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CLINICAL REPORT

Obturator fabrication incorporating computer-aided design and 3-dimensional printing technology: A clinical report

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ABSTRACT

This article reports an approach to fabricating a maxillary obturator using the computer-aided design and computer-aided manufacturing (CAD-CAM) process. The maxillary definitive cast and the trial tooth arrangement were separately scanned and superimposed. The virtual cast created from the scan data was surveyed, and the framework was designed using specific software. The definitive cobalt-chromium framework was fabricated by using 3-dimensional (3D) selective laser sintering (SLS) technology. After framework trial placement, the definitive obturator prosthesis was processed using conventional heat-polymerizing resin with the lost-wax processing technique. Using CAD technology and 3D metal printing resulted in improved fit, function, and esthetics for the definitive obturator prosthesis. (J Prosthet Dent 2019;121:694-7)

Computer-aided design and computer-aided manufacturing (CAD-CAM) technology has been implemented in the fabrication of dental prostheses for many years.[1] The technology has advanced to removable prosthodontics and has been used in the fabrication of removable partial denture (RPD) frameworks.[2]

Current digital technologies enable the design of RPD components on 3-dimensional (3D) representations of the patient instead of on gypsum casts by using geometric analysis tools that create designs of micrometer-level accuracy that can be viewed in cross section.[3,4] The virtual model can then be used to design and print the framework design in resin followed by casting metal frameworks or to print the metal or resin frameworks directly.[3-6]

Eggbeer et al[3] used stereolithography technology to build resin RPD frameworks, which were cast in a cobalt-chromium alloy using conventional casting techniques. This approach reduced framework misfit due to errors introduced in the steps of the conventional fabrication method.[7-10]

The application of CAD and selective laser sintering (SLS) technology in direct printing of the RPD metal framework potentially reduces further errors compared with the conventional method of fabrication.[4] Clinically acceptable fit has been reported for RPD frameworks fabricated with rapid prototyping.[1,11] Studies have also reported improved mechanical properties, higher patient satisfaction in terms of denture cleaning, speaking, mastication, and comfort, reduced laboratory time, and availability of saved data for future prosthesis reproduction as some of the other advantages of the SLS technique.[12-14]

This clinical report described the fabrication of a definitive RPD obturator using CAD and SLS technology for a patient who had undergone hemimaxillectomy.

CLINICAL REPORT

A 17-year-old white man presented to the clinic of the advanced specialty education program in prosthodontics at Loma Linda University School of Dentistry requesting replacement of a deficient and unesthetic interim obturator made approximately 8 years earlier. Fractures and missing denture teeth, lack of retention, and plaque accumulation were noted on the interim obturator prosthesis. His medical history revealed a history of leukemia and subsequent treatment with chemotherapy and radiation. A maxillary sinus infection developed as a complication of

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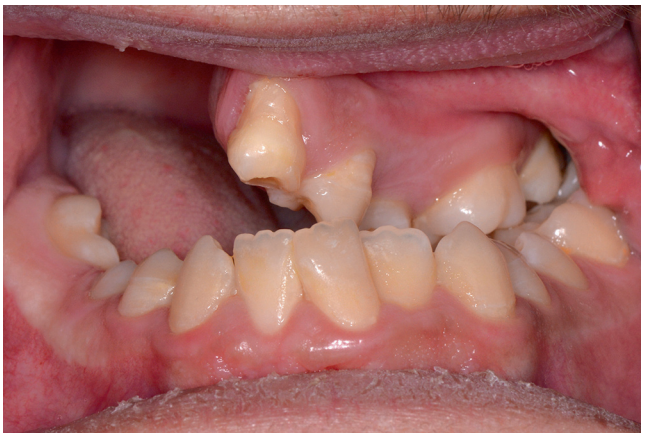

Figure 1. Frontal view in maximal intercuspal position without interim obturator.

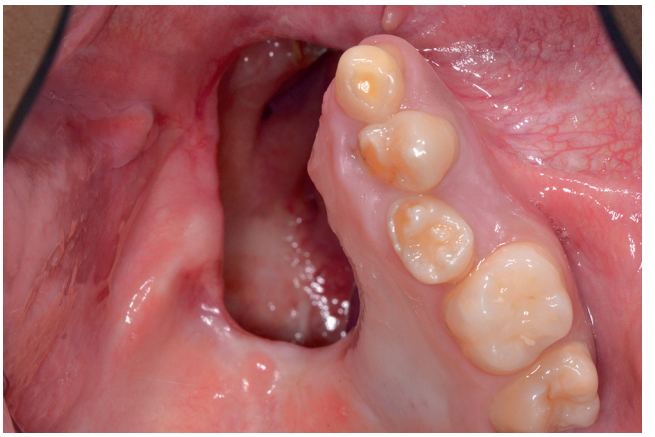

Figure 2. Occlusal view of maxillary arch.

chemotherapy, which resulted in a right side hemimaxillectomy involving the inferior rim of the orbital bone. The patient reported that his leukemia had been in remission for 10 years. Extraorally, scar tissues from surgery on the right eyelid and superior aspect of the bridge of the right side of the nose were visible. Nose deviation to the right and lip incompetency at rest were evident.

An intraoral examination revealed an oronasal communication resulting from the hemimaxillectomy. Five maxillary teeth remained from the left lateral primary incisor to the left second permanent molar (Figs. 1 and 2). According to the classification system proposed by Okay et al,[15] the maxillary defect was classified as class III, subclass F because of the involvement of more than 50% of the palatal surface which extended vertically to the orbital floor. The Aramany classification for the framework design of obturators for patients who undergo maxillectomy was class IV.[16]

Preliminary impressions were made with a modified stock tray (COE Spacer Disposable Trays; GC America) using heavy- and light-body polyvinyl siloxane (PVS) impression material (EXAMIX NDS PVS Material; GC America). After the diagnostic casts were poured using Type IV scannable dental stone (FujiRock OptiXscan; GC America), a wax rim was fabricated for maxillomandibular relation record.

For esthetics and appropriate lip support, the denture tooth arrangement had to be anterior to the existing natural teeth. This resulted in a second row of denture teeth (BlueLine DCL; Ivoclar Vivadent AG) arranged buccally and additional to the patient's natural teeth (first row). This twin row tooth arrangement also assisted in achieving more occlusal contacts and better soft tissue support (Fig. 3).[17]

The maxillomandibular relationship records were made at the second appointment, followed by esthetic and functional tooth trial placements at the third appointment. The facial tooth (second row) arrangement improved the patient's lip support at the appropriate vertical dimension. The esthetics, phonetics, and vertical

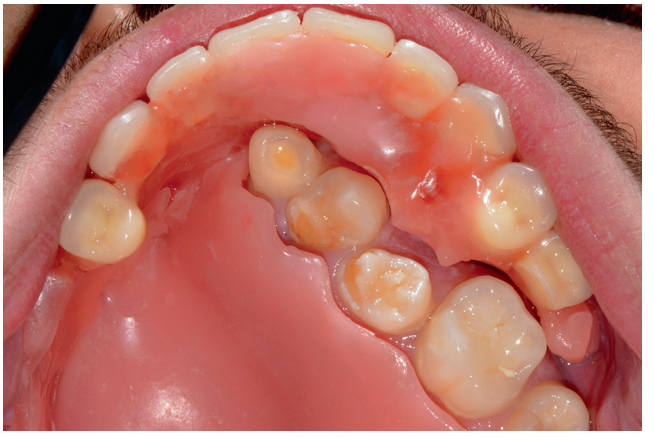

Figure 3. Trial placement for esthetic evaluation.

dimension were assessed. Rest seats were prepared on planned abutments, and wet gauze was placed in the defect to prevent impression material from flowing into the oronasal cavity. A custom tray (Triad TruTray VLC Custom Tray Material, Clear; Dentsply Sirona) with a green modeling plastic impression compound was used to border mold and capture the extensions for the obturator. A definitive impression was made with the custom tray using heavy- and light-body PVS impression material (EXAMIX NDS PVS Impression Material; GC America). Type IV scannable dental stone (FujiRock OptiXscan; GC America) was used to pour the definitive cast.

The maxillary definitive cast and trial tooth arrangement were scanned (Lab Scanner, D900; 3Shape) and superimposed. Superimposition was done to appropriately design and define the outline of the metal bar facial to the RPD framework underneath the maxillary anterior teeth for retention and support of the acrylic resin (Figs. 4 and 5). The digital surveying and digital designing using 3Shape software (3Shape Removable Partial Design; Core3dcentres) was performed. The framework was 3D printed in gray resin (Grey Resin, GPGR 04; Formlabs, Inc) and evaluated on the definitive cast to confirm adaptation.

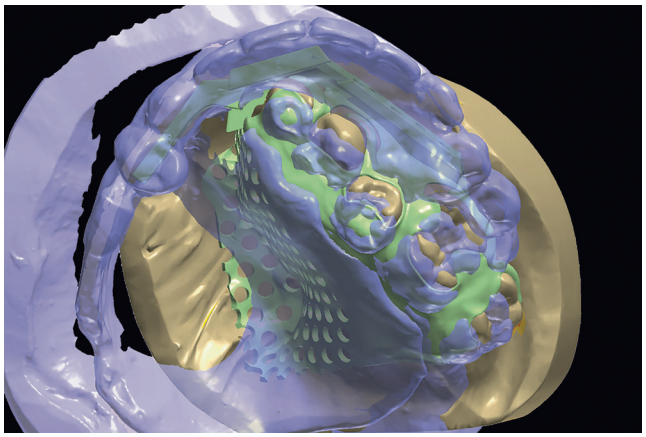

Figure 4. Digital superimposition of teeth and framework.

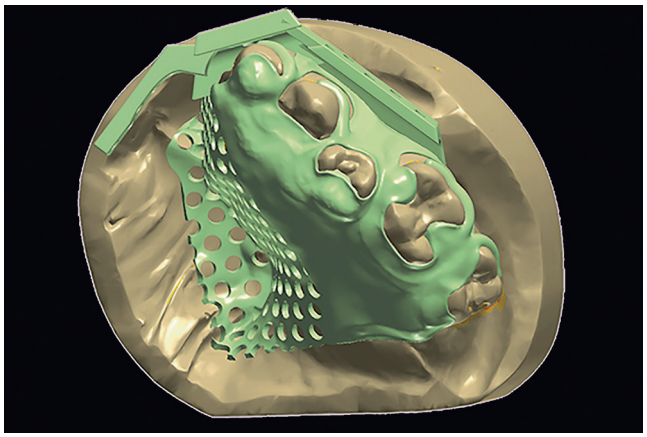

Figure 5. Definitive framework design.

After evaluation of the resin framework, the digital design of the framework was imported into the company web portal (3DRPD; 3DRPD Co) to be printed in cobalt-chromium alloy (Vitalium). The printed metal framework was placed and adjusted intraorally by marking high pressure or ill-fitting areas after identification with a disclosing medium (Occlude Aerosol Indicator Spray; Pascal Co, Inc) (Fig. 6). Custom tray material (Triad VLC custom tray material; Dentsply Sirona) was added to the framework for border molding. The margins of the oronasal defect and the right buccal mucosa were border molded by using a green stick modeling plastic impression compound to capture muscle movements. The definitive impression was made with medium-body PVS impression material (Aquasil; Dentsply Sirona). Following the technique described by Leupold and Kratochvil[18] in 1965, the impression was placed on the sectioned definitive cast and then poured in Type IV stone to create an altered cast. The altered cast was mounted, and the tooth arrangement was transferred to the framework for trial placement. A palatogram (with medium-body PVS) was also performed during the wax denture trial placement stage.[19] The waxed obturator was flasked and processed using the lost-wax processing technique with heat-polymerized acrylic resin (Fig. 7).

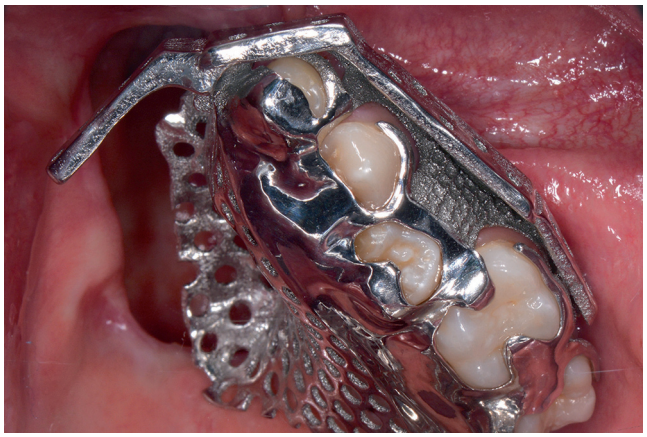

Figure 6. Framework trial placement.

DISCUSSION

Before fabrication of the conventional obturator, a vascularized bone-containing free flap was also provided as a treatment option to provide bony foundation for dental implants and better support and cross-arch stability for the obturator. However, as the patient declined further surgeries, the described treatment approach was chosen.

Providing good support, stability, and sufficient retention for maxillofacial prostheses is essential for the successful functioning of the prosthesis. It is even more challenging for prosthesis design when major anatomic structures have been ablated with tumor removal. Using CAD-CAM technology and digital fabrication methods helped accomplish the more complicated metal framework design in this situation. Digital surveying of the scanned model in the virtual space determined the ideal path of insertion with desired undercut location and amount more easily and accurately than conventional surveying. Excellent fit between the metal framework and the natural teeth and good adaptation of the denture base to the supporting tissues helped enhance the stability and retention of the obturator.[20,21]

Early prepubertal childhood hemimaxillectomy had resulted in severe horizontal reverse occlusion due to limited transversal palatal growth. The maxillary remaining palatal arch rotated and migrated to the midline resulting in insufficient lip support and tooth articulation. With the twin row arrangement, the obturator provided labial support for esthetics and for occlusal contacts to articulate with mandibular dentition. The design of the framework provided appropriate support to the denture teeth and prevented a cantilever effect. The metal clasp assembly on the remaining dentition fit precisely to provide adequate retention, stability, and support. The result was a

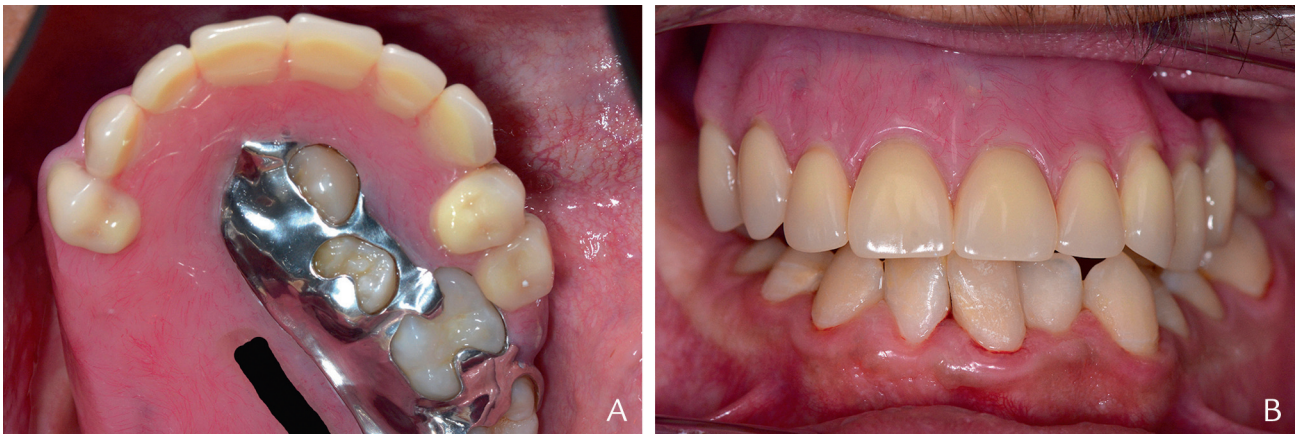

Figure 7. Definitive obturator. A, Occlusal view. B, Frontal view in maximal intercuspal position.

complex framework design which cannot be easily achieved with a conventional casting technique. The printed wax resin was a cost-effective method for assessing the framework fit to confirm the accuracy of the scan data before the actual fabrication of the metal alloy framework. Despite the report by Eggbeer et al,[3] the printed resin model was not used as a sacrificial pattern in the process of framework fabrication. The SLS technology helped create a well-fitting framework.

Another benefit of the CAD digital workflow was the ability to superimpose the scanned trial denture teeth onto the patient's virtual definitive cast. This facilitated the virtual evaluation of the relationship of the designed framework and the planned denture teeth. Using digital technology in this manner reduced both laboratory working time and the dental materials required.

An implant-assisted prosthesis is a good option for rehabilitating these kind of defects. However, in this situation, because of the patient's young age and financial constraints, the presented treatment was chosen.

SUMMARY

Application of digital surveying and SLS are contemporary techniques for designing and fabricating metal frameworks for various prostheses. In the patient presented, incorporating a digital technique not only helped accomplish a more complicated framework design but also resulted in acceptable fit, function, and esthetics for the definitive obturator.

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