THE JOURNAL OF PROSTHETIC DENTISTRY

DENTAL TECHNIQUE

Fabrication of facially guided CAD-CAM complete dentures: A dental technique

Guillermo Galván Lobo, DDS,[a] Manel Cruz Vida, CDT,[b] Nancy E. Hartrick, DDS,[c] and Guillermo Galván Guerrero, DDS[d]

ABSTRACT

An alternative protocol is presented to design computer-aided design and computer-aided manufacturing (CAD-CAM) complete dentures and overdentures using a facially guided digital design. The facially guided design protocol with CAD-CAM facilitated communication between the clinician and dental laboratory technician. A monolithic denture and overdenture were fabricated guided by preliminary dentures with 3-dimensionally (3D) printed denture bases and milled wax teeth. (J Prosthet Dent xxxx;xxx:xxx-xxx)

A complete denture produced with computer-aided design and computer-aided manufacturing (CAD-CAM) technology was first described in 1994,[1] and digital denture construction was described by Goodacre et al[2] in 2012. Since then, a wide variety of materials and software programs have been developed to improve the digital clinical workflow.[3,4]

Both subtractive and additive manufacturing have been applied to the digital fabrication of complete dentures.[5] With subtractive manufacturing, denture bases are milled from a prepolymerized resin blank, and denture teeth can be milled or prefabricated depending on the system selected. Limitations include wastage and the monochromatic and unesthetic milled teeth produced, although some systems address this issue by utilizing multilayer teeth with improved esthetics.[6] Additive manufacturing with 3-dimensional (3D) printing has become popular in a variety of applications.[7]

Facially guided design has been implemented into complete denture clinical protocols.[8,9] However, integration of the design procedures into the fabrication process is lacking. The presented technique describes a protocol to design and produce facially guided CAD-CAM complete dentures and overdentures accurately.

TECHNIQUE

1. Make polyvinyl siloxane (PVS) impressions (Aquasil Soft Putty; Dentsply Sirona) and occlusion records using a bimaxillary tray (Centric Tray; Ivoclar AG). Obtain the craniomaxillary relationship with a digital facebow (UTS CAD; Ivoclar AG) (Fig. 1). Make extraoral and intraoral digital photographs and panoramic radiographs (Fig. 2).
2. Scan the PVS impressions with an extraoral scanner (D750; 3Shape A/S) to obtain virtual casts (Dental System; 3Shape A/S) (Fig. 3A) and align them with the digital facebow parameters (Dental System; 3Shape A/S) (Fig. 3B). Mark anatomic reference points (maxillary tuberosity, incisal papilla, canine eminences, deepest area of the mucolabial sulcus, retromolar trigone or retromolar fossa, and center of the alveolar crest). Design preliminary complete dentures following standard denture parameters. Maxillary: slight labial

Supported by the Department of Dentistry at the University of Barcelona, Barcelona, Spain. Materials provided by Ivoclar AG.
The described technique was developed at Clínica Galván Lobo.
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
[a]Private practice, Valladolid, Spain; Guest Professor, Department of Dentistry, University of Barcelona, L´Hospitalet de Llobregat, Barcelona, Spain; and Researcher, Bellvitge Biomedical Research Institute (IDIBELL), Barcelona, Spain.
[b]Dental Technician, DMD99 Dental Laboratory, Mataró, Spain.
[c]Private practice, Royal Oak, Mich., Kois Center, Seattle, Wash ; and Clinical Instructor, Kois Center, Seattle, Wash.
[d]Private practice, Valladolid, Spain, Kois Center, Seattle, Wash; Guest Professor, Department of Dentistry, University of Barcelona, L´Hospitalet de Llobregat, Barcelona, Spain; Guest Professor, Department of Dentistry, International University of Catalunya, San Cugat del Valles, Barcelona, Spain; and Clinical Instructor, Kois Center, Seattle, Wash.

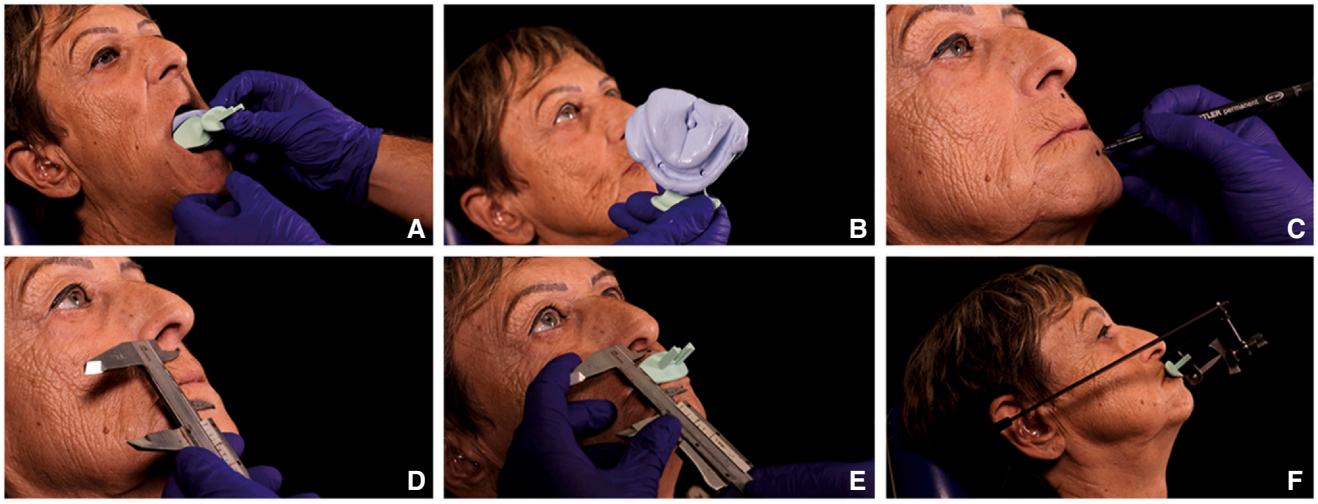

Figure 1. Impression making, occlusal records using bimaxillary tray and craniomaxillary relationship registration. A, Bimaxillary tray insertion. B, Silicone impression making. C, Vertical occlusal dimension determination. D, Vertical occlusal dimension measurement. E, Vertical occlusal dimension verification. F, Craniomaxillary relationship registration.

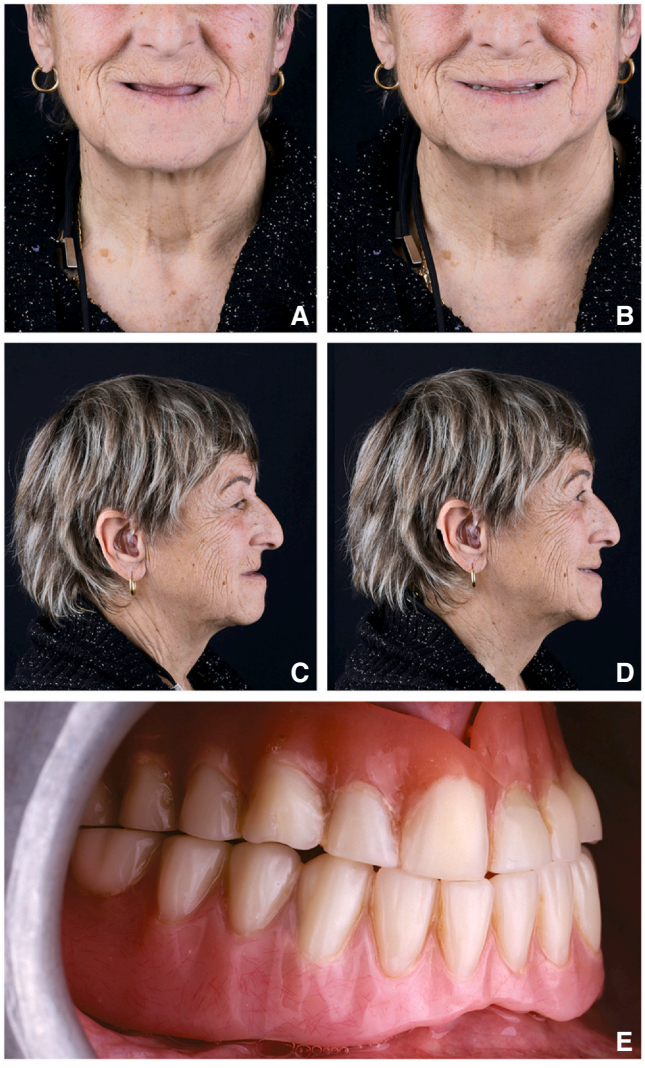

Figure 2. Pretreatment photographs. A, Edentulous portrait. B, Prosthetic portrait. C, Edentulous profile. D, Prosthetic profile. E, Intraoral view.

inclination and the maxillary labial surface 7 mm anterior to the line bisecting the incisive papillae, 4-mm-wide anterior and gradually becoming wider posterior to measure 7 mm and 22-mm high from the labial flange lateral to the labial frenum, and 18-mm high from the buccal flange to the tuberosity area. Mandibular: 18 mm from the labial flange lateral to the labial frenum and should be level with the acrylic resin base posteriorly, 4-mm wide anteriorly, and increasing posteriorly to be 7 mm wide in the molars area. Provide a preliminary denture relief of 0.35 mm (Fig. 4). These preliminary dentures are composed of 2 components: the printed denture bases (Anycubic, Photon Mono X2; Anycubic) and a milled wax disk (4Disk Wax; 4Design S.r.l.) CAD-CAM library (Dental System; 3Shape A/S) tooth block (Ivoclar PrograMill PM7; Ivoclar AG) using the dental library from the dual color resin disk (Ivotion; Ivoclar AG) (Fig. 5A).

3. Coat the intaglio of the preliminary complete dentures with PVS adhesive (VPS Tray Adhesive; 3M) (Fig. 5B) and fill with medium-body PVS material (Aquasil Ultra+ Medium Regular Set; Dentsply Sirona) obtaining definitive functional mucosal impressions.
4. Adjust the occlusion of the relined preliminary dentures.
5. Make extraoral and intraoral digital photographs.
6. Scan the preliminary complete dentures and digital occlusion records with an intraoral scanner (TRIOS 3; 3Shape A/S) and with an extraoral scanner (D750; 3Shape A/S) to verify the accuracy of the standard tessellation language (STL) files.
7. Place teeth in the CAD software program (Dental System; 3Shape A/S) and select shade for the teeth and gingiva. Both shades should match with a dual

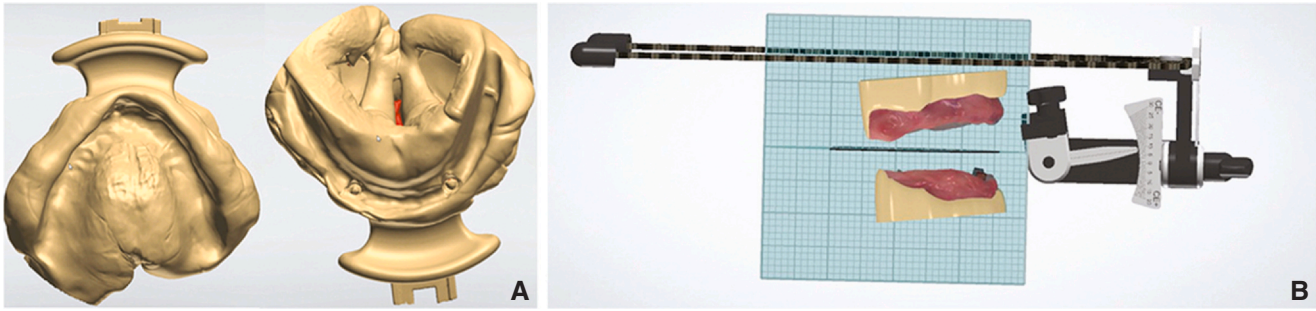

Figure 3. Virtual dental cast processing. A, Digitalized silicone impressions. B, Virtual casts mounted in digital articulator.

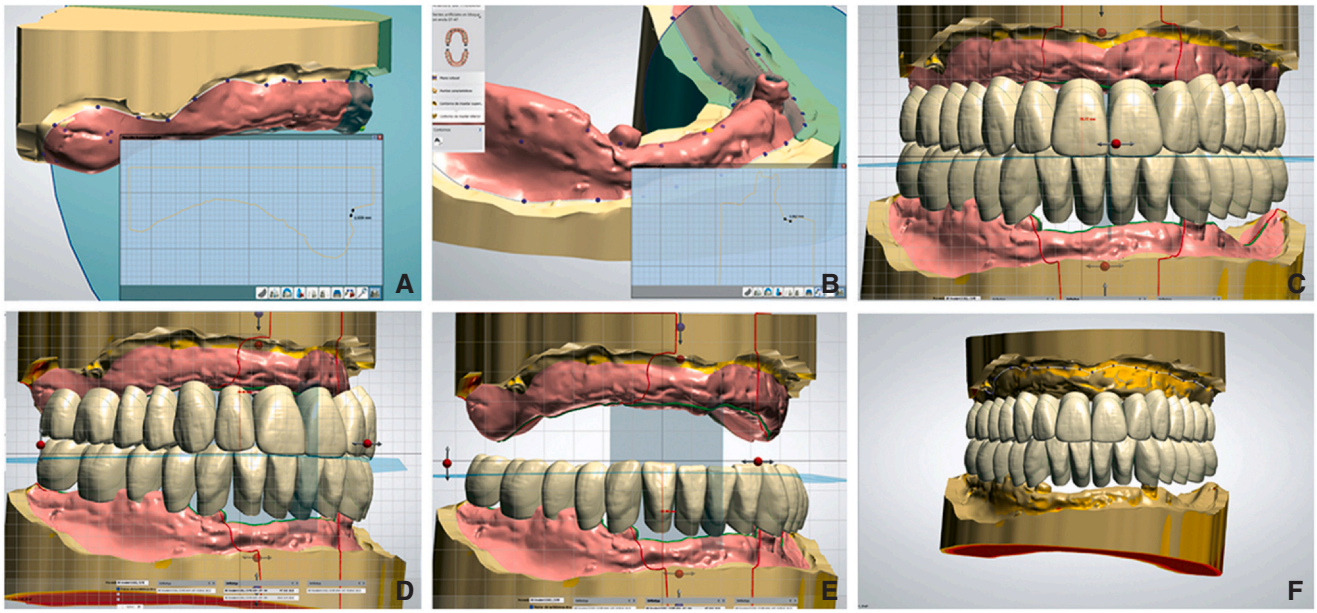

Figure 4. Preliminary denture design. A, Maxillary prosthetic extension determination. B, Mandibullar prosthetic extension determination. C, Initial occlusal proposal. D, Maxillary preliminary denture standard parameter verification. E, Mandibular preliminary denture standard parameter verification. F, Preliminary dentures definitive occlusal scheme.

color resin disk (Ivotion; Ivoclar AG). Mark anatomic reference points on the maxillary and mandibular casts. Draw definitive prosthesis extensions on the mucosal impressions obtained from the functionalized preliminary dentures. Use the automatic initial proposal suggested by the smile design generator module (Smile Composer, Dental System; 3Shape A/S). Overlap digital photographs with the digital intraoral scans of the preliminary dentures using the digital smile design tool (Real View, Dental System; 3Shape A/S) to facilitate final esthetic corrections (Fig. 6). Calculate the milling strategy and fabricate both prostheses. Generate a cam5 file, position it in the dual color resin disk (Ivotion; Ivoclar AG), and locate connection bars on each denture. Remove the dentures from the milling machine, mark interdental angles, and polish (Fig. 7).

8. Insert definitive removable prostheses. Use autopolymerizing resin (Quick Up; Voco GmbH) to retain the abutment housing (LOCATOR; Zest Anchors Co) in the denture.

When the dentures are evaluated in the mouth, minimal occlusal adjustment should be needed. After the function and comfort of both prostheses have been determined with minor occlusal adjustments, polish if needed (Fig. 8).

DISCUSSION

The protocol presented involves a semidigital complete removable dental prosthesis fabrication workflow in 3 clinical visits. This technique includes virtual digital prosthetic design using specific dental libraries and digital

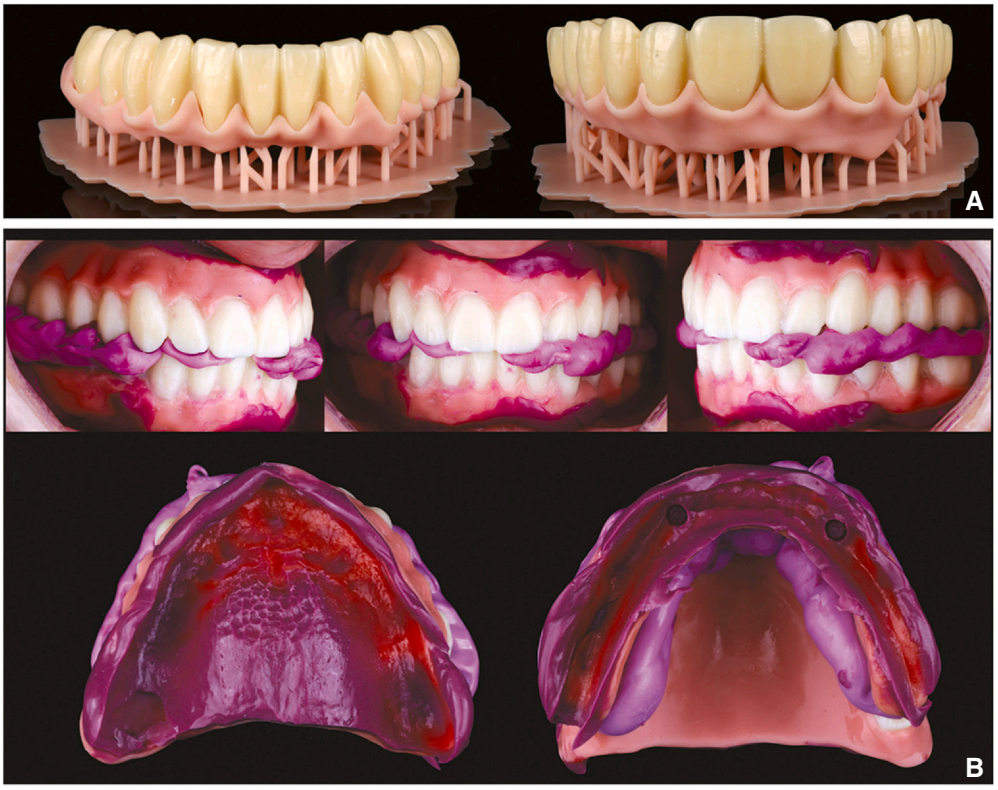

Figure 5. Preliminary dentures. A, Mandibular and maxillary preliminary denture. B. Functionalized preliminary dentures.

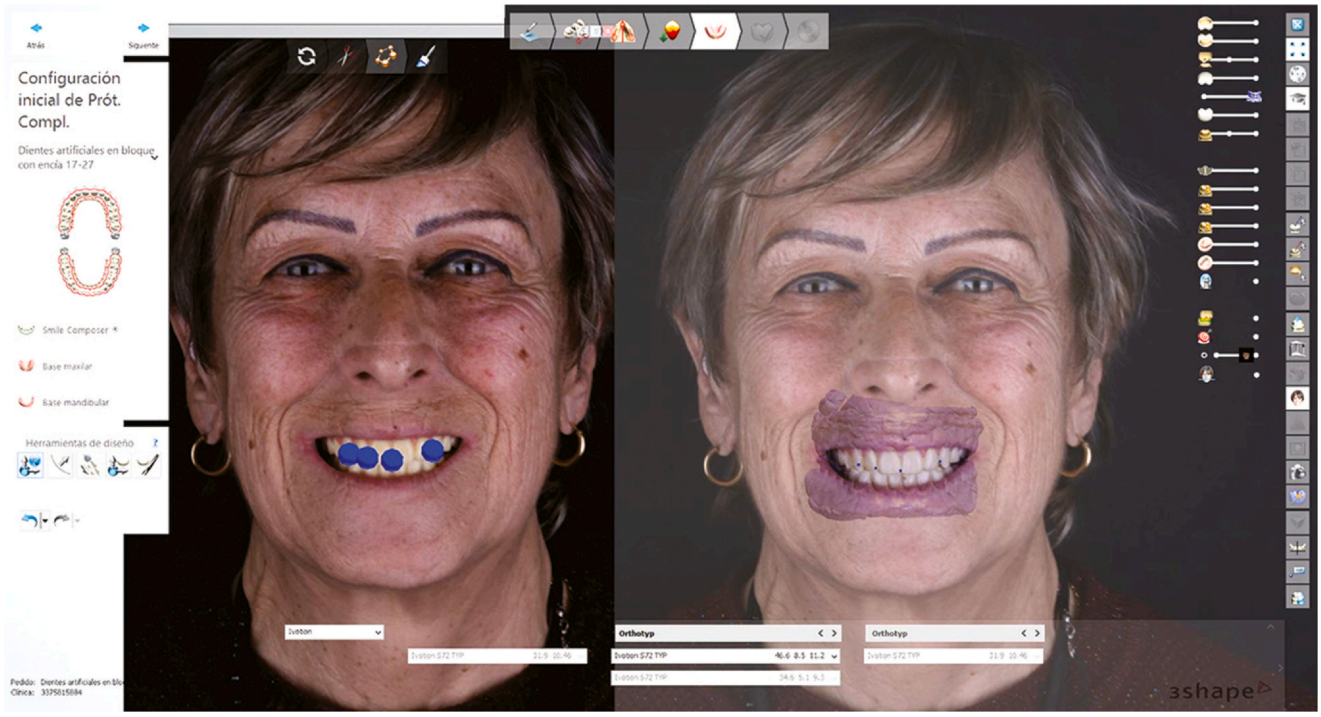

Figure 6. Facially guided definitive prothesis digital design protocol.

photographs, as well as a monolithic denture or over-denture fabrication protocol with high-impact resin. The technique provides a time saving, improved process by incorporating wax rims with teeth, thereby reducing the number of clinical visits. Additionally, clinician-technician communication is facilitated by incorporating the

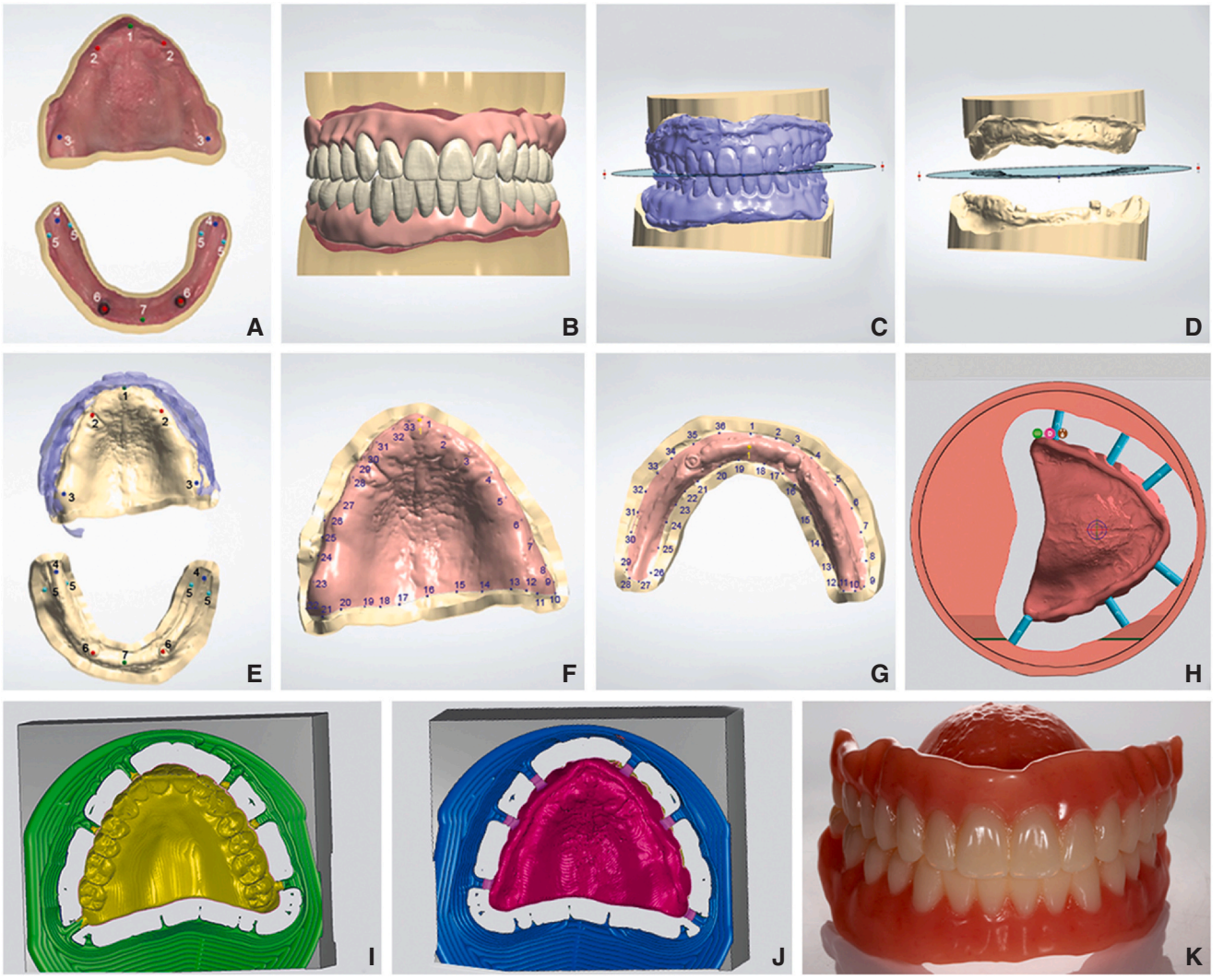

Figure 7. Definitive monolithic denture fabrication. A, Anatomic reference points: 1, Incisal papilla. 2, Maxillary canine sites. 3, Maxillary tuberosity. 4, Retromolar trigome. 5, Deepest mucolabial sulcus. 6, Mandibular canine sites. 7, Center of alveolar crest. B, Initial definitive prosthesis design. C, Preliminary denture digitalized occlusal record. D, Rehabilitation position. E, Preliminary denture digitalized sagittal record. F, Maxillary definitive prosthesis margin extension. E, Mandibular definitive prosthesis margin extension. H, Connection bar placement. I, Cameo milling strategy. J, Intaglio milling strategy. K, Definitive prostheses.

discussion of key information throughout the design and fabrication process.

CAD software programs provide powerful tools and strategies to produce high-level dental prostheses with more precision than with conventional protocols, providing definitive prostheses with excellent esthetics and function without additional visits. Preliminary dentures make digital smile design possible for prosthesis fabrication. In addition, digital photography makes it possible to foresee esthetic outcomes before the fabrication of the definitive prostheses. Furthermore, CAD-CAM technology improves treatment precision by using digital dental libraries that allow the dental laboratory technician to overlap the wax rims with the definitive tooth arrangement design. Milled wax facilitates occlusal adjustment because of the manageability of the wax. Another advantage is that the high strength monolithic dentures and overdentures do not require metal reinforcement.

As an alternative to the described technique, complete white resin trial dentures can be fabricated. However, pink esthetics play an essential role in esthetic oral rehabilitation[10,11]; therefore, both pink and white esthetics require assessment to achieve successful outcomes. Moreover, bilaminate preliminary dentures allow greater correction, since the milled wax teeth can be detached if needed.[12–14] The presented technique can be applied to other more complex clinical situations such as complete arch implant-supported dentogingival prostheses.

Figure 8. Treatment outcome photographs. A, Extraoral views. B, Intraoral views.

SUMMARY

A 3-visit novel workflow for the CAD-CAM fabrication of removable complete dentures based on preliminary dentures was described and should lead to more cost-efficient treatment plans while achieving precise and successful outcomes.

PATIENT CONSENT

Written informed consent was obtained prior to the submission of the data collected in this technique description.

REFERENCES

1. Maeda Y, Minoura M, Tsutsumi S, Okada M, Nokubi T. A CAD/CAM system for removable denture. Part I: fabrication of complete dentures. *Int J Prosthodont.* 1994;7:17–21.
2. Goodacre CJ, Garbacea A, Naylor WP, Daher T, Marchack CB, Lowry J. CAD/CAM fabricated complete dentures: concepts and clinical methods of obtaining required morphological data. *J Prosthet Dent.* 2012;107:34–46.
3. Baba NZ, AlRumaih HS, Goodacre BJ, Goodacre CJ. Current techniques in CAD/CAM denture fabrication. *Gen Dent.* 2016;64:23–28.
4. Mubaraki MQ, et al. Assessment of conventionally and digitally fabricated complete dentures: A comprehensive review. *Materials (Basel).* 2022;15:3868.
5. Schweiger J, Stumbaum J, Edelhoff D, Guth JF. Systematics and concepts for the digital production of complete dentures: Risks and opportunities. *Int J Comput Dent.* 2018;21:41–56.
6. Yilmaz B, Azak AN, Alp G, Ekşi H. Use of CAD-CAM technology for the fabrication of complete dentures: An alternative technique. *J Prosthet Dent.* 2017;118:140–143.
7. Anadioti E, Kane B, Soulas E. Current and emerging applications of 3D printing in restorative dentistry. *Curr Oral Health Rep.* 2018;5:133–139.
8. Hassan B, Greven M, Wismeijer D. Integrating 3D facial scanning in a digital workflow to CAD/CAM design and fabricate complete dentures for immediate total mouth rehabilitation. *J Adv Prosthodont.* 2017;9:381–386.
9. Hassan B, Gimenez Gonzalez B, Tahmaseb A, Greven M, Wismeijer D. A digital approach integrating facial scanning in a CAD-CAM workflow for complete-mouth implant-supported rehabilitation of patients with edentulism: A pilot clinical study. *J Prosthet Dent.* 2017;117:48–92.
10. Spear FM, Kokich VG. A multidisciplinary approach to esthetic dentistry. *Dent Clin North Am.* 2007;51:487–505.
11. Bhuvaneswaran M. Principles of smile design. *J Conserv Dent.* 2010;13:225–232.
12. Deng K, Chen H, Wang Y, Zhou Y, Sun Y. Evaluation of functional suitable digital complete denture system based on 3D printing technology. *J Adv Prosthodont.* 2021;13:361–372.
13. Yang Y, Zhu X, Wang Z, Liu X, Tan J, Wang Y. A digital workflow for single complete denture using a multi-functional diagnostic denture. *J Dent Sci.* 2023;18:889–892.
14. Zhang Y, Yu H, Li K, Zhang Y, Gao B, Wu J. Digital fabrication of complete dentures using a combination of additive and subtractive manufacturing technologies. *Heliyon.* 2023;9:e16168.

Corresponding author:
Dr Guillermo Galván Lobo
Calle Acera de Recoletos, 12, 1°A
Valladolid 47004
SPAIN
Email: galvanloboguillermo@gmail.com

Acknowledgments
The authors thank Dr Carles Subirá Pifarré for his contribution to the development of this clinical protocol.

https://doi.org/10.1016/j.prosdent.2023.10.018