Dental implants have become a predictable treatment option for the patient with complete or partial edentulism. A 3- to 6-month healing period is usually recommended to achieve osseointegration before loading the implants with a prosthesis. Immediate restoration of endosseous root form implants was first described for the patient with complete edentulism in whom a fixed implant-supported prosthesis is placed the same day of implant surgery. The cross-arch stabilization of the implants through the prosthesis during immediate loading procedures may provide the stability necessary for the implants to osseointegrate.

While conventional implant placement for patients with complete edentulism involves implants placed perpendicular to the occlusal plane to simulate the direction of the roots of natural teeth, several authors have introduced the concept of having implants placed in a tilted direction in an attempt to overcome areas where bone availability is insufficient and to reduce the length of distal cantilevers. Tilted implants generate better biomechanical responses and do not differ significantly either in implant failure rate compared with upright implants or in marginal bone loss. According to the tilted implant positioning protocol, a total of 4 implants might be sufficient to support a complete-arch, implant-supported prosthesis effectively. However, several authors have reported a high prevalence of mechanical and prosthetic complications.

The surgical protocol for immediate loading with 4 implants with the distal 2 implants placed in a tilted position involves reducing the residual alveolar ridge to provide space for the prosthetic components. Misch et al indicated that, ideally, a 14-mm space is required between the incisal edge of the mandibular anterior teeth and the crest of the bone after alveolar ridge reduction.

As a variation from the protocol introduced by Maló et al, several authors have applied the guided surgery protocol for the all-on-4 procedure. According to the guided surgery protocol, a surgical guide is made based on data obtained through cone-beam computed tomography (CBCT), and implant surgery is performed without raising a flap. The objectives are to reduce patient discomfort by not raising a flap, reduce surgical time, and enhance implant placement accuracy by...
reducing operator error. However, flapless surgery does not enable the clinician to access the alveolar crest and perform osteoplasty before implant surgery. This may lead to insufficient space for the prosthetic components when the definitive prosthesis is designed.

The purpose of this clinical report was to demonstrate a treatment planning and surgical sequence that enables the operator to perform guided alveolar ridge reduction based on the prospective interim prosthesis and to perform guided implant placement after the alveolar ridge reduction has been completed.

CLINICAL REPORT

A 66-year-old white woman presented at the Center for Prosthodontics and Implant Dentistry at Loma Linda University seeking treatment for her mandibular partial and maxillary complete edentulism (Fig. 1). Her residual mandibular teeth had a poor prognosis. After discussing different treatment options, the decision was made to fabricate a maxillary complete denture, extract the remaining mandibular teeth, and place 4 dental implants in the mandible to support an implant-supported fixed prosthesis. An interim implant-supported fixed prosthesis would be placed the day of implant surgery.

Following conventional prosthodontic procedures, preliminary impressions were made of the maxilla and mandible with alginate impression material (Kromopan 100 chromatic alginate; Kromopan USA) in stock trays. Custom acrylic resin trays were fabricated and border molded intraorally. After definitive stone casts had been fabricated and the tooth arrangement confirmed intraorally, interim maxillary and immediate mandibular complete dentures were fabricated.

A CBCT was obtained and the data sent via email to a printing facility to have stereolithographic casts made of the mandible arch (Stereolithographic Model; Biomedical Modeling Inc). The fabrication process included the application of red dye to simulate the position of the inferior alveolar nerve.

The immediate complete denture was duplicated with a denture duplicator (Lang Denture Duplicator; Lang Dental). The duplicate immediate complete denture was then superimposed on the stereolithographic cast to evaluate the distance between the incisal edges of the anterior mandibular teeth and the crest of the residual alveolar ridge. This distance was measured with a peri-odontal probe (PCPUNC15 Probe; Hu-Friedy) (Fig. 2), revealing insufficient space between the incisal edges of the mandibular anterior teeth and the residual alveolar ridge (10 mm rather than the necessary minimum of 14 mm). An alveolar ridge reduction of at least 4 mm was required.

An acrylic resin alveolar ridge reduction guide (GARR) was then fabricated from autopolymerized acrylic resin (DuraLay; Reliance Dental Mfg Co) along the periphery of the stereolithographic cast and at a level consistent with the required alveolar ridge reduction. With the GARR, the crest of the residual alveolar ridge on the stereolithographic cast was reduced in the laboratory with an acrylic bur (UC251E regular cross CUTiE; Axis/Kerr Dental) (Fig. 3). The implant replicas were then placed freehand on the stereolithographic cast. The appropriate location was determined by evaluating critical anatomic landmarks (mental nerve location, lingual...
plate, buccal plate, and anterior mental loop of the inferior alveolar nerve) and by using the duplicate of the immediate complete denture to ensure the proper location of the occlusal screw access on the definitive prosthesis. The 2 distal implants were placed in a tilted position, and the 2 anterior implants were placed in an upright position (Fig. 4A). This positioning aimed to reduce the length of the distal cantilevers.

Guided laboratory abutments (Guided Laboratory Abutment; Nobel Biocare) were placed on the implant replicas with the corresponding screws (Guided Laboratory Screw; Nobel Biocare). Temporary titanium copings (Guided Titanium Temporary Coping; Nobel Biocare) were secured on the replicas and autopolymerizing acrylic resin (Ortho Resin; Dentsply Caulk) was applied externally (Fig. 4B); the corresponding metal sleeves (Guided Sleeve; Nobel Biocare) provided by the manufacturer were embedded in the autopolymerizing acrylic resin. In addition, 2 guide pins (Guided Pin; Nobel Biocare) were embedded in the acrylic resin material facially to assist in securing the guide during surgery.

After removing the excess acrylic resin material and polishing, the implant placement guide (IPG) was completed (Fig. 4B).

The surgical procedure was performed under local anesthesia. After removing the residual natural teeth, full thickness labial to lingual flaps were reflected. Under copious saline irrigation, the residual alveolar ridge was reduced with a surgical bur (Pear bur; ACE Surgical Supply Co). The GARR was positioned on the residual alveolar ridge, and the alveolar ridge reduction was aided by the GARR (Fig. 5A), duplicating the simulated alveolar ridge reduction. The IPG was then secured on the alveolus with the anchoring pins. After confirming the stability of the guide, the osteotomies were prepared under copious saline irrigation with the drilling protocol provided by the manufacturer for guided implant surgery. Successive guided drill guides (Guided Drill Guide; Nobel Biocare) designed according to the diameter of the drills (Guided Twist Drill; Nobel Biocare) were used progressively during the osteotomy process for each implant (Fig. 5B). Four threaded root form implants

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**Figure 3.** A, Acrylic resin guide used to simulate alveolar ridge reduction in laboratory. B, Sufficient space between incisal plane and reduced alveolar ridge confirmed.

**Figure 4.** A, Dental implant surgery simulated with stereolithographic cast. B, Surgical guide complete with guided sleeves and guided pins embedded in autopolymerizing acrylic resin.
(Nobel Replace Select; Nobel Biocare) 10 mm in length and 4.3 mm in diameter were placed through the IPG to duplicate the position of the implants on the stereolithographic cast. All dental implants were placed with 35-Ncm torque. After implant placement was completed, the IPG was removed, multiunit abutments were placed (Multi-unit Abutment; Nobel Biocare), and temporary metal abutments (TMAs) were secured on top of the implants. A rubber dam was placed on top of the TMA to stop acrylic resin material contaminating the surgical field. The immediate complete denture was then modified by opening access holes to accommodate the TMA, and autopolymerizing acrylic resin (Pattern Resin; GC America Inc) was applied around the access holes of the immediate complete denture and the TMA to connect the TMA with the immediate complete denture. Once the acrylic resin had polymerized, the converted prosthesis was picked up intraorally, further modified in the laboratory, polished, and placed in the patient’s mouth on the day of surgery.

A period of 6 months was allowed for the implants to osseointegrate and to evaluate the esthetics, function, occlusion, and phonetics of the interim prosthesis before fabricating the definitive restoration. The restorative phase included the fabrication of a definitive stone cast. The restorative space available between the incisal edges of the anterior teeth of the immediate complete denture and the residual alveolar ridge was confirmed with a periodontal probe (Fig. 6).

Scannable abutments provided by the manufacturer were placed on the implant analogs, and the position of the implants was captured with a laboratory scanner (NobelProcera 2G Scanner; Nobel Biocare). The maxillary occlusal plane was also scanned, and a titanium bar milled with a computer-aided design and computer-aided manufacturing (CAD/CAM) milling process (Procera; Nobel Biocare). After confirming the fit of the metal frame intraorally, acrylic resin denture teeth were placed on the frame with denture base wax (Baseplate Wax; Henry Schein Inc). The arrangement was evaluated intraorally to verify esthetics, occlusion, occlusal vertical dimension, and speech and was processed with high-impact acrylic resin (High Impact-45; Lang Dental Manufacturing Co, Inc). The definitive prosthesis along with a new complete maxillary denture were delivered. The fit, esthetics, and occlusion of the definitive prostheses were then verified intraorally (Fig. 7) and a panoramic radiograph was made (Fig. 8).

**DISCUSSION**

Flapless guided implant surgery has been shown to be more accurate than freehand surgery. However, even with improved accuracy, significant differences in actual implant placement and the initially planned implant position have been reported. Tahmaseb et al. in a systematic review, revealed a total mean error or 1.12 mm at the entry point as measured in 1530 implants.
and 1.39 mm at the apex as measured in 1465 implants. However, relatively large deviations in the level of inaccuracy were found, and publications have reported a maximum or 7.1 mm of error at the apex and of 4.5 mm at the entry point. Interestingly, a bone-anchored surgical guide for completely edentulous patients offered significantly less accurate implant positioning than the other types of surgical guides. The level of accuracy of the technique used for this patient is unknown. However, because the flaps were raised before the surgical template was secured on the bone, the authors suggest that the template might offer better accuracy than conventional flapless bone-anchored templates, because the soft tissue limiting factor is eliminated after flap elevation. The fit of the template was based on bone anatomy and was not related to soft tissue thickness, soft tissue compressibility, or soft tissue enlargement after local anesthetics had been administered. A clinical, animal, or in vitro study comparing the planned and virtual implant positioning by using this technique is needed to validate its accuracy.

Regardless of the different accuracy levels and implant survival rates, guided implant surgery has been associated with a high degree of surgical and mechanical complications, significantly higher than with conventional free-hand implant surgery. D’haese et al in a review of the literature revealed a maximum complication rate of 42% when stereolithographic guided surgery was combined with immediate loading. Di Giacomo et al reported a 34.41% complication rate. Tahmaseb et al in a systematic review revealed a 36.4% complication rate that pertained to either the surgical phase or the immediate restorative phase when implants were immediately loaded. Complications included template fractures during surgery, limited primary implant stability necessitating a change of plan, and prosthesis fracture. With regard to the reported fracture of the guided surgery template, the presented technique may offer a solution by offering the operator the option of fabricating a guide with increased thickness that will improve the mechanical properties. The currently available surgical guides have typically a standardized thickness that seems to be insufficient to withstand the compressing and tensile forces during implant surgery. With the presented technique, the clinician may instruct the laboratory technician to fabricate a template with increased thickness to reduce the possibility of fracture.

The main disadvantage of the proposed technique is the additional cost involved in producing a stereolithographic cast and fabricating the IPG. The operating clinician needs to evaluate the potential benefits along with the increased cost and lack of research data regarding the proposed technique before implementing it in routine clinical practice.

**SUMMARY**

The treatment presented enabled alveolar ridge reduction according to a presurgically modified cast. This technique may assist the clinician in obtaining adequate space for the restorative prosthesis and enhance the accuracy of alveolar ridge reduction and dental implant placement. A clinical study is needed to evaluate the accuracy of alveolar ridge reduction and the accuracy of dental implant placement when the described procedure is used.

**REFERENCES**


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