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DENTAL TECHNIQUE

Use of intraoral digital scanning for a CAD/CAM-fabricated milled bar and superstructure framework for an implant-supported, removable complete dental prosthesis

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ABSTRACT

This report describes a clinical technique for fabricating a maxillary implant-supported, removable complete dental prosthesis by using an intraoral digital scanner to register implant positions and soft tissue morphology. The presented technique uses computer-aided design/computer-aided manufacturing (CAD/CAM) technology with a subtractive manufacturing process to fabricate a milled bar (infrastructure framework) and an additive process to fabricate a friction fit, superstructure framework. This digital restorative pathway may decrease patient discomfort and reduce the labor associated with fabricating implant-supported, removable complete dental prostheses. (J Prosthet Dent 2015;■:■-■)

Maxillary implant overdentures can be classified into 2 types: implant mucosa and implant-supported prostheses.[1] Implant mucosa-supported prostheses allow some movement through tissue rests, whereas implant-supported prostheses do not.[1] Two recent systematic reviews analyzed the survival rate of implants supporting these restorations.[2,3] A maxillary removable complete dental prosthesis supported by 4 or 6 implants with a splinted bar anchorage has a high implant survival rate (>97% per year).[2] However, when 4 or fewer implants were used to retain a maxillary removable complete dental prosthesis, the risk of implant loss associated with nonsplinted anchorage systems increased.[2,3] The maxillary implant-supported, removable complete dental prosthesis with a milled bar (infrastructure framework) and a friction fit, superstructure framework may prevent prosthesis rotation and may provide hygienic access and esthetic outcomes for patients with a moderately to severely resorbed maxilla.[4] This design has demonstrated a lower prosthetic complication rate and has reduced maintenance requirements compared to implant mucosa-supported, removable complete dental prosthesis.[5,6] Its higher initial cost may be compensated by less maintenance.[1]

With the increasing cost of material and the complexity of laboratory procedures, computer-aided design/computer-aided manufacturing (CAD/CAM) technology has been used to fabricate different types of dental restorations.[7-9] A transition from closed to open architecture in dental CAD/CAM technologies[10] has created greater flexibility in the digital dental treatment pathway, and various data acquisition sources (intraoral scanner, laboratory cast scanner, cone-beam computed tomography) can be combined with different compatible CAD software programs to design restorations. A wide range of computer-aided subtractive and additive manufacturing technologies can then be selected for use with associated restorative materials.[10-12] Although subtractive manufacturing has been primarily used in dentistry, additive manufacturing processes can create fine detail and complex internal geometries and lower the waste associated with its production process.[10,11]

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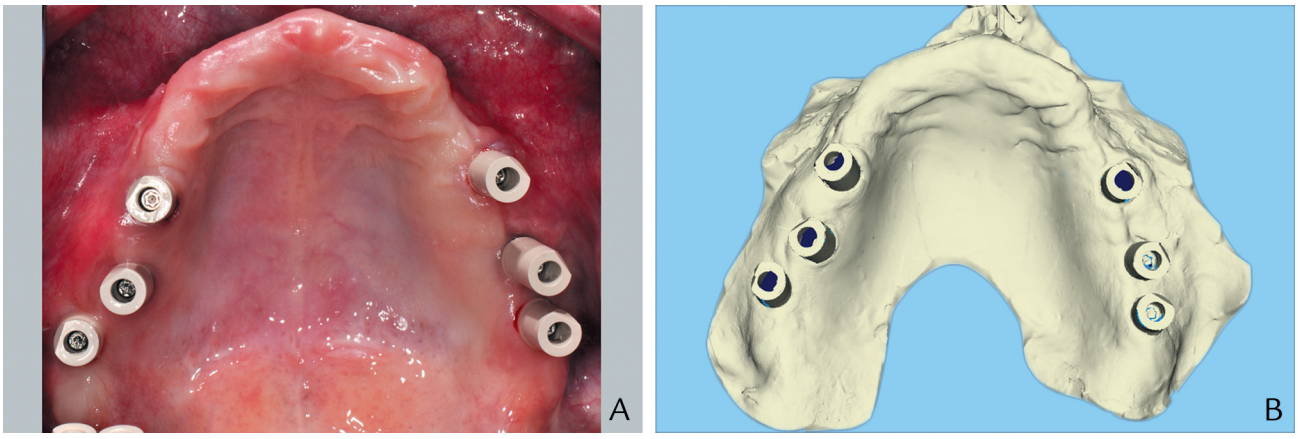

Figure 1. A, Occlusal view of maxillary arch with secured scannable impression copings. B, Definitive digital impression with registration of implant positions and static soft tissue morphology.

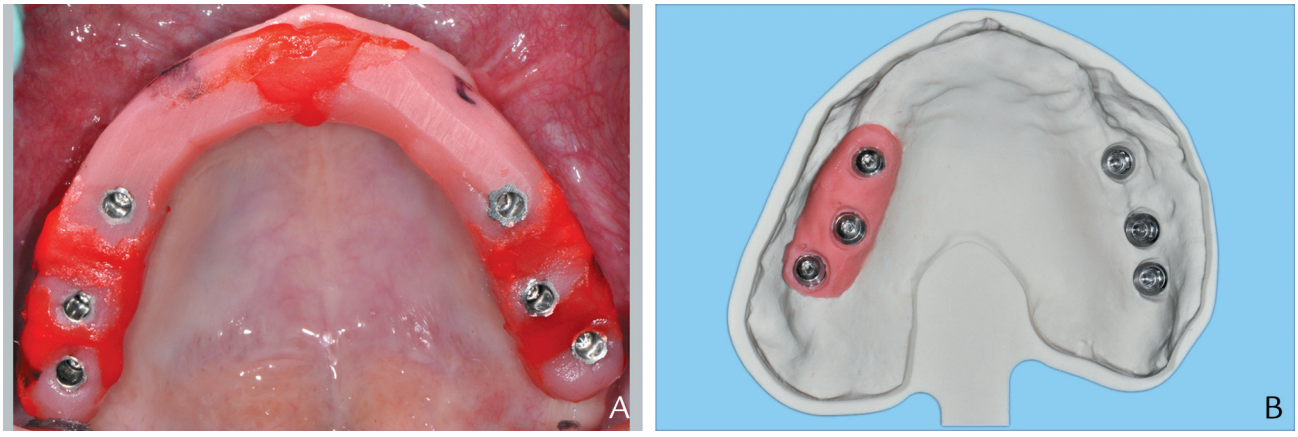

Figure 2. A, Verification device luted with autopolymerizing acrylic resin. B, Milled polyurethane definitive cast with corrected implant analog positions and removable periimplant soft tissue replica.

Acquiring digital data (intraoral digital impression) for conventional removable complete dental prostheses for the edentulous arch is challenging. It is difficult to register the dynamic movement of the muscles and jaws with an intraoral scanner.[13] Recently, clinical reports have provided proof of concepts on the application of digital data acquisition for conventional removable partial dental prostheses in Kennedy Class III clinical situations[14] and implant-supported fixed complete dental prostheses[15] in which the dynamic registration of soft tissue was not as critical. In addition to soft tissue registration, scannable impression copings (Scan body; Straumann) can be used in conjunction with the intraoral digital scanner (iTero; Align Technology) to acquire digital data at the implant level in both partially and completely edentulous patients.[15]

This article describes a digital work flow using digital data acquisition of soft tissue morphology and implant positions for a maxillary implant-supported, removable complete dental prosthesis with a milled bar and a friction fit, superstructure framework, which was

Figure 3. Trial insertion of prosthetic tooth arrangement.

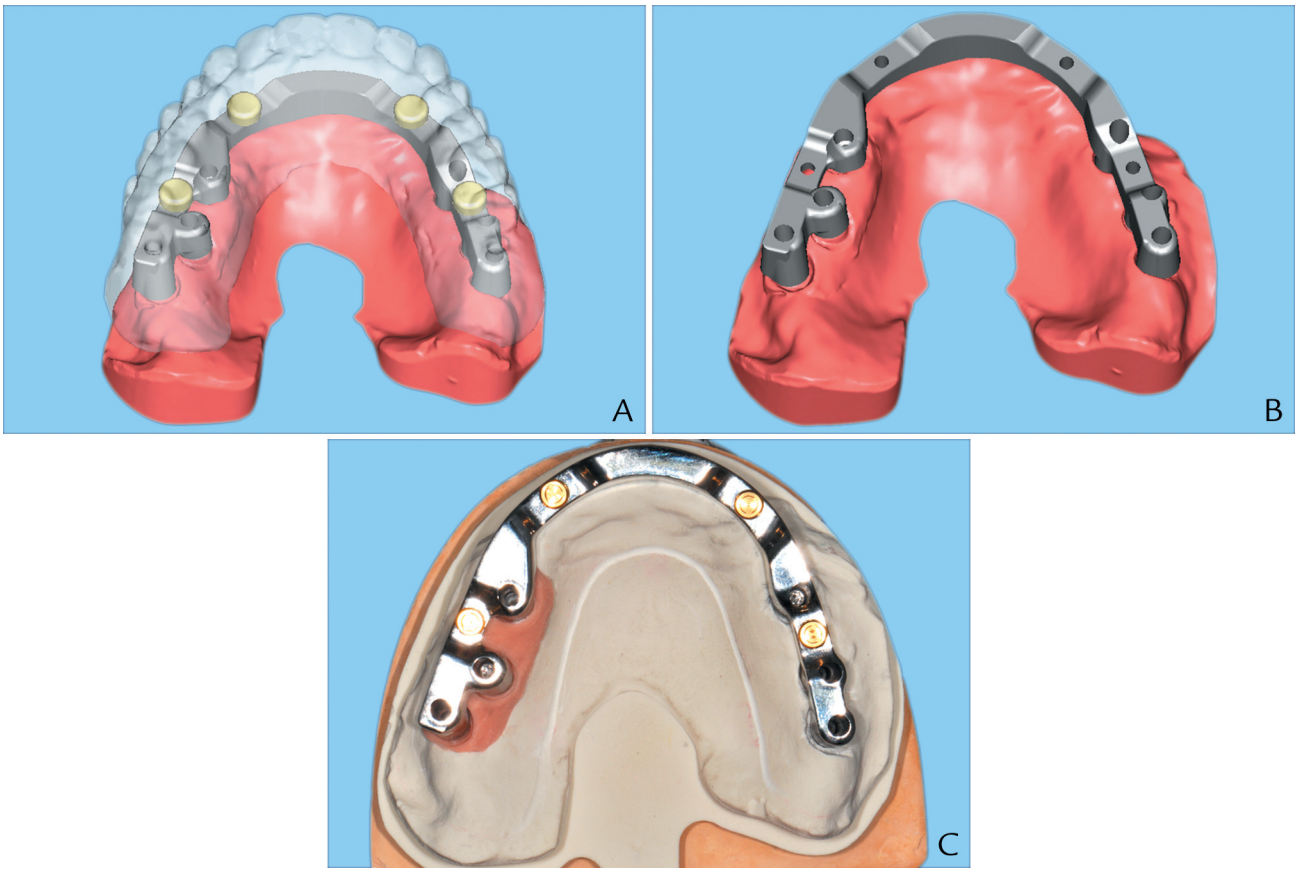

Figure 4. A, Digital design for CAD/CAM-fabricated milled bar. B, Platforms approximately 10 mm in length and 3 mm below occlusal surface placed at canine and first molar areas of milled bar, representing future locations of attachments. C, Completed CAD/CAM-fabricated milled bar with attachments (Locator Bar Female; Zest Anchors) secured in place and seated on milled polyurethane definitive cast.

designed and fabricated by using subtractive and additive manufacturing processes.

TECHNIQUE

First clinical appointment, intraoral digital scanning:

1. Examine existing implants and make a definitive implant-level digital impression with an intraoral scanner (iTero; Align Technology Inc) and scannable impression copings (Scan body RN; Straumann) (Fig. 1A). Send the definitive impression (Fig. 1B) to the manufacturer (iTero; Align Technology Inc) and selected dental laboratory (Roy Dental Laboratory) for milled polyurethane definitive cast fabrication.

First laboratory procedure, milled definitive cast and verification device fabrication:

1. Make a removable stone base for the milled polyurethane definitive cast with corresponding inserted analogs (RN Reposition analog; Straumann) and a segmental verification device with interim abutments (RN synOcta temporary post, Bridge; Straumann).[15]

Second clinical appointment: verify stone cast fabrication:

1. Connect the segmental verification device with autopolymerizing acrylic resin (Pattern Resin LS; GC America) intraorally (Fig. 2A) and fabricate a verification stone cast.[15]

Second laboratory procedure, define cast verification and fabricate record base:

1. Use the verification device to confirm implant analog positions in the milled polyurethane definitive cast. Correct the implant analog positions and soft tissue profile with the technique described by Lin et al,[16] if necessary (Fig. 2B).
2. Fabricate an implant-retained record base.

Third clinical appointment, interocclusal record taking and prosthetic tooth selection:

1. Complete a facebow transfer and interocclusal record by using the implant-retained record base. Select prosthetic teeth (BlueLine DCL; Ivoclar Vivadent) and articulate the definitive casts with the obtained facbow and interocclusal record on a

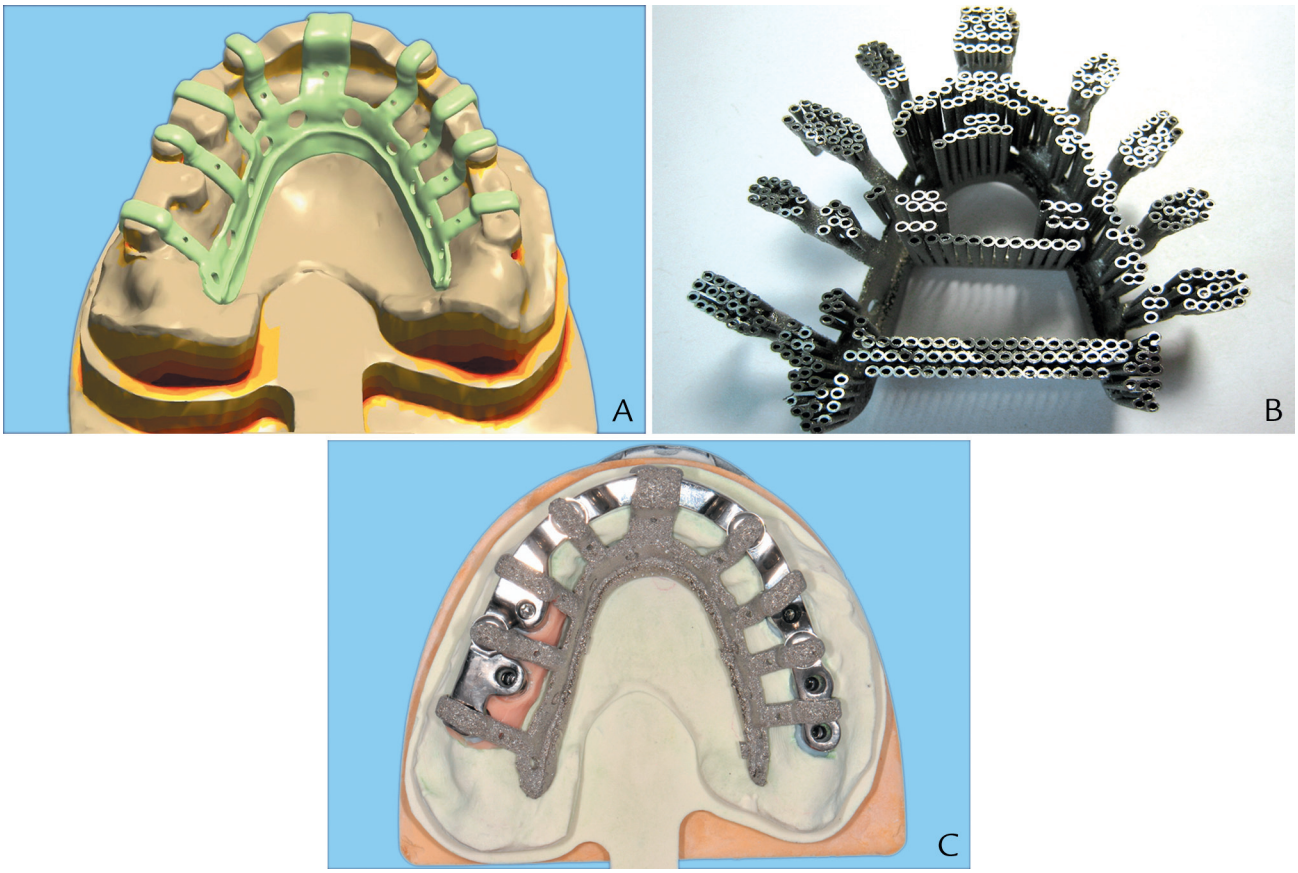

Figure 5. A, Digital design for CAD/CAM-fabricated superstructure framework. B, As-manufactured superstructure framework made with computer-aided additive manufacturing process before laboratory adjustment. C, Adjusted superstructure framework on milled bar and milled polyurethane definitive cast.

semiadjustable articulator (Hanau Modular Articulator; Whip Mix Corp).

Third laboratory procedure, diagnostic tooth arrangement:

1. Arrange the prosthetic teeth on the implant-retained record base.

Fourth clinical appointment, trial insertion of tooth arrangement:

1. Evaluate the trial arrangement intraorally and make necessary adjustments to achieve optimal esthetics, function, and occlusion (Fig. 3).
2. Fabricate a facial matrix with polyvinyl siloxane putty (Sil-Tech; Ivoclar Vivadent) around the facial surface of the adjusted trial arrangement and definitive cast assembly to preserve the spatial orientation of the prosthetic teeth.

Fourth laboratory procedure, CAD/CAM-fabricated milled bar design and fabrication:

1. Send the trial arrangement, milled polyurethane definitive cast, and verification stone cast to a CAD/CAM facility (Cagenix; Cagenix Inc) and have the facility technician design a CAD/CAM-fabricated milled bar (AccuFrame; Cagenix Inc) with 3- to 5-degree taper on the axial walls by using the trial arrangement to assess the restorative space and the verification stone cast to confirm the accurate interimplant relationship (Fig. 4A).
2. Create platforms approximately 10 mm in length and 3 mm below the occlusal surface of the milled bar at the canine and first molar areas to accommodate future attachment placement (Locator; Zest Anchors). Create 1 mm of space between the intaglio surface of the milled bar and the soft tissue to provide access for adequate oral hygiene (Fig. 4B).
3. Secure the attachments (Locator Bar Female; Zest Anchors) with 30 Ncm torque on the CAD/CAM-fabricated milled bar and secure the milled bar onto the milled polyurethane definitive cast (Fig. 4C).

CAD/CAM-fabricated superstructure framework design and fabrication:

1. Send the definitive cast-milled bar assembly to a separate CAD/CAM facility (Bego USA; Bego). Scan the assembly with a laboratory scanner

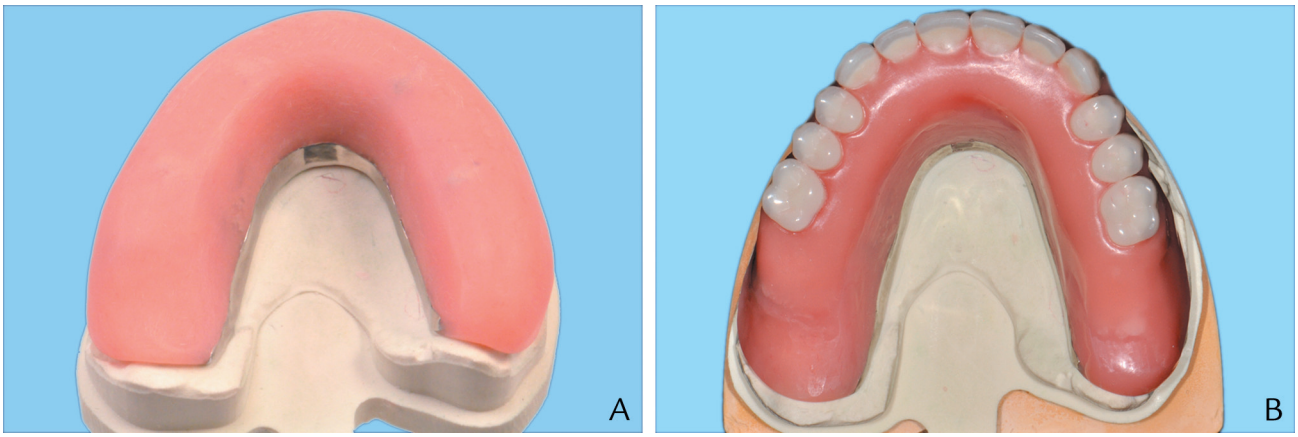

Figure 6. A, Processed denture base. B, Definitive prosthetic tooth arrangement.

(3shape Lab Scanner; 3shape A/S) and perform digital survey, relief, and blockout on the scanned virtual cast in the CAD software (3Shape Dental System 2014 version 2.9.9.4; 3shape A/S). Design the superstructure framework with intimate fit between the metal intaglio surface of the framework and the milled bar to support the overdenture (Fig. 5A).
2. Approve the superstructure framework design with the facility technician and use a computer-aided additive manufacturing process (Selective Laser Melting process; Bego) to fabricate the superstructure framework from cobalt-chromium alloy (Wirobond C+; Bego) (Fig. 5B). Confirm the fit of the CAD/CAM-fabricated, superstructure framework on the milled bar and milled polyurethane definitive cast (Fig. 5C).

Processed denture base fabrication and definitive tooth arrangement:

1. Place the housings (Locator; Zest Anchors) on the attachments (Locator Bar Female; Zest Anchors) and use autopolymerizing acrylic resin (Jet Denture Repair; Lang Dental Manufacturing) to lute the attachment housings to the superstructure framework. Fabricate a processed denture base with injection-molded, heat polymerizing acrylic resin (SR Ivocap High Impact; Ivoclar Vivadent) (Fig. 6A).
2. Use the facial putty matrix as a reference to arrange the prosthetic teeth on the processed denture base (Fig. 6B).

Fifth clinical appointment, trial insertion of milled bar and definitive tooth arrangement:

1. Confirm the fit of the CAD/CAM-fabricated milled bar (AccuFrame; Cagenix), superstructure framework (Selective Laser Melting process; Bego), and processed denture base intraorally. Verify the appropriate extension for the processed base and adjust the extension as necessary. Evaluate and confirm the functional and esthetic outcome of the definitive tooth arrangement.

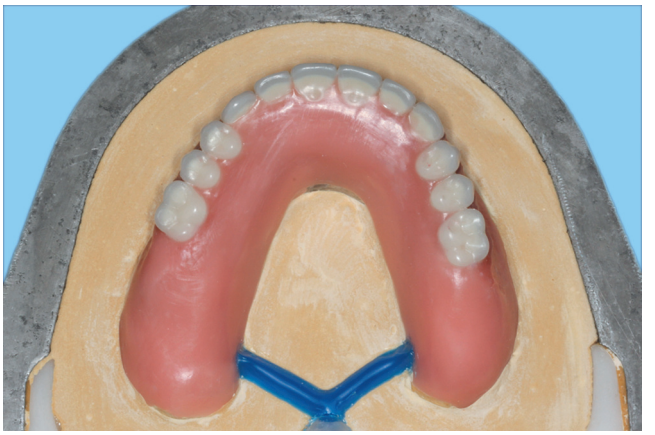

Figure 7. Invested definitive prosthetic tooth arrangement in processing flask.

Fifth laboratory procedure, completion of definitive prosthesis:

1. Block out the intaglio surface of the processed denture base with polyvinyl siloxane putty (Sil-Tech; Ivoclar Vivadent) and invest the adjusted definitive tooth arrangement in the processing flask (Ivocap; Ivoclar Vivadent) with type III dental stone (Buff Stone; Whip Mix Corp) (Fig. 7). Process the definitive tooth arrangement with injection-molded, heat polymerizing acrylic resin (SR Ivocap; Ivoclar Vivadent). Finish and polish the definitive prosthesis.

Sixth clinical appointment, insertion of definitive prosthesis:

1. Confirm the fit of the CAD/CAM-fabricated milled bar (AccuFrame; Cagenix) intraorally and with a radiograph (Fig. 8A). Secure the milled bar to the implants with 35 Ncm torque.
2. Seat the maxillary implant-supported, removable complete dental prosthesis on the secured milled

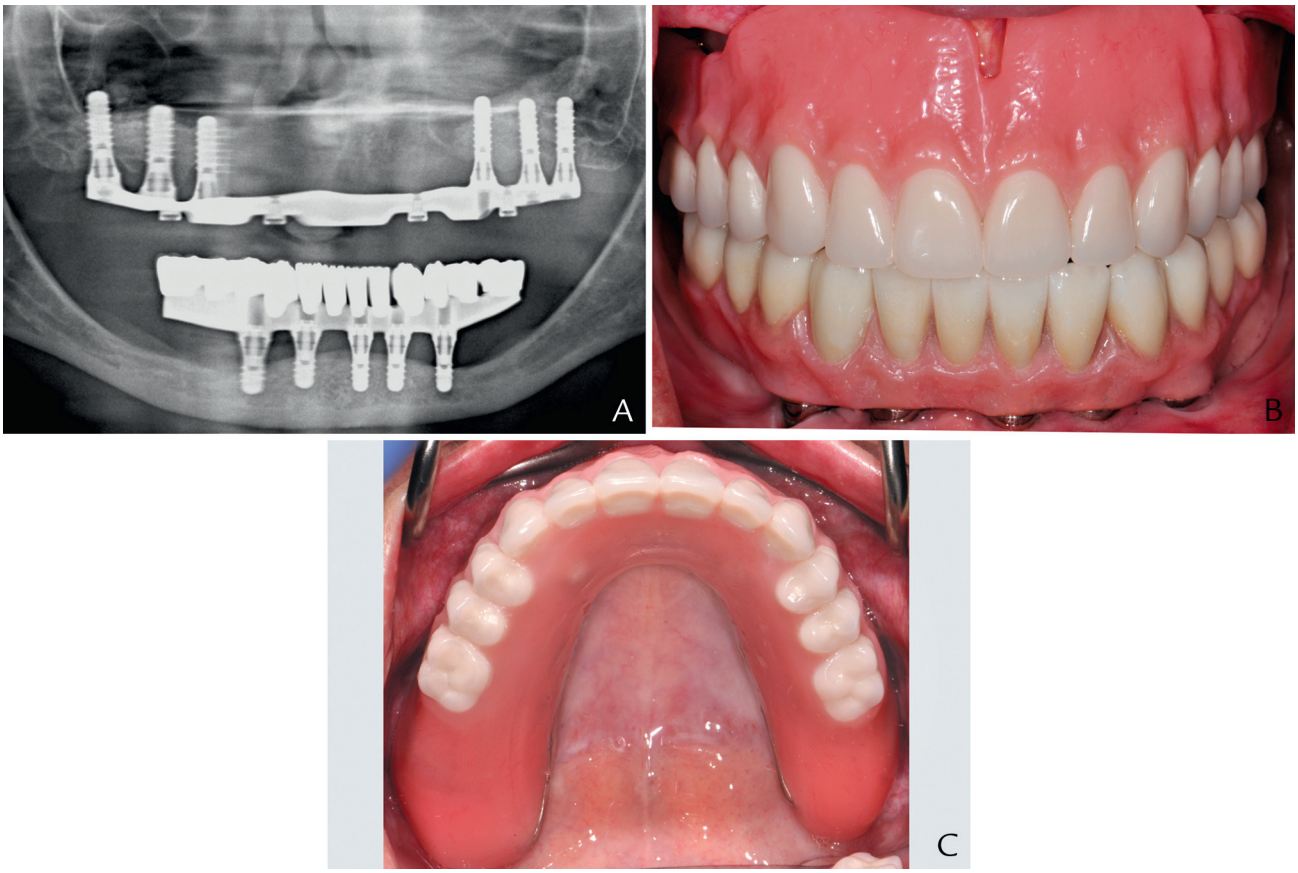

Figure 8. A, Panoramic radiograph of definitive prostheses. B, Intraoral facial view of definitive prostheses. C, Intraoral occlusal view of maxillary definitive prosthesis.

bar and adjust the intaglio surface and occlusal contacts with a laboratory carbide cutting instrument (Carbide Cutter; Brasseler USA) as necessary (Fig. 8B, C).

3. Provide the patient with oral hygiene instructions and schedule periodic maintenance appointments.

DISCUSSION

This article described a digital work flow for the fabrication of a maxillary implant-supported, removable complete dental prosthesis. An intraoral digital scanner was used to register the implant positions and static soft tissue morphology. The limitation of this technique is that the dynamic registration of soft tissue extension may not be captured as well as with conventional impression techniques. This limitation was overcome in this report by retracting the soft tissue (cheeks and lips) fully during the soft tissue extension registration and by obtaining a digital impression with overextended soft tissue morphology. Another possible limitation is related to the large size of the intraoral digital scanner tip, which may prevent the complete scanning of palatal tissue morphology for patients with a deep palatal vault. The design of an implant-supported, removable complete dental prosthesis without complete palatal coverage was used in this report to satisfy the patient's wish for a palateless prosthesis and to decrease the required appointment time for a full palatal scan. A processed denture base was used to verify the appropriate soft tissue extension and fit intraorally, and the denture base was adjusted accordingly. The intraoral digital scanner may benefit patients with a severe gag reflex, sensitivity to certain dental impression materials, or patients with dental anxiety. In addition, the intraoral scanner may be able to register the soft tissue morphology in a passive manner to obtain a mucostatic impression, which can be an advantage for patients with hyperplastic edentulous ridges.[17]

A verification device and stone cast were fabricated with an additional clinical appointment and laboratory procedures to promote the passive fit of the milled bar. The clinical trial insertion of the CAD/CAM-fabricated milled bar was then omitted before the design and fabrication of the CAD/CAM-fabricated superstructure framework. These proposed procedures allowed the concurrent trial insertion of the milled bar and definitive tooth arrangement in 1 clinical appointment. However, the possible consequences of the misfit of the milled bar

with the proposed treatment protocol may be significant and may involve remaking the CAD/CAM-fabricated superstructure framework, processed denture base, and definitive tooth arrangement. An additional appointment for the clinical trial insertion of the CAD/CAM-fabricated milled bar may be used to provide an opportunity for clinical verification before subsequent laboratory procedures (fabrication of CAD/CAM-fabricated superstructure framework, processed denture base, and definitive tooth arrangement).

An open-architecture intraoral digital scanner and 2 CAD/CAM systems were used in the clinical report. The open architecture provided the clinician and technician with the flexibility to select the appropriate design and manufacturing pathway for the CAD/CAM-fabricated milled bar and superstructure framework. The CAD/CAM approach provided an accurate, cost-effective pathway for fabricating the definitive prostheses.[8,9] In this clinical report, a subtractive manufacturing process was used to fabricate the milled bar, and an additive manufacturing process with selective laser melting was used to fabricate the superstructure framework. This process may provide a more time- and cost-effective approach than conventional casting techniques. Although CAD/CAM technologies provide many advantages, both the clinician and the dental technician will require additional training and experience to become proficient in the rapidly evolving field of digital dentistry.

SUMMARY

This technique report provided a work flow for the intraoral digital registration of implant positions and static soft tissue morphology used in conjunction with various CAD/CAM technologies (subtractive and additive manufacturing processes) to fabricate a maxillary implant-supported, removable complete dental prosthesis.

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