Dental Traumatology

Dental Traumatology 2015; doi: 10.1111/edt.12253

Computer-aided planning and surgical guiding system fabrication in premolar autotransplantation: a 12-month follow up

CASE REPORT

Wicher Joerd van der Meer[1], Johan Jansma[2], Konstantina Delli[2], Christos Livas[1]

[1]Department of Orthodontics, University of Groningen, University Medical Center Groningen; [2]Department of Oral and Maxillofacial Surgery, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands

Abstract – This case report describes the autotransplantation of maxillary right second premolar into the contralateral position in a 14-year-old female using computerized tomographic data and a customized guiding system produced by computer-aided design/computer-assisted manufacture technology. Using innovative surgical guides and keys with navigation features, modification of the recipient socket and handling of the transplant were facilitated without harming the periodontal membrane. Postoperative clinical and radiographic examination showed periodontal and pulp healing earlier than 6 months after surgery.

Key words: tooth autotransplantation; cone beam computed tomography; computer-assisted surgery

Correspondence to: Christos Livas, Department of Orthodontics, University of Groningen, University Medical Center Groningen, Hanzeplein 1, Triade gebouw, Ingang 24, 9700 RB Groningen, The Netherlands
Tel.: +31503612483
Fax: +31503619712
e-mail: c.livas@umcg.nl

Accepted 8 November, 2015

Autotransplantation may be preferred as an alternative to later implant placement in young individuals with tooth agenesis and in cases of loss due to trauma and unfavorable eruption of permanent teeth. The success rate of the autotransplantation procedure is affected by the extra-alveolar time of the donor tooth, but also by factors such as and the distance between the recipient site tissues and the root surface, which may significantly affect the viability of periodontal ligament (PDL) cells (1). The use of preformed surgical stents has been recommended to reduce the extra-alveolar time and mechanical trauma of the transplanted tooth PDL during socket preparation. In particular, acrylic tooth replicas based on preoperative radiographs, metal rounded (2) and toothlike templates (3) may be used to precontour the recipient alveolar bone to accommodate the transplant. Recently, developments in computed tomography (CT) (1) and cone beam computed tomography (CBCT) (4–7) have enabled the fabrication of accurate customized surgical templates.

This case illustrates the application of computer-aided design/computer-assisted manufacture (CAD/CAM) technology in planning and performing a premolar autotransplantation in a young orthodontic patient.

Case report

A 14-year-old girl was referred to the clinic of the Department of Orthodontics, University Medical Center Groningen, Groningen, the Netherlands, for consultation. The patient was diagnosed with Class II Division 2 malocclusion with ½–1 premolar width Class II molar relationship, deep bite, and retroclination of the maxillary and mandibular incisors. The radiographic examination revealed agenesis of 24, 25, 35, 38, 45, 48, and ½–¾ root development of 15 (Fig. 1). To compensate for the absence of both premolars in the left maxillary posterior segment and to minimize the consequences of extensive orthodontic tooth movement, autotransplantation of the immature 15 into the position of the agenetic 25 was planned. The virtual position of the autotransplanted premolar was reproduced from computerized tomographic data.

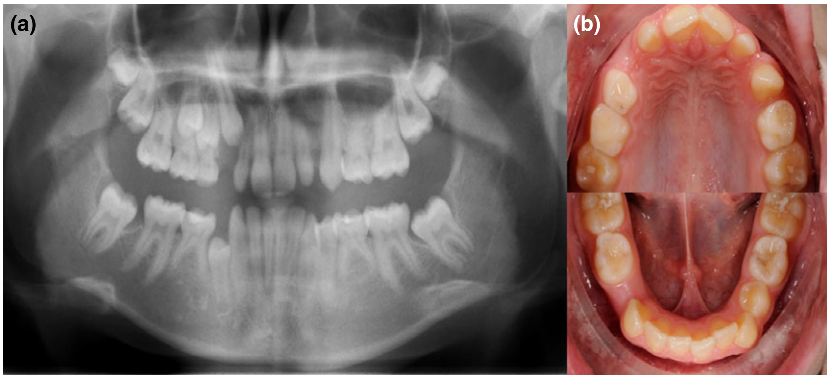

Fig. 1. Diagnostic records: Orthopantomogram (a); intra-oral occlusal photographs (b).

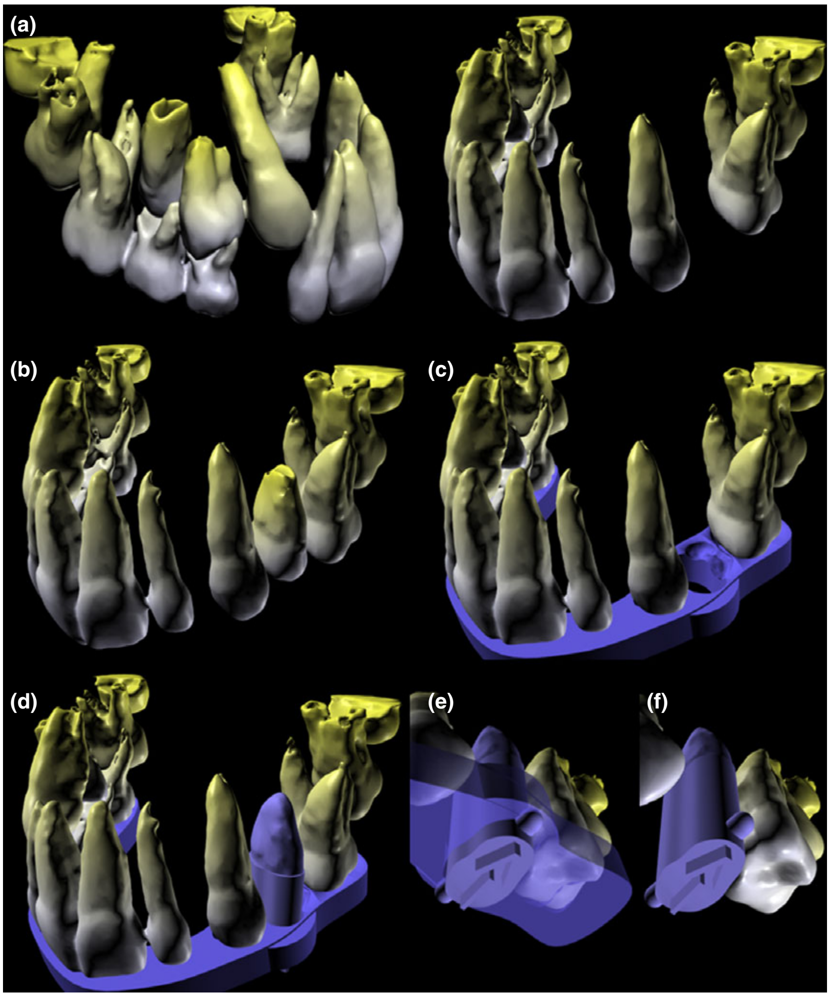

Fig. 2. 3D representation of the maxillary dentition (a). Simulation of the autotransplantation of 15 into the location of the agenetic 25 (b). Surgical guide seated on the occlusal surfaces of the maxillary teeth (c). Surgical guiding system: guide and transplant key (d). Direction indicator crafted on the key's occlusal surface; arrow points to the buccal direction (e). Copy of the transplant key (f).

Surgical guide system fabrication

A small field CBCT dataset (3D eXam; KAVO, Amersfoort, the Netherlands) of the patient's upper jaw was made. The patient was asked to slightly open the mouth to ensure that the maxillary and mandibular teeth were separated. The CBCT machine was set to a voxel size of 0.3 mm, which surpasses the 0.5 mm resolution prescribed for planning implants using Nobelguide (Nobel Bioresearch, Gothenburg, Sweden) or Simplant (Materialise, Leuven, Belgium). These settings were chosen to obtain the lowest possible dose for the patient while maintaining the best imaging result for optimal planning. The CBCT dataset was converted to a surface model with 'Devide' freeware (TU Delft Graphics Group, Technical University of Delft, Delft, the Netherlands) using an optimal threshold to depict bone or teeth. In addition, digital registration of the dentition was performed with the aid of the Lava COS intraoral scanner (3M ESPE Dental Products, Zoeterwoude, the Netherlands). Three separate entities, that is, bone, teeth, and the digital impression of the teeth, were imported into 3DS MAX software (Autodesk; San Rafael, CA, USA). Three-dimensional (3D) models of the tooth crowns and roots that had been extracted from the CBCT dataset and the digital impression were aligned and registered in GOM Inspect which is free software (GOM GmbH; Braunschweig, Germany) (Fig. 2a).

In 3DS MAX software, 15 was separated from the other teeth of the CBCT teeth dataset, and positioned at the location of 65 according to the orthodontic treatment plan (Fig. 2b).

A surgical guide was digitally designed in the 3DS MAX software using the dentition for stable anatomical fixation, and extending between maxillary first molars (Fig. 2c). This guide was made to fit to the dentition by first expanding the digital dentition by 0.1 mm, activating a 'shell' command, and then digitally subtracting the dentition from the guide design using a Boolean operation. Expansion of the dentition was performed to ensure a proper fit. The 3D model of 15 was also expanded 0.5 mm to prevent compression forces on the PDL during the operation. A handle was modeled on the donor tooth to serve as a fit key during the socket preparation (Fig. 2d). The handle was constructed under an angle toward the buccal side of the teeth and the front to facilitate the handling for the surgeon, while also indicating the buccal side with a letter 'B' (Fig. 2e). Additionally, a second copy of 15 was fabricated to test whether the new socket had been prepared to the proper depth and angulation (Fig. 2f). The distance from the top of the guide to the tip of the planned position of the root tip was measured in the software and noted on the patient's chart.

Finally, the digitally designed guide was prepared for export using the 'stl check' command and exported as stl-file and sent to a dental laboratory, where the guide and the two keys were milled in clear plastic.

Surgical technique

Under local anesthesia, 65 was extracted, and the new recipient socket was prepared using the guide and keys described above (Fig. 3a–d). During this procedure, the maxillary sinus floor was perforated, as anticipated by 3D planning, and subsequently elevated. After extracting 55, 15 was removed as atraumatically as possible, inspected, and without further adjustment of the autotransplantation site, replanted in the new location, while keeping the extra-alveolar time to a minimum (Fig. 3f). The donor tooth was stabilized with a resorbable suture

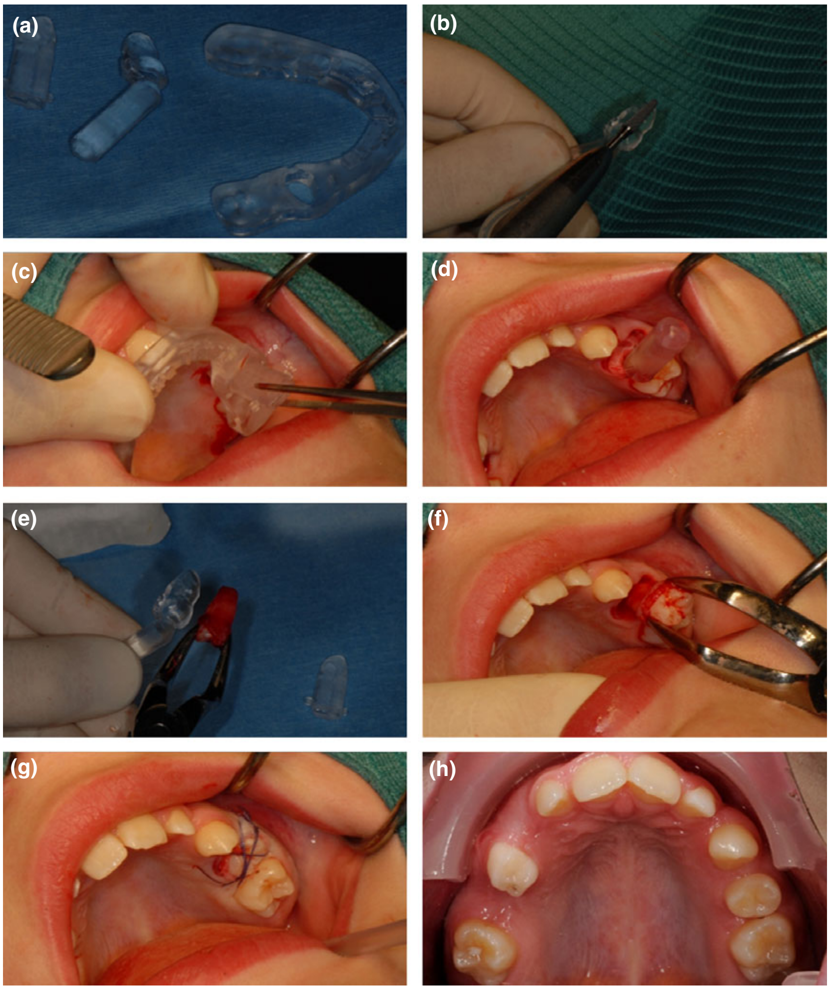

Fig. 3. Surgical guide, transplant key with handle, and copy of transplant key (a). Selection of appropriate surgical bur (b). Modification of the recipient socket after drilling using the surgical guiding system (c, d). Side-by-side comparison of the extracted 15 and the transplant key (e). Positioning of 15 into the new socket (f). Fixation of the autotransplanted 15 in infra-occlusion (g). Occlusal view of the maxillary dentition 6 months postoperatively (h).

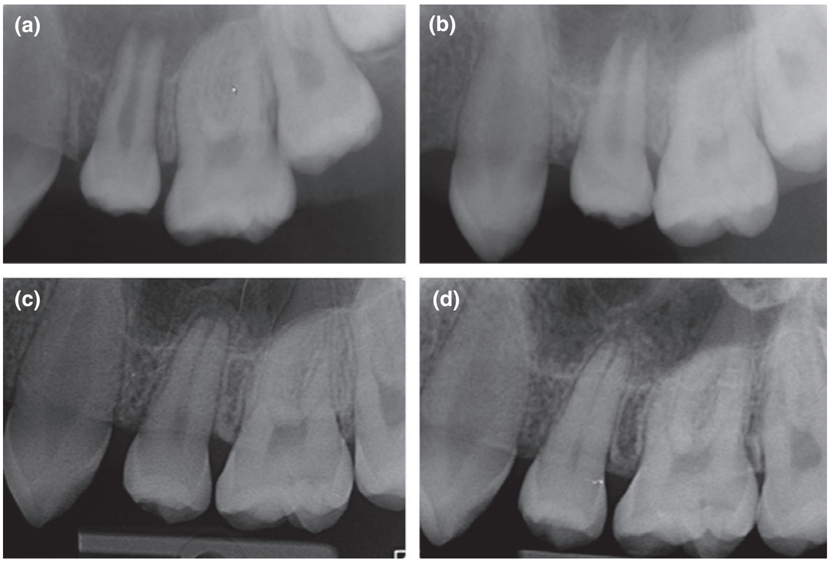

Fig. 4. Periapical radiographs taken 2 weeks after the surgical procedure (a), 3 months (b), 6 months (c), and 12 months postoperatively (d).

that crossed the occlusal surface in infra-occlusion to prevent overloading and injury to the periodontium (Fig. 3g).

Postoperative examination

Periapical radiographs were taken 2 weeks after autotransplantation and 3, 6, and 12 months postoperatively according to the guidelines for replanted permanent teeth with open apex published by the International Association of Dental Traumatology (8). Following the first months after surgery, an open apex and an enlarged periodontal space were present on the periapical images (Fig. 4b). At 6-month follow up, the transplant showed signs of vitality during pulp testing with cold spray, while continuous root development and pulp obliteration were radiographically observed (Fig. 4c). Using the neighboring teeth on the successive radiographs as reference, tooth eruption took place with the autotransplanted premolar approaching the occlusal plane (Fig. 3f).

Discussion

Computer-aided design/computer-assisted manufacture technology has been widely applied to design and manufacture surgical templates for dental implant positioning. The accuracy of CAD/CAM guiding systems in implant dentistry has been confirmed by a recent systematic review, although the authors highlighted significant parameters calling for improvement (9).

Our approach enabled a detailed preoperative planning and optimal orientation of the maxillary right second premolar using a customized surgical guide seated on the occlusal surfaces of the maxillary teeth and transplant keys. Furthermore, shaping of navigation features on the key surface enhanced atraumatic handling of the donor tooth and preservation of the periodontal membrane, a critical success factor in tooth autotransplantation (4). Periodontal healing, defined as surrounding of root periphery by newly formed periodontal space, was confirmed on the successive periapical radiographs. There was evidence of pulp healing, clinically and radiographically evaluated by signs of pulp canal obliteration. Eruption of the autotransplanted premolar occurred earlier than the first six postoperative months, which is in agreement with a previous study (10).

Despite the reduced patient exposure to radiation with CBCT compared to CT, radiation risk should still be considered in treatment decision making. At present, the relatively high cost of purchasing CBCT, 3D software and printer or dental laboratory services may hinder application of this technique in standard practice. Finally, from the operator's perspective, any claimed advantages must be weighed against the learning curve of the new technique.

To the authors' knowledge, this is the first description of a CAD/CAM autotransplantation guiding system that includes a static surgical guide to accommodate the transplant replica and a copy of the transplant key of innovative design. Future research should focus on providing more insight into 3D planning of autotransplantation procedures. Specifically, such studies may place emphasis on the clinical comparison between using preformed and customized surgical keys, and non-computer-based techniques.

References

1. Lee SJ, Jung IY, Lee CY, Choi SY, Kum KY. Clinical application of computer-aided rapid prototyping for tooth transplantation. Dent Traumatol 2001;17:114–9.
2. Day PF, Lewis BR, Spencer RJ, Barber SK, Duggal M. The design and development of surgical templates for premolar transplants in adolescents. Int Endod J 2012;45:1042–52.
3. Ashkenazi M, Levin L. Metal tooth-like surgical templates for tooth autotransplantation in adolescents. Dent Traumatol 2014;30:81–4.
4. Honda M, Uehara H, Uehara T, Honda K, Kawashima S, Honda K et al. Use of a replica graft tooth for evaluation before autotransplantation of a tooth. A CAD/CAM model produced using dental-cone-beam computed tomography. Int J Oral Maxillofac Surg 2010;39:1016–9.

5. Shahbazian M, Jacobs R, Wyatt J, Willems G, Pattijn V, Dhoore E et al. Accuracy and surgical feasibility of a CBCT-based stereolithographic surgical guide aiding autotransplantation of teeth: in vitro validation. J Oral Rehabil 2010;37:854–9.
6. Keightley AJ, Cross DL, McKerlie RA, Brocklebank L. Autotransplantation of an immature premolar, with the aid of cone beam CT and computer-aided prototyping: a case report. Dent Traumatol 2010;26:195–9.
7. Park JM, Tatad JC, Landayan ME, Heo SJ, Kim SJ. Optimizing third molar autotransplantation: applications of reverse-engineered surgical templates and rapid prototyping of three-dimensional teeth. J Oral Maxillofac Surg 2014;72: 1653–9.
8. International Association of Dental Traumatology. In: Dental trauma guidelines revised 2012. Available at: https://www.iadt-dentaltrauma.org. [Accessibility verified August 11, 2015].
9. Van Assche N, Vercruyssen M, Coucke W, Teughels W, Jacobs R, Quirynen M. Accuracy of computer-aided implant placement. Clin Oral Implants Res 2012;23 Suppl 6:112–23.
10. Paulsen HU, Andreasen JO, Schwartz O. Pulp and periodontal healing, root development and root resorption subsequent to transplantation and orthodontic rotation: a long-term study of autotransplanted premolars. Am J Orthod Dentofacial Orthop 1995;108:630–40.