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CLINICAL REPORT

CAD-CAM–fabricated interim fixed complete-arch implant-supported restorations based on the existing dentition

Jingjing Shao, MDS,[a] Hai Qing, DDS, PhD, MDS,[b] Zhimin Zhu, PhD, MDS,[c] and Lei Li, PhD, MDS[d]

ABSTRACT

An interim restoration is often used to assess the patient's functional and esthetic needs for implant-supported complete-arch fixed prostheses. A digital protocol for accurately transferring information from the existing dentition to the interim restoration is required. The purpose of this clinical report was to describe a digital workflow to fabricate an interim fixed restoration by using the vertical dimension of occlusion and occlusal relationship from the original dentition to provide an accurate, efficient, and predictable computer-aided design and computer-aided manufacturing (CAD-CAM) interim complete-arch implant-supported restoration. (J Prosthet Dent 2019;121:717-23)

Implant-supported complete-arch fixed prostheses have been a treatment option for edentulous patients for decades.[1,2] The conventional workflow is multistep, time-consuming, and sometimes tedious, especially when an interim restoration is involved. With the development of digital technologies in dentistry, the predictability of clinical and laboratory procedures has significantly improved.[3,4] For example, during complete-mouth fixed rehabilitation using dental implants, a prosthesis-guided implant surgical template and the interim restoration can be fabricated with digital technology before implant placement.[3,5]

After extraction of a periodontally compromised dentition, an interim restoration is required to restore function and esthetics when the primary stability of the implants is achieved and immediate loading is feasible. The interim fixed complete-arch implant-supported restoration also provides information on occlusal vertical dimension (OVD), tooth shape, and position for the definitive restoration.[6,7] Two main approaches have been used to fabricate the interim restoration. The first is the registration of the position of the implants after their surgical placement and the fabrication of the interim fixed prosthesis by the dental technician, which is sometimes unsuccessful because of inaccuracy of the occlusal registration and impression.[8-10] The second is a chairside conversion of an existing removable complete prosthesis. Clinically converted prostheses are often nonreinforced acrylic resin and sometimes face difficulty to adapt to the modified alveolar ridge after extraction of the teeth.[11,12] This clinical report describes a workflow to digitally fabricate a computer-aided design and computer-aided manufacturing (CAD-CAM) interim fixed complete-arch restoration based on the exact occlusion relationship, tooth position, and tooth contour of the original dentition.

CLINICAL REPORT

A 50-year-old man was referred to the prosthodontic department of the West China Dental Hospital with a complaint of mobile teeth and poor masticatory function. The extraoral examination did not reveal any abnormalities. During the intraoral examination, defective restorations were noted in both the maxillary and mandibular dentitions (Fig. 1). Miller grade II mobility was observed of the maxillary right third molar and grade I mobility was observed of the mandibular right second and third molars, mandibular left third molars, and fixed partial denture replacing the maxillary anterior teeth. The posterior fixed partial dentures had only limited mobility.

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[a]Postgraduate student, West China School of Stomatology, Sichuan University, Chengdu, PR China.
[b]Assistant Professor, Department of Restorative Dentistry, Maurice H. Kornberg School of Dentistry, Temple University, Philadelphia, Pa.
[c]Professor, Department of Oral Prosthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu, PR China.
[d]Professor, Department of Oral Prosthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu, PR China.

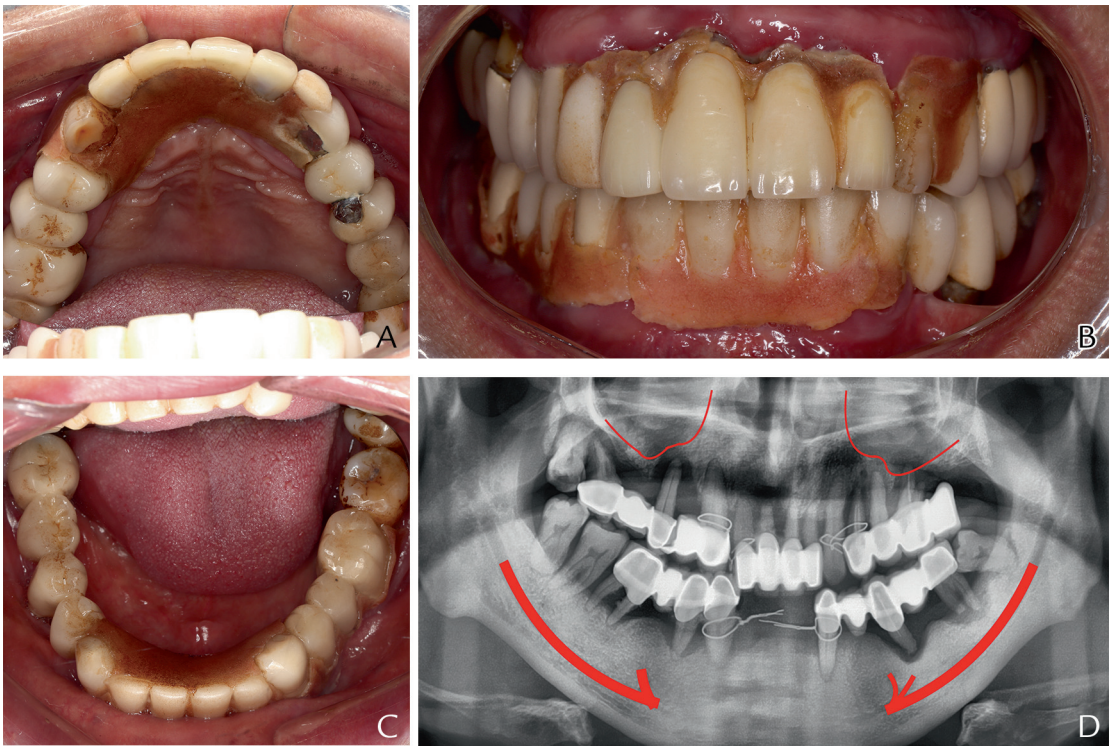

Figure 1. Pretreatment images. A, Maxillary occlusal view. B, Frontal view. C, Mandibular occlusal view. D, Panoramic radiograph.

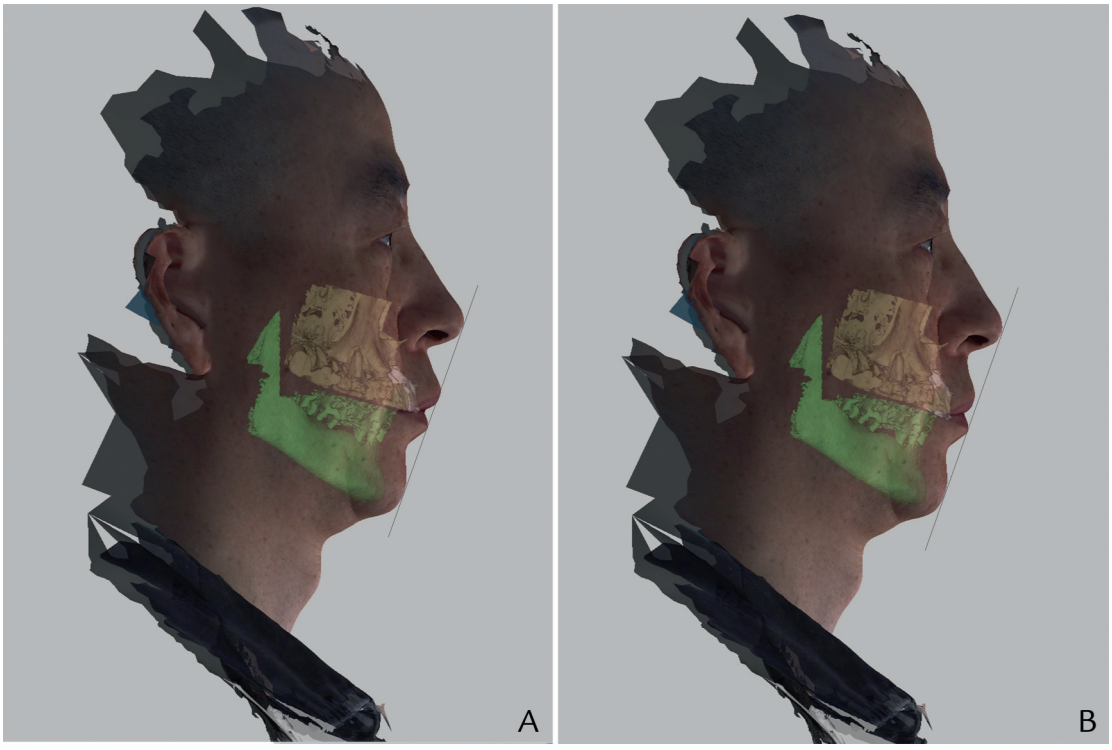

Figure 2. A, Infusion of CBCT scan with 3D facial image in Dolphin software. B, Prediction of lateral profile with 3.0-mm retrusion of anterior teeth. CBCT, cone beam computed tomography.

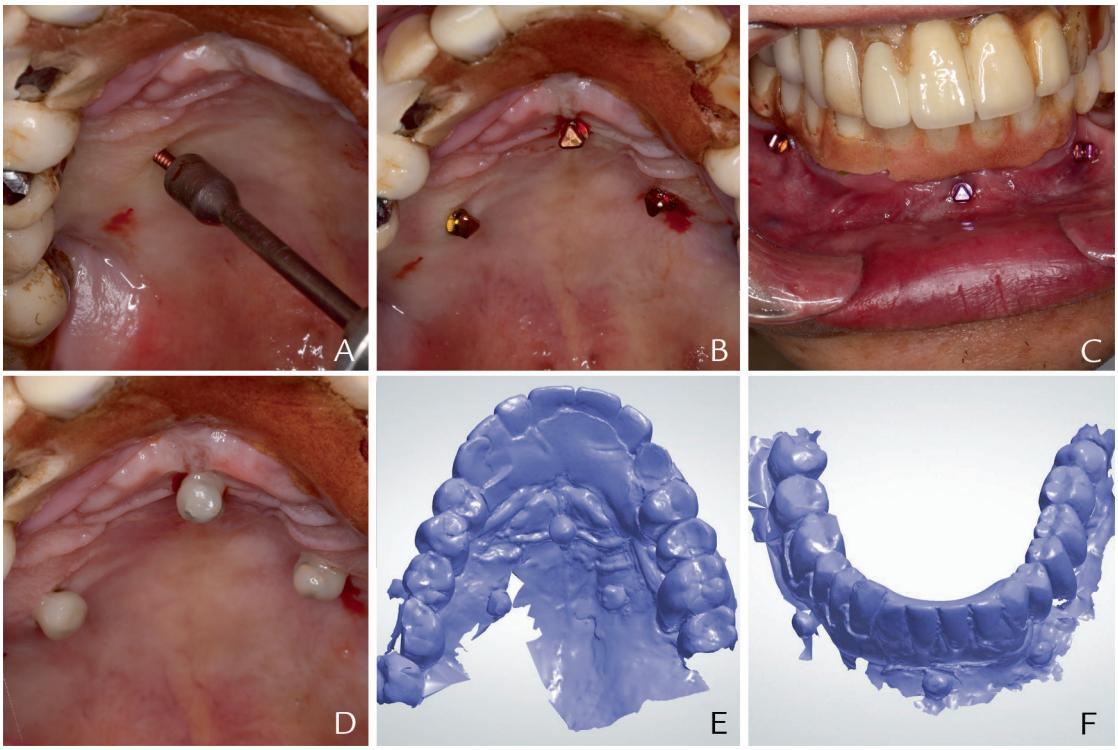

Figure 3. A, Installing mini-implant. B, Three mini-implants in maxilla. C, Three mini-implants in mandible. D, Flowable composite resin markers on mini-implants. E, Maxillary arch scan. F, Mandibular arch scan.

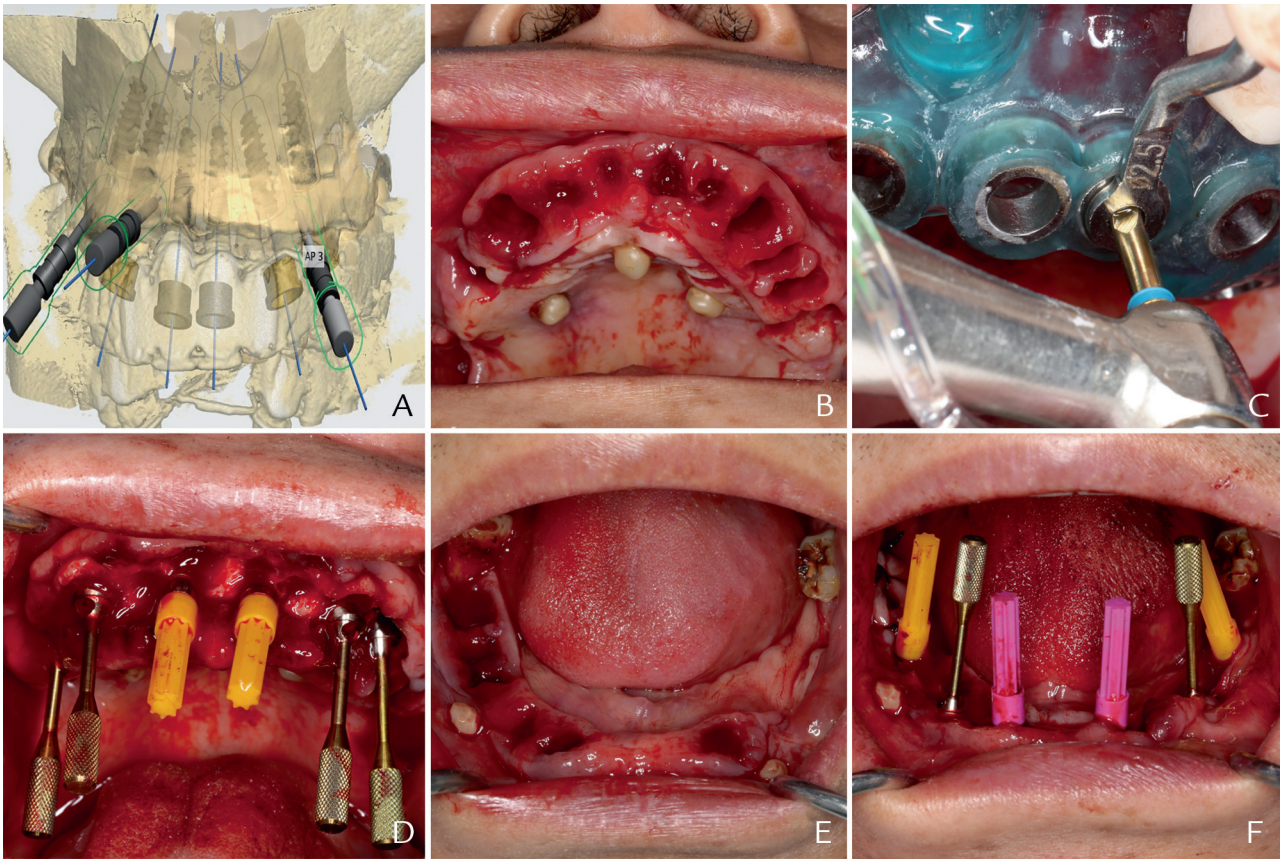

Figure 4. A, Maxillary surgical template designed. B, Maxillary arch with teeth extracted. C, Guided drilling of pilot holes. D, Adjustment of insertion path with tilted abutments. E, Mandibular arch with teeth extracted. F, Adjusted mandibular multiunit abutments.

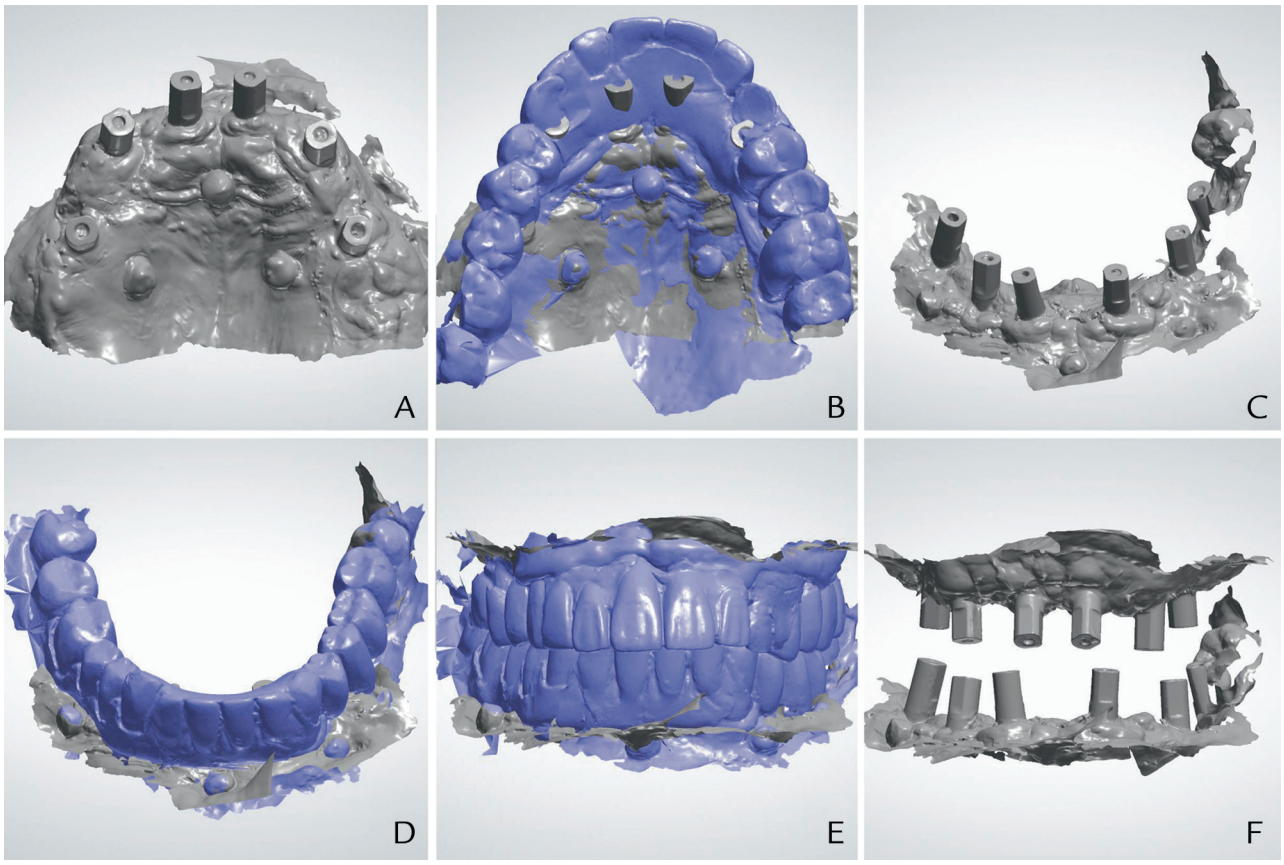

Figure 5. A, Postoperative maxillary digital scan. B, Fusion of preoperative and postoperative maxillary digital scans. C, Postoperative mandibular digital scan. D, Fusion of preoperative and postoperative mandibular digital scans. E, Maximum intercuspal position of original dentition. F, Arches with implant positions.

A cone beam computed tomography scan and panoramic radiograph showed severe alveolar bone resorption (Fig. 1D).

After treatment options were discussed, the patient elected an implant-supported fixed restoration and requested immediate fixed restorations for function and esthetics. In addition, he complained that his maxillary anterior teeth protruded and asked for esthetic improvements of the lower third facial profile. Facial profile can be improved through combined orthodontic and orthognathic surgical treatments, and the relationship between incisors and lip movements has been studied.[13-15] Recently, accurate soft-tissue predictions have proved to be achievable with the Dolphin software (Dolphin Imaging & Management Solutions; Patterson Dental).[16] The new tooth arrangement was analyzed using retrusion analyses in the software. Virtually retruding the incisal edges of the anterior teeth about 3.0 mm (Fig. 2) was found to give the best esthetic outcome with 2.0 mm of lip retraction.

Before the digital intraoral scans, 6 mini-implants (VectorTAS; Ormco) were placed, 3 in the maxilla and 3 in the mandible (Fig. 3A-C). Flowable light-polymerized composite resin (Beautifil Flow Plus; Shofu) was injected on top of the mini-implants and shaped as a dome with a diameter of approximately 2.0 mm for image superimposition of the intraoral scan data before and after the surgery (Fig. 3D). The arches were scanned separately, and then the maximum intercuspal position was scanned as the first set of digital scans in standard tessellation language (STL1) to obtain information regarding the OVD, maximum intercuspal position, tooth shape, and positioning (Fig. 3E, F). The modified dentition was designed based on the original dentition and retrusion analysis, and a maxillary surgical template was fabricated accordingly (Fig. 4A).

The surgical procedures were performed under local anesthesia. The remaining teeth were extracted in a minimally invasive way (Fig. 4B). The sharp alveolar crests and socket prominences were removed using rongeurs, and no further bone reduction was performed because of a low smile line. In the maxilla, the pilot drill was guided by the template, and then the implants (NobelActive; Nobel Biocare) were inserted following the manufacturer's guidelines (Fig. 4C, D). In the mandible, 6 implants were placed free hand on the designed sites

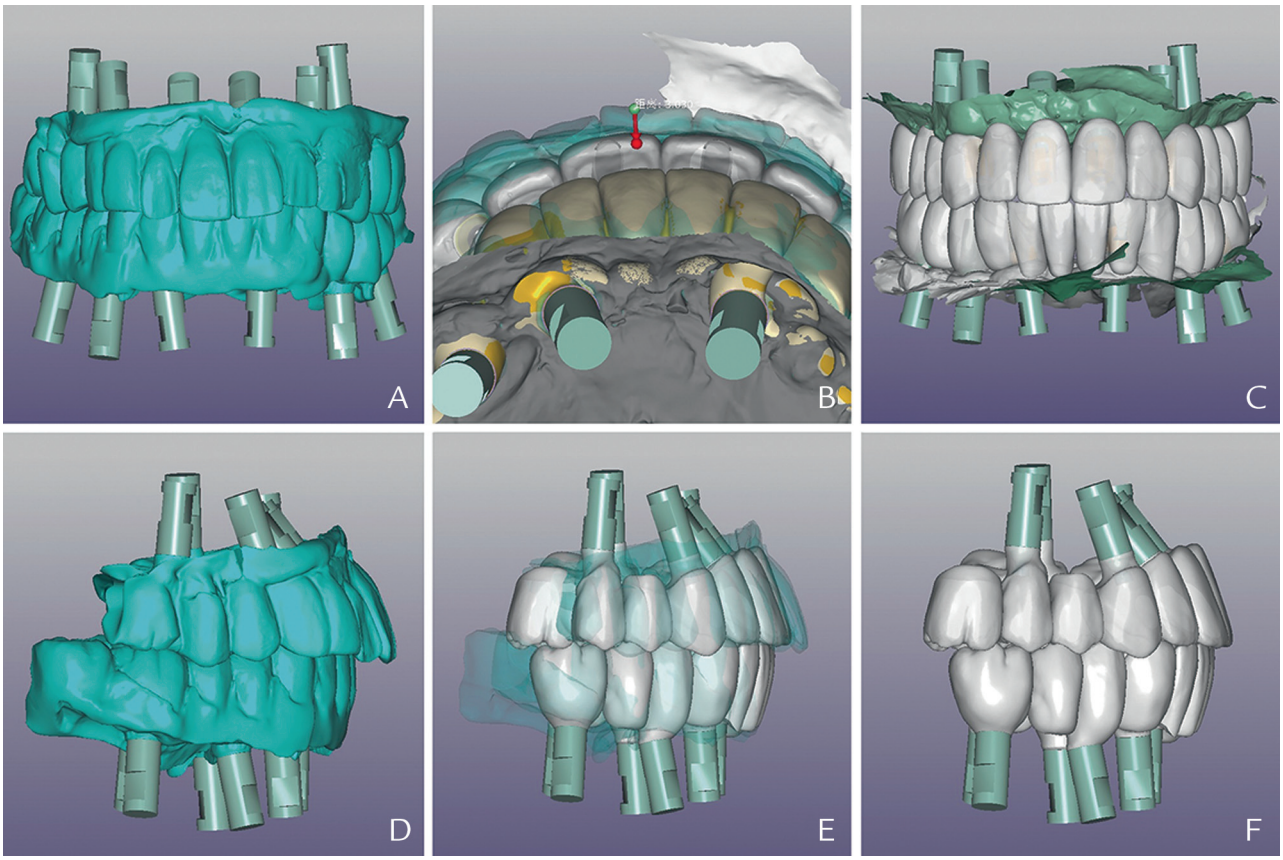

Figure 6. A, Frontal view of original dentition. B, Occlusal view of 3.0-mm retrusion of anterior teeth. C, Frontal view of modified dentition. D, Lateral view of original dentition. E, Lateral view of virtual retrusion of anterior teeth. F, Lateral view of modified dentition.

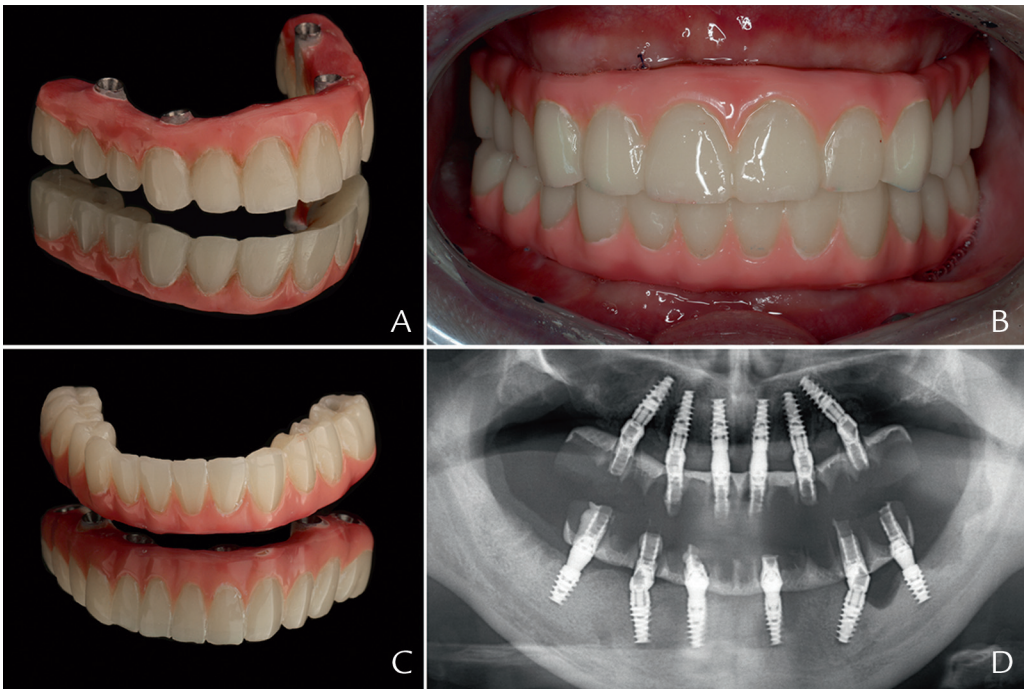

Figure 7. A, Maxillary complete-arch interim restoration. B, Intraoral view. C, Mandibular complete-arch interim restoration. D, Panoramic radiograph after delivery of restorations.

Figure 8. A, Postoperative left 45-degree-angled view. B, Postoperative frontal view. C, Postoperative right 45-degree-angled view. D, Pretreatment lateral facial profile. E, Prediction of lateral facial profile using Dolphin software. F, Postoperative lateral facial profile.

with proper angulations (Fig. 4E, F). All the implants reached a final insertion torque >50 Ncm, and then angulated abutments were selected for the tilted implants. After adding screwed scan bodies to the multiunit abutments, the second set of digital scans (STL2) was made, and implant 3D positions were registered in both the arches (Fig. 5A-C). Image fusion of the intraoral scan data before and after the surgery was performed by semiautomatic 3D object adjustment. The images (STL1 and STL2) were virtually fused by matching resin markers that were present on the intraoral scan, creating the STL3 file. In this way, OVD, tooth shape, and positioning of the original dentitions were transferred to the arches with implant positions (Fig. 5B, D-F). The interim restoration with retruded anterior teeth was also designed based on the STL3 files (Fig. 6A-F). The casts of both jaws were 3D printed with resin (J700; Stratasys), and implant analogs were inserted. Interim fixed restorations were CAD-CAM–fabricated from a resin block (PMMA disk; Yamahachi), and titanium interim copings were placed with resin cement (RelyX U200; 3M ESPE). Pink resin (Ceramage; Shofu) was added to simulate the color of the gingival tissue (Fig. 7). Four days after the surgery, interim complete-arch fixed restorations were delivered with good fit, esthetics, and occlusion (Fig. 7B, D). The patient was satisfied with his new fixed rehabilitation (Fig. 8A-C), and the new lateral facial profile was similar to the presurgery prediction by the Dolphin Software (Fig. 8D-F).

DISCUSSION

With this digital workflow, different scans were superimposed to obtain a single file containing the essential information. Parameters including esthetic qualities, functional OVD, occlusal relationships, and gingival aspects were digitally transferred from the original dentition to the virtual arches with implants to facilitate a high-quality, definitive, complete-arch prosthesis.[17] This approach is not appropriate for patients with a loss of OVD, inadequate occlusal scheme, or abnormal occlusal or incisal planes. For edentulous arches, the tissue surface does not have enough unique points between sets of data created by 3D scanners. An inaccurate and noisy mesh with a compounding error as the images are stitched together makes the scanning procedure time-consuming.[18] An intraoral scanner (TRIOS; 3Shape) failed to capture a part of the left posterior arch due to

lack of attached gingiva and hemorrhage, which fortunately did not affect the surface matching of the scan bodies. For clinical scenarios with the remaining teeth, image fusion of the intraoral scan data before and after implant placement is accurate.[19] However, after extraction of the dentition, finding markers to fuse digital scans can be difficult because of the mobility and swelling of the soft tissue after the surgery and local anesthesia. To overcome these problems, the authors developed a method in which markers were placed on the fixed mini-implants to achieve good-fit matching between scans. However, resin markers placed on the mandible with a shallow vestibular fold left no space for seating an implant template. Therefore, 6 implants on the mandible were placed free hand. In the future, mini-implants in this workflow could be replaced by regular implants with a wide diameter which function as both markers for image fusion and anchors for implant templates.

SUMMARY

This clinical report demonstrated a method of digitally transferring data from the original dentition to the immediate implant-supported complete-arch restoration. In this way, without errors from conventional protocols, the workflow was accurate and predictable.

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Corresponding author:
Dr Lei Li
Department of Oral Prosthodontics
West China Hospital of Stomatology, Sichuan University
No 14, Sec.3, Renminnan Road
Chengdu 610041
PR CHINA
Email: leelei@scu.edu.cn

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