Eighteen-Month Outcomes of Titanium Frameworks Using Computer-Aided Design and Computer-Aided Manufacturing Method

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Purpose: *The aim of the report is to introduce a new software and a new scanner with a noncontact laser probe and to present outcomes of computer-aided design and computer-aided manufacturing titanium frameworks using this new software and scanner with a laser probe.*

Materials and Methods: *Seven patients received 40 implants placed using a 1-stage protocol. After all implants were planned using an implant planning software (Nobel-Clinician), either 5 or 6 implants were placed in each edentulous arch. Each edentulous arch was treated with a fixed dental prosthesis using implant-supported complete-arch milled-titanium framework using the software (NobelProcera) and the scanner. All patients were followed up for 18 ± 3 months. Implant survival, prosthesis survival, framework fit, marginal bone levels, and maintenance requirements were evaluated.*

Results: *One implant was lost during the follow-up period, giving the implant survival rate of 97.5%; 0.4 ± 0.2 mm marginal bone loss was noted for all implants after 18 ± 3 months. None of the prostheses needed a replacement, indicating the prosthesis success rate of 100%.*

Conclusion: *The results of this clinical study suggest that titanium frameworks fabricated using the software and scanner presented in this study fit accurately and may be a viable option to restore edentulous arches. (Implant Dent 2017;26:480–484)*

Key Words: implant, mandible, prosthesis, survival, maintenance

Computer-aided design and computer-aided manufacturing (CAD/CAM) technology has dramatically improved both surgical and restorative aspects of implant dentistry.[1–8] CAD/CAM fabrication of frameworks has resulted in elimination of distortion, better fit, and fewer fabrication steps.[2,9,10] A few recent studies revealed that the CAD/CAM frameworks were significantly more accurate than the cast frameworks.[9,11]

A few 3-dimensional (3-D) planning softwares to design and to fabricate surgical guides and frameworks are available in the market.[2,12,13] A company (NobelBiocare USA, Yorba Linda, CA) recently launched a new software (Procera, version 4.0.10.5; NobelBiocare USA) and a new scanner (Procera Forte; NobelBiocare USA), which have several novelties compared with the previous versions. When the former version of the scanner was used, a wax pattern fabrication for each framework before scanning was necessary.[2] The probe of the scanner, a 2-mm ball, needed to touch the wax pattern during scanning, which was one of the drawbacks of this process. Wax pattern contours were frequently modified to accommodate the probe's size and shape, thus allowing a complete scan of the framework. These modifications, however, required additional finishing after the framework was fabricated because the modified wax did not represent ideal framework contours. The new scanner, benefitting from data acquisition via a noncontacting laser, can fabricate most implant-supported framework designs without using a wax pattern.

This clinical report aimed to introduce the new software and scanner and to describe the design and fabrication of implant-supported, screw-retained milled-titanium frameworks and also to present the 18-month outcomes of patients treated with this technique.

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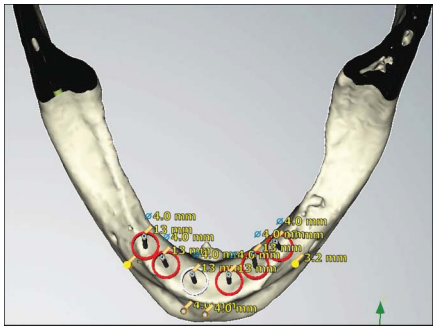


Fig. 1. Position of implants was determined using NobelClinician software. Occlusal view of the implants and mandible can be seen on the 3-D model.

MATERIALS AND METHODS

Seven patients with at least one edentulous arch or a failing dentition, who were looking for an implant-supported fixed dental prosthesis (FDP), were included in this study. This study has been approved (protocol number: HSC20130042E) by the Institutional Review Board of the University of Texas, Health Science Center at San Antonio, TX. Clinical and radiographic examinations were completed before their inclusion to this treatment. Seven patients (6 females, 1 male), aged 52 to 77 years (mean age 66 ± 10 years), received 40 implants. Of the 40 implants, 18 were placed into fresh extraction sockets. For each edentulous arch, either 5 or 6 implants were planned using an implant planning software (NobelClinician; NobelBiocare USA) (Fig. 1). Each patient signed an informed consent before implant placement and/or extractions. Then, all 40 implants (NobelReplace Straight Groovy; NobelBiocare USA) were placed using 1-stage surgical approach (Table 1). The implants were left to heal 3 months in the mandible and 6 months in the maxilla for osseointegration.

The following steps were followed to fabricate each implant-supported, screw-retained FDP. The healing abutments were unscrewed, and impression copings were screwed on the implants. An implant-level impression using closed-tray impression copings (NobelBiocare USA) and vinyl polysiloxane impression material (Aquasil; Dentsply Intl, York, PA) was made. After implant replicas (NobelBiocare USA) were connected to the impression copings, the definitive cast using type IV dental stone (ResinRock; Whip Mix Corp., Louisville, KY) was poured. Maxillary and mandibular trial dentures (Ivoclar Vivadent Inc., Amherst, NY) were fabricated using traditional prosthetic methods. A trial denture insertion was performed, and centric occlusion, esthetics, phonetics, and occlusal vertical dimension were confirmed. Each definitive cast was sprayed with zinc oxide powder (Dr. Scholl's Spray Powder; Bayern, Chicago, Illinois) (Fig. 2), and then the scanning abutments were screwed on the implant replicas. The definitive cast with scanning abutments was scanned (Figs. 3–5). This allowed the software (NobelProcera, version 4.0.10.5; NobelBiocare USA) to locate the implant platforms. The definitive cast without scanning abutments was scanned. This allowed the software to register the tissue surface. Then, each trial denture was scanned after it was sprayed with zinc oxide

Table 1. Details of the Implants Used in This Study

Type of Implants	Diameter and Length of Implants (mm)	No. Implants
NobelReplace Straight Groovy	4 × 10	2
NobelReplace Straight Groovy	4 × 11.5	2
NobelReplace Straight Groovy	4 × 13	14
NobelReplace Straight Groovy	4 × 15	14
NobelReplace Straight Groovy	5 × 11.5	1
NobelReplace Straight Groovy	5 × 13	1
NobelReplace Tapered Groovy	3.5 × 10	1
NobelReplace Tapered Groovy	4.3 × 10	5

For each edentulous arch, either 5/6 implants were planned using an implant planning software. Forty implants were placed using 1-stage surgical approach.



Fig. 2. Mandibular definitive cast was sprayed with zinc oxide powder before placing scanning abutments, after a trial denture insertion was performed, and centric occlusion, esthetics, phonetics, and occlusal vertical dimension were confirmed.

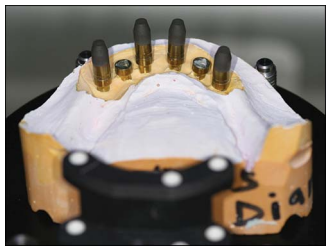


Fig. 3. Scanning abutments were screwed on the implant replicas. The previously sprayed definitive cast was mounted for scanning.



Fig. 4. The laser probe created a red dot during scanning process. The area pointed by red line was captured by the scanner, which shows the implant locations.

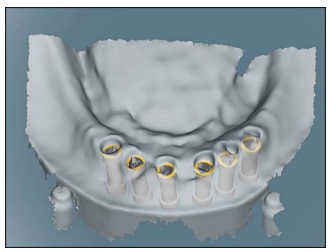


Fig. 5. Occlusal view of mandibular cast with implant positions was generated after scanning process. The position of each implant was visually determined in the mandible.

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Fig. 6. Each trial denture was scanned after it was sprayed with zinc oxide powder and seated on the definitive cast, after the determination of implant locations and tissue surface.

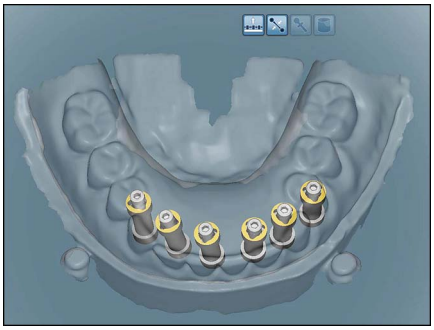


Fig. 8. Occlusal view of trial denture overlapping mandibular cast including implants can be seen after scanning process. This shows the location of each implant screw and denture teeth locations.

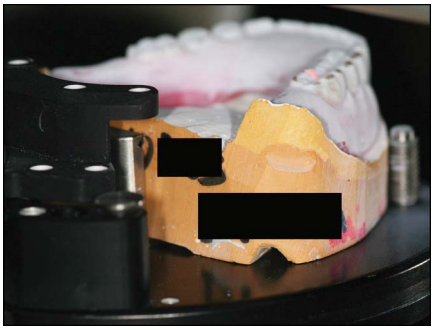


Fig. 7. The red line was generated by laser probe during trial denture scanning process. This captures the denture teeth locations and denture surface.

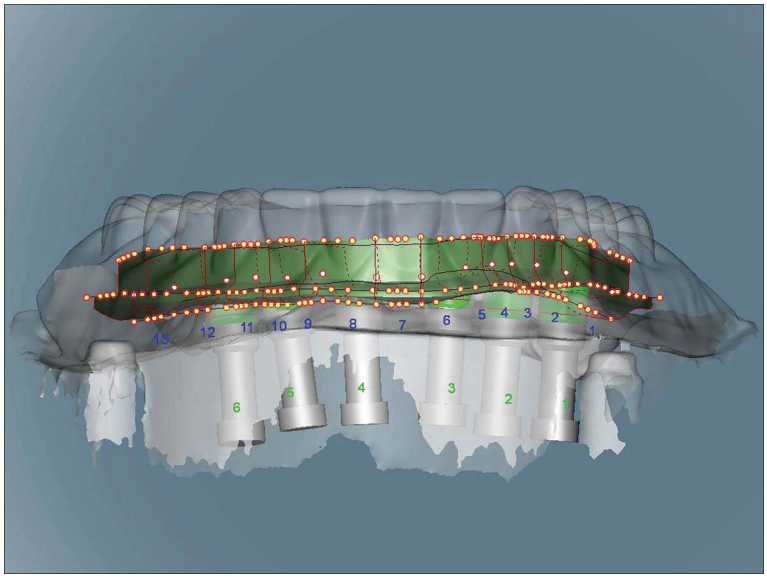


Fig. 9. Frontal view of final design of mandibular framework. Height, width, and shape of framework can be determined according to scan of trial denture using special markers provided by software.

powder (Dr. Scholl's Spray Powder; Bayern, Chicago, Illinois) and seated on the definitive cast (Figs. 6 and 7). If the scanning process was performed accurately, the planning software overlays these 3 different scans without any problems (Fig. 8). The height, width, and shape of framework were determined according to the scan of the trial denture (Figs. 9 and 10). This information for each arch was sent online to the NobelBiocare Production Center in Mahwah, NJ

In the Production Center, complete-arch titanium frameworks were milled from titanium blocks using CAD/CAM technology. The frameworks were returned to our clinic 3 days after the scanning. After confirming the fit of each titanium framework on the definitive cast, they were intraorally verified (Fig. 11). Each milled framework was secured with a single screw to an implant, and accurate fit was verified radiographically. The denture teeth were transferred from the previously fabricated trial denture to the framework. A second trial denture insertion was performed to evaluate centric occlusion, esthetics, phonetics, and occlusal vertical dimension. The implant-supported, screw-retained FDPs were processed, finished, and polished in the laboratory. The implant-supported, screw-retained FDPs were screwed on the implants. Screw access holes were covered using cotton pellets and composite resin

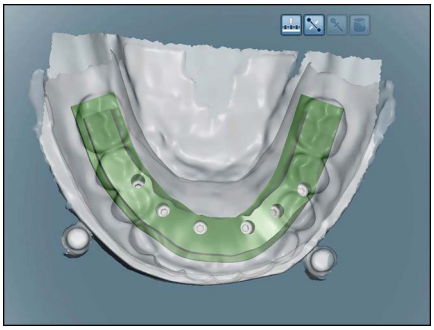


Fig. 10. Occlusal view of final design of mandibular framework can be seen. Note that each item can be easily seen by dentist as each item has different color.

(Figs. 12 and 13). The patients returned to our clinic 1, 3, 6, 9, 12, 15, and 18 months after implant placement for follow-up appointments.

RESULTS

The patients were followed up for 18 ± 3 months. One implant was lost before the prosthesis insertion, indicating the implant survival rate of 97.5%. The average marginal bone loss was 0.4 ± 0.2 mm from the metal framework try-in appointment to the last recall appointment for all implants.

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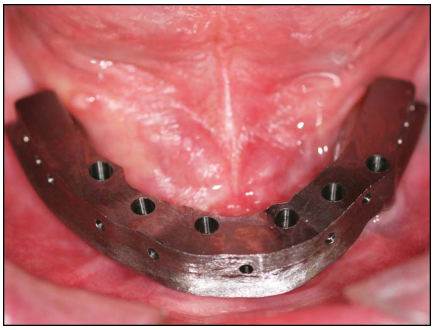


Fig. 11. Clinical fit of the mandibular framework was verified. Note retention features created after milling process.



Fig. 12. The implant-supported, screw-retained FDPs were screwed on the implants. Screw access holes were covered using cotton pellets and composite resin.

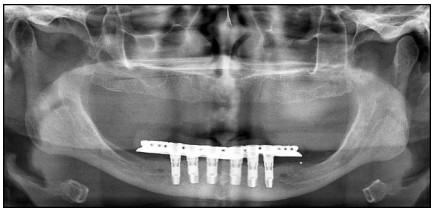


Fig. 13. Panoramic radiographs after maxillary complete denture and mandibular FDP were inserted.

The average marginal bone resorptions were 0.5 ± 0.1 and 0.3 ± 0.2 mm for the implants placed in fresh extraction sockets and healed ridges, respectively. Periapical radiographs using the paralleling technique were taken at the framework try-in appointment to verify the fit and at the last recall appointment. The average of mesial and distal marginal bone changes were recorded for each implant using a software (Axium, British Columbia, Canada).

All frameworks fit accurately, which was verified by single screw test and digital radiographs. No sectionings and weldings were needed for any framework. During the follow-up period, 3 occlusal adjustments were made without removing the prostheses and one broken denture tooth was attached back on the framework using autopolymerizing acrylic resin. None of the prostheses needed a replacement, indicating the prosthesis success rate of 100%.

DISCUSSION

In this study, the procedure for fabricating mandibular implant-supported FDP by using CAD/CAM technology and 3-D design software has been described and the outcomes of these patients were presented. The first advantage of this technique is the ability to design the framework based on the final prosthodontic restoration. The other important advantage is the significant reduction in laboratory time and complexity when compared with more traditional techniques involving fabrication of the bar patterns with acrylic resin, investment, and casting of dental alloys.[14–16] However, it should be kept in mind that this type of procedure requires a dental technician who has experience in digital implant treatment planning and using special scanners to determine the implant positions and shape of the final prosthesis.[17–19] Also, the titanium frameworks presented in this study were fabricated in the state-of-the-art production center using very precise CAD/CAM milling machines.[20,21]

There are few *in vitro*[22,23] and clinical studies[24] regarding the marginal fit of CAD/CAM frameworks available. However, direct comparisons between this study and other studies may not be made, as the previous studies used other types of designs, implants, softwares, and scanners. Ortorp and Jemt[24] compared the clinical and radiographic performances of implant-supported prostheses using computer numerical control titanium frameworks and using cast gold alloy frameworks in the edentulous jaw. Their 126 edentulous patients were provided with 67 prostheses with titanium frameworks (test) and with 62 prostheses with gold alloy castings (control). The prosthesis and implant cumulative survival rates were 95.6% compared with 98.3% and 95.0% compared with 97.9% for test and control groups after 10 years, respectively. In the test and control groups, mean marginal bone resorptions were 0.7 mm. One prosthesis was lost in each group because of loss of implants, and one prosthesis failed because of framework fracture in the test group.

In the present study, one implant was lost before the prosthesis insertion, indicating the implant survival rate of 97.5%. The average marginal bone loss was 0.4 ± 0.2 mm during the follow-up period. The implants placed into fresh extraction sockets showed more bone loss compared with the ones placed in the healed sites. It is expected to have more bone loss with fresh extraction sockets as remodeling of extraction sockets is less predictable. In this study, all frameworks fit accurately and no sectionings and weldings were needed for any framework. During the follow-up period, 3 occlusal adjustments were made and one broken denture tooth was attached back on the framework. However, no prostheses needed a replacement, indicating the prosthesis success rate of 100%.

There are few studies regarding implant placement in fresh extraction sockets in the literature.[25–28] Meloni and coworkers placed 60 implants, and 22 of them were placed in fresh extraction sockets. They followed up these patients for a year. They observed an average periimplant marginal bone loss of 1.4 ± 0.3 mm. Their bone loss is greater than the one presented in this study. This difference might have resulted as they used different type of the implant design, final restorations, and flapless surgical protocol. Because they used flapless surgical technique, they did not make alveoloplasty before the implant placement. However, in the present study, the soft tissue flaps were elevated, the teeth were extracted, the alveoloplasty was performed for each socket, and then the implants were placed. Therefore, periimplant bone levels stayed more stable over time, resulting in less marginal bone loss.

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It should be kept in mind that each person involved in similar type of treatment should possess the knowledge to use this software and hardware, which requires advanced training and experience. Otherwise, failures would be inevitable and costly. Although each step was explained and illustrated in this report, the readers need to make sure that they have proper knowledge, armamentarium, and experience before attempting to this type of treatment.

CONCLUSION

This study illustrates how to fabricate titanium frameworks using a new planning software and a new scanner using noncontact laser. The 18-month outcomes of this clinical study indicate that milled-titanium frameworks fabricated using the software and the scanner presented in this study fit accurately and can be used as an alternative to cast frameworks to restore edentulous arches.

DISCLOSURE

The authors claim to have no financial interest, either directly or indirectly, in the products or information listed in the article.

APPROVAL

This study has been approved (protocol number: HSC20130042E) by the Institutional Review Board of the University of Texas, Health Science Center at San Antonio, TX.

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