THE JOURNAL OF PROSTHETIC DENTISTRY

DENTAL TECHNIQUE

A digital workflow using a smartphone-based photogrammetry app for capturing implant positions in complete arch fixed implant-supported prostheses

Miguel Gómez-Polo, DDS, PhD,[a] Emilio Rodríguez-Fernández, DDS, MSD, PhD,[b] Solange Vasquez-Ramos, DDS, MSc,[c] and Marta Revilla-León, DDS, MSD, PhD[d]

ABSTRACT

Complete arch implant-supported restorations require the accurate digital acquisition of implant position, soft tissue anatomy, and interarch relationships. Traditional photogrammetry systems, while accurate, are often limited by cost, equipment complexity, and lack of portability. This manuscript describes a novel scanning workflow for fabricating implant-supported prostheses in which a smartphone-based photogrammetry system (PGAPP) was used to record implant positions. The photogrammetry file was aligned automatically with the intraoral soft tissue scan through the shared geometry of the scan bodies. The technique simplified data acquisition, increased clinical accessibility, and provided a cost-effective digital alternative for fabricating complete arch implant-supported prostheses in clinical practice. (J Prosthet Dent 2026;135:241-246)

Accurate acquisition of implant position is essential for the fabrication and success of complete arch, implant-supported prostheses.[1–6] Intraoral scanners (IOSs) have been frequently used; however, their accuracy is influenced by operator-, environmental-, and patient-related factors.[7–10]

Photogrammetry (PG) devices have been used for complete arch implant-supported restorations as an alternative to IOS workflows.[11–15] PG determines the 3-dimensional (3D) position of dental implants by processing multiple extraoral images of optical markers placed intraorally.[6,15–19] Most PG systems use an extraoral stereoscopic camera and a proprietary algorithm to calculate implant positions.[20–26] Recently, intraoral PG technology has been integrated into an IOS device model, enabling the combination of both technologies to reduce costs and merge all information into a single file, including implant positions, soft tissues, and remaining teeth.[26]

Despite the reported accuracy of conventional PG systems,[11,12,14,27] they present some limitations, such as high equipment costs[26] and limited portability.[28] Recently, a smartphone-based PG system (PIC dental app, v.1.3.1; PIC dental), consisting of a smartphone-based algorithm that processes a series of extraoral images to generate a standard tessellation language (STL) file with implant positions and angulations, has been developed to overcome these drawbacks. This smartphone approach has been reported to improve accessibility to PG and reduce workflow complexity when providing complete arch implant-supported restorations, offering a cost-effective and user-friendly alternative to traditional PG workflows.[26,29–31]

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.
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]Associate Professor, Department of Conservative Dentistry and Prosthodontics, School of Dentistry, Complutense University of Madrid (UCM), Madrid, Spain; and Director, Postgraduate Program in Advanced Implant-Prosthodontics, Complutense University of Madrid (UCM), Madrid, Spain.
[b]Part-Time Professor, Postgraduate Program in Oral Surgery, Periodontics and Implantology, Camilo José Cela University (UCJC) – HM Hospitals, Madrid, Spain.
[c]PhD Candidate, School of Dentistry, Complutense University of Madrid (UCM), Madrid, Spain; and Collaborating Faculty Member, Postgraduate Program in Advanced Implant-Prosthodontics, Complutense University of Madrid (UCM), Madrid, Spain.
[d]Affiliate Assistant Professor, Graduate Prosthodontics, Department of Restorative Dentistry, School of Dentistry, University of Washington, Seattle, WA; Faculty and Director of Research and Digital Dentistry, Kois Center, Seattle, WA; and Adjunct Professor, Department of Prosthodontics, School of Dental Medicine, Tufts University, Boston, MA.

A novel digital workflow for fabricating complete arch implant-supported prostheses using a smartphone-based photogrammetry system to capture implant positions is described. This workflow integrated a conventional implant digital scan with scannable healing abutments to acquire soft tissue and remaining tooth information, extending the clinical application of photogrammetry by offering a streamlined, accessible, and fully digital workflow suitable for clinical practice.

TECHNIQUE

A patient requiring maxillary and mandibular complete arch implant-supported fixed prostheses underwent complete mouth extractions with immediate implant placement and immediate loading in both arches. Six implants were present in the maxilla, 2 Grand Morse Implants (Neodent) and 4 Anyridge implants (MegaGen) and 6 in the mandible (Anyridge; MegaGen). Transepithelial abutments (multi-unit abutments IPD/*WR*-MR; IPD) were subsequently placed on each implant. This clinical scenario was selected to demonstrate the photogrammetry-based scanning workflow using a smartphone-based application. The procedure was explained to the patient, who agreed to participate and authorized the use of this treatment for publication by signing an informed consent form.

The next steps were followed:

1. Install the smartphone-based PG system app (PIC dental app v.1.3.1; PIC dental) before the procedure and create an account with an active subscription, either individual or through a registered laboratory. Enter the patient’s information and indicate which arch is receiving the treatment. After creating the treatment, a virtual odontogram will appear, where the implant sites and the corresponding optical markers (PIC Transfer, HC MUA Metal, Ø4.8 mm; PIC Dental) can be selected (Fig. 1A, B).
2. Once the teeth have been extracted, place the implants (Anyridge Implants; MegaGen), connect the transepithelial multiunit abutments (MUA) (Multiunit abutment IPD/*WR*-MR; IPD) at the recommended torque, and screw the optical markers (PIC Transfer, HC MUA Metal, Ø4.8 mm; PIC Dental) onto the MUAs at 10-Ncm torque. Select either regular or small optical markers based on intraoral space and interocclusal clearance. Either size may be used, without a minimum number of optical markers for any of them. Ensure the surgical field is clean before placing the components. Some teeth can be maintained until the end of the registration procedure to provide references for the design of the interim rehabilitation and facilitate the collection of the interarch relationship.

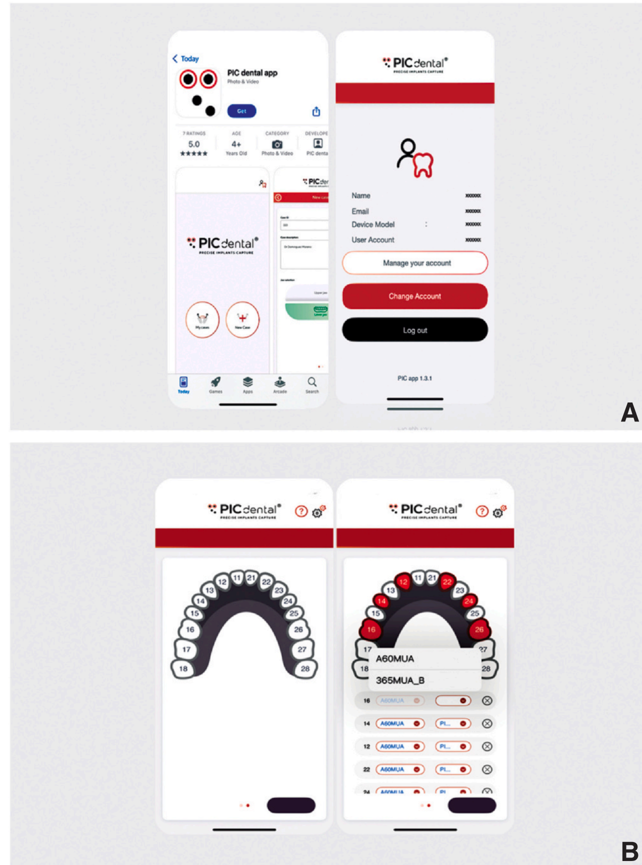

Figure 1. PG mobile application interface. A, Access to application download interface, user account screen showing personal and device information, and account management options. B, Implant selection interface displaying tooth numbers and corresponding prosthetic components.

3. Verify that all components are stable and visible from multiple angles. Confirm that no soft tissue interferes with the optical markers and that there is no rotational or vertical movement once in position (Fig. 2A).[7,32]
4. Position a calibrated smartphone (iPhone 15 Pro; Apple Corp) about 40 cm in front of the patient's mouth using both hands to ensure stability during capture according to the app’s instructions. Maintain the patient’s head in a comfortable and immobile position during the procedure. Activate the “Focus Finder” mode to optimize the images (Fig. 2B).[33]
5. Slowly capture between 20 images by placing the smartphone at a central frontal angle for the first photograph and then varying the inclination upward and downward. Repeat the same sequence from both right and left lateral views.[26] Validate that all optical markers are visible in every frame. Reacquire any out of focus photographs and monitor the app for alerts regarding insufficient coverage. Repeat the same procedure in the opposing arch.

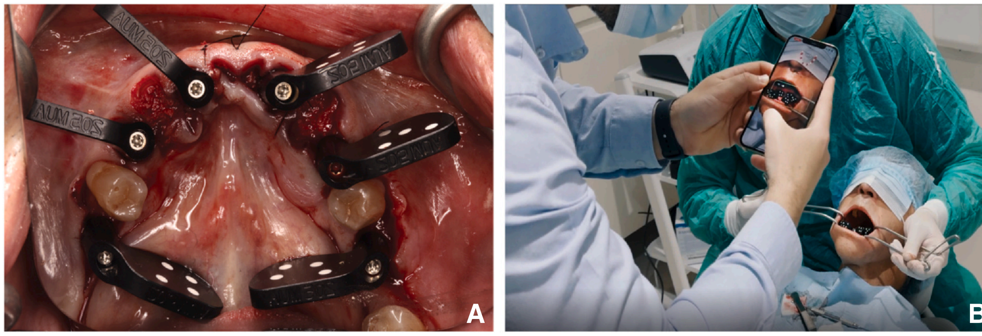

Figure 2. Optical markers placed on multi-unit abutments and tightened to 10 Ncm. A, Intraoral occlusal view showing clean surgical field and no soft tissue interference. B, Image acquisition using smartphone device.

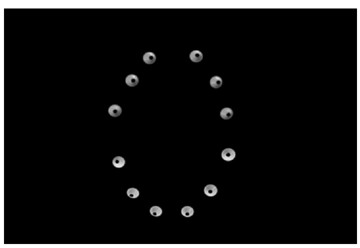

Figure 3. Spatial arrangement of implant vectors displayed after automatic reconstruction in PIC dental app.

6. Complete the photogrammetric acquisition through the app. Allow the app to process the data automatically. After image validation, the application automatically reconstructs a 3D vector file that defines the spatial position and angulation of the implants. Select the appropriate scan body from the integrated component library to render its geometry on each implant. Following completion, a notification is sent to confirm the generation of the file, which is an open-format STL file. Soft tissue and remaining teeth are not included in the file; only implant position[18,19] (Fig. 3). Remove the optical markers from each MUA after completing the photogrammetric acquisition.
7. Repeat steps 2 to 6 in the opposing arch to obtain the position of the implants in both arches.
8. Screw scannable healing abutments (SHAs) (Tissue Shapers; MedicalFit) at 10-Ncm torque onto the multi-unit abutments (Fig. 4). This step may also be performed by using conventional implant scan bodies (ISBs).
9. Obtain a digital scan of the arch, including the SHAs with a conventional IOS (iTero Lumina; Align Technology). Maintain a constant scanning distance for optimal resolution and an accurate capture of the soft tissue anatomy and geometric shape of the ISBs).
10. Repeat steps 8 and 9 in the opposing arch to obtain the soft tissue geometry and remaining teeth information. Then, add the occlusal registration to relate the 2 arches. Once this information has been registered, the remaining teeth may be extracted. In the presented treatment, the maxillary right and left canines and the mandibular right and left second premolars were extracted at this time.
11. Import the STL files from the IOS and the PGAPP into a dental CAD software program (exocad software; exocad GmbH). Both files share the same coordinate system (x-, y-, and z-axis), allowing automatic alignment based on the geometry of the SHAs, physically captured in the intraoral scan and virtually rendered in the PGAPP file during the photogrammetric process.

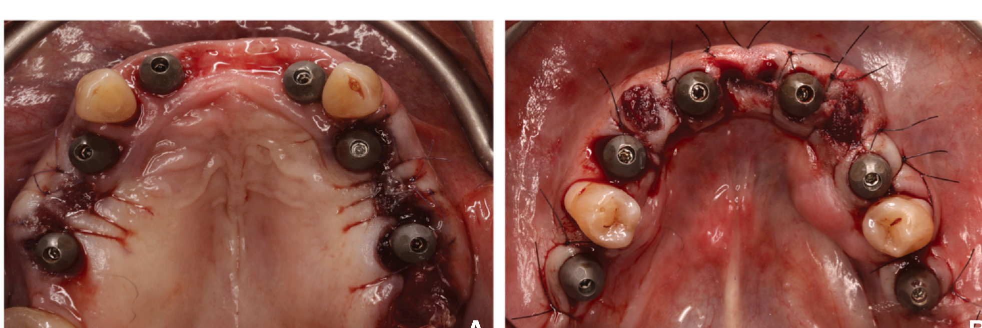

Figure 4. Placement of scan bodies on multi-unit abutments for intraoral scanning. A, Maxillary arch. B, Mandibular arch.

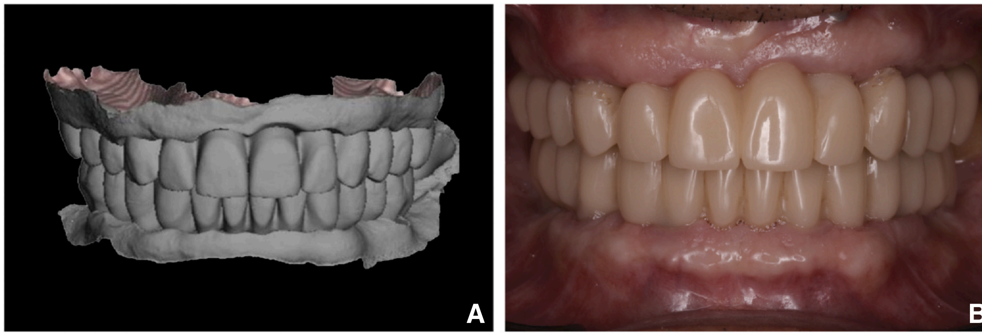

Figure 5. Design and clinical placement of interim prostheses. A, Digital design of screw-retained interim restorations. B, Interim prostheses placed intraorally after computer-aided manufacturing.

12. Select the appropriate implant system libraries to define the abutment interfaces. Design the screw-retained interim prostheses. Finalize the design according to the selected material and occlusal scheme and manufacture the interim prostheses using subtractive computer-aided manufacturing (CAM) technology[34,35] (Fig. 5A).
13. Deliver and screw the milled polymethyl methacrylate (HADB22-D2 Monolayer PMMA blocks; Huge) interim prostheses at the recommended torque (15 Ncm). Verify passive fit, esthetics, and occlusion intraorally. Make the necessary adjustments and tighten the prostheses to the recommended torque (Fig. 5B).
14. Perform a dual intraoral scan after the osseointegration period. First, scan the tissue support and emergence profile by scanning the arch while the interim prosthesis is in place. Then, remove the prosthesis and place the SHAs to prevent tissue collapse. Perform the second scan to record the remodeled soft tissue contours. Before fabrication, use both scans to update the definitive prostheses' digital design in the computer-aided design (CAD) program and then mill the definitive restoration (IPS e.max ZirCAD Prime; Ivoclar AG) to be placed intraorally[33] (Fig. 6).

DISCUSSION

This technique describes a photogrammetry workflow through a smartphone-based application to register the 3D spatial position and angulation of implants in complete arch implant-supported rehabilitations. The only prerequisite for the workflow is a compatible iOS device (iPhone 14 Pro, 14 Pro Max, 15 Pro, 15 Pro Max, 16 Pro, 16 Pro Max; Apple) and a set of optical markers. In contrast, traditional photogrammetry systems depend on large and expensive equipment. This simplified protocol enhances accessibility and portability in clinical settings.

From a clinical standpoint, this approach reduces operative complexity and overall chair time by eliminating steps such as conventional impressions, splinting processes, or passive fit verification. The digital nature of data acquisition and processing facilitates the rapid delivery of interim prostheses with greater confidence in fit accuracy, particularly in scenarios requiring immediate interim restorations. Intraoral photogrammetry is dependent on variables that include the number of captures, overlap percentage, acquisition distance, lens distortion, and image resolution. Differences in accuracy between the use of regular or small markers have not been previously reported. These factors are managed by

Figure 6. Final scans, manufacturing, and delivery of definitive prostheses. A, Sequential intraoral scans: first with interim prosthesis in place to record tissue support, followed by second scan with scan bodies placed to capture remodeled emergence profile. B, Screw-retained definitive prostheses milled in monolithic zirconia. C, Definitive prostheses placed intraorally.

the smartphone PGAPP using a proprietary algorithm created by the company. Although operator-dependent, the system provides real-time guidance to ensure complete coverage and data quality.

Conventional intraoral and extraoral photogrammetry systems have demonstrated high accuracy in capturing implant positions for complete arch implant-supported prostheses, with linear deviations reported to range from 14 to 90 µm, depending on variables such as scanning conditions, implant distribution, and scanning distance.[11,12,16,17,19–25] Compared with these traditional systems, a recent study reported that the workflow with the smartphone PGAPP held a mean linear deviation of 30.92 ±20.88 µm and an angular discrepancy of 0.16 ±0.09 degrees, compared with 18.21 ±12.21 µm and 0.10 ±0.07 degrees, respectively, under comparable in vitro conditions.[26] Although the smartphone PGAPP demonstrates slightly higher deviations than the conventional extraoral PG system, its precision remains clinically acceptable, and it offers several benefits, including portability, affordability, and ease of adaptability to clinical practice.

Despite promising in vitro findings, accuracy data on smartphone-based photogrammetry workflows remain limited. This technique has shown the potential to simplify the provision of complete arch implant-supported prostheses while maintaining high accuracy and an efficient workflow. Studies, particularly in vivo investigations, are needed to validate its performance across a range of implant configurations and prosthetic indications.

SUMMARY

A digital workflow for fabricating complete arch, implant-supported prostheses using a smartphone-based photogrammetry system to capture implant positions is presented. Soft tissue data are acquired via intraoral scanning, and automatic alignment in the CAD software is enabled by matching the physical scan bodies from the intraoral scan with their digitally rendered equivalents from the photogrammetry file. This technique offers a portable, cost-effective alternative to traditional photogrammetry systems, streamlining data acquisition and prosthesis fabrication in clinical practice.

REFERENCES

1. Ma B, Yue X, Sun Y, Peng L, Geng W. Accuracy of photogrammetry, intraoral scanning, and conventional impression techniques for complete-arch implant rehabilitation: An in vitro comparative study. *BMC Oral Health*. 2021;21:636.
2. Gómez-Polo M, Ballesteros J, Perales-Padilla P, Perales-Pulido P, Gómez-Polo C, Ortega R. Guided implant scanning: A procedure for improving the accuracy of implant-supported complete-arch fixed dental prostheses. *J Prosthet Dent*. 2020;124:135–139.
3. Gómez-Polo M, Ballesteros J, Padilla PP, Pulido PP, Revilla-León M, Ortega R. Merging intraoral scans and CBCT: A novel technique for improving the accuracy of 3D digital models for implant-supported complete-arch fixed dental prostheses. *Int J Comput Dent*. 2021;24:117–123.
4. Katsoulis J, Takeichi T, Sol Gaviria A, Peter L, Katsoulis K. Misfit of implant prostheses and its impact on clinical outcomes. Definition, assessment and a systematic review of the literature. *Eur J Oral Implantol*. 2017;10:121–138.
5. Rutkunas V, Larsson C, Vult von Steyern P, Mangano F, Gedrimiene A. Clinical and laboratory passive fit assessment of implant-supported zirconia restorations fabricated using conventional and digital workflow. *Clin Implant Dent Relat Res*. 2020;22:237–245.
6. Pinto RJ, Casado SA, Chmielewski K, Caramês JM, Marques DS. Accuracy of different digital acquisition methods in complete arch implant-supported prostheses: An in vitro study. *J Prosthet Dent*. 2024;132:172–177.
7. Gómez-Polo M, Donmez MB, Çakmak G, Yilmaz B, Revilla-León M. Influence of implant scan body design (height, diameter, geometry, material, and retention system) on intraoral scanning accuracy: A systematic review. *J Prosthodont*. 2023;32:165–180.
8. Revilla-León M, Kois DE, Kois JC. A guide for maximizing the accuracy of intraoral digital scans. Part 1: operator factors. *J Esthet Restor Dent*. 2023;35:230–240.
9. Revilla-León M, Kois DE, Kois JC. A guide for maximizing the accuracy of intraoral digital scans. Part 2: patient factors. *J Esthet Restor Dent*. 2023;35:241–249.
10. Abduo J, Elseyoufi M. Accuracy of Intraoral Scanners: A systematic review of influencing factors. *Eur J Prosthodont Restor Dent*. 2018;30:101–121.
11. Pozzi A, Carosi P, Gallucci GO, Nagy K, Nardi A, Arcuri L. Accuracy of complete-arch digital implant impression with intraoral optical scanning and stereophotogrammetry: An in vivo prospective comparative study. *Clin Oral Implants Res*. 2023;34:1106–1117.
12. Pozzi A, Agliardi E, Lio F, Nagy K, Nardi A, Arcuri L. Accuracy of intraoral optical scan versus stereophotogrammetry for complete-arch digital implant impression: An in vitro study. *J Prosthodont Res*. 2024;68:172–180.
13. Kosago P, Ungurawasaporn C, Kukiattrakoon B. Comparison of the accuracy between conventional and various digital implant impressions for an implant-supported mandibular complete arch-fixed prosthesis: An in vitro study. *J Prosthodont*. 2023;32:616–624.
14. Rodríguez-Fernández E, Sánchez-Gil A, Salama M. Photogrammetry is superior to conventional impression techniques in cases requiring six or more implants. *EC Dent Sci*. 2020;19:1–9.
15. Liu XJ, Fu HC, Lai JY, Shi BL, Liu. Accuracy of traditional open-tray impression, stereophotogrammetry, and intraoral scanning with prefabricated aids for implant-supported complete arch prostheses with different implant distributions: An in vitro study. *J Prosthet Dent*. 2024;132:602.e1–602.e9.
16. Estibalez-Recasens M, Serrano-Granger C, Santamaría-Laorden A, Andreu-Vazquez C, Orejas-Perez J. Precision of stereophotogrammetry in complete arch implant recordings: A clinical study. *J Prosthet Dent*. 2025;133:1242–1249.
17. Revilla-León M, Gómez-Polo M, Drone M, Barmak AB, Kois JC, Alonso Pérez-Barquero J. Accuracy of complete arch implant scans recorded by using intraoral and extraoral photogrammetry systems. *J Prosthet Dent*. 2025;134:2508–2514.
18. Sánchez-Monescillo A, Hernanz-Martín J, González-Serrano C, González-Serrano J, Duarte Jr S. All-on-four rehabilitation using photogrammetric impression technique. *Quintessence Int*. 2019;50:288–293.
19. Peñarrocha-Oltra D, Agustín-Panadero R, Bagán L, Giménez B, Peñarrocha MA. Impression of multiple implants using photogrammetry: Description of technique and case presentation. *Med Oral Patol Oral Cir Bucal*. 2014;19:e366–e371.
20. Revilla-León M, Gómez-Polo M, Drone M, et al. Influence of implant reference on the scanning accuracy of complete arch implant scans captured by using a photogrammetry system. *J Prosthet Dent*. 2025;133:252–257.
21. Joensahakij N, Serichetaphongse P, Chengprapakorn W. The accuracy of conventional versus digital (intraoral scanner or photogrammetry) impression techniques in full-arch implant-supported prostheses: a systematic review. *Evid Based Dent*. 2024;25:216–217.
22. Revilla-León M, Att W, Özcan M, Rubenstein J. Comparison of conventional, photogrammetry, and intraoral scanning accuracy of complete-arch implant impression procedures evaluated with a coordinate measuring machine. *J Prosthet Dent*. 2021;125:470–478.
23. Clozza E. Intraoral scanning and dental photogrammetry for full-arch implant-supported prosthesis: A technique. *Clin Adv Periodontics*. 2024;14:244–249.
24. Pozzi A, Laureti A, Tawil I, et al. Intraoral photogrammetry: Trueness evaluation of novel technology for implant complete-arch digital impression in vitro. *Clin Implant Dent Relat Res*. 2025;27:e70049.
25. Brakoč J, Todorović A, Mangano FG, Glišić M, Sćepanović M. Accuracy of intraoral photogrammetry versus direct digital implant impressions in the fully edentulous lower jaw: An in vitro study. *J Dent*. 2025;156:105654.

26. Santamaría-Laorden A, Marugán AM, Andreu-Vázquez C, Orejas-Pérez J. Complete arch implant capture using a photogrammetry algorithm and smartphone app: An in vitro study. *J Dent*. 2025;161:105969.
27. Gómez-Polo M, Barmak AB, Ortega R, Rutkunas V, Kois JC, Revilla-León M. Accuracy, scanning time, and patient satisfaction of stereophotogrammetry systems for acquiring 3D dental implant positions: A systematic review. *J Prosthodont*. 2023;32:208–224.
28. Galantucci LM, Lavecchia F, Percoco G. A new three-dimensional photogrammetric face scanner for the morpho-biometric 3D feature extraction applied to a massive field analysis of Italian attractive women. *Procedia CIRP*. 2013;5:259–264.
29. Deli R, Gioia ED, Galantucci LM, Percoco G. Accurate facial morphologic measurements using a 3-camera photogrammetric method. *J Craniofac Surg*. 2011;22:54–59.
30. Liu C, Artopoulos A. Validation of a low-cost portable 3-dimensional face scanner. *Imaging Sci Dent*. 2019;49:35–41.
31. Mai HN, Lee DH. Accuracy of mobile device–compatible 3D scanners for facial digitization: Systematic review and meta-analysis. *J Med Internet Res*. 2020;22:e22228.
32. Abduo J, Judge RB. Implications of implant framework misfit: A systematic review of biomechanical sequelae. *Int J Oral Maxillofac Implants*. 2014;29:608–621.
33. Revilla-León M, Gómez-Polo M, Drone M, et al. Impact of scanning distance on the accuracy of a photogrammetry system. *J Dent*. 2024;142:104854.
34. Hammerle C, Stone P, Jung R, Kapos T, Brodala N. Consensus statements and recommended clinical procedures regarding computer-assisted implant dentistry. *Int J Oral Maxillofac Implants*. 2009;24:126–131.
35. Suganna M, Kausher H, Ahmed TS, et al. Contemporary evidence of CAD-CAM in dentistry: A systematic review. *Cureus*. 2022;14:e31687.

Corresponding author:
Dr Miguel Gómez-Polo
School of Dentistry
Complutense University of Madrid (UCM)
Plaza Ramón y Cajal s/n
Madrid 28033
SPAIN
Email: mgomezpo@ucm.es

https://doi.org/10.1016/j.prosdent.2025.09.017