THE JOURNAL OF PROSTHETIC DENTISTRY

DENTAL TECHNIQUE

An additively manufactured intraoral scan body for aiding complete-arch intraoral implant digital scans with guided integration of 3D virtual representation

Marcelo Gabriel Pérez-Giugovaz, DDS,[a] Meredith Mosier, DDS,[b] and Marta Revilla-León, DDS, MSD[c]

ABSTRACT

This article describes a polymeric additively manufactured intraoral scan body that facilitates a complete-arch intraoral implant digital scan and guides the superimposition procedures between the facial and digital scans comprising the patient's 3D virtual representation. Furthermore, this novel intraoral scan body can be modified for the patient's specific arch dimensions, enhancing patient comfort and facilitating digitizing. (J Prosthet Dent 2020;■:■-■)

A successful esthetic prosthesis can be optimized with a facially driven diagnostic waxing.[1-5] Different techniques have been described to merge digital patient information with cone beam computed tomography (CBCT) scans to obtain a 3D virtual representation.[6-18] However, the integration of facial and complete-arch implant digital scans by using a single intraoral scan body—without the use of the CBCT—has not been described.

Intraoral scanners (IOSs) provide a clinically acceptable alternative to conventional impression making for crowns and short-span fixed prostheses.[19-23] However, complete-arch implant digital scans have been reported to lack accuracy.[24-29] A custom polymeric device to improve the accurate digitalization of implant positions on completely edentulous patients has been described.[30,31] The objective of this device was to support the digitizing procedures, but it did not include the integration of the patients' facial scans.

The present article describes a technique for merging a patient's facial scans with complete-arch implant digital scans guided by an intraoral additively manufactured (AM) scan body. As a result, a facially driven maxillary complete-arch implant-supported interim prosthesis can be fabricated.

TECHNIQUE

1. Import the virtual design of the intraoral scan body[32,33] (Fig. 1A) to the printer software program (Anycubic i3; Anycubic). Select a vat-polymerization 3D printer (Photon 1; Anycubic) to manufacture the polymeric (OptiPrint Temp Crown & Bridges B1; Dentona) intraoral scan body. Follow the post-processing procedures recommended by the manufacturer (Fig. 1B, 1C).
2. During the first clinical appointment, duplicate the patient's interim maxillary complete denture.[33] Then, trim away the palatal coverage and reposition the duplicated denture in the patient's mouth. Use flowable composite resin material and add dot and line markers to the soft tissue of the uncovered palate. Record prepreparation maxillary and mandibular natural dentition and interocclusal digital scans by using an IOS (TRIOS 3; 3Shape A/S) according to the protocol recommended by the manufacturer under 1000-lux illuminance (Fig. 2A).[34,35]

[a]Director, Graduate in Digital Dentistry, Catholic University of Córdoba, Córdoba, Argentina; and Director, Centro de Capacitación CAD3D, City Bell-La Plata, Buenos Aires, Argentina; and Private practice, City Bell-La Plata, Buenos Aires, Argentina.
[b]Private practice, Dallas, Texas.
[c]Assistant Professor and Assistant Program Director AEGD Residency, Comprehensive Dentistry Department, College of Dentistry, Texas A&M University, Dallas, Texas; and Affiliate Faculty, Graduate Prosthodontics, Department of Restorative Dentistry, School of Dentistry, University of Washington, Seattle, Wash; and Researcher at Revilla Research Center, Madrid, Spain.

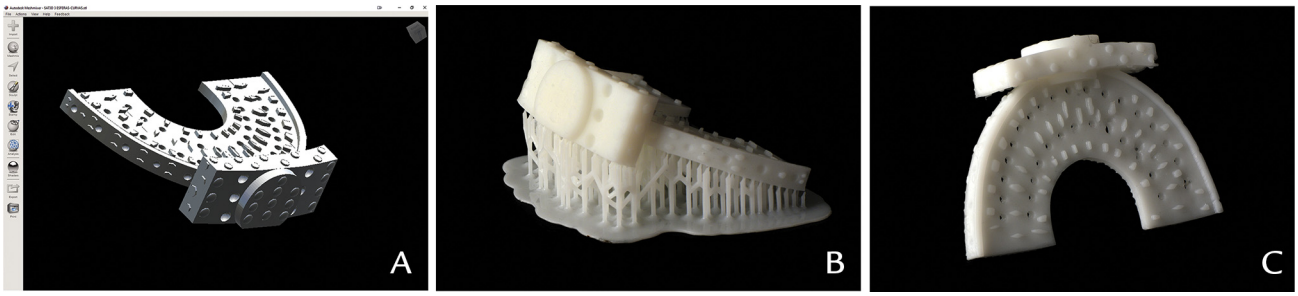

Figure 1. A, Virtual design of intraoral scan body. B, Before removing supportive material. C, After postprocessing procedures.

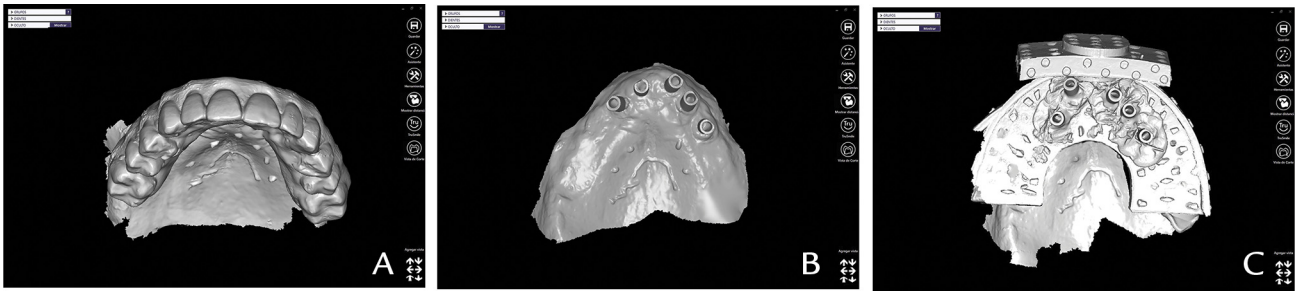

Figure 2. A, Prepreparation maxillary scan with duplication of interim complete denture lacking palatal coverage positioned in patient's mouth. B, Intraoral maxillary digital scan with implant scan bodies positioned. C, Intraoral digitization of intraoral scan body splinted to implant scan bodies.

Figure 3. Facial reference scan of patient with intraoral scan body positioned in mouth.

Figure 4. Completed maxillary reference scan.

3. Remove the healing abutments and hand tighten an implant scan body until stable on each implant as instructed by the manufacturer. Obtain a new maxillary digital scan by using the same IOS (Fig. 2B). Splint the intraoral scan body to the implant scan bodies by using an autopolymerizing acrylic resin (Pattern Resin LS; GC). Then, record a maxillary reference digital scan including the composite resin markers positioned on the palate (Fig. 2C).
4. Without removing the intraoral scan body, mark landmarks on the nose and forehead with a thin hypoallergenic eyeliner (ColorStay Liquid Eye Pen–Sharp line; Revlon) and record a facial reference scan by using a facial scanner (Bellus FacePro; Bellus 3D, Inc) according to the manufacturer's instructions (Fig. 3). Then, remove the splinted intraoral scan body by unscrewing the implant scan bodies and replace the healing abutments. Complete the digitizing of the buccal surface of the intraoral scan body extraorally by using the same IOS (Fig. 4). Finally, capture 4 more facial scans with the patient at rest and in smile positions both with and without the duplicated interim complete denture.

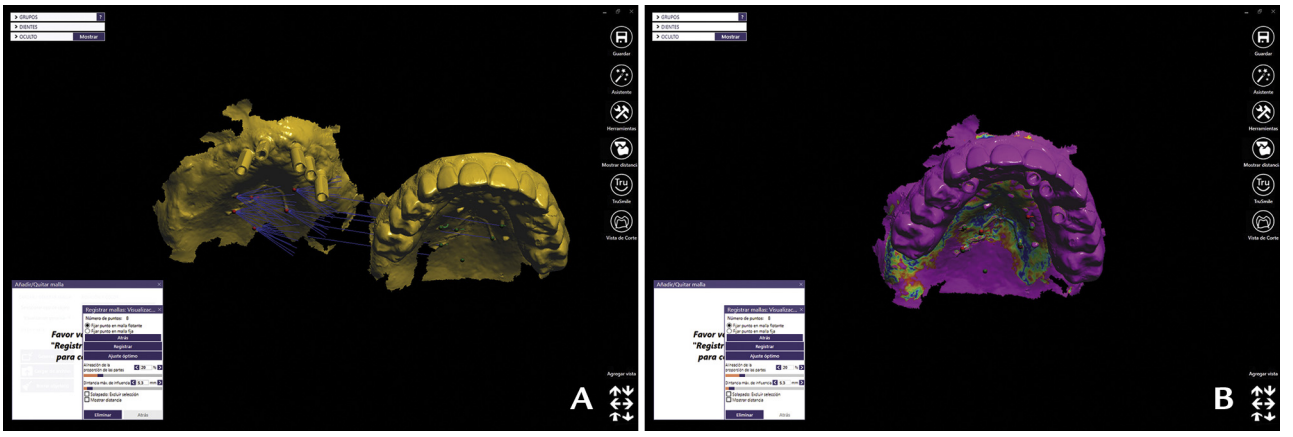

Figure 5. A, Superimposition of prepreparation maxillary digital scan and maxillary digital scan with implant scan bodies positioned in mouth by using iterative closest point technique. B, After merging procedures.

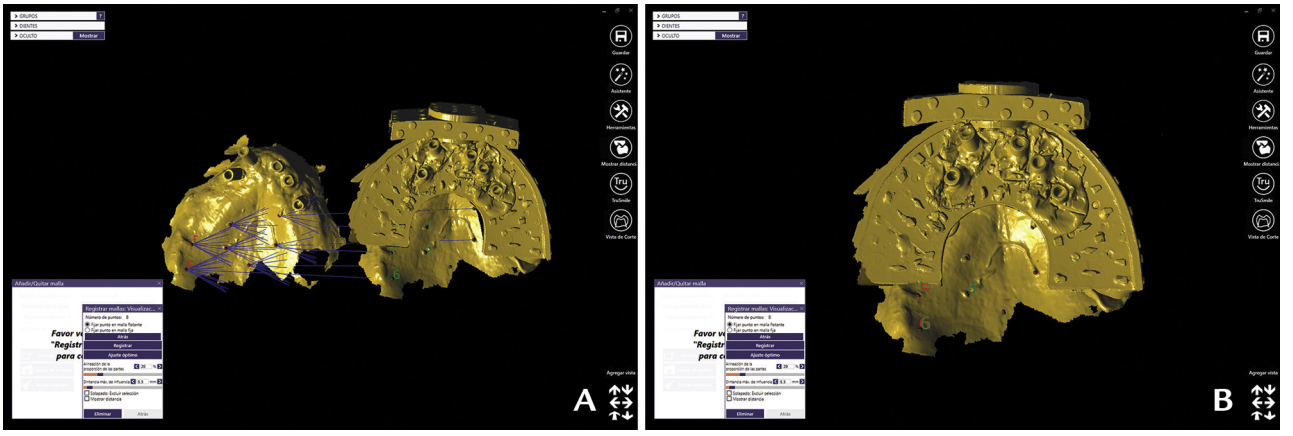

Figure 6. A, Superimposition of maxillary digital scan with implant scan bodies positioned in mouth and maxillary reference scan by using iterative closest point technique. B, After merging procedures.

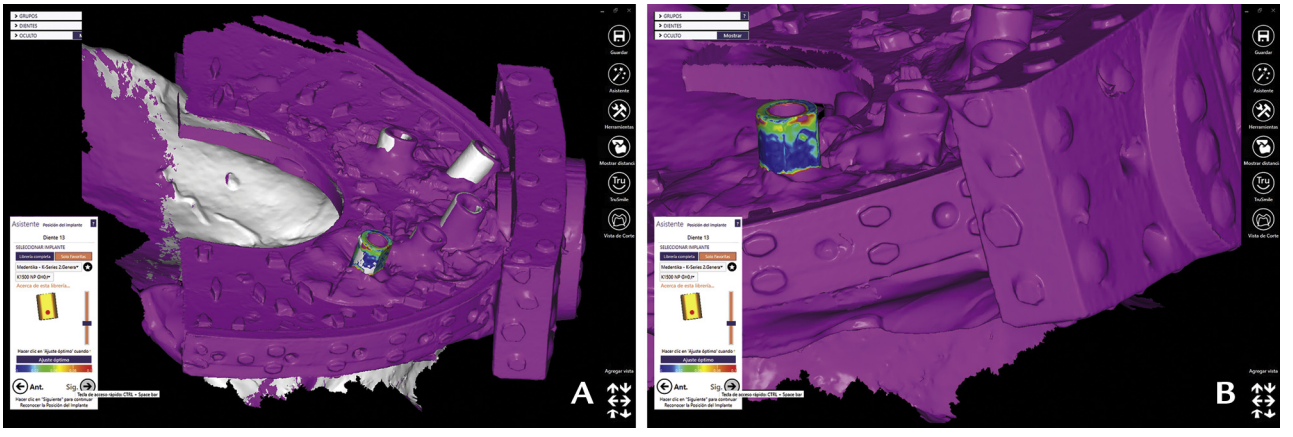

Figure 7. A, Implant positions determined by using scan bodies of maxillary reference digital scan as reference. B, Closer view of scan body superimposition to determine implant position.

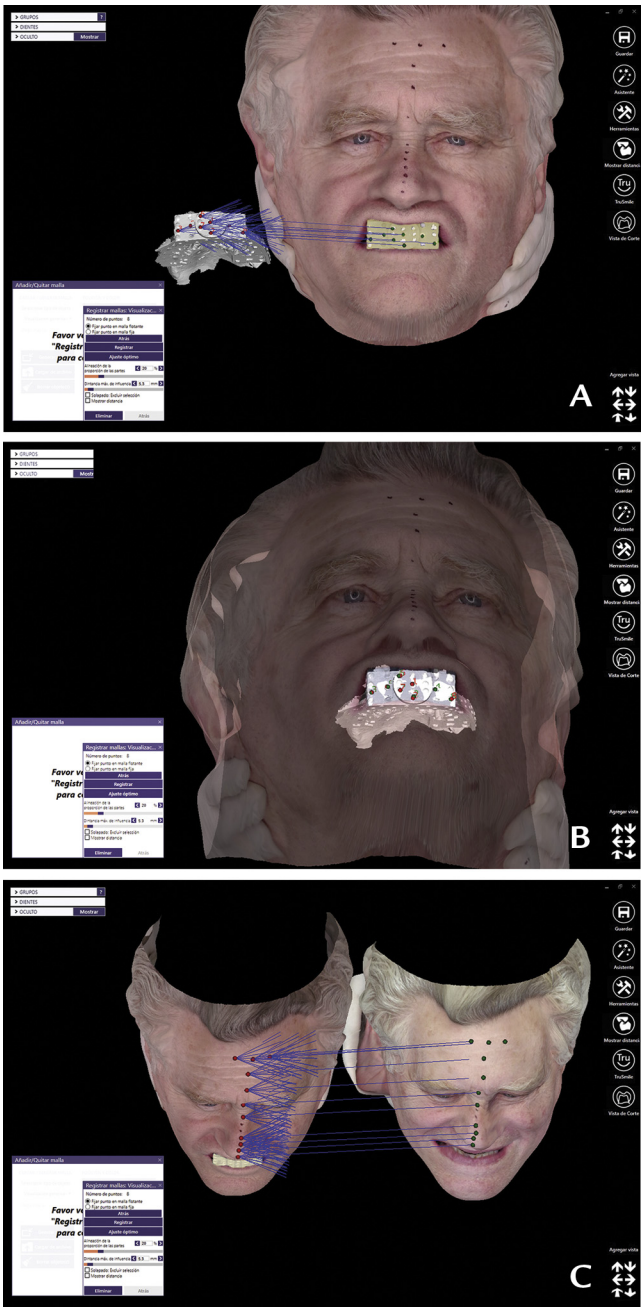

Figure 8. A, Superimposition of facial reference scan and maxillary reference digital scan by using iterative closest point technique. B, After merging procedures. C, Superimposition of facial reference scan and smile facial scan by using iterative closest point technique.

5. Import the patient's files into a CAD software program (Matera 2.4; exocad). By using the iterative closest point technique, superimpose the digital files by following this sequence:
   - Merge the prepreparation maxillary digital scan and the maxillary digital scan with the implant scan bodies positioned in the patient's mouth. Use the composite resin markers on the palate as the common element in both files (Fig. 5).
   - Superimpose the maxillary digital scan with the implant scan bodies positioned in the patient's mouth and the maxillary reference digital scan. Use the composite resin markers on the palate as the common element in both files (Fig. 6).
   - Determine the implant positions with the CAD tools by using the scan bodies of the maxillary reference digital scan (Fig. 7).
   - Merge the maxillary reference and the facial reference scans. Use the intraoral scan body as the common element in both files (Fig. 8). Merge the reference facial scan and the smile facial scan by using the forehead and nose landmarks as a common element in both files. Subsequently, repeat the procedure to superimpose the rest and the smile facial scans. When the procedures are

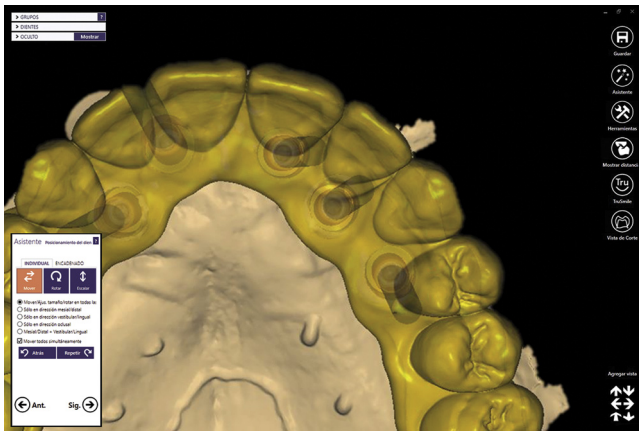

Figure 9. Diagnostic maxillary waxing elaborated by using dental computer-aided design software program (Matera 2.4; exocad).

Figure 10. Additively manufactured screw-retained evaluation prosthesis.

Figure 11. Additively manufactured screw-retained implant-supported interim prosthesis. A, Smile. B, Intraoral view.

completed, a 3D representation of the patient is obtained.

6. Arrange the maxillary teeth with the digital tools of the CAD software program (Fig. 9) by using the prepreparation maxillary scan as a reference for the interim complete denture. The design should include a standard titanium base implant abutment to allow a screw-cementable placement.[36] Export the STL file.
7. Use the STL file of the virtual design to additively manufacture the screw-retained teeth trial denture by using a 3D printer (Optiprint Temp Crown & Bridge A3; Dentona) and pink (Optiprint Denture; Dentona) and tooth-colored interim resin (FreeShape 120; Ackuretta) according to the manufacturer's instructions (Fig. 10).
8. During the second clinical appointment, evaluate the esthetics, phonetics, and function of the AM screw-retained trial denture. After obtaining patient consent and if no changes are needed, deliver it as a screw-retained implant-supported interim prosthesis (Fig. 11). If changes are needed, modify the maxillary tooth arrangement as needed in step 4 and repeat steps 5 and 6.
9. Evaluate the function, phonetics, and esthetics of the interim implant-supported prostheses for 3 months. If the patient does not present any complication, use the initial virtual planning in conjunction with the digitized maxillary interim provisional to design the definitive prostheses.

DISCUSSION

Improved scanning accuracy of complete-arch implant digital scans has been reported when a polymeric device is used.[31] In the present technique, a similar intraoral device was used to assist with transferring the implant positions by using an IOS; moreover, the intraoral device also facilitated the integration of the patient's 3D facial scans. The virtual design of the intraoral scan body can be modified to improve adaptation to the arch shape and dimensions of each patient, easing the splinting and digitalization procedures. A more economical and more accessible 3D printer can be selected to fabricate the intraoral scan body because it does not require the high manufacturing accuracy of other dental devices.

The technique combined the workflow between the dental laboratory technician and the clinician for the integration of digital patient information into a CAD software program. A learning curve is required to understand the digital technologies and alignment procedures.

As a conventional alternative, the maxillary interim complete denture could have been converted into a screw-retained implant-supported prostheses. However, the technique described provided several advantages, including recording the definitive implant cast and the superimposition of the facial and intraoral digital scans, resulting in the patient's 3D virtual representation. The technique facilitated a facially driven maxillary diagnostic waxing and simplified the complete-arch implant-supported interim prosthesis fabrication. The 3D representation included a visualization of the initial clinical conditions, including the interim complete denture, vertical dimension, and definitive implant cast, which could be used to design the definitive prostheses.

SUMMARY

This article describes a technique for merging facial and complete-arch implant digital scans guided by an addi-

tively manufactured intraoral marker to obtain a reliable 3D patient representation and a definitive virtual implant working cast. The size-customizable intraoral marker splinted to the implant scan bodies facilitated the digitalization of the implant positions of the edentulous arch.

REFERENCES

1. Goldstein RE. Esthetics in dentistry. In: . Principles, communication, treatment methods. vol 1. 3rd ed. Ontario: BC Decker; 1998. p. 85-112.
2. Chiche GJ, Pinault A. Esthetics of anterior fixed prosthodontics. Chicago: Quintessence; 1996. p. 33-50.
3. Fradeani M. Esthetic rehabilitation in fixed prosthodontics. In: . Esthetic analysis: a systematic approach to prosthetic treatment. vol 1. Chicago: Quintessence; 2004. p. 22-30.
4. Rufenacht CR. Fundamentals of esthetics. Chicago: Quintessence; 1990. p. 205-41.
5. Spear FM, Kokich VG. A multidisciplinary approach to esthetic dentistry. Dent Clin North Am 2007;51:487-505.
6. Piedra-Cascón W, Hsu VT, Revilla-León M. Facially driven digital diagnostic waxing: new software features to simulate and define restorative outcomes. Curr Oral Health Rep 2019;6:284-94.
7. Rosati R, De Menezes M, Rossetti A, Sforza C, Ferrario VF. Digital dental cast placement in 3-dimensional, full-face reconstruction: a technical evaluation. Am J Orthod Dentofacial Orthop 2010;138:84Y88.
8. Joda T, Brägger U, Gallucci G. Systematic literature review of digital three-dimensional superimposition techniques to create virtual dental patients. Int J Oral Maxillofac Implants 2015;30:330-7.
9. Joda T, Gallucci G. The virtual patient in dental medicine. Clin Oral Implants Res 2015;26:725-6.
10. 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;117:486-92.
11. Coachman C, Calamita MA, Coachman FG, Coachman RG, Sesma N. Facially generated and cephalometric guided 3D digital design for complete mouth implant rehabilitation: a clinical report. J Prosthet Dent 2017;117:577-86.
12. Rangel FA, Maal TJ, Bergé SJ, Van Vlijmen OJ, Plooij JM, Schutyser F, et al. Integration of digital dental casts in 3-dimensional facial photographs. Am J Orthod Dentofacial Orthop 2018;134:820Y826.
13. Pozzi A, Arcuri L, Moy PK. The smiling scan technique: facially driven guided surgery and prosthetics. J Prosthodont Res 2018;62:514-7.
14. Mangano C, Luongo F, Migliario M, Mortellaro C, Mangano FG. Combining intraoral scans, cone beam computed tomography and face scans: the virtual patient. J Craniofac Surg 2018;29:2241-6.
15. Cascón WP, De Gopegui JR, Revilla-León M. Facially generated and additively manufactured baseplate and occlusion rim for treatment planning a complete-arch rehabilitation: a dental technique. J Prosthet Dent 2019;121:741-5.
16. Revilla-León M, Besné-Torre A, Sánchez-Rubio JL, Fábrega JJ, Özcan M. Digital tools and 3D printing technologies integrated into the workflow of restorative treatment: a clinical report. J Prosthet Dent 2019;121:3-8.
17. Bohner L, Gamba DD, Hanisch M, Marcio BS, Tortamano Neto P, Laganá DC, et al. Accuracy of digital technologies for the scanning of facial, skeletal and intraoral tissues: a systematic review. J Prosthet Dent 2019;121:246-51.
18. Revilla-León M, Raney L, Piedra Cascón W, Barrington J, Zandinejad A, Özcan M. Digital workflow for an esthetic rehabilitation using a facial and intraoral scanner and an additive manufactured silicone index: a dental technique. J Prosthet Dent 2020;123:564-70.
19. Al-Jubuori O, Azari A. An introduction to dental digitizers in dentistry. A systematic review. J Chem Pharm Res 2015;7:10-20.
20. Chochlidakis KM, Papaspyridakos P, Geminiani A, Chen CJ, Feng IJ, Ercoli C. Digital versus conventional impressions for fixed prosthodontics. A systematic review and meta-analysis. J Prosthet Dent 2016;116:184-90.
21. Tsirogiannis P, Reissmann DR, Heydecke G. Evaluation of the marginal fit of single-unit, complete-coverage ceramic restorations fabricated after digital and conventional impressions: a systematic review and meta-analysis. J Prosthet Dent 2016;116:328-35.
22. Goracci C, Franchi L, Vichi A, Ferrari M. Accuracy, reliability, and efficiency of intraoral scanners for full-arch impressions: a systematic review of the clinical evidence. Eur J Orthod 2016;38:422-8.
23. Ahlholm P, Sipilä K, Vallittu P, Jakonen M, Kotiranta U. Digital versus conventional impressions in fixed prosthodontics: a review. J Prosthodont 2018;27:35-41.
24. Rutkūnas V, Gečiauskaitė A, Jegelevičius D, Vaitiekūnas M. Accuracy of digital implant impressions with intraoral scanners. A systematic review. Eur J Oral Implantol 2017;0:101-20.
25. Medina-Sotomayor P, Pascual-Moscardó A, Camps I. Relationship between resolution and accuracy of four intraoral scanners in complete-arch impressions. J Clin Exp Dent 2018;10:e361-6.
26. Papaspyridakos P, Chen CJ, Gallucci GO, Doukoudakis A, Weber HP, Chronopoulos V. Accuracy of implant impressions for partially and completely edentulous patients: a systematic review. Int J Oral Maxillofac Implants 2014;29:836-45.
27. Flügge T, van der Meer WJ, Gonzalez BG, Vach K, Wismeijer D, Wang P. The accuracy of different dental impression techniques for implant-supported dental prostheses: a systematic review and meta-analysis. Clin Oral Implants Res 2018;29:374-92.
28. Kim KR, Seo KY, Kim S. Conventional open-tray impression versus intraoral digital scan for implant-level complete-arch impression. J Prosthet Dent 2019;122:543-9.
29. Kim RJ, Benic GI, Park JM. Trueness of digital intraoral impression in reproducing multiple implant position. PLoS One 2019;14:e0222070.
30. Iturrate M, Minguez R, Pradies G, Solaberrieta E. Obtaining reliable intraoral digital scans for an implant-supported complete-arch prosthesis: a dental technique. J Prosthet Dent 2019;121:237-41.
31. Iturrate M, Eguiraun H, Solaberrieta E. Accuracy of digital impressions for implant-supported complete-arch prosthesis, using an auxiliary geometry part-an in vitro study. Clin Oral Implants Res 2019;30:1250-8.
32. Perez MG. Kit de alineador. Argentina. Patent 2018. p. 93933.
33. Wagner AG. Making duplicate dentures for use as final impression trays. J Prosthet Dent 1970;24:111-3.
34. Revilla-León M, Jiang P, Sadeghpour M, Piedra-Cascón W, Zandinejad A, Özcan M, et al. Intraoral digital scans-part 1: influence of ambient scanning light conditions on the accuracy (trueness and precision) of different intraoral scanners. J Prosthet Dent 2020;124:372-8.
35. Revilla-León M, Subramanian SG, Özcan M, Krishnamurthy VR. Clinical study of the influence of ambient light scanning conditions on the accuracy (trueness and precision) of an intraoral scanner. J Prosthodont 2020;29:107-13.
36. Uludag B, Ozturk O, Celik G, Goktug G. Fabrication of a retrievable cement- and screw-retained implant-supported zirconium fixed partial denture: a case report. J Oral Implantol 2008;34:59-62.

Corresponding author:
Dr Marta Revilla-León
3302 Gaston Ave, Room 713, Dallas
TX 75246
Email: revillaleon@tamu.edu

Copyright © 2020 by the Editorial Council for *The Journal of Prosthetic Dentistry*.
https://doi.org/10.1016/j.prosdent.2020.11.011