Complete Oral Rehabilitation With Implants Using CAD/CAM Technology, Stereolithography, and Conoscopic Holography

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A 64-year-old totally edentulous female initially presented with ill-fitting removable prostheses. A comprehensive treatment plan with dental implants was accepted by the patient. Clinical and laboratory procedures were executed using various computer technologies including computed tomography, rapid prototyping, and optical scanning using conoscopic holography. A review of the patient's treatment and various modalities used are the focus of this patient report. (Implant Dent 2012;21:8–12)

Key Words: dental implants, osseointegration, surgical template

Technology is changing the way practitioners are able to plan treatment for their patients and is allowing them to offer solutions to their patients that were not available before. Specifically in the area of implant dentistry, dentists and technicians alike are able to use medical imaging to help idealize implant locations as they relate to the bone and mucosa. Ultimately, preplanning of patient treatment using medical imaging leads to more predictable esthetic and functional prosthetic rehabilitations.

The patient treatment described in this report uses various modalities at various stages to deliver the patient's desired final result. Computed tomography (CT) is a medical imaging technique in which images are digitally acquired in slices, which are reformatted into virtually any 2-dimensional or 3-dimensional (3D) perspective.[1] Stereolithography (STL),[2–4] sometimes referred to as 3D printing, is a rapid prototyping technique that takes a geometric definition from a medical image volume, like a CT scan, and then uses a 3D biomedical visualization software package to convert it into a suitable 3D format that can be produced. Conoscopic holography[5] is an optical scanning technique based on optical propagation through birefringent crystals where the projected and reflected beams travel the same linear pathway to and from the scanned object. All of these modalities in concert with one another allowed for the delivery of maxillary and mandibular implant-supported fixed prostheses in the following patient report.

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CASE REPORTS

Patient

A 64-year-old white female presented to a private practice specializing in prosthodontics. At her initial presentation, she was completely edentulous with a high smile line (Fig. 1). Her current removable complete dentures were ill-fitting, and her chief complaint was that she "no longer felt comfortable in public." The patient claims she had been wearing dentures for 40 years. Her medical history is noncontributory, only suffering from small bouts of arthritis and low blood pressure.

A cone beam computed tomography scan (i-CAT; Imaging Sciences International, Hatfield, PA) revealed atrophic ridges and the poor prognosis for removable prosthetics (Fig. 2). The patient also had a Class III occlusal scheme that was determined via diagnostic models and a lateral cephalometric radiograph.

A comprehensive treatment plan was developed between the prosthodontist and the laboratory technician which included maxillary- and mandibular-guided implant placement. The patient accepted the treatment plan offered which culminated with maxillary and mandibular implant-supported screw-retained final restorations built with milled titanium frameworks.

Presurgical Procedures

Treatment began with the fabrication of new removable prostheses. It is the authors' opinion that all dental implant treatment must be prosthetically driven. These new removable prostheses act as a template for the design of the final prostheses in this particular guided surgical protocol (NobelClinician; Nobel Biocare, Yorba Linda, CA).[6–8]

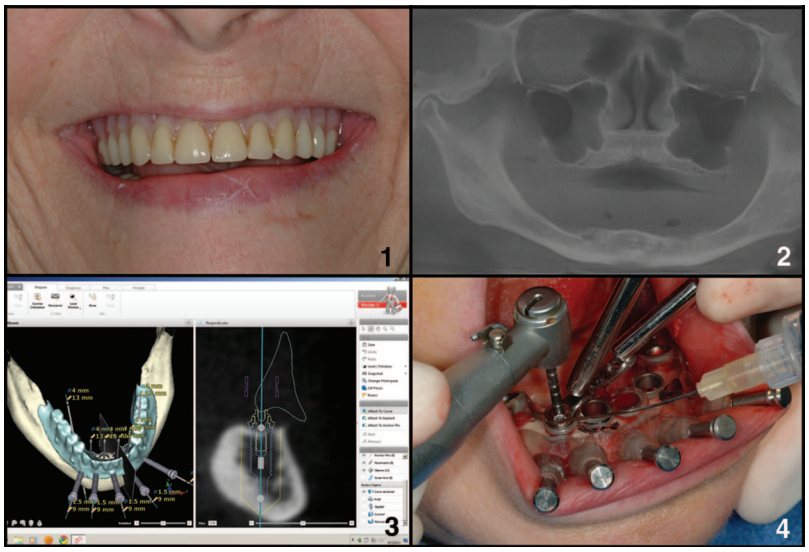

Fig. 1. Frontal view of patient at initial presentation illustrating worn and ill-fitting removable dentures.
Fig. 2. Panoramic radiograph from the pretreatment cone beam computed tomography scan reveals atrophied edentulous arches.
Fig. 3. Screen capture from the NobelClincian software of finalized mandibular virtual implant planning with 6 implants and 5 anchor pins.
Fig. 4. Osteotomy preparation for a Brånemark System MKIII RP implant in the mandibular anterior.

Radiopaque markers (gutta-percha; Coltene Whaledent, Cuyahoga Falls, OH) were embedded into the removable prostheses with each site about 1.5 mm in circumference. A polyvinyl siloxane (Regisil 2x; Dentsply, Milford, DE) centric occlusal index was taken to stabilize the removable prostheses during the forthcoming CT scanning procedures.

The dual CT scan technique associated with this guided surgery protocol was accomplished, and the digital imaging and communications in medicine (DICOM) files were exported to the diagnostic and virtual treatment planning software (NobelClinician; Nobel Biocare, Yorba Linda, CA). The maxillary and mandibular virtual surgeries were designed and approved by both the prosthodontist and the laboratory with the final prostheses in mind. The maxillary virtual implant planning was designed with 8 external connection implants (NobelSpeedy Groovy; Nobel Biocare, Yorba Linda, CA) and 4 anchor pins. Six of these implants were planned in the anterior maxilla, and 2 of these implants were planned in the pterygomaxillary region.[9,10] In the mandible, 6 external connection implants (Brånemark System MKIII; Nobel Biocare, Yorba Linda, CA) and 5 anchor pins were positioned (Fig. 3).

The computer-assisted design files of the maxillary and mandibular virtual plannings were transmitted through the internet to the production facility (NobelProcera, Mahwah, NJ) where those files dictated the stereolithic construction of the surgical templates. Also fabricated at the production facility were stereolithic duplicates of the patient's removable prostheses that were part of the dual CT scan protocol. The 2 templates and duplicate dentures were sent to the laboratory for construction of maxillary and mandibular all-acrylic resin provisional prostheses.

The laboratory used the surgical templates to retroengineer an implant-level maxillary and mandibular master cast with a soft tissue replication. The stereolithic duplicate dentures were used in conjunction with the polyvinyl siloxane occlusal index (from the day of the CT scan) to position the master casts in an articulator. This technique allows for precise replication of what exists clinically with the existing removable prostheses. The laboratory technician then chose appropriate collar heights for transmucosal abutments (Multi-Unit; Nobel Biocare, Yorba Linda, CA), which were positioned for each of the 14 implants. The prosthetic cylinders (Temporary Titanium Coping Multi-Unit; Nobel Biocare, Yorba Linda, CA) were adjusted as necessary for the all-acrylic resin provisional prostheses, and teeth were positioned in relationship to the master casts exactly how the teeth were positioned in the stereolithic duplicate dentures. Before sending the completed laboratory work back to the prosthodontist, indexes were fabricated on the articulator between each surgical template and the opposing duplicate denture.

Implant Placement and Provisional Prosthesis Delivery

The patient was anesthetized with 8 carpules of 1.8 mL Bupivacaine 1:200,000 (Arestream Health; Cambridge, ON). The mandibular surgical template was carefully positioned with the laboratory-fabricated index against the maxillary removable denture. After the anchor pins were placed, the 6 external connection implants were installed with the depth-controlled drilling system through the surgical template (Fig. 4). The surgical template was then removed, and the mandibular removable denture was replaced to create the reference for delivery of the maxillary surgical template. Anchor pins were installed to secure the maxillary surgical template and allow for the placement of 8 external connection implants.

The transmucosal abutments that were used on the master cast to fabricate the provisional prostheses were sterilized and then transferred to the patient. These abutments will remain in place as long as the implants are clinically successful. Keeping the implant-abutment interface intact from baseline reduces the effect of the microgap that occurs with removal and replacement of abutments in conventional 2-piece implant systems.[11,12] The all-acrylic resin provisional prostheses that were prefabricated in the laboratory were delivered with retaining screws (Prosthetic Screw Multi-

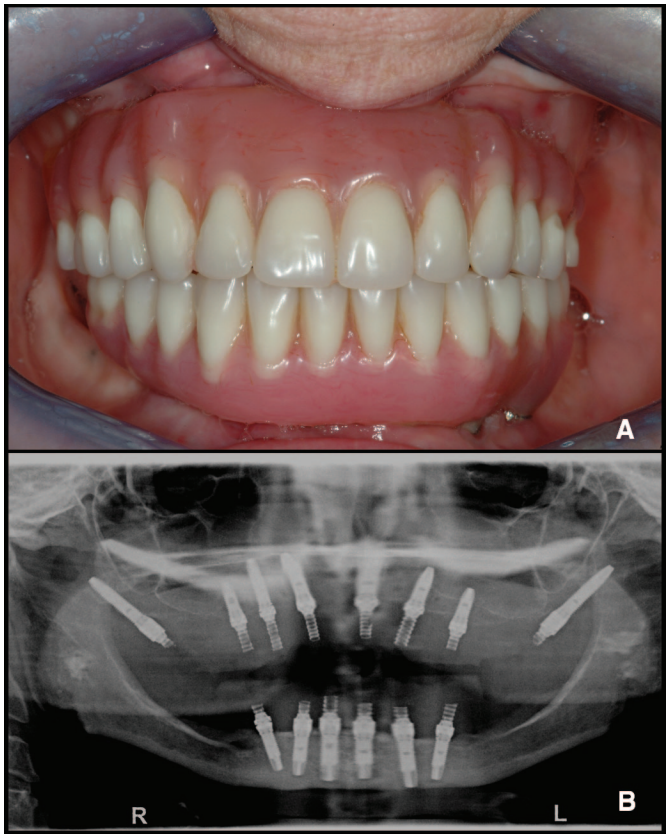

Fig. 5. A, Frontal view of maxillary and mandibular all-acrylic resin screw-retained provisional prostheses. **B**, Panoramic radiograph 48 hours after implant placement. One temporary cylinder in each arch is not completely seated onto the abutment despite all screws tightened to the recommended 15 N/cm torque.

Unit; Nobel Biocare, Yorba Linda, CA), thereby immediately loading the maxillary and mandibular implants (Fig. 5A and B).

Final Prosthesis Construction

Three months after implant placement, the patient presented for final impressions. As observed in the panoramic radiograph 48 hours after implant placement (Fig. 5B), not all the temporary cylinders were seated fully onto the abutments and therefore the provisional prosthesis could not be used as the impression splint to create an accurate master cast. It was noted that one of the maxillary implants was not integrated, and it was removed. The appropriate temporary cylinder in the all-acrylic resin provisional prosthesis was removed, and the prosthesis was refined and polished. No provisions for replacement of the implant were made as it was determined that the final restoration would be adequately supported by the remaining 7 implants.

Direct transfer copings (Open Tray Impression Coping Multi-Unit; Nobel Biocare, Yorba Linda, CA) were installed and connected with dental floss and pattern resin (GC Resin; GC America, Alsip, IL) to stabilize the impression. The newly fabricated impression splint was captured in the impression. Abutment analogs (Multi-Unit Abutment Replica; Nobel Biocare, Yorba Linda, CA) were installed into the direct transfer copings. A soft tissue replication material (Gingifast Rigid; Zhermack, Eatontown, NJ) was used followed by minimal expansion die stone (Die-Keen; Heraeus Kulzer, South Bend, IN) to fabricate the master casts. These casts were articulated using the patient's provisional restorations as the jaw relationship was to be replicated in the final restorations. Esthetic modifications from the provisional prostheses were noted for the laboratory.

The final prosthesis design for both the maxilla and the mandible was a computer numeric controlled (CNC)-milled titanium framework (NobelProcera Implant Bridge; Nobel Biocare, Mahwah, NJ) veneered with thermocure acrylic resin (Clássico; Artigos Odontológicos Clássico, São Paulo, Brazil) and acrylic denture teeth (Blueline; Ivoclar, Amherst, NY). It has been well documented in the literature that CNC-milled frameworks for edentulous arches have higher accuracy of fit to the master cast than traditional casting techniques.[13–16]

Facial and occlusal matrices (Zetalabor; Zhermack, Eatontown, NJ) were made to record tooth position to fabricate an acrylic-resin pattern of the framework. The same type of temporary cylinders used in the provisional prostheses was used to build the pattern and secure it to the master cast. The temporary cylinders were connected with autopolymerizing methylmethacrylate resin (Unifast Trad; GC America, Alsip, IL). The resin patterns were designed to consider strength of the milled titanium framework and space for veneering materials.

The maxillary pattern was connected to the specific holder for the optical scanner (NobelProcera Scanner; Nobel Biocare, Yorba Linda, CA) with old lab burs and pattern resin. Specific abutment replica position locators were installed onto the master cast, which was then secured to the scanner. These locators were scanned to determine the precise position of the replicas in the master cast. A similar position locator that mates with the temporary cylinder in the resin pattern was connected. These positions were acquired by the optical scanner as well. Finally, the resin pattern itself is scanned to acquire its 3D shape as it relates to the cylinder positions. This is done in 2 stages: the tissue side is scanned first, followed by the tooth side. The scanner holder has 3 reference "dimples" that allow these 2 stages of scanning to be merged to-

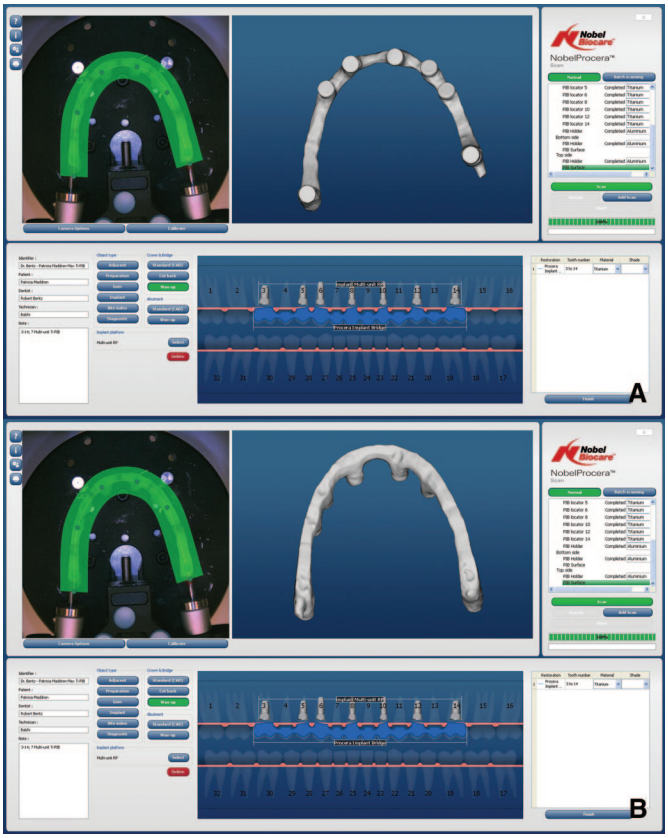

Fig. 6. A, Screen capture from the NobelProcera software scanning module illustrating the tissue surface of the resin pattern. Part of the pattern resin connection to the holder on the patient's right side was picked up during the scanning procedures. **B**, Screen capture from the NobelProcera software scanning module illustrating the tooth surface of the resin pattern. Part of the pattern resin connection to the holder on the patient's right side was picked up during the scanning procedures.

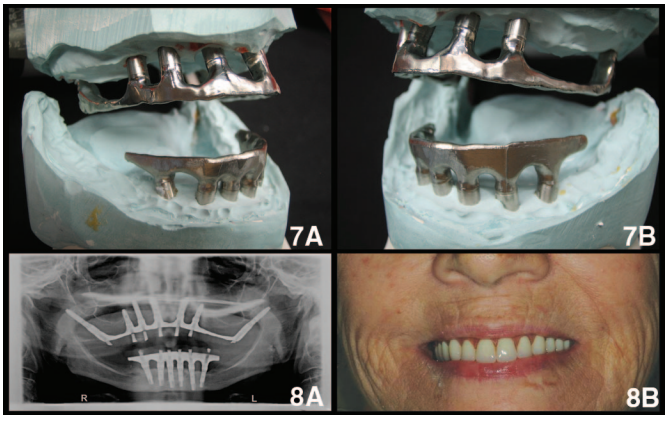

Fig. 7. A, Right lateral view of articulated master casts with CNC-milled titanium frameworks in place. **B**, Left lateral view of articulated master casts with CNC-milled titanium frameworks in place.

Fig. 8. A, Panoramic radiograph 2 years after implant placement. **B**, Frontal view of patient at 2 years after implant placement with definitive CNC-milled titanium frameworks.

gether to create the STL file (Fig. 6A and B) that is ultimately sent to the production facility for copymilling. The STL file can be modified in the software to trim any excess material that was picked up from the connection of the resin pattern to the scanner holder. The same scanning process was completed for the mandibular pattern.

A solid block of titanium grade 2 is milled according to the STL file that is transmitted to the production facility (NobelProcera, Mahwah, NJ). Figure 7, A and B, shows the CNC-milled implant bridges placed onto the master casts to confirm seat. The frameworks were roughened with old or dull burs to increase the mechanical retention of a pink opaquer (Gradia; GC America, Alsip, IL). The denture teeth were set into position in wax which was then tried clinically to obtain patient acceptance. After final approval, the prostheses were processed with the thermocure acrylic resin. The prostheses were then delivered, and the fit was checked clinically and radiographically. Prosthetics screws were torqued to the recommended 15 N/cm. The patient has been followed for routine hygiene maintenance for the past 2 years (Fig. 8A and B).

CONCLUSION

The patient treated in this report experienced a life-changing experience with dental implant therapy in a minimally invasive treatment approach. The combination of medical imaging, CAD software, and stereolithography allowed for the design of a surgical template that resulted in flapless dental implant placement. Definitive prostheses were made using the latest optical scanning technology available, resulting in passive-fitting frameworks. Blending of these technologies resulted in a stable and predictable reconstruction for this edentulous patient.

DISCLOSURE

The authors claim to have consulting fees and/or honoraria and/or support for travel "not for this study but for lectures on various Nobel Biocare products at study clubs or annual sessions," an ongoing relationship with Nobel Biocare.

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