Outcome of Autotransplantation of Mature Third Molars Using 3-dimensional–printed Guiding Templates and Donor Tooth Replicas

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Abstract

Autotransplantation exhibits a number of advantages compared with other treatment options (ie, dental implants or fixed partial prostheses), such as greater resistance to occlusal loading, maintenance of the periodontal ligament and surrounding bone, and the potential for better esthetics. The aim of this study was to determine clinical outcomes for autotransplanted teeth with complete root formation using 3-dimensional–printed guiding templates and tooth replicas. Twenty-seven third molars with completely formed roots were autotransplanted. Each donor tooth and recipient site were examined clinically and radiographically (periapical radiographs). A selective cone-beam computed tomographic scan was taken of each donor tooth and recipient site. The images of the selected donor teeth were segmented and saved as stereolithography files. Similar to virtual planning of dental implants, correct angulation, rotation, and accurate positioning of the donor teeth were predefined using the stereolithography files. According to the virtually defined positions and dimensions of the donor teeth, 3-dimensional guiding templates and donor tooth replicas were printed. All autotransplantations were performed according to 1 treatment protocol and surgical technique. In 22 of the 24 transplanted teeth, no inflammation occurred during the healing period. At 2 years, no pathologic radiolucency or tooth resorption was observed in the 22 donor teeth. The autotransplanted teeth fulfilled the success criteria in 22 cases for a 91.7% success rate. Digital planning could potentially provide an accurate alternative to current autotransplantation techniques. *(J Endod 2018;■:1–8)*

Key Words

3-dimensional–printed guiding template, autotransplantation, digital planning, tooth replica

Significance

Planning of the ideal 3D position of the donor teeth allows the minimization of surgical risks as well as a reduction of extraoral time. 3D-printed guiding templates and tooth replicas could potentially provide a relatively accurate alternative for currently available treatment approaches.

Autogenous tooth transplantation refers to the repositioning of an autogenous tooth in another tooth extraction site or a surgically formed recipient site. This procedure is used to replace teeth that are, for example, missing congenitally or that involve ectopic eruption, severe caries, periodontal disease, trauma, or endodontic failure when a suitable donor tooth is available (1–3). By using the patient's own tooth, autotransplantation exhibits a number of advantages compared with other treatment options (ie, dental implants or fixed partial prostheses), such as greater resistance to occlusal loading, maintenance of the periodontal ligament (PDL) and surrounding bone, and the potential for better esthetics (4, 5).

After its first reported clinical application in 1950 (6), the success rate of tooth autotransplantation has gradually increased thanks to advances in diagnostic and surgical techniques, such as computer-aided rapid prototyping (CARP) models. Since the 1990s, many studies examining the healing of periodontal tissues and periodontal membrane and root resorption have drawn new clinical interest (7–9). However, most studies have focused on the autotransplantation of teeth with incomplete root formation (10–12), which limits the applications of this technique in patients in their early 20s and younger.

In order to expand the potential therapeutic applicability of tooth autotransplantation, teeth with complete root formation could be considered for use as donor teeth. Previous research has determined no substantial difference in the autotransplantation success rate between mature and immature teeth. Yu et al (13) reported a 93.1% long-term survival rate of mature third molar autotransplantation in fresh extraction sockets. These results are similar to those obtained by Lundberg and Isaksson (7), Tsukiboshi (3), and Mejàre et al (8).

Successful autotransplantation can offer promising results although complications caused by documented risk factors may influence the outcome. The most important factor for the success of autogenous tooth transplantation is the vitality of the PDL attached to the transplanted tooth (3). Mechanical injuries during extraction or traumatic press-fit placement in the recipient alveolus and biochemical factors because of prolonged extra-alveolar duration may damage the PDL, leading to progressive root resorption. Additionally, besides sufficient preparation of the recipient alveolus, root morphology

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and development appear to influence a negative outcome (14–16). Therefore, an accurate clinical and radiologic examination can enhance treatment planning, ensuring an atraumatic and minimally invasive procedure for autotransplantation (17).

As technology advances, more digitalized approaches can be introduced to aid and reduce the complexity of autotransplantation techniques (18). By applying 3-dimensional (3D) tooth replicas, the extraoral time is significantly reduced, and the suitability between the donor tooth and the recipient site is improved (19, 20). The aim of this study was to investigate the clinical outcomes for autotransplanted teeth with complete root formation using 3D-printed guiding templates and tooth replicas. To accomplish this goal, 24 cases of autotransplanted teeth were evaluated for up to 2 years.

Materials and Methods

Subject Materials

This study analyzed the dental records and radiographs of 27 patients (15 men and 12 women) in whom 27 third molars with completely formed roots were autotransplanted in the Department of Endodontics at Universitat Internacional de Catalunya, St Cugat del Vallès, Barcelona, Spain. The age of the patients at the time of surgery ranged from 20–59 years with a mean age of 41.5 years. All of the patients included in this retrospective study had no severe systemic disease (American Society of Anesthesiologists classification 1 or 2), and all permanent teeth had complete root formation (root development stage 5 and 6 by Moorrees et al [21]) as the donor teeth.

Preoperative Preparation

On the first visit, the patient's medical history was reviewed, and a thorough dental history was recorded. Clinical and radiographic (periapical [PA] radiographs) examination of the donor tooth and recipient site was performed. PA radiographs were obtained with a paralleling technique using a beam-aiming device (XCP-DS Sensor Positioning System; Dentsply Rinn, Elgin, IL) to standardize the radiographs. All PA radiographs were taken with a dental X-ray machine (Heliodent DS; Sirona Dental Systems, LLC, Charlotte, NC) using a digital radiography system (Kodak RVG 6100; Carestream Health, Rochester, NY). Autotransplantation was performed as a result of nonrestorable teeth in 23 patients and vertical root fracture in 4 patients. In all cases, the recipient sites were the first or second molar areas (Table 1).

A selective cone-beam computed tomographic scan (CS 9300; Carestream Health) was acquired on the donor tooth and the recipient site. The operating parameters were set at 8.0 mA and 84 kV, and the exposure time was 12 seconds. The scan position was with the occlusal plane parallel to the floor according to the manufacturer's recommendations. The smallest possible field of view was used (5×5 cm), and the scan volumes were exported to the Digital Imaging and Communications in Medicine (DICOM) format. Written informed consent was obtained from each patient at this stage. If the donor tooth was accessible, the endodontic treatment was completed before surgery. However, in most cases, the donor was impacted or erupted in a position that hindered endodontic access. Thus, the root canal treatment was started 2 weeks after transplantation.

TABLE 1. The Number of Autotransplanted Teeth Distributed according to the Recipient Site

Transplanted tooth	Recipient sites							
	#2	#3	#15	#14	#19	#18	#30	#31
#1	1	1	1	2		1		1
#16	1		1	2		2	1	
#17		1	1		1	2	1	1
#2	1		1		1	1		2
Sum	3	2	4	4	2	6	2	4

Virtual Surgical Planning, 3D Tooth Replicas, and 3D-printed Guiding Templates

The cone-beam computed tomographic DICOM files were imported to surgical planning software designed for guided implant surgery (NemoScan; Nemotec, Madrid, Spain). Crown, root length, and the cervical dimension of the donor tooth were measured and compared with the residual bone height and width of the recipient site. Anatomic relationships with the inferior alveolar nerve and maxillary sinus were also determined preoperatively. Based on this analysis, the donor teeth were selected for autotransplantation.

From these DICOM files, the images of the selected donor teeth were segmented and saved as stereolithography (STL) files. Similar to virtual planning of dental implants, correct angulation, rotation, and accurate positioning of the donor teeth were predefined using the STL files. Their exact 3D positions were selected in relation to anatomic space and adjacent dental structures. In some cases, a 3- or 4-mm apicoectomy in the donor teeth was digitally performed to minimize the preparation of the recipient site. According to the virtually defined positions and dimensions of the donor teeth, 3D guiding templates were designed with the occlusal surfaces of the adjacent teeth (2 or 3 according to the clinical case) to position the donor teeth in the recipient sites. Finally, the 3D guiding templates were exported as STL files and sent together with the segmented donor teeth to a 3D printer for fabrication (Form 2; Formlabs, Somerville, MA). Both the donor teeth replicas and the templates were printed in a biocompatible resin (Dental LT Clear Resin, Formlabs).

Surgical Procedure

All autotransplantations were performed according to the same treatment protocol and surgical technique by an experienced surgeon (F.R.) and an experienced endodontist (F.A.). The sequence of the autotransplantation technique is summarized in Table 2.

Amoxicillin 500 mg and ibuprofen 400 mg were prescribed 1 hour before the surgery. After local anesthetic injection (lidocaine 2% with epinephrine 1:100,000), the recipient site tooth was extracted without the need to perform a mucoperiosteal flap elevation. To reduce bone trauma, the tooth was sectioned with a tungsten carbide bur (FG H254-010; Komet Dental/Gebr Brasseler GmbH & Co KG, Lemgo, Germany) and then luxated passively with forceps. After extraction, the recipient socket was prepared a little larger than the donor using surgical round burs at low speed and copiously irrigated with saline solution. After confirming the suitability of the 3D tooth replica in the recipient site and the proper placement of the 3D-printed guiding template, the donor tooth was extracted. To minimize trauma during the extraction, an intracrevicular incision was made before luxation to preserve as much PDL on the root as possible. Then, the donor tooth was engaged and passively luxated with the forceps beak placed above the cementoenamel junction. The use of elevators was minimized to prevent any damage to the cementum and the PDL. When the donor tooth was impacted and surgically extracted, the same luxation protocol was used after the flap elevation and osteotomy around the donor tooth. The optimal placement of the donor tooth to the recipient site was established by using the 3D-printed guiding template.

Finally, all the transplanted teeth were stabilized with nonabsorbable surgical sutures and a wire splint to optimize reattachment and block bacterial invasion into the blood clot between the tooth and