Dental Traumatology

Dental Traumatology 2010; **26**: 195–199; doi: 10.1111/j.1600-9657.2009.00851.x

Autotransplantation of an immature premolar, with the aid of cone beam CT and computer-aided prototyping: a case report

CASE REPORT

Alexander J. Keightley, David L. Cross, Robert A. McKerlie, Laetitia Brocklebank

Glasgow Dental Hospital and School, Glasgow, UK

Correspondence to: David L. Cross, Glasgow Dental Hospital and School, 378 Sauchiehall Street, Glasgow G2 3JZ, UK
Tel.: +0141 211 9813
Fax: +0141 211 9873
e-mail: d.cross@dental.gla.ac.uk

Accepted 23 September, 2009

Abstract – Autotransplantation of immature teeth has good survival rates, and has benefits over ossointegrated implants in the growing child, but is very technique sensitive. Spiral CT imaging has been previously used in adult patients to enable computer-aided prototyping to produce a surgical template of the donor tooth, further increasing success rates. *Case report*: The case presented describes management of a 9-year-old girl with the combination of hypodontia affecting the upper lateral incisors as well as a severely ectopic maxillary canine. Cone beam CT was used in combination with computer-aided prototyping to produce a surgical template of an immature mandibular second premolar. The surgical template was used to prepare the transplant site before the donor tooth was extracted, greatly reducing the time from extraction to implantation. By 6 months posttransplant the tooth was clinically sound, and continued root development and laying down of dentine was visible radiographically. *Discussion*: This paper demonstrates the use of a novel technique to aid the surgical procedure of autotransplantation of immature premolar teeth. The use of autotransplantation in this case allowed the difficult situation of two missing units in the upper left quadrant to be reduced to one unit, while retaining symmetry in the upper arch. Compared to previous studies, the use of cone beam CT to create a 3D prototype reduced radiation dose compared to spiral CT and drastically reduced the extra-oral time of the donor tooth from extraction to transplantation.

Autotransplantation as a technique for replacement of teeth was first reported in the 1950s when immature third molars were used to replace decayed first molars (1). Survival rates for autotransplantation of immature premolar teeth have been shown to be 95% over 5 years (2). The autotransplanted tooth also has the capacity for functional adaptation and preservation of the alveolar ridge, which is advantageous when compared to ossointegrated implants that are stationary and do not erupt to compensate for further growth. This is an important consideration when dealing with missing teeth, whether congentital or acquired, in the young patient.

The combination of spiral CT imaging and computer-aided prototyping to produce a surgical template for the donor tooth has been shown to be useful in increasing success rate by avoiding injury to the delicate donor tooth (3).

In the case presented, the patient has the combination of hypodontia affecting the upper lateral incisors as well as a severely ectopic maxillary canine. Cone beam CT (CBCT) was used in combination with computer-aided prototyping to produce a surgical template for a mandibular second premolar. The surgical template was used to prepare the transplant site before the donor tooth was extracted. This method was successfully used to transplant a mandibular second premolar to replace the ectopic canine.

Case report

A 9-year-old girl was referred to the Paediatric Department at Glasgow Dental Hospital & School, following trauma to the upper left central incisor. A simple enamel-dentine fracture was repaired with composite. An incidental diagnosis was also made of hypodontia affecting the upper lateral incisors and an ectopic upper left canine. She had no relevant medical history. She was referred to the appropriate joint clinic.

A full case assessment was completed on a joint pediatric/orthodontic hypodontia clinic. The patient had a mild class II division I malocclusion on a mild class II skeletal base, with an average Frankfort-mandibular planes angle, no transverse asymmetry, and the lips were incompetent with lip trap. Intra-orally the patient was in the mixed dentition. The upper arch had approximately 3 mm of anterior spacing, and the lower arch was mildly crowded. In occlusion there was a 6-mm overjet and an increased complete overbite with upper and lower centre lines being concurrent. The molar relationship on both sides was ½ class II (Fig. 1).

Fig. 1. Pretreatment intra-oral photographs.

Radiographically, hypodontia of the upper lateral incisors was confirmed with all other teeth in the permanent dentition present including third molars, the lower second premolars had 2/3 root development and the upper left canine was noted to be ectopic (Figs 2 and 3). Standard radiographic imaging found the position of the ectopic canine to be so unfavorable, as to contraindicate either exposure and alignment or surgical transplantation. At this point it was decided to evaluate the possibility of transplanting a lower second premolar into the upper left canine position.

To fully assess the position of the ectopic canine and the donor tooth it was decided to undertake 3D imaging using a CBCT scan (i-CAT™; Imaging Sciences International, Hatfield, PA, USA) (Fig. 4). Images were acquired using a view height of 6 cm and a resolution of 0.4 mm voxels. The view height of 6 cm was used to visualize both mandible and maxilla (4). The areas of interests, including the donor tooth and its relationship to the inferior dental nerve, and the recipient site and its bone volume, were visualized in iCAT Vision.

The 3D image of the 23 revealed it to be significantly ectopic and inverted. Due to the difficult and traumatic surgical access required for removal, the oral surgeon advised leaving the ectopic 23 *in situ*, but monitor radiographically every 2–3 years. A treatment plan was agreed consisting of autotransplantation of tooth 35 to the 23 site following extraction of tooth 63, and to begin orthodontic treatment with an upper removable appliance and lower fixed appliance. After success of the autotransplant was confirmed both clinically and radiographically, teeth 45, 52 and 62 would be extracted and an upper fixed appliance used to close space. Thereafter tooth 13 and the transplanted tooth could be altered in appearance to simulate the missing teeth 12 and 22. Orthodontic retention would be provided by vacuum formed retainers initially. One of the benefits of this treatment approach was to remove the need for a fixed prosthesis or implants in the upper arch to replace the missing lateral incisors.

Fig. 2. Pretreatment panoramic radiograph showing grossly ectopic 23.

Fig. 3. Pretreatment periapical of 62 and 63, showing significant root resorption of 62.

To produce the surgical template the data from iCAT Vision was exported as a DICOM file (Digital Imaging and Communications in Medicine) into Maxilim, 3D optimized maxillofacial surgery software (Medicim, Mechelen, Belgium), using the Creatim function. Within the program a 3D model was generated (Fig. 5). The donor tooth was then isolated using the plane osteotomy functions within the software. The data was exported as an STL file (stereolithography) for transfer to the 3D printer.

The STL file was opened in Z-Print software linked to a 3D printer (Z-Printer 310 Plus; Z Corporation,

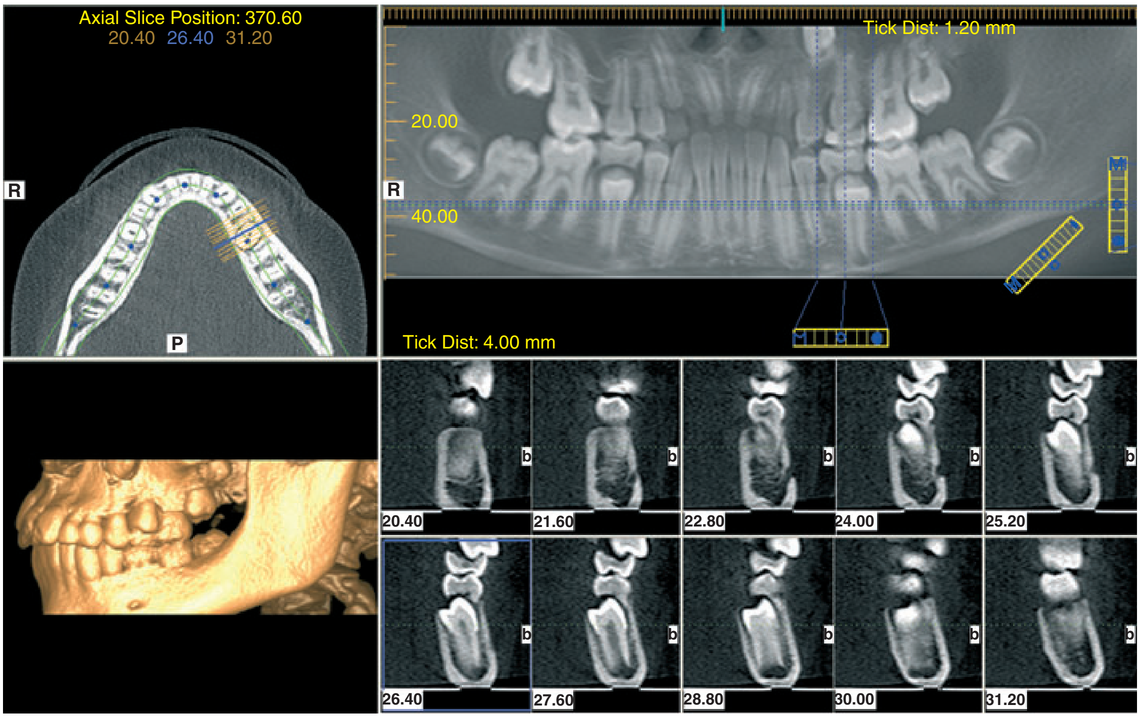

Fig. 4. Visualization of donor tooth within i-CAT viewer, demonstrating axial slices of donor tooth 35 and 3D reconstruction of maxilla and mandible.

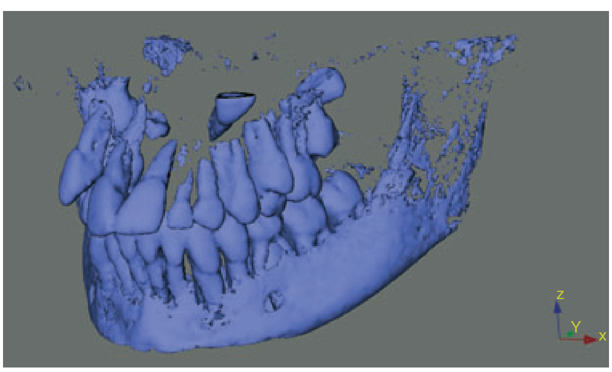

Fig. 5. 3D reconstruction of maxilla and mandible using cone beam CT data in Maxilim software, grossly ectopic 23 demonstrated, crown not completely viewed due to view height of CT scan.

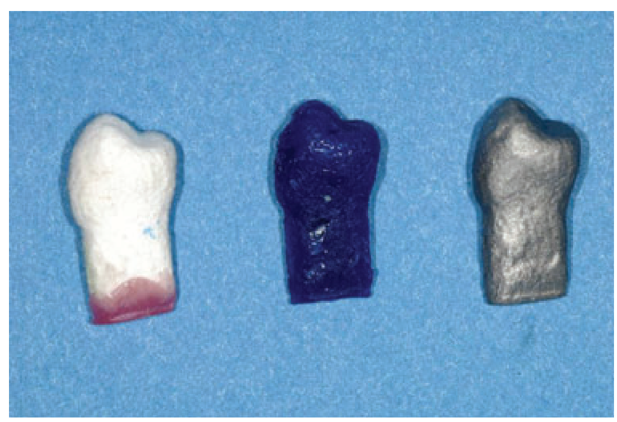

Fig. 6. Stages of template fabrication; 3D resin prototype with 1.5 mm wax addition to root apex, wax model, cobalt chrome surgical template.

Burlington, MA, USA). This printer produces a 3D resin model of the donor tooth. This was then copied in wax, where 1.5 mm was added to the length of the immature root apex, before being cast in cobalt-chrome. The cobalt-chrome model was then sterilized for use as a surgical template to guide preparation of the upper left canine socket for receiving the transplanted lower left second premolar. The addition of 1.5 mm to the root length of the model was designed to compensate for addition root development in the time between the scan and the surgery, to position the tooth minimally out of occlusion and ensure adequate space for the delicate periodontal cells at the end of the root (Fig. 6).

The transplantation procedure was preformed under general anesthetic at Yorkhill Royal Hospital for Sick Children in Glasgow by a specialist in both paediatric dentistry and oral surgery. The surgical procedure was as follows: first the deciduous lower left second molar was extracted and the unerupted lower left second premolar was carefully exposed but left loose in the socket. The upper left deciduous canine was then extracted and the recipient site prepared to fit using the surgical template. The lower left second premolar was then carefully extracted, with the follicle present around the neck of the tooth, and then immediately placed into the prepared socket. Finally it was sutured into place with a 4/0 vicryl rapide sling, and left to heal. The extra-oral time from extraction of the lower left second premolar to transplantation was estimated to be less than 1 min.

At follow-up, 1 month following transplantation the mobility of the tooth was grade 1 and was unresponsive to electric pulp testing and ethyl chloride. There was some occlusal interference which was corrected by placing some temporary glass ionomer on the occlusal surfaces of the lower first molars. A periapical radiograph showed the pulp starting to sclerose, which is a positive sign of continued pulpal vitality (Fig. 7).

At 2 months posttransplantation the mobility had reduced to less than 0.5 mm, though the tooth remained unresponsive to electric pulp testing and ethyl chloride. Then at the 4-month review the tooth was found to be responsive to both electric pulp testing and ethyl chloride. The mobility was resolved and the tooth was clinically sound. A periapical film taken at the 6-month review showed the laying down of secondary dentine and continued root formation (Fig. 8), sensibility tests remain positive and the tooth was clinically normal (Fig. 9).

Further orthodontic treatment has proceeded as planned. The ectopic upper left canine will remain *in situ* but be kept under radiographic review.

Discussion

The use of CT scan to fabricate of a 3D model to aid auto-transplantation was first reported by Lee et al. (3). These authors described a technique using spiral CT with a rapid prototyping machine to fabricate a tooth sized model in starch or resin. All autotransplanted teeth in the study were from adult patients with closed apices and therefore required: RCT prior to surgery, extraction under local anaesthetic, apicetomy with retrograde root filling carried out extra-orally at chairside before transplantation to the prepared donor site. The extra-oral time for these teeth ranged from 3 min to 17.5 min (3).

In contrast, the method described in this case report uses CBCT to generate an image of the donor and recipient site as well as the transplant tooth. This data was then used to fabricate a 3D model of the donor tooth to allow preparation of the implant site prior to autotransplantation. The transplanted tooth had an open apex and consequently did not require RCT or apicetomy as revascularization occurs relatively quickly. The use of a 3D model reduced the 'extra-oral' time to less than one minute which will hopefully lead to increased success rates.

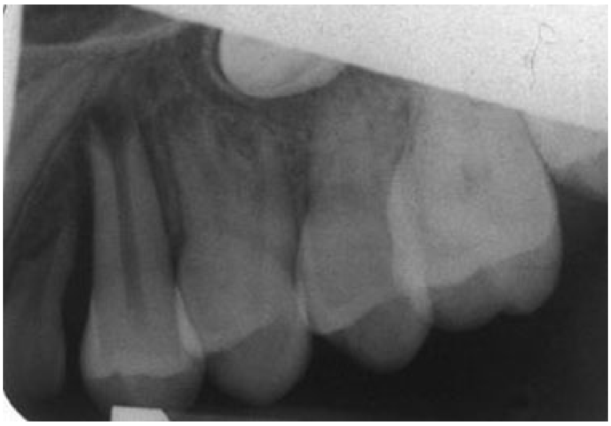

Fig. 7. Periapical of upper left anterior region 1 month after transplant, transplanted tooth shows an open apex and enlarged periodontal space.

Fig. 8. Periapical of upper left anterior region 6 months after surgery. Transplanted tooth showing signs of vitality, continued root development and pulp canal obliteration.

It has been shown that if the donor tooth is stored extra-orally whilst the socket is further modified that this significantly increases the probability of future pulp necrosis (5). The use of surgical templates fabricated to average tooth dimensions to facilitate autotransplantation has been reported previously (6). By using the technique described in this report to create a surgical template that is identical to the donor tooth, the recipient site can be closely contoured to fit the donor tooth, thereby allowing the immediate placement into the prepared socket. Other factors which affect the healing and long term vitality of the donor tooth, and which this technique improves are: the accuracy of the fit of the socket; the ability to prepare the socket so the donor tooth will be optimally positioned; and the reduced handling of the donor tooth. Having a socket which

Fig. 9. Posttransplant intra oral photographs.

accurately fits the donor tooth means that there will be good blood supply to promote revascularization. Whilst the reduced handling of the donor tooth lessens the possibility of damage to the delicate PDL or Hertwig's root sheath. It has also been commented on that autotransplantation is a very technique sensitive procedure (5). By using a surgical template it is hoped that a positive outcome will be less reliant on operator skill.

The use of auto transplantation in this case has several advantages. It allowed the difficult situation of two missing units in the upper left quadrant to be reduced to one unit as well as retaining symmetry in the upper arch. Both the upper right permanent canine and the transplanted tooth will require minimal alteration to their morphology to mimic the appearance of lateral incisors. The autotransplanted tooth will retain alveolar bone volume and attached gingival height, and the distinct advantage of being able to adapt to continued facial growth. Esthetically the use of the auto transplanted premolar has had an immediate effect as the buccal appearance is very similar to that of a canine.

Alternative treatment options for this patient were limited. Surgical exposure and successful orthodontic alignment of the ectopic upper left canine was considered unlikely due to it position (Figs 2 and 3). Similarly, auto transplantation of the ectopic upper left canine was deemed inappropriate due to the difficulty of surgical access. Single tooth implants have no role to play in growing children due to the problem of osseo-integration. In these patients, implants effectively behave like an ankylosed tooth, and will not move with the growing alveolar arch. They therefore become submerged and displaced and require further surgery in later years to first remove then replace the implant and superstructure when growth is complete.

A clinical protocol on the use of implants in growing children suggests that when a single unit is missing, implants should be withheld until dentoalveolar development is demonstrated to be completed (7). In the case presented, this would mean either maintaining the deciduous tooth, or using a provisional space maintainer until growth is completed before definitive restoration.

Auto transplantation has a clinical history of over 50 years, and therefore there is a significant amount of published data demonstrating its efficacy as a technique and its long term success rates. For auto transplantation longer term studies have shown, that with appropriate case selection and careful surgical technique, the survival rates to be 90% over an average of 26.4 years (8).

Auto transplantation has previously been shown to be a useful technique for dealing with the difficult clinical situation of missing anterior units in the growing child. This case demonstrates the use of a novel technique to aid the surgical procedure of auto transplantation of immature teeth making the procedure more predictable. We believe that this makes the surgical procedure easier, reduces the time from extraction to transplantation and will lead to increased success rates. The increased availability of CBCT and the reduced dose compared to spiral CT should result in the method described being applicable to more auto-transplantation cases.

References

1. Apfel H. Autoplasty of enucleated prefunctional third molars. J Oral Surg 1950;8:189–200.
2. Andreason J, Paulsen H, Yu Z, Bayer T, Schwartz O. A long-term study of 370 autotransplanted premolars. Part II. Tooth survival and pulp healing subsequent to transplantation. Eur J Orthod 1990;12:14–24.
3. Lee S-J, Jung I-Y, Lee C-Y, Choi SY, Kum K-Y. Clinical application of computer-aided rapid prototyping for tooth transplantion. Dent Traumatol 2001;17:114–9.
4. Roberts JA, Drage NA, Davies J, Thomas DW. Effective dose from cone beam CT examinations in dentistry. Br J Radiol 2009;82:35–40.
5. Andreasen JO, Paulsen HU, Yu Z, Bayer T, Schwartz O. A long-term study of 370 autotransplanted premolars, Part II. Tooth survival and pulp healing subsequent to transplantation. Eur J Orthod 1990;12:14–24.
6. Meechan JG, Carter NE, Gillgrass TJ, Hobson RS, Jepson NJ, Nohl FS et al. Interdisciplinary management of hypodontia:oral surgery. Br Dent J 2003;194:423–7.
7. Sharma A, Vargervik K. Using implants for the growthing child. J Calif Dent Assoc 2006;34:719–24.
8. Czochrowska E, Stenvik A, Bjercke B, Zachrisson B. Outcome of tooth transplantation: Survival and success rates 17–41 years posttreatment, Am J Orthod Dentofacial Orthop 2002;121: 110–9.