THE JOURNAL OF PROSTHETIC DENTISTRY

DENTAL TECHNIQUE

Obtaining reliable intraoral digital scans for an implant-supported complete-arch prosthesis: A dental technique

Mikel Iturrate, PhD,[a] Rikardo Minguez, PhD,[b] Guillermo Pradies, PhD,[c] and Eneko Solaberrieta, PhD[d]

ABSTRACT

This article describes a technique for obtaining an accurate complete-arch digital scan for an edentulous patient. To achieve this, an auxiliary polymeric device that simulates a denture is designed, fabricated, and placed in the mouth. This device, having the geometry of a typical dental arch, facilitates the digitalization of the edentulous complete arch. This is because the change in radius of the curvature (change of geometry) enables the scanner to perform a more accurate alignment. Initially, the necessary location of the implants is acquired, and then the soft tissue is added. This technique can achieve accurate complete-arch digital scans. Distances between implants are closer to the gold standard when using this auxiliary geometry piece than those obtained without using it. (J Prosthet Dent 2019;121:237-41)

The use of computer-aided design and computer-aided manufacturing (CAD-CAM) technologies in dentistry has continued to grow. Among many other applications, one of the most developed application has been replacing conventional dental impressions with digital scans.[1,2] For implant dentistry, the clinical validity of the digital scan is determined by the passive fit between the superstructure and the implants.[3] However, an acceptable misfit value has yet to be determined.[4] Excessive misfit may lead to mechanical failures or biological complications.[5,6]

The trueness and precision of intraoral scanners have been evaluated.[7-18] However, accuracy is still a problem, particularly for complete-arch scans, as the acquisition of larger areas with an intraoral scanner is more challenging.[19] One difficulty is joining the multiple captures

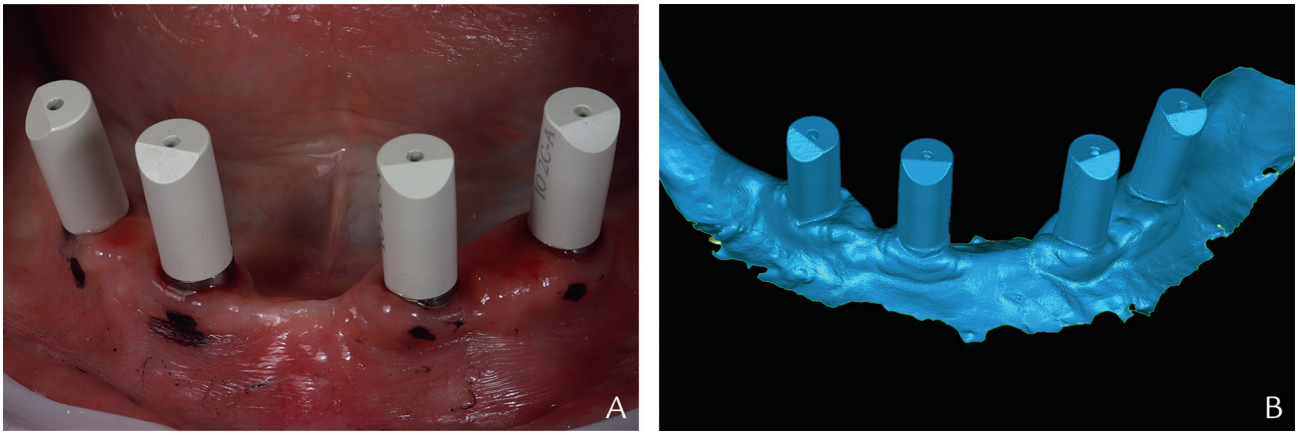

Figure 1. A, Treatment of edentulous patient with 4 scannable copings. B, STL file after scanning. STL, standard tessellation language.

Supported by Country Council of Gipuzkoa grant 84/17, 2017.
[a]Assistant Professor, Department of Graphics Design and Engineering Projects, University of the Basque Country, Bilbao, Spain.
[b]Professor, Department of Graphics Design and Engineering Projects, University of the Basque Country, Bilbao, Spain.
[c]Professor, Department of Buccofacial Prostheses, Stomatology I, Faculty of Odontology in Complutense, University of Madrid, Madrid, Spain.
[d]Assistant Professor, Department of Graphics Design and Engineering Projects, University of the Basque Country, Bilbao, Spain.

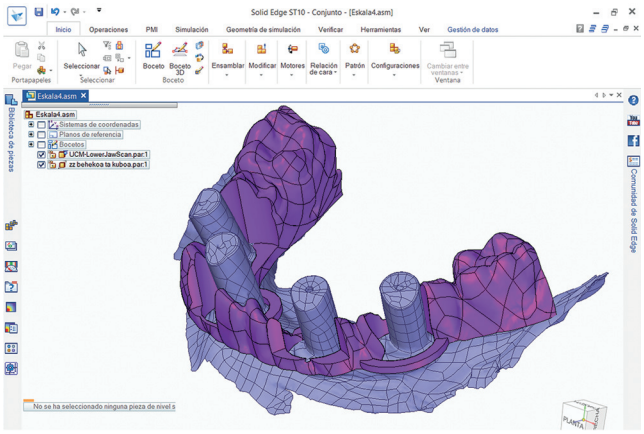

Figure 2. Auxiliary device design process.

obtained with the cameras of the intraoral scanners.[20] Using the standard method or with stereophotogrammetry, scans are obtained in a single step, although for devices using stereophotogrammetry, it is necessary to later make an image of the soft tissues. However, with intraoral scanners, the scanning process involves multiple captures over time, the number of which increases with the area to be restored. The scanner software creates the 3-dimensional (3D) representation by aligning the different captured images. In each alignment, an error occurs, and the more alignments there are, the greater the accumulated error. In addition, these alignments are more complicated in situations where the geometry has no change in radius of curvature, such as the spaces between implants in edentulous patients.[17,21,22] The scanner requires an irregular shape with no repetitive adjacent surface structures for an accurate digital scan. This is why obtaining the complete-arch digital scan of an edentulous patient is challenging.

A system using stereophotogrammetry technology (PIC Camera; PIC Dental) seeks to overcome this challenge by using an extraoral camera. This camera provides a standard tessellation language (STL) file

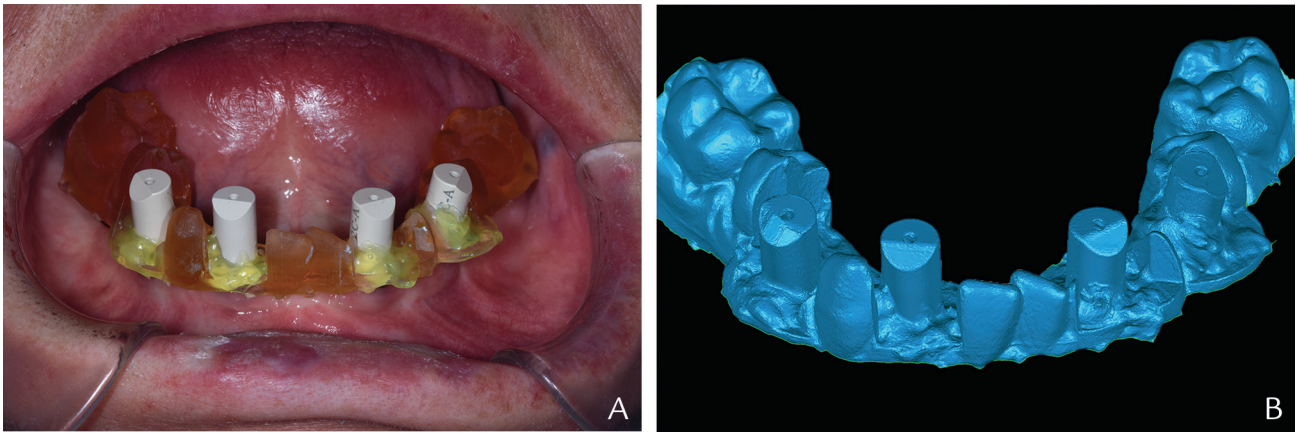

Figure 3. A, Auxiliary device fixed to edentulous jaw with scannable copings. B, STL file after scanning. STL, standard tessellation language.

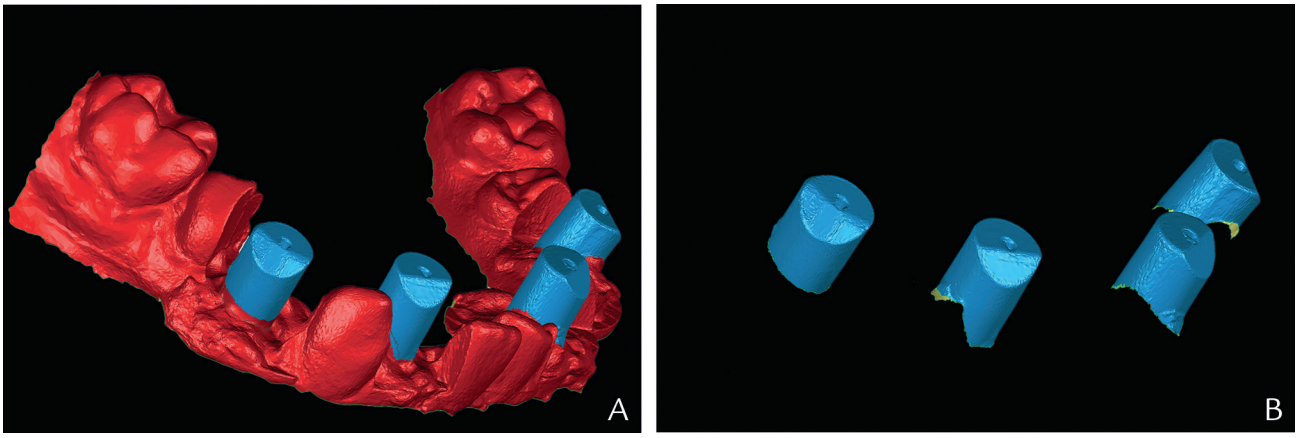

Figure 4. A, Selection of auxiliary devices and soft tissues with reverse engineering software. B, Reference position of scannable copings after erasing auxiliary device and soft tissues.

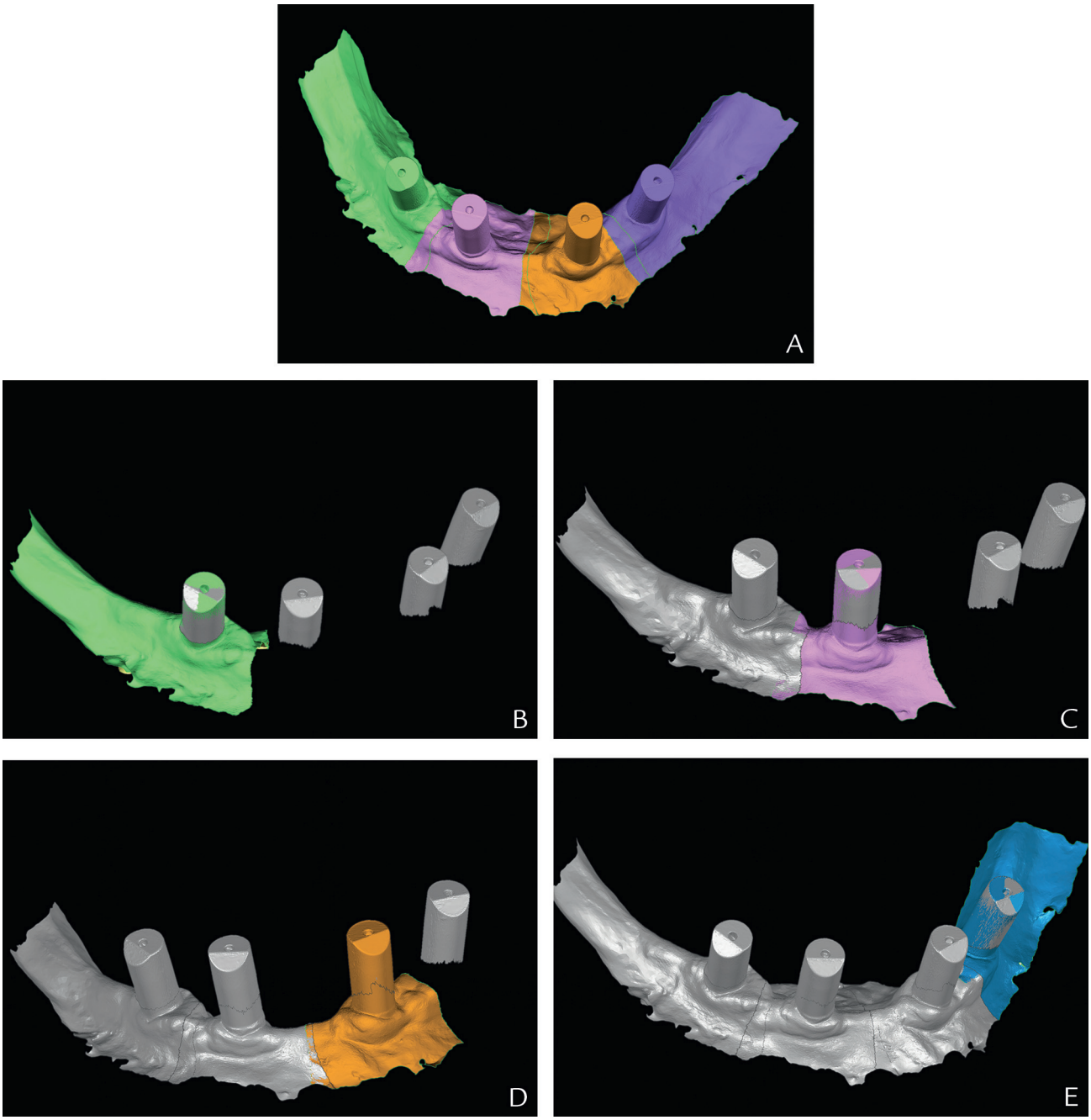

Figure 5. A, Virtual partition of digital scan of complete arch. B-E, Each split part of complete arch.

where targets (PIC Abutments; PIC Dental) placed on the implants are positioned with high accuracy. By complementing this STL file with a dental digital scan, a highly accurate complete-arch scan is achieved.[4,23] The dental digital scan can be obtained by using an intraoral scanner or by digitizing a gypsum cast by using a laboratory scanner.

The objective of this technique was to describe a way to obtain accurate complete-arch digital scans without stereophotogrammetry. The technique requires a single device: the intraoral scanner. However, the area must be scanned twice to restore and build the digital image by combining 2 STL files.

TECHNIQUE

The technique consists of obtaining 2 different STL files. One file provides an accurate position of the scannable copings (Scan Body; Straumann) with the surrounding soft tissues hidden. The second STL file

provides an image of the soft tissues, and the digital image is achieved by combining the 2 files.

1. Make an implant-level digital complete-arch scan of the edentulous patient, including the scannable copings (Scan Body; Straumann, with an intraoral scanner (True Definition, v6.0; 3M ESPE) (Fig. 1).
2. Based on the STL file obtained in Step 1 and using a 3D-design software (Solid Edge; Siemens AG), design the auxiliary device, which fits in the patient's mouth. This design will depend on the number and position of the scannable copings and must leave them visible for the intraoral scanner. The design broadly replicates a complete denture (Fig. 2)
3. Fabricate the auxiliary device in acrylonitrile butadiene styrene (ABS) by using a 3D printer (3D Dimension Elite; Stratasys). ABS is a common nontoxic thermoplastic polymer. Among other features, it is opaque and shows in the scan.
4. Seat the auxiliary device in the patient's mouth, leaving the upper side of the scannable copings visible, and lute it into place with light-polymerizing resin (Conlight; Kuss Dental)
5. Make a second complete-arch digital scan of the edentulous patient, using the intraoral scanner. As the auxiliary device provides the scanner with shapes that facilitate the alignment of the multiple images, an accurate position is achieved of the scannable copings and consequently of the implants (Fig. 3).
6. Using reverse engineering software (Geomagic Studio; 3D Systems), remove the auxiliary device from the digital image (Fig. 4). Leaving as much surface area as possible of the scannable copings, erase the rest of the mesh. These copings will be the reference position for constructing the definitive digital complete-arch image.
7. Using the reverse engineering software, virtually partition the digital scan achieved in the first step. Split the image obtained from the scanning without the auxiliary device into as many parts as scannable copings (Fig. 5).
8. Using the reverse engineering software, align each part of the split digital scan (obtained in Step 6) with the accurately positioned scannable copings (obtained in Step 7). These accurately positioned scannable copings are those obtained with the auxiliary device. This device reduces the error in distances between scannable copings.

DISCUSSION

This technique offers a solution for obtaining complete-arch digital scans of edentulous patients, where scanning could be complicated.[17] The scanner requires an irregular shape with no repetitive adjacent surface structures to perform accurate digital scans, and in edentulous patients, this is what is missing.

The use of the auxiliary device fills this deficit. Its use has some drawbacks–it must be fabricated, properly fixed in the mouth, and requires 2 scans, all of which increase material costs and time. However, a single intraoral scanner is used and is applicable to both complete and partial-arch restorations.

SUMMARY

The technique presented in this article improves the accuracy of a complete-arch scanning for an edentulous patient. In areas with homogeneous geometry, a low-cost and easy-to-fabricate device with auxiliary geometry produced in ABS with a 3D printer was added.

By combining scans and using reverse engineering software, an accurate complete-arch image of an edentulous patient is achieved.

REFERENCES

1. Kim J-E, Amelya A, Shin Y, Shim J-S. Accuracy of intraoral digital impressions using an artificial landmark. J Prosthet Dent 2017;117:755-61.
2. Rekow ED. Dental CAD/CAM systems. J Am Dent Assoc 2006;137:5S-6S.
3. Branemark PI. Osseointegration and its experimental background. J Prosthet Dent 1983;50:399-410.
4. Pradíes G, Ferreiroa A, Özcan M, Giménez B, Martínez-Rus F. Using stereophotogrammetric technology for obtaining intraoral digital impressions of implants. J Am Dent Assoc 2014;145:338-44.
5. Giménez B, Özcan M, Martínez-Rus F, Pradíes G. Accuracy of a digital impression system based on active wavefront sampling technology for implants considering operator experience, implant angulation, and depth. Clin Implant Dent Relat Res 2015;17:e54-64.
6. Winter W, Mohrle S, Holst S, Karl M. Bone loading caused by different types of misfits of implant-supported fixed dental prostheses: a three-dimensional finite element analysis based on experimental results. Int J Oral Maxillofac Implants 2010;25:947-52.
7. Hack GD, Patzelt SBM. Evaluation of the accuracy of six intraoral scanning devices: an in-vitro investigation. Am Dent Assoc 2015;10:1-5.
8. Omar Ali A. Accuracy of digital impressions achieved from five different digital impression systems. Dentistry 2015;5:300. doi: 10.4172/2161-1122.1000300.
9. Patzelt SBM, Emmanouilidi A, Stampf S, Strub JR, Att W. Accuracy of full-arch scans using intraoral scanners. Clin Oral Investig 2014;18:1687-94.
10. Patzelt SBM, Bishti S, Stampf S, Att W. Accuracy of computer-aided design/computer-aided manufacturing–generated dental casts based on intraoral scanner data. J Am Dent Assoc 2014;145:1133-40.
11. Ender A, Mehl A. Accuracy of complete-arch dental impressions: a new method of measuring trueness and precision. J Prosthet Dent 2013;109:121-8.
12. Ender A, Mehl A. In-vitro evaluation of the accuracy of conventional and digital methods of obtaining full-arch dental impressions. Quintessence Int 2014;46:9-17.
13. van der Meer WJ, Andriessen FS, Wismeijer D, Ren Y. Application of intraoral dental scanners in the digital workflow of implantology. PLoS One 2012;7:1-8.
14. Güth JF, Edelhoff D, Schweiger J, Keul C. A new method for the evaluation of the accuracy of full-arch digital impressions in vitro. Clin Oral Investig 2016;20:1487-94.
15. Syrek A, Reich G, Ranftl D, Klein C, Cerny B, Brodesser J. Clinical evaluation of all-ceramic crowns fabricated from intraoral digital impressions based on the principle of active wavefront sampling. J Dent 2010;38:553-9.
16. Zarauz C, Valverde A, Martínez-rus F, Hassan B, Pradíes G. Clinical evaluation comparing the fit of all-ceramic crowns obtained from silicone and digital intraoral impressions. Clin Oral Investig 2016;20:799-806.

17. Andriessen FS, Rijkens DR, Van Der Meer WJ, Wismeijer DW. Applicability and accuracy of an intraoral scanner for scanning multiple implants in edentulous mandibles: a pilot study. J Prosthet Dent 2014;111:186-94.
18. Ender A, Attin T, Mehl A. In vivo precision of conventional and digital methods of obtaining complete-arch dental impressions. J Prosthet Dent 2016;115:313-20.
19. Flügge T, Att W, Metzger M, Nelson K. Precision of dental implant digitization using intraoral scanners. Int J Prosthodont 2016;29:277-83.
20. Zimmermann M, Koller C, Rumetsch M, Ender A, Mehl A. Precision of guided scanning procedures for full-arch digital impressions in vivo. J Orofac Orthop 2017;78:466-71.
21. Anh JW, Park JM, Chun YS, Kim M, Kim M. A comparison of the precision of three-dimensional images acquired by 2 digital intraoral scanners: effects of tooth irregularity and scanning direction. Korean J Orthod 2016;46:3-12.
22. Vandeweghe S, Vervack V, Dierens M, De Bruyn H. Accuracy of digital impressions of multiple dental implants: an in vitro study. Clin Oral Implants Res 2016;28:648-53.
23. Peñarrocha-Oltra D, Agustín-Panadero R, Bagán L, Giménez B, Peñarrocha M. Impression of multiple implants using photogrammetry: description of technique and case presentation. Med Oral Patol Oral Cir Bucal 2014;19:366-71.

Corresponding author:
Dr Eneko Solaberrieta Mendez
Department of Graphics Design and Engineering Projects
University of the Basque Country UPV/EHU
Plaza Europa 1
20.018 Donostia – San Sebastian
SPAIN
Email: eneko.solaberrieta@ehu.eus

Acknowledgments
The authors thank Dr Javier Etxaniz from Trento dental clinic and the Odontolan Otaduy dental laboratory for their support and assistance with the research work.

https://doi.org/10.1016/j.prosdent.2018.03.008