlling postoperative complications. Rapid healing of the periodontal ligament has an eminent role in promoting root survival in autologous tooth grafts. Physiological micromovement of autologous teeth aids in periodontal revascularisation [11]. Rigid fixation inhibits this movement, which is not supportive for periodontal revascularisation and may also increase the risk of plaque accumulation [12]. Therefore, use of flexible wires is recommended for elastic fixation, which can not only keep the tooth stable in the alveolar socket but also provide required flexibility to enable the donor tooth to receive appropriate periodontal stimulation.

The reported success rates for revascularisation of mature teeth with fully developed roots were distinctly lower, and endodontic treatment was considered a standard procedure after transplantations of mature teeth [13]. Extraoral endodontic treatment should be avoided since it lengthens the extraoral time and raises the possibility of contaminating dentinal tubules and periodontal cells. On the other hand, excessively postponed endodontic treatment, would lead to an increased risk of root resorption [14]. In the present case, impacted tooth had a closed apex and endodontic treatment was done after one week of autotransplantation. Autotransplantation is reported to have a 98% and 95% success rate with immature teeth and mature teeth, respectively [15,16]. Orthodontic treatment can be initiated after confirmation of the presence of lamina dura and regeneration of periodontal space. In the present case orthodontic treatment was resumed after three months of passive phase for healing and initial stability.

Autotransplantation has a number of advantages over other treatments. The transplant has a normal periodontal membrane, and can be moved orthodontically like any other tooth. A normal marginal gingival contour is routinely established and bone is also effectively regenerated around restored transplanted teeth. When osseointegrated single-tooth implants were compared with autotransplanted teeth, the survival rates were comparable [17].

Autotransplantation can be considered 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 meticulous planning and careful execution in order to achieve greater chances of long-term survival of the transplanted tooth.

CONCLUSION(S)

Despite of the extremely complicated clinical scenario of horizontally impacted maxillary canine with a long and curved root tip which was highly positioned close to the nasal floor, unfavourable for orthodontic alignment and challenging even in terms of extraction and surgical repositioning, autotransplantation was successfully accomplished in this case. Although the anatomical limitations did not permit repositioning of the canine in its ideal position during the surgical procedure, accurate timing of endodontic treatment and timely initiation of orthodontic traction forces following a short stabilising phase, helped to align the canine in its ideal position without exhibiting any kind of complications such as ankylosis, root resorption or periapical infection leading to mobility. A stable, aesthetic outcome was obtained without prosthetic restoration. Use of a digital guide plate and 3D printed donor tooth model shortened socket preparation time, minimised extra-alveolar duration, and reduced positioning attempts. These digital aids offer valuable guidance for improving predictability and long-term success in tooth autotransplantation

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