Application of digital diagnostic impression, virtual planning, and computer-guided implant surgery for a CAD/CAM-fabricated, implant-supported fixed dental prosthesis: A clinical report

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This clinical report demonstrated the use of an implant-supported fixed dental prosthesis fabricated with a contemporary digital approach. The digital diagnostic data acquisition was completed with a digital diagnostic impression with an intraoral scanner and cone-beam computed tomography with a prefabricated universal radiographic template to design a virtual prosthetically driven implant surgical plan. A surgical template fabricated with computer-aided design and computer-aided manufacturing (CAD/CAM) was used to perform computer-guided implant surgery. The definitive digital data were then used to design the definitive CAD/CAM-fabricated fixed dental prosthesis. (J Prosthet Dent 2014;112:402-408)

Computer-guided (static) implant surgery is defined by the use of a static surgical template that reproduces a virtual implant surgical plan from computed tomographic data and does not allow intraoperative modification of implant position.[1-3] The benefit of computer-guided surgery is a more predicable implant placement with a surgical template fabricated with computer-aided design and computer-aided manufacturing (CAD/CAM) based on a prosthetically driven treatment planning process in a virtual implant planning software.[4,5] The conventional cast-based implant planning and surgical template fabrication approach does not allow visualization of all prosthetic and anatomic parameters simultaneously during the planning process, and the resulting surgical template does not provide exact 3-dimensional guidance during implant placement.[6] Most of the available systems for computer-guided implant surgery share a similar treatment protocol. A radiographic template with fiducial markers represents the desired prosthetic treatment plan. Cone-beam computed tomography (CBCT) is performed with the patient wearing a radiographic template. The resulting CBCT data are imported into virtual implant planning software to formulate a prosthetically driven implant surgical plan.[7] Although concerns about the accuracy of computer-guided implant surgery still exist,[1] it may help the clinician to perform successful implant surgery without flap elevation, causing less discomfort to the patient.[8]

SIM/Plant (Columbia Scientific Inc) was the first commercially available virtual dental implant planning software. Introduced in 1993, it allowed clinicians to interactively plan implant placement with CBCT images.[9,10] Modern virtual implant planning software, such as NobelClinician (Nobel Biocare), coDiagnostiX (Dental Wings GmbH), and VIP Software (BioHorizons), allows a virtual implant surgical plan to be sent to a processing center for a CAD/CAM fabricated surgical template.[9,10] A different process can then be used to fabricate CAD/CAM surgical templates, such as additive manufacturing technologies (stereolithography) or computer-driven drilling.[2,6,11,12]

The use of digital impression for the fabrication of definitive prostheses on natural dentition and dental implants has become available,[13-16] and it offers some advantages over conventional impression techniques. A clinical study found that overall patient preference was significantly in favor of the digital technique.[17] The iTero System (Align Technology) has been used to acquire definitive implant-level impression for implant-supported prostheses with the option of milled definitive cast with removable implant analog (Repositionable Implant Analog; Straumann).[14-19] Although the accuracy of digital data acquisition at the implant level and of the resulting cast has not been widely studied, it may provide clinicians with an alternative workflow and improve clinical efficiency.[20,21]

This clinical report demonstrated the use of an implant-supported fixed dental prosthesis fabricated with a digital workflow. Digital diagnostic impression, virtual planning, computer-guided implant surgery, and an immediate provisionalization protocol were used to complete treatment

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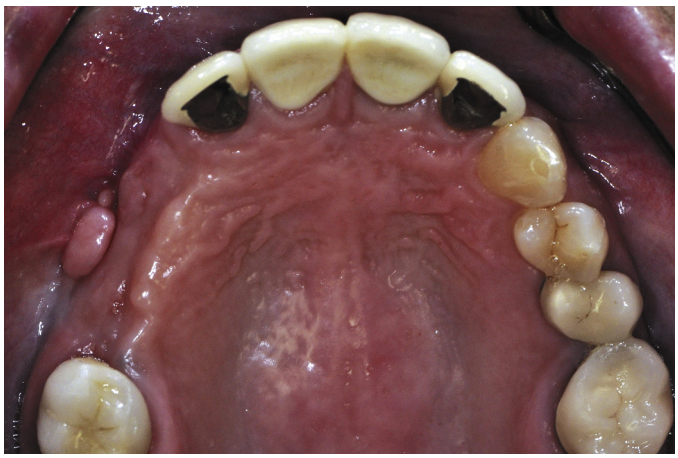
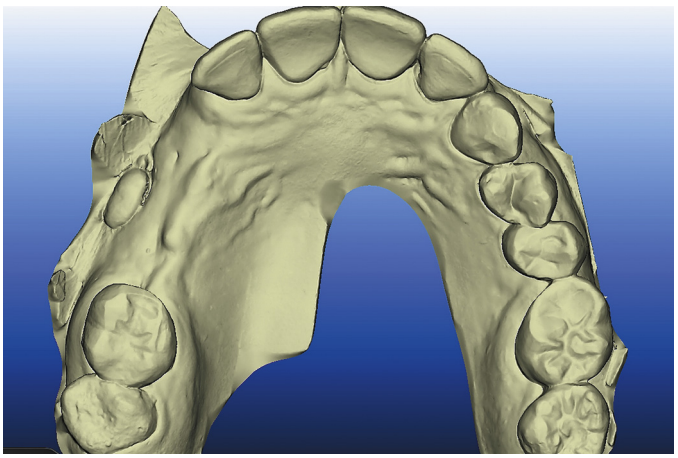
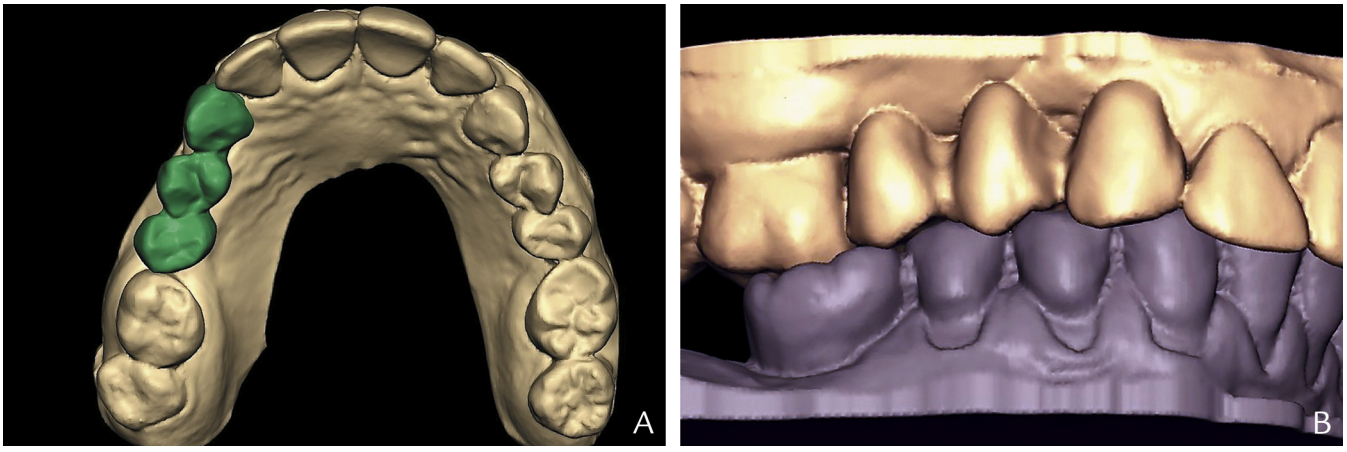


1 Pretreatment condition, occlusal view.



2 Diagnostic data acquisition with intraoral digital scanner.



3 Virtual diagnostic waxing created in CAD/CAM software. A, Occlusal view. B, Buccal view.

with a CAD/CAM-fabricated, implant-supported fixed dental prosthesis.

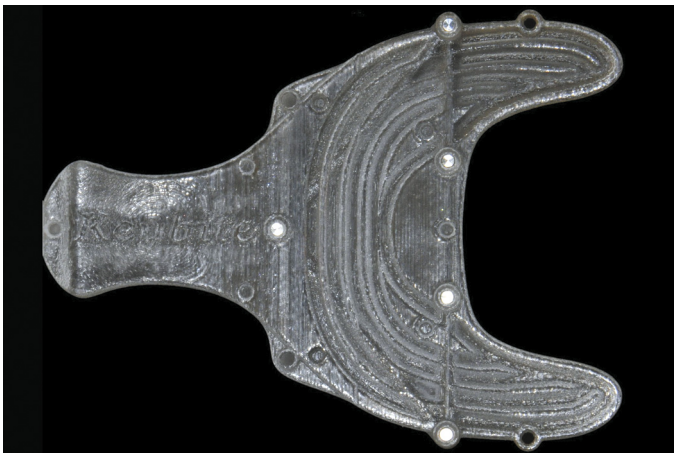
CLINICAL REPORT

A 55-year-old white woman presented at the Graduate Prosthodontics Clinic, Department of Oral Health and Rehabilitation, School of Dentistry, University of Louisville, for the replacement of missing right maxillary canine and premolars. The teeth had been previously removed with a simultaneous ridge preservation procedure. A clinical intraoral and radiographic examination found no contraindications for dental treatment (Fig. 1). The patient wanted to have her missing dentition restored with a fixed dental prosthesis, and a treatment option with 2 dental implants and an implant-supported fixed dental prosthesis was presented, which she accepted. A digital treatment pathway with computer-guided implant surgery and an immediate provisionalization protocol was chosen. It required the use of 2 dental laboratories, the first for the virtual planning and CAD/CAM-fabricated surgical template and the second for the interim and definitive prosthesis.

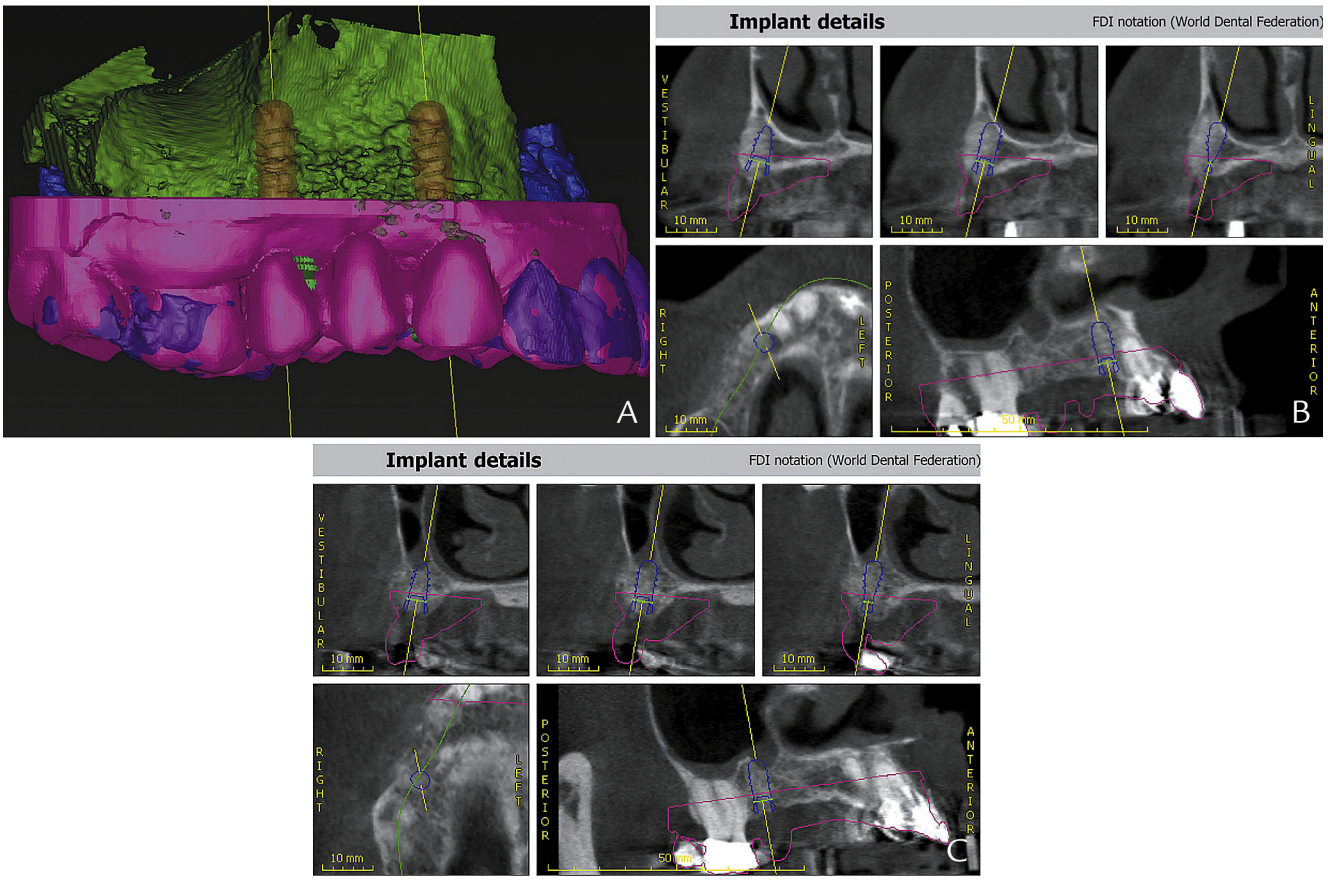
An intraoral digital scanner (iTero; Align Technology) was used to make digital diagnostic impressions for both the maxillary and mandibular arches with an interocclusal registration (Fig. 2). The approved scan data were forwarded to the selected dental laboratory (ProPrecision Guides), where virtual diagnostic casts and virtual diagnostic waxing were created (Fig. 3). CBCT for the maxillary anterior region was recommended for preoperative assessment, and the patient was scanned with a prefabricated universal radiographic template with fiducial markers (Keybite; ProPrecision Guides) (Fig. 4). The radiologic report from the CBCT confirmed that there was no evidence of pathosis and minimal atrophy of the edentulous ridge (in width) with evidence of bone grafting materials. However, the remaining ridge height necessitated simultaneous sinus grafting and implant placement. Digital stereolithography files (STL) generated from the virtual diagnostic casts and waxing were imported into virtual implant planning software (coDiagnostiX; Dental Wings GmbH). The Digital Imaging and Communications in Medicine data (DICOM) from the CBCT was also imported into the virtual implant planning software and merged with the STL files. A virtual prosthetically driven implant surgical

plan was completed in the virtual planning software (Fig. 5). The approved surgical plan was transmitted to the selected dental laboratory (Pro-Precision Guides), where a CAD/CAM-fabricated surgical template (Fig. 6) was created for subsequent computer-guided implant surgery and CAD/CAM-fabricated diagnostic casts (Fig. 7A, B). An immediate provisionalization protocol was planned. The interim implant-supported fixed dental prosthesis was made in the dental laboratory (Roy Dental Laboratory) on the CAD/CAM fabricated cast from autopolymerizing acrylic resin (Jet Tooth Shade Acrylic; Lang Dental) and provisional abutments (RN Temporary synOcta Post, Bridge; Straumann) (see Fig. 7C).

The computer-guided implant surgery was performed under local anesthesia. An intrasulcular full-thickness flap was raised to facilitate the planned osseous recontouring and sinus grafting procedure. Graft material containing mineralized cortical particulate (Guidor Allograft; Sunstar Americas Inc) was used for the sinus grafting procedure to prepare the site for the simultaneous implant placement at the maxillary second premolar location. Two implants (Straumann standard Plus, SLActive, guided 4.1 mm × 10 mm; Institut Straumann AG) were placed with the guidance provided by the CAD/CAM-fabricated surgical template (Fig. 8). The flap was coronally repositioned, and primary closure of the flap was obtained.



4 Prefabricated universal radiographic template with fiducial markers.

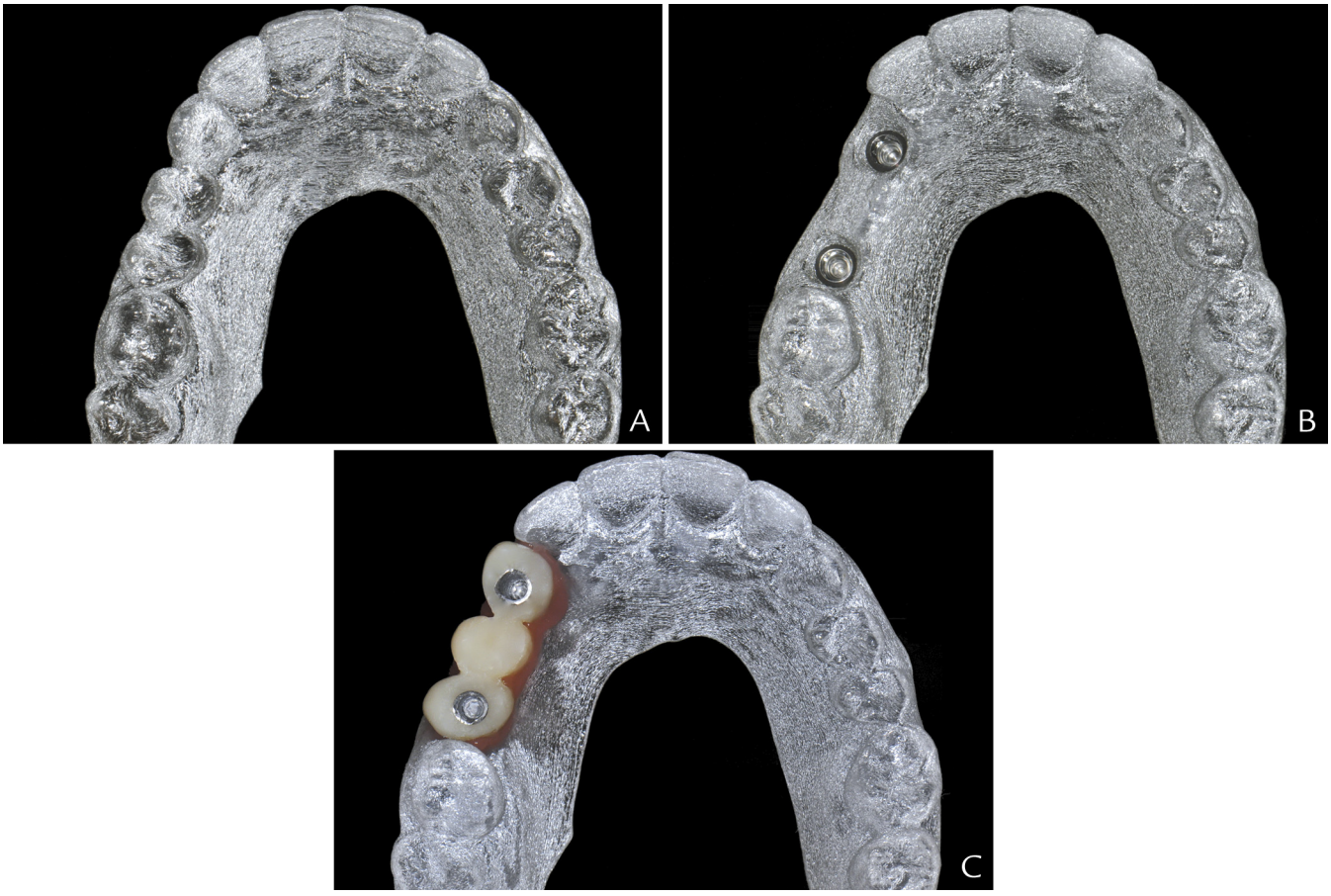


5 A, Demonstration of virtual prosthetically driven implant placements merged with DICOM file from CBCT and STL files generated from virtual diagnostic casts and waxing. B, Detailed prosthetically driven surgical plan for right maxillary canine. C, Detailed prosthetically driven surgical plan for right maxillary second premolar.

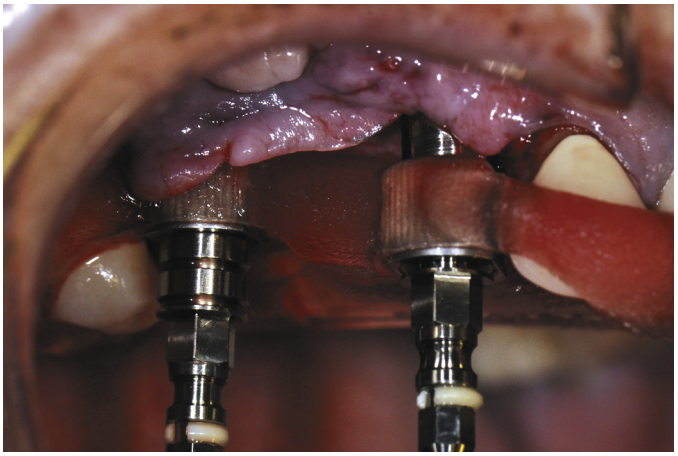
Because of the concerns of passivity of the interim restoration,[1] the laboratory-fabricated interim implant-supported fixed dental prosthesis was separated with a diamond disk (911.11.220 DS DIAM DISC; Brasseler USA) and reconnected with autopolymerizing acrylic resin (Jet Tooth Shade Acrylic; Lang Dental).

The patient was observed for 8 weeks with uneventful healing before the definitive impression appointment. An intraoral digital scanner (iTero; Align Technology) was used to acquire the definitive digital data with the scannable impression copings (Scan Body; Straumann AG) (Fig. 9). The milled definitive polyurethane cast was then fabricated by the manufacturer (iTero; Align Technology). The soft tissue profile at the periimplant area and the pontic site was transferred to the milled definitive polyurethane cast with the interim implant-supported fixed dental prosthesis and polyvinyl siloxane material (Softissue Moulage; Kerr Dental Laboratory Products) (Fig. 10).[12] The modified definitive cast with the desired soft tissue profile was digitized with a laboratory-based scanner (CS2 scanner; Institut Straumann AG) and used to design the definitive fixed dental prosthesis framework (Fig. 11). The approved framework design was sent to the production facility (Straumann USA)

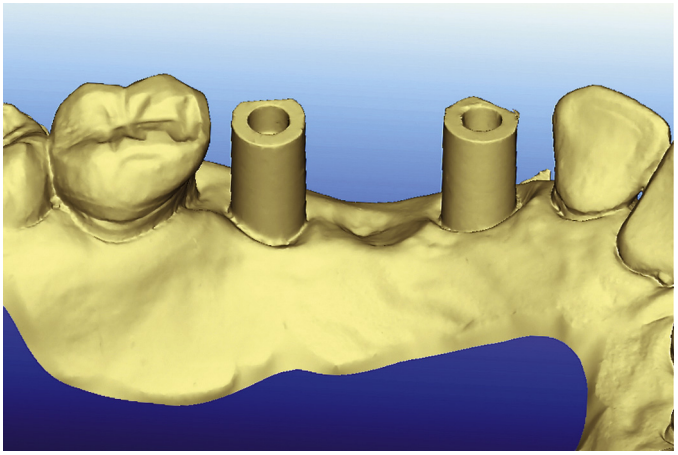
6 CAD/CAM fabricated surgical template for computer-guided surgery.



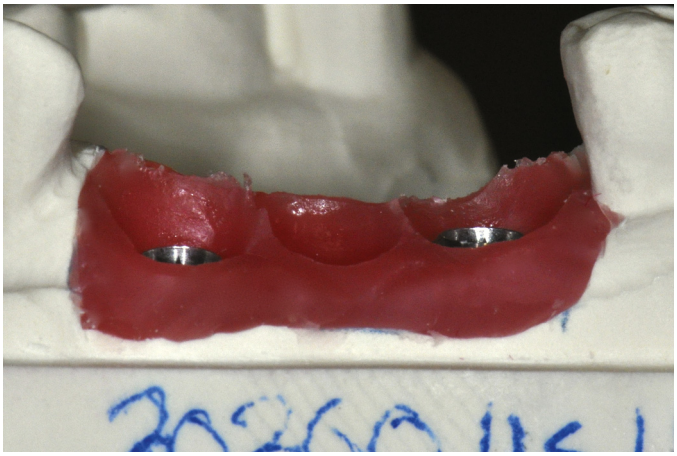
7 CAD/CAM fabricated casts. A, Diagnostic cast representing result from virtual diagnostic waxing. B, Diagnostic cast with implant analogs (RN synOcta analog; Straumann USA) representing planned implant placements. C, Completed interim implant-supported fixed dental prosthesis.



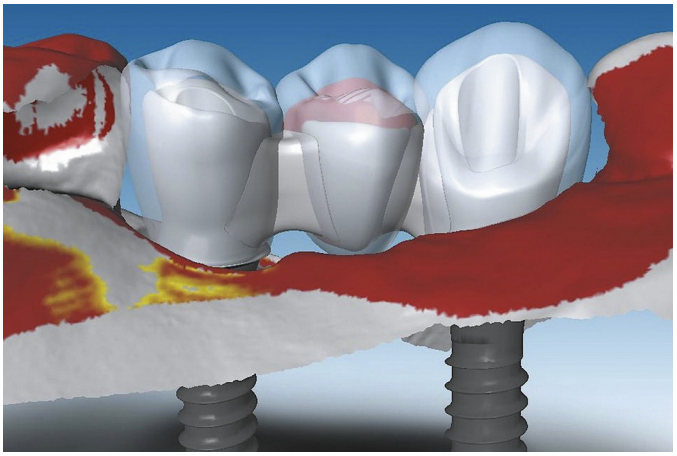
8 CAD/CAM fabricated surgical template was used to complete computer-guided surgery for 2 dental implants.



9 Definitive digital data acquisition made with intraoral digital scanner and scannable impression copings.



10 Modified milled definitive polyurethane cast with desired soft tissue profile at periimplant area and pontic site.



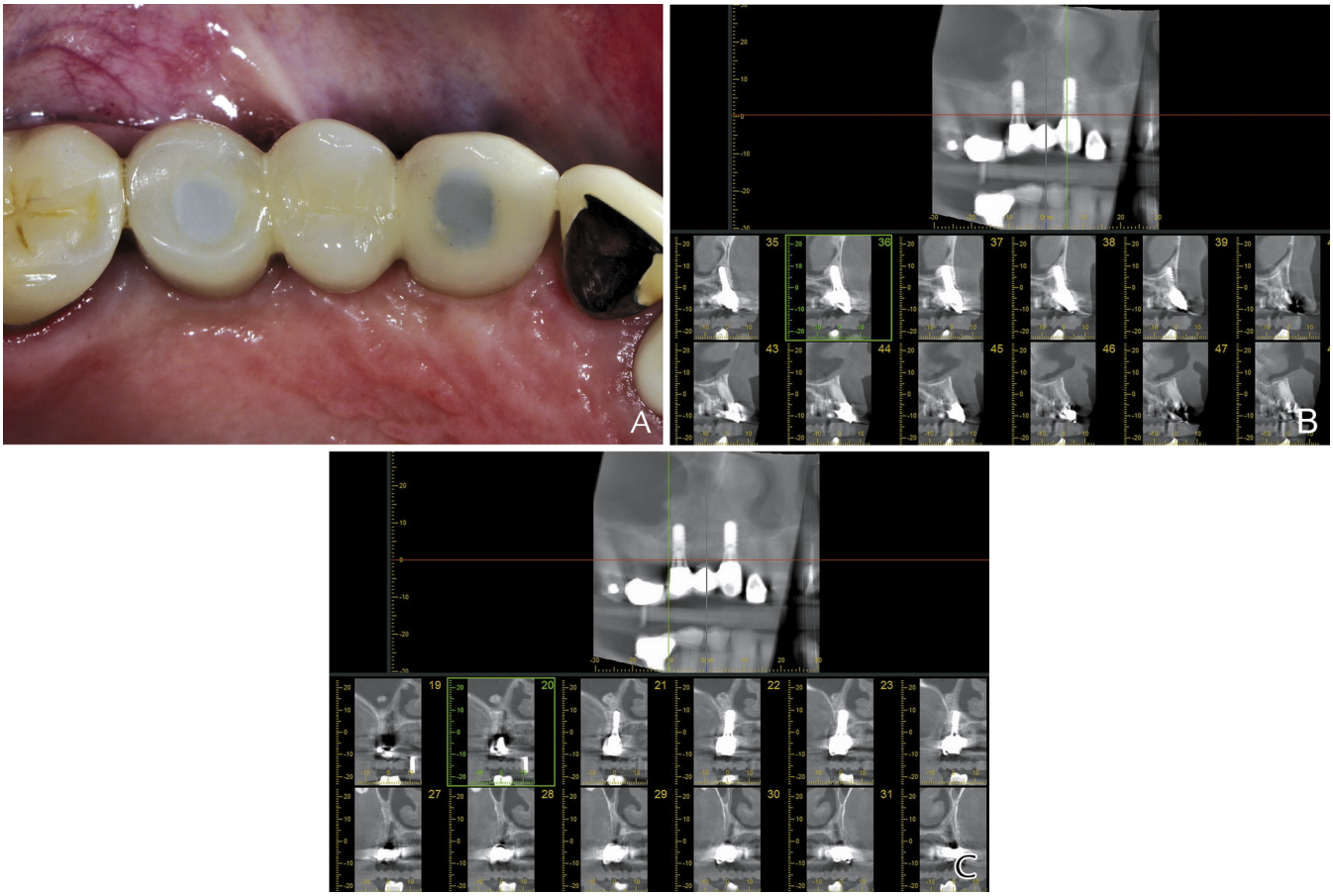
11 Design of CAD/CAM-fabricated definitive fixed dental prosthesis framework.

for fabrication from cobalt-chromium alloy (Coron; Straumann USA).

The framework was evaluated intraorally, and the definitive casts and framework were returned to the dental laboratory for completion. At the insertion appointment, all the necessary adjustments were made to achieve a satisfactory clinical outcome. The definitive metal ceramic fixed dental prosthesis was secured to the implants with a 35-Ncm preload (Fig. 12A). A high-resolution localized CBCT scan (60×60 mm, 90 kV, 3 mA, 180-degree Standard mode; effective doses, 23 μSv per CT image; 3D Accuitomo 170; J. Morita USA) of the implants was used for posttreatment assessment. The radiologic report showed that both implants were well integrated and that the bone augmentation material in the right sinus was homogeneous (see Fig. 12B, C).

DISCUSSION

The advantages of the workflow presented were reduced treatment time and cost. The digital diagnostic impression and a CBCT scan were completed in a single visit. Because a prefabricated universal radiographic template (Keybite; ProPrecision Guides) was used, the cost of a customized radiographic template was eliminated. The proposed workflow has several limitations. The CAD software may not permit a highly customized virtual diagnostic waxing, and the completed virtual diagnostic waxing cannot be transferred to the patient for a trial insertion. These limitations may limit the esthetic outcome of the definitive prosthesis. The CAD/CAM-fabricated diagnostic cast with the implant analogs (RN synOcta analog; Straumann USA) is an additional cost of the proposed workflow. However, this cast can be omitted if an immediate provisionalization protocol is not planned or if an interim implant-supported fixed dental prosthesis is fabricated intraorally. Furthermore, both the clinician and the dental laboratory technician require additional system-specific training and experience with the proposed digital workflow.



12 Definitive metal-ceramic fixed dental prosthesis. A, Occlusal view. B, Posttreatment CBCT at right maxillary canine area. C, Posttreatment CBCT scan showing implant at right maxillary second premolar area.

SUMMARY

This clinical report proposed a digital workflow to provide a CAD/CAM-fabricated, implant-supported fixed dental prosthesis with a digital diagnostic impression, virtual planning, computer-guided implant surgery, and immediate provisionalization.

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NOTEWORTHY ABSTRACTS OF THE CURRENT LITERATURE

A retrospective analysis of 800 Brånemark System implants following the All-on-Four™ protocol

Balshi TJ, Wolfinger GJ, Slauch RW, Balshi SF
J Prosthodont 2014;23:83-8

Purpose. The purpose of this study was to retrospectively evaluate implant survival rates in patients treated with the All-on-Four™ protocol according to edentulous jaws, gender, and implant orientation (tilted vs. axial).

Materials and Methods. All Brånemark System implants placed in patients following the All-on-Four™ protocol in a single private practice were separated into multiple classifications (maxilla vs. mandible; male vs. female; tilted vs. axial) by retrospective patient chart review. Inclusion criteria consisted of any Brånemark System implant placed with the All-on-Four™ protocol from the clinical inception (May 2005) until December 2011. Life tables were constructed to determine cumulative implant survival rates (CSR). The arches, genders, and implant orientations were statistically compared with ANOVA.

Results. One hundred fifty-two patients, comprising 200 arches (800 implants) from May 2005 until December 2011, were included in the study. Overall implant CSR was 97.3% (778 of 800). Two hundred eighty-nine of 300 maxillary implants and 489 of 500 mandibular implants survived, for CSRs of 96.3% and 97.8%, respectively. In male patients, 251 of 256 implants (98.1%) remain in function while 527 of 544 implants (96.9%) in female patients survived. Regarding implant orientation, 389 of 400 tilted implants and 389 of 400 axial implants osseointegrated, for identical CSRs of 97.3%. All comparisons were found to be statistically insignificant. The prosthesis survival rate was 99.0%.

Conclusions. The results from this study suggest that edentulous jaws, gender, and implant orientation are not significant parameters when formulating an All-on-Four™ treatment plan. The high CSRs for each variable analyzed demonstrate the All-on-Four™ treatment as a viable alternative to more extensive protocols for rehabilitating the edentulous maxilla or mandible.