Clinical and Laboratory Steps for Fabricating a Complete-Arch Fixed Prosthesis Using CAD/CAM

Senthil Keerthi, DDS1
Periklis Proussaefs, DDS, MS2
Jaime Lozada, DDS3

The fabrication of a full-arch maxillary prosthesis has been associated with several prosthetic complications and difficulties. Even though it has been reported that phonetics, esthetics, and proper lip support are difficult to achieve, there is a scarcity in the literature regarding the clinical and laboratory procedures necessary to minimize these complications. This article provides clinical and laboratory steps that may enable the clinician to achieve more predictable restorative results when using computer-aided design/computer-assisted manufacture (CAD/CAM) to fabricate a full-arch maxillary implant-supported prosthesis. The technique presented here describes the use of an implant-retained diagnostic wax-up that is subsequently duplicated to an interim polymethylmethacrylate prosthesis using CAD/CAM before fabricating the definitive restoration. (Int J Periodontics Restorative Dent 2015;35:473–480. doi: 10.11607/prd.2472)

Dental implants have become an established treatment modality for the totally1 and partially edentulous patient.2,3 Full-arch fixed implant-supported prosthesis has been associated with a high biologic success rate4 after long-term use, along with various technical and prosthodontic complications.1,4,5 Special consideration has been given to the full-arch maxillary implant-supported fixed prosthesis because it has been associated with esthetic and phonetic difficulties.7–10 Therefore, adequate planning is needed when fabricating a maxillary full-arch fixed prosthesis. The extension of the maxillary alveolar ridge resorption and the need for adequate lip support determine the potential for fabricating a fixed maxillary prosthesis.6–12 In some clinical situations where advanced maxillary alveolar ridge resorption is observed, an implant-supported overdenture may offer superior esthetics and/or phonetics.8–11 The fabrication of a flange in a fixed maxillary prosthesis can compromise the access for oral hygiene.6–8

Even though it has been reported that the fabrication of a maxillary full-arch implant-supported fixed prosthesis requires careful treatment planning and prosthetic design,10,13 there is a scarcity in the literature regarding laboratory and clinical guidelines for the fabrication of such a prosthesis. The current article

1Postgraduate Student, Advanced Education Program in Implant Dentistry, Loma Linda University, Loma Linda, California, USA.
2Assistant Professor, Advanced Education Program in Implant Dentistry, Loma Linda University, Loma Linda, California; Private Practice in Prosthodontics, Ventura, California, USA.
3Program Director, Advanced Education Program in Implant Dentistry, Loma Linda University, Loma Linda, California, USA.

Correspondence to: Dr Periklis Proussaefs, 3585 Telegraph Road, Suite C, Ventura, CA 93003, USA; email: DrProussaefs@gmail.com.

©2015 by Quintessence Publishing Co Inc.
offers clinical and laboratory steps for the fabrication of a screw-retained implant-supported maxillary full-arch fixed prosthesis by incorporating a conventional wax-up of the tentatively designed prosthesis and newly developed computer-aided design/computer-assisted manufacture (CAD/CAM) technology.

**Case report**

A 61-year-old white man presented at the Center for Prosthodontics and Implant Dentistry at Loma Linda University (Loma Linda, California) seeking treatment for his completely edentulous maxilla. His mandibular arch had been restored with a metal acrylic implant-supported fixed prosthesis. After discussing various treatment options, a decision was made to restore the maxilla with a fixed implant-supported prosthesis. Eight threaded root form implants (Replace Conical Connection, Nobel Biocare) were placed on the maxillary arch. Before implant placement, a new maxillary complete denture had been fabricated. A duplicate of the new maxillary complete denture was made and used as a surgical template during implant placement. Implant placement and postoperative healing occurred without surgical complication (Fig 1).

After osseointegration was confirmed, a preliminary impression was made from the maxillary arch with the open tray technique and by using a custom tray and polyvinylsiloxane impression material (Aquasil, Dentsply). The open tray impression copings were anchored with implant replicas and a preliminary cast was obtained. The preliminary cast was used to fabricate an acrylic resin bar (Pattern resin LS, GC America) by splinting the impression copings in the laboratory. The acrylic resin bar was sectioned with a diamond disc (Kontour Stone, Brasseler USA) to obtain eight separate impression coping/acrylic resin units that were anchored on the implants intraorally (Fig 2a). After the impression copings were hand-tightened (Fig 2a), the acrylic bar was connected as one piece intraorally by applying acrylic resin in the spaces that had been previously created in the laboratory. The acrylic bar was then picked up intraorally (Fig 2b) with the polyvinylsiloxane impression material using a
previously described technique. In the laboratory, acrylic tissue-colored condensation polysiloxane (Gi-Mask, Coltene/Whaledent) was used to simulate soft tissue.

Four nonengaging, temporary, implant abutments were placed on four of the posterior implant analogs. The height of the abutments was reduced according to the available interocclusal space. Autopolymerizing acrylic resin (Jet Tooth Shade Acrylic, Lang Dental) was placed around the temporary abutments and extended around the contours of the maxillary arch to provide a framework for the fabrication of the wax pattern (Fig 3). A screw-retained implant-supported wax pattern was then fabricated by applying tooth-colored and pink wax (Geo Classic Opaque-Tooth color-75G#497-0400, Renfert) to simulate tooth anatomy and soft tissue esthetics, respectively (Fig 4). A silicone matrix (Lab-putty, Coltene/Whaledent) was used as a guide and was based on teeth position and flange thickness of the interim complete denture.

The wax pattern was then screw retained intraorally through the temporary abutments (Fig 5). Intraoral evaluation of the diagnostic wax pattern allowed evaluation of esthetics, contours, lip support, and access for oral hygiene.

The diagnostic wax pattern was then transferred to the laboratory, placed on the master stone cast, and subsequently scanned with a laboratory scanner unit (Model S600, Zirkonzahn). Scanning abutments were also placed and implant positions were scanned as well by using the same laboratory scanner. The software incorporated in the specific scanner had the potential to superimpose data from the scanned diagnostic wax-up and the scanned stone model with the scanning abutments in place (Fig 6). Therefore, the technician, in cooperation with the operating clinician, had the ability to digitally design a prosthesis that was based on a clinically confirmed diagnostic wax-up. After digitally duplicating the design of the diagnostic wax pattern, an interim prosthesis was fabricated by milling a polymethylmethacrylate (PMMA) blank (98 × 20 mm PMMA Disc Model 5215, Talladium) through a five-axis milling machine (Model M5, Zirkonzahn). The software for the aforementioned scanner had the ability...
to uniformly cut back the gingival area of the prosthesis to a desired thickness so space would be provided to apply tissue-colored composite resin to esthetically simulate soft tissue. After milling the PMMA blank, tissue-colored composite resin (Gradia, GC International) was applied and subsequently light cured to esthetically simulate gingiva (Fig 7). The esthetics, lip support, occlusion, and accessibility for oral hygiene were then confirmed intraorally (Fig 7c). The interim PMMA prosthesis was placed intraorally for 2 weeks to allow the patient to confirm esthetics and function. A cotton pellet and temporary filling material (Cavit G, 3M ESPE Dental) were placed in the occlusal access holes of the interim PMMA prosthesis.

After confirming esthetics and function, the interim prosthesis was removed and scanned with the same scanner that was used to scan the diagnostic wax pattern. The interim prosthesis was digitally duplicated through the software that is incorporated with the specific laboratory scanner. The definitive prosthesis was milled through the same milling machine. The definitive prosthesis was designed with a uniform 1-mm cutback on the facial aspect of the maxillary anterior left and right canines and incisors so that sufficient space would be available for porcelain application after the sintering process. Similarly a 1-mm cutback was designed along the soft tissue area so tissue-colored porcelain can be applied after sintering. A zirconia blank (Prettau zirconia 22 × 95 mm, Zirkonzahn) was used for milling the definitive prosthesis. After milling of the zirconia was complete to the level of “green state milled zirconia,” the prosthesis was stained for the portion representing the teeth and for the portion representing the soft tissue. Water-based stain provided by the manufacturer (Aquarell stain, ZirkonZahn) was implemented. After the staining was applied, the prosthesis was sintered (Zirkonofen 600/V2, ZirkonZahn) according to the manufacturer’s recommendations.
After sintering was complete, tooth-colored porcelain was applied facially to the maxillary anterior left and right canines and incisors (Vita VM9, Vident) and firing of the tooth-colored porcelain was completed in a porcelain oven (Model JP 1200, Pentron) according to the manufacturer’s recommendations. Subsequently, tissue-colored porcelain was applied (Ice Zirkon Ceramics, Zirkonzahn) and fired according to the manufacturer’s recommendations.

The prosthesis was designed so that a space was available to insert titanium metal sleeves in the prosthesis according to a previously described technique. With this technique, the zirconia had no contact with the titanium implant surface; the prosthesis was secured on the implants through the titanium surface of the sleeves.

The definitive prosthesis was a virtual simulation of the intraorally verified diagnostic wax pattern and interim PMMA prosthesis (Fig 8). The fit, esthetics, and occlusion of the definitive prosthesis were then verified intraorally (Fig 9). Occlusal abutment screws were torqued according to the manufacturer’s recommendations (35 Ncm), and a fast-setting light body polyvinylsiloxane (Exafast NDS Fast Set, GC America) along with composite resin (Herculite Ultra, Kerr) were placed at the occlusal access holes.

Discussion

The significance of this article is that it merges conventional and modern prosthodontics. A conventional fully contoured wax-up that is implant supported is converted to a full-arch implant-supported fixed prosthesis through CAD/CAM technology. The described technique offers some guidelines to the clinician to fabricate such a prosthesis. An opportunity is given to the patient and dentist to evaluate esthetics, phonetics, contours, and cleansibility of the prospective implant-supported fixed prosthesis.

The presence of dental implants enables the clinician to have the
diagnostic wax pattern screw retained on the implants, simulating the design of the definitive prosthesis. In the described case, four temporary abutments were used in the posterior area of the maxilla. This enabled the fabrication of a full-contoured wax pattern in the anterior area. Placement of temporary abutments in the anterior area would interfere with the esthetic zone.

Several authors have recommended the use of dentures placed on an acrylic resin base plate to fabricate a diagnostic silicone jig in the laboratory. However, a fully contoured diagnostic wax pattern offers superior precision and more customization, because the clinician is not confined within the contours offered by the denture manufacturer. Chairside modification of the wax-up is relatively easy to accomplish compared with prefabricated acrylic dentures. Similarly, modification of the gingival esthetics is more effective through a diagnostic wax pattern as opposed to denture base.

In the described technique, a milled full-arch zirconia prosthesis was selected. Although milled metal frames have been associated with superior fit compared with cast metal frames, knowledge regarding the fit of a full-arch zirconia frame is limited. In a laboratory study, Sachs et al indicated that the mean marginal opening gap dimensions for a full-arch zirconia prosthesis was 29 µm. Although clinically acceptable, on single units, the same authors reported an opening gap of 18 µm; it was speculated that the sintering process may affect the accuracy of the framework fit. Further studies are needed to evaluate the consistency of fit in full-arch zirconia implant-supported restorations. In addition, long-term data on this type of prosthesis are lacking. Limmer et al reported minimal complications when 17 monolithic zirconia full-arch fixed prostheses were evaluated. However, in that study, all subjects had a complete denture as the opposing dentition, diminishing occlusal forces. In addition, the reported data were derived from 1-year follow-up examinations, therefore, midterm or long-term data are still not available. The most common complication the authors encountered was chipping of the opposing dentures.

It is generally accepted that the full-arch zirconia fixed prosthesis lacks the resiliency observed in conventional metal acrylic implant-supported fixed prosthesis. The lack of resiliency arising from the absence of a periodontal ligament in implant-supported restorations demands the use of highly sophisticated materials when trying to overcome fatigue resistance caused by occlusal loading. In a complex biomechanical system, implants, abutments, frameworks, screws, masticatory muscles, temporomandibular joints, and esthetic veneering materials share masticatory stress conduction. Therefore acrylic dentures or porcelain veneering materials are most commonly prone to fracture. In the case presented here, the strategy was to have a combination of a maxillary zirconia prosthesis opposing a mandibular metal acrylic implant-supported fixed prosthesis as suggested by others. This option reduces the overall stiffness of the prosthetic elements. However, patients need to be informed about the anticipated repeated fracturing of the acrylic veneering material.

An alternative prosthodontic design of the presented clinical situation would involve fabrication of several (typically three) separate implant-supported fixed partial dentures with smaller span. Although this may theoretically reduce the amount of distortion imposed by the sintering process on the framework, in this prosthodontic design, the transition line between the individual fixed partial dentures will impose an esthetic concern.

A disadvantage of the described prosthodontic treatment is related to the probability of fracture of the facial veneer porcelain material. Porcelain chipping or acrylic fracture is a phenomenon that occurs very often on metal ceramic or metal acrylic full-arch implant-supported fixed prostheses. Sousa et al reported porcelain chipping or delamination of maxillary layered full-arch implant-supported prosthesis in 46.8% of cases after a follow-up period ranging between 12 and 29 months. While an alternative could be the use of monolithic zirconia full-arch prostheses to reduce the possibility of fracture, such an application has been associated with a compromised esthetic outcome.

Some authors have advocated the use of individual crowns cemented on a single full-arch frame. This treatment modality offers superior
esthetics and provides the clinician the ability to replace a single crown if a porcelain fracture occurs. However, the operator has limited access to the abutment screws that secure the framework in place. The prosthesis may be difficult to retrieve if an abutment screw fractures or loosening occurs.

In the presented prosthetic treatment, titanium sleeves were used so the zirconia frame has no contact with the implant platform. In an in vitro study, Stimmelmayr et al19 demonstrated that the use of titanium cores results in increased strength of the zirconia abutments. Similar results were reported by Kim et al20 in another in vitro study. Klotz et al21 demonstrated that zirconia abutments cause more implant wear along the implant platform than titanium abutments; therefore, direct contact of the zirconia frame with the implant platform should be avoided.

In the present clinical situation, the patient was given a resilient splint. Protecting the restorations with an occlusal splint is another method typically used, particularly when the patient has parafunctional habits.30

**Conclusion**

Intraoral evaluation of a screw-retained wax pattern is essential for the design and fabrication of a maxillary full-arch implant-supported fixed prosthesis. CAD/CAM technology enables the operator to duplicate the wax pattern to an interim prosthesis and subsequently to the definitive restoration. Long-term studies are needed to evaluate the potential and limitations of the presented prosthesis.

**Acknowledgments**

The authors would like to acknowledge Marc Tillman, CDT, and Spectrum Dental Laboratories for fabricating the definitive prosthesis. They would also like to thank Miroljub Ilich, CDT, for his laboratory support on the wax pattern. The authors reported no conflicts of interest related to this study.

**References**


