

Original article: Beyond Scanning: Photogrammetry, a Novel Digital Molding Technology



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ABSTRACT



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Photogrammetry is a digital imaging technique that uses multiple photographs taken from different angles to accurately determine spatial relationships and produce three-dimensional models. Originally developed for industrial and cartographic purposes, photogrammetry has recently gained attention in dentistry due to its potential for enhancing precision in digital workflows. This review introduces the fundamental principles of photogrammetry and examines its use with both intraoral and extraoral devices. Clinical applications across implantology, orthodontics, and maxillofacial surgery are discussed, highlighting the method's advantages in capturing the spatial position of dental and facial structures with high accuracy and efficiency. Despite its benefits, photogrammetry also presents limitations, including sensitivity to technical and environmental variables, as well as a need for further validation through real-world clinical studies. The advent of portable and user-friendly systems has expanded access to this technology in dental practice, indicating that photogrammetry may play a significant role in improving the accuracy and quality of digital treatment planning and execution.

1. Introduction

Digital dentistry has become increasingly integrated into contemporary dental practice, with intraoral scanners, 3D printers, and milling machines serving as fundamental components (1, 2). Intraoral scanners represent optical digital impression techniques, typically comprising a camera, dedicated software, and an associated computer system. The operational principle of these scanners parallels human vision, involving the projection of light onto the object of interest, with subsequent reflection captured by the camera scanner via an internal mirror. Multiple images are acquired from varying perspectives, and these data are then transmitted to the processing software, which reconstructs a three-dimensional digital model (3). While the accuracy of early digital methods was debated issue compared to conventional impression techniques, a substantial body of literature now indicates that both approaches can achieve clinically acceptable outcomes (4-6).

Photogrammetry has emerged as a noteworthy digital

technique in recent years, enabling the precise determination of spatial coordinates of objects through the acquisition of multiple images from diverse viewpoints (7, 8). The image processing workflow in photogrammetry software involves the initial matching of homologous points across different images to generate a sparse point cloud, followed by the creation of a dense surface model and subsequent texture mapping to enhance visual detail (9). The potential of photogrammetry in dentistry was first proposed by Jemt et al. in 1999 for the accurate localization of implants in edentulous patients (10). Early photogrammetry systems utilized custom-fabricated lightboxes, digital single-lens reflex (DSLR) cameras with specialized lenses, and machine-prepared abutments or markers (11,12). Contemporary systems benefit from higher-resolution optics and the use of coded abutments to enhance accuracy. Recognizing the stringent precision requirements of the oral environment and the demand for portability, sophisticated and portable photogrammetry devices have been developed for both intraoral and extraoral applications (12). The PIC camera exemplifies

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a portable extraoral photogrammetry device incorporating dual cameras and a charge-coupled device (CCD) thermal sensor (13), while the iCam4D represents other devices, such as those equipped with four cameras (14). Notably, commercial manufacturers have integrated photogrammetry capabilities into their latest intraoral scanners, such as the Shining 3D Aoralscan Elite (15). These advancements suggest a paradigm shift towards fully digital workflows for impression acquisition and prosthetic fabrication with enhanced accuracy, potentially addressing previous concerns regarding the limitations of digital methods in full-arch restorations (16, 17).

The resurgence of photogrammetry, evidenced by its incorporation into contemporary intraoral scanning systems, underscores the importance of understanding its principles and applications. Consequently, this discussion will address fundamental questions regarding the definition and applications of photogrammetry in dentistry, its potential to supplant traditional impression techniques, and its capacity to generate superior three-dimensional models, elucidating the underlying reasons for any observed improvements.

2. Materials and Methods

This scoping review aimed to map the existing literature on the application of photogrammetry in dental implant procedures. To achieve this objective, a comprehensive search for relevant articles published between 2000 and 2025 was conducted across reputable scientific databases, including PubMed, Web of Science, and Google Scholar. The search strategy employed the following keywords: "photogrammetry," "stereophotogrammetry," "dental implants," and "dental impression technique." The article selection process involved an initial identification of 470 potentially relevant articles based on title and abstract screening. Subsequently, a thorough review was performed

applying the following inclusion and exclusion criteria: only articles published from 2008 onwards were included, while studies not in English or those for which the full text was unavailable were excluded. Following this screening process, a final selection of 38 articles was included for detailed analysis in this review. The study types reviewed primarily consisted of comparative analyses, technical reports.

3. Results

In the scientific database search, 73 articles were retrieved from Scopus (35 articles), PubMed (29 articles), and Web of Science (9 articles). After removing duplicate articles, 55 studies were reviewed by two individuals independently, based on predetermined criteria. By examining the titles and abstracts of the articles, 42 relevant articles were selected for further study. We carefully studied all 38 articles and conducted a comprehensive review of photogrammetry, examining all its aspects.

4. Discussion

In their study conducted in 2019, Sanchez et al. (17) delineated the application of extraoral photogrammetry for the acquisition of digital implant impressions in edentulous mandibular patients. Utilizing a dedicated extraoral camera system (PICcamera, PIC Dental), the methodology parallels intraoral scanning with a critical distinction: the incorporation of specifically coded "scan bodies" affixed to the osseointegrated implants (Figure 1). These scannable abutments, also termed photogrammetry abutments, possess unique identifying codes that, in conjunction with CCD sensors of the camera, facilitate precise system recognition and the subsequent generation of high-resolution three-dimensional models (17; Figure 2).



Figure 1. Coded Photogrammetry Scan Bodies of the PIC Camera System, Named PIC Transfer. These pieces can be at the abutment level or implant level. (Image source: www.picdental.com/pic-system/pic-transfers, accessed on April 2, 2025.)

Clozza (2023) detailed a methodology for acquiring digital dental impressions utilizing an extraoral photogrammetry device (18). The described protocol involves the following steps: initially, a digital scan of the patient's maxilla is obtained prior to any extractions or

implant placement, subsequently leading to the fabrication of a three-dimensional printed model of the upper jaw. Following tooth extraction and the placement of implants with multi-unit abutments, scan bodies are affixed, and intraoral scans of both the maxillary and

mandibular arches are captured to record the occlusal relationship. The aforementioned 3D-printed model is also employed to aid in the acquisition of this inter-arch registration. Subsequently, specialized photogrammetry scan bodies (Icambody) are attached to the implants, and further image acquisition is performed using an extraoral photogrammetry device (Icam4D). These disparate datasets are integrated within the dental laboratory to generate a highly accurate three-dimensional model delineating the implant positions. A provisional dental prosthesis is then fabricated and evaluated intraorally. Upon the verification of satisfactory fit, the definitive prosthesis is manufactured (18).

Alternatively, a fully digital workflow utilizing photogrammetry commences with an intraoral scan to precisely capture the patient's soft tissue morphology and occlusal relationship. Subsequently, specialized photogrammetry abutments, available in abutment-level and fixture-level configurations, are attached. Utilizing these abutments, a photogrammetry file is generated. The integration of the intraoral scan and the photogrammetry file facilitates the precise determination of implant location and orientation, ultimately enabling the design and fabrication of the definitive dental prosthesis (12).

Recent advancements in intraoral scanning technology include the introduction of 2024 models equipped with integrated intraoral photogrammetry (IPG), facilitating its adoption in dental clinical settings. While conventional intraoral scanners are optimally suited for dentate and partially edentulous arches, IPG is particularly recommended for completely edentulous patients and cases involving implants placed at significant angulations (15).

A 2024 investigation by Revilla-León et al. examined the effect of camera-to-marker distance on the accuracy of extraoral photogrammetry (19). Employing a PIC System (PIC Dental) camera, the study evaluated distances of 20, 30, and 35 centimeters. The findings indicated the highest accuracy at a distance of 30 centimeters, although the variations across the tested distances were not statistically significant (19).

Only one recent study has directly compared intraoral and extraoral photogrammetry. In their 2025 comparative analysis, Revilla-León et al. (15) evaluated the accuracy of four extraoral systems (PIC, Icam4D, Grammee, OxoFit) and one intraoral system (Elite from Shining 3D). Their findings revealed that the intraoral system achieved clinically comparable accuracy to the tested extraoral systems (15).

The utilization of coded markers is integral to achieving high accuracy in photogrammetry. These self-identifying markers enable more rapid and precise image acquisition compared to markers relying on basic physical characteristics (20). These markers typically present smooth, cylindrical surfaces featuring white circular codes with diverse patterns, including ARtag, RENE tag, Pi-Tag, reacTIVision, and RatiosInvarDent (RID) (21-23). These coded patterns facilitate the system's ability to identify and correlate corresponding points across multiple images, a critical process for precise three-dimensional model generation (20; Figure 3).

Photogrammetry finds utility across diverse domains within dentistry. Its applications are broadly categorized into facial scanning, orthognathic surgery planning, and implantology, as detailed in Table 1. In facial scanning, photogrammetry serves as a mechanism for capturing impressions, particularly in midface defects (24). The technique precisely records dental and maxillomandibular relationships in facial analyses (25). Motta et al. (26) employed photogrammetry to ascertain head and neck positioning, identifying a significant correlation between head posture and bruxism. Furthermore, facial scans derived from photogrammetry have demonstrated potential in apnea prediction (27) and as valuable orthodontic records (28).

Preoperatively, photogrammetry facilitates the creation of detailed records for orthognathic surgical interventions. Research in this area suggests its utility in predicting hemifacial microsomia treatment outcomes and evaluating cleft palate surgery results (29, 30).

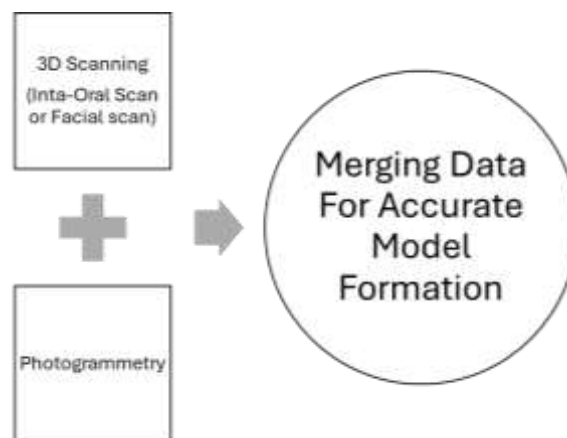


Figure 2. Schematic illustration of modeling using photogrammetry



Figure 3. Photogrammetry marker code patterns in order from left to right: RID, RUNE, reacTIVision, Artag, Pi-tag (21-23). [Reproduced from: Bergamasco F et al., CVPR 2011, 2011, with permission from IEEE], [Reproduced from: Bergamasco F, Albarelli A, Torsello A, Machine Vision and Applications, 2013, with permission from Springer Science.] and [Reproduced from: Fiala M, editor, 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05), 2005, with permission from IEEE.]

Table 1. Studies on using photogrammetry in dentistry

Application classification	Application in detail	Year	Author	Results
Facial Scan	Facial Scan and Jaw Relation	2008	Knyaz et al. (25)	Accurate recording of dental and jaw relationships with facial context using photogrammetry.
	Facial Scan and Prediction of Sleep Apnea	2009	Lee et al. (27)	3D modeling to assess the likelihood of obstructive sleep apnea.
	Head Position and Bruxism Correlation	2011	Motta et al. (26)	Determining head position and the relationship between head position and bruxism.
	Facial Scan and Pre-Orthodontic Evaluation	2021	Pojda et al. (28)	Using photogrammetry for orthodontic records
Implant Scan	Multiple Implants	2014	Peñarrocha-Oltra et al. (13)	Using photogrammetry for digital implant impressions
	Implants for Temporary Prosthesis	2018	Gomez-polo et al. (36)	Using photogrammetry for the fabrication of passive-fit temporary prostheses.
	Multiple Implants with Unfavorable Angles	2019	Molinero-Mourelle et al. (35)	Using photogrammetry and intraoral scanners for the fabrication of passive prostheses in multiple implants with unfavorable angulations.
	Implant-Supported Oral Rehabilitation	2016	Sánchez-Monescillo et al. (33)	Full-arch implant rehabilitation using photogrammetry.
	Implant Location Determination	2015	Agustín-Panadero et al. (31)	Precise localization of implants using photogrammetry.
	Implant Location Determination	2014	Pradies et al. (34)	Precise localization of implants using photogrammetry.
Orthognathic Scan	Pre-Surgical Record and Prediction of Surgical Outcome in Hemifacial Microsomia	2010	Jayarathne et al. (30)	Pre-surgical evaluation of treatment outcomes using photogrammetry and mirror imaging.
	Comparison of Cleft Palate Surgery Results Before and After Surgery	2011	Krimmel et al. (29)	Pre-surgical 3D model creation using photogrammetry and comparison with post-surgical models

A particularly well-investigated application of photogrammetry lies in the generation of accurate three-dimensional models for precisely locating intraoral implants. Studies advocate for its adoption due to its inherent accuracy, procedural efficiency, and cost-effectiveness (31-34). The high degree of accuracy afforded by this methodology enables the reliable recording of implant positions, even in instances of suboptimal placement (35). A primary historical limitation to the widespread clinical adoption of photogrammetry was the limited accessibility of specialized devices within dental practices. Nonetheless, the advent of portable extraoral photogrammetry systems, such as the PIC camera and iCam4D, alongside intraoral photogrammetry devices, such as the Shining 3D Aoralscan Elite, has effectively mitigated this barrier, facilitating the integration of photogrammetric benefits into routine clinical workflows (12, 15).

A 2023 systematic review by Hussein concludes that

photogrammetry is an efficient and potentially reliable tool for transferring implant positions in dental workflows, capable of replacing conventional methods. It identifies two main applications: capturing 3D implant coordinates for CAD software and digitizing tissue images. The transfer of implant positions was the most researched application, with the PIC camera system being the most popular due to its convenience and acceptable accuracy. Clinical reports and case series yielded positive outcomes (accurate passive fit, low cost, minimal complications, and patient satisfaction) (37). A wide array of investigations have assessed the accuracy of photogrammetry in comparison with alternative methodologies, as presented in Table 2 (32, 21, 37, 38). Comparative analyses of three-dimensional models generated via photogrammetry and conventional plaster casts have demonstrated high accuracy associated with the photogrammetric technique (21). Furthermore, studies comparing photogrammetry with intraoral

scanners and traditional methods have indicated that photogrammetry exhibits either superior or equivalent

accuracy (32, 37, 38).

Table 2. Studies comparing the accuracy of photogrammetry systems to other techniques

Year	Author	Photogrammetry Type	Comparison	Result
2017	Fu et al. (37)	Extraoral DSLR Photogrammetry	Accuracy of gypsum casts vs. photogrammetric 3D models	Both were clinically acceptable in terms of accuracy.
2008	Wong et al. (38)	Extraoral 3dMDface Photogrammetry	Evaluation of photogrammetry accuracy in cranial anthropometry	Photogrammetry results were reliable.
2021	Ma et al. (39)	Extraoral ICam4D Photogrammetry	Intraoral scanner TRIOS 3 vs. extraoral photogrammetry vs. conventional impressions in multiple implants for completely edentulous patients	Photogrammetry showed the highest accuracy in impressioning multiple implants for completely edentulous patients.
2019	Lavorgna et al. (32)	Extraoral FaceShape Maxi 6 Photogrammetry	Intraoral scanners, Trios 3Shape, Planmeca Emerald vs. extraoral photogrammetry	Photogrammetry had similar accuracy to intraoral scanners.



Interpreting our findings and planning future research requires acknowledging several limitations. First, this review only considered studies in scientific databases, potentially missing relevant research that was not included there. Second, comparing studies directly was difficult due to differences in how they were conducted, the photogrammetry equipment used, and how accuracy was measured. Third, the majority of retrieved studies involved models, with fewer investigations on real patients. Beyond these limitations of our review process, photogrammetry itself has inherent constraints. Like any imaging method, its accuracy can be affected by the camera, lighting, distance to the object, and the surface of the object. Furthermore, taking multiple pictures from different angles might be difficult in some areas of the mouth. In addition, the initial cost of photogrammetry equipment can be a significant obstacle for some dental practices, and using the devices and software effectively requires specific training. Finally, achieving high accuracy demands careful image capture, which could make procedures take longer. Considering these limitations, future research should focus on a thorough investigation of the factors that affect photogrammetry accuracy. This includes examining different intraoral photogrammetry systems, comparing various photogrammetry techniques, and rigorously evaluating how well they work in actual clinical practice.

5. Conclusions

This comprehensive review assessed the application of photogrammetry within digital dentistry, evaluating its utility, benefits, and inherent limitations as reported in the current literature. The findings pointed out that photogrammetry, recognized as an accurate and efficient imaging modality, demonstrates applicability across diverse dental specialties, including implantology, orthodontics, and maxillofacial surgery. The high degree of accuracy afforded by photogrammetry facilitates precise documentation of the spatial relationships of implants, dentition, and facial structures, thereby potentially enhancing the quality of digitally driven dental

interventions. The advent of portable intraoral and extraoral photogrammetry systems has increased the accessibility of this technology within dental practices, enabling the integration of its advantages into routine clinical workflows. In general, photogrammetry is establishing itself as a significant asset in digital dentistry, offering the potential to improve the precision, efficiency, and predictability of various dental treatments.

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Not Applicable

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Authors' Contributions

Maryam Jahangiri: Conceptualization, Investigation, Methodology, Resources, Writing-Original Draft, Writing-Review & Editing **Shojaedin Shayegh:** Supervision, Validation, Project administration

Conflict of Interests

The authors declare no conflict of interest

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request. Moreover, the datasets supporting the conclusions of this article are included within the article.

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References

- Gawali N, Shah PP, Gowdar IM, Bhavsar KA, Giri D, Laddha R. The evolution of digital dentistry: A comprehensive review. *J Pharmacy Bioallied Sci.* 2024;16(Suppl 3): S1920-S1922. [DOI: 10.4103/jpbs.jpbs_11_24] [PMID] [PMCID]
- Panahi O, Zeinaldin M. Digital dentistry: revolutionizing dental care. *J Dent App.* 2024;10(1):1121. [Link]
- Richert R, Goujat A, Venet L, Viguie G, Viennot S, Robinson P, et al. Intraoral scanner technologies: a review to make a successful impression. *J Healthc Eng.* 2017;2017(1):8427595. [DOI: 10.1155/2017/8427595] [PMID] [PMCID]
- Afrashtehfar KI, Alnakeb NA, Assery MK. Accuracy of intraoral scanners versus traditional impressions: A rapid umbrella review. *J Evid Based Dent Pract.* 2022;22(3):101719. [DOI: 10.1016/j.jebdp.2022.101719] [PMCID]
- Zarbakhsh A, Jalalian E, Samiei N, Mahgoli MH, Kaseb Ghane H. Accuracy of digital impression taking using intraoral scanner versus the conventional technique. *Front Dent.* 2021; 18:6. [DOI: 10.18502/fid.v18i6.5649] [PMID] [PMCID]
- Tomita Y, Uechi J, Konno M, Sasamoto S, Iijima M, Mizoguchi I. Accuracy of digital models generated by conventional impression/plaster-model methods and intraoral scanning. *Dent Mater J.* 2018;37(4):628-33. [DOI: 10.4012/dmj.2017-208] [PMID]
- Kraus K. Photogrammetry: geometry from images and laser scans. Walter de Gruyter. 2007. [Link]
- Rivara F, Lumetti S, Calciolari E, Toffoli A, Forlani G, Manfredi E. Photogrammetric method to measure the discrepancy between clinical and software-designed positions of implants. *J Prosthet Dent.* 2016;115(6):703-711. [DOI: 10.1016/j.prosdent.2015.10.017] [PMID]
- Zotti F, Rosolin L, Bersani M, Poscolere A, Pappalardo D, Zerman N. Digital dental models: is photogrammetry an alternative to dental extraoral and intraoral scanners? *Dent J.* 2022;10(2):24. [DOI: 10.3390/dj10020024] [PMID] [PMCID]
- Jemt T, Bäck T, Petersson A. Photogrammetry--an alternative to conventional impressions in implant dentistry? A clinical pilot study. *Int J Prosthodont.* 1999;12(4):363-368. [PMID]
- Bratos M, Bergin JM, Rubenstein JE, Sorensen JA. Effect of simulated intraoral variables on the accuracy of a photogrammetric imaging technique for complete-arch implant prostheses. *J Prosthet Dent.* 2018;120(2):232-241. [DOI: 10.1016/j.prosdent.2017.11.002] [PMID]
- Hussein MO. Photogrammetry technology in implant dentistry: A systematic review. *J Prosthet Dent.* 2023;130(3):318-326. [DOI: 10.1016/j.prosdent.2021.09.015] [PMID]
- 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(4): e366-371. [DOI: 10.4317/medoral.19365] [PMID] [PMCID]
- 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(3):470-478. [DOI: 10.1016/j.prosdent.2020.03.005] [PMID]
- 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 Prosthe Dent.* 2025. [DOI: 10.1016/j.prosdent.2025.01.041] [PMID]
- Peñarrocha-Oltra D, Agustín-Panadero R, Pradiés G, Gomar-Vercher S, Penarrocha-Diago M. Maxillary full-arch immediately loaded implant-supported fixed prosthesis designed and produced by photogrammetry and digital printing: a clinical report. *J Prosthodont.* 2017;26(1):75-81. [DOI: 10.1111/jopr.12364] [PMID]
- 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(4):288-293. [DOI: 10.3290/j.qi.a42098] [PMID]
- Clozza E. Intraoral scanning and dental photogrammetry for full-arch implant-supported prosthesis: A technique. *Clin Adv Periodontics.* 2024;14(4):244-249. [DOI: 10.1002/cap.10269] [PMID]
- Revilla-León M, Gómez-Polo M, Drone M, Barmak AB, Guinot-Barona C, Att W, et al. Impact of scanning distance on the accuracy of a photogrammetry system. *J Dent.* 2024; 142:104854. [DOI: 10.1016/j.jdent.2024.104854] [PMID]
- Chen Y, Zhu M, He B, Deng Z. Efficient intraoral photogrammetry using self-identifying projective invariant marker. *Int J Comput Assist Radiol Surg.* 2024;19(4):767-778. [DOI: 10.1007/s11548-023-03039-1] [PMID]
- Fiala M. ARTag, a fiducial marker system using digital techniques. 2005 IEEE Computer Society Conference on Computer Vision and Pattern Recognition (CVPR'05). 2005;2:590-596. [DOI:10.1109/CVPR.2005.74]
- Bergamasco F, Albarelli A, Rodola E, Torsello A. Rune-tag: A high accuracy fiducial marker with strong occlusion resilience. *CVPR 2011; IEEE.* 2011. [Link]
- Bergamasco F, Albarelli A, Torsello A. Pi-tag: a fast image-space marker design based on projective invariants. *Machine Vision App.* 2013; 24:1295-310. [DOI:10.1007/s00138-012-0469-6]
- Jahangiri M, Hakimaneh SMR, Bafandeh MA, Bakhtiari F, Shayegh SS. Application of digital molding in maxillofacial prosthetics: A narrative review: Digital molding in maxillofacial prosthetics. *Galen Med J.* 2024;13(SP1):e3656. [DOI:10.31661/gmj.v13iSP1.3656]
- Knyaz V, Zheltov SY. Photogrammetric techniques for dentistry analysis, planning and visualisation. *Proceedings ISPRS Congress Beijing; 2008.* [Link]
- Motta LJ, Martins MD, Fernandes KPS, Mesquita-Ferrari RA, Biasotto-Gonzalez DA, Bussadori SK.

- Craniocervical posture and bruxism in children. *Physiother Res Int.* 2011;16(1):57-61. [DOI: 10.1002/pri.478] [PMID]
27. Lee RW, Petocz P, Prvan T, Chan AS, Grunstein RR, Cistulli PA. Prediction of obstructive sleep apnea with craniofacial photographic analysis. *Sleep.* 2009;32(1):46-52. [PMID] [PMCID]
 28. Pojda D, Tomaka AA, Luchowski L, Tarnawski M. Integration and application of multimodal measurement techniques: relevance of photogrammetry to orthodontics. *Sensors.* 2021;21(23):8026. [DOI: 10.3390/s21238026] [PMID][PMCID]
 29. Kimmel M, Schuck N, Bacher M, Reinert S. Facial surface changes after cleft alveolar bone grafting. *J Oral Maxillofac Surg.* 2011;69(1):80-83. [DOI: 10.1016/j.joms.2010.03.009] [PMID]
 30. Jayaratne YS, Lo J, Zwahlen RA, Cheung LK. Three-dimensional photogrammetry for surgical planning of tissue expansion in hemifacial microsomia. *Head Neck.* 2010;32(12):1728-35. [DOI: 10.1002/hed.21258] [PMID]
 31. Agustín-Panadero R, Peñarrocha-Oltra D, Gomar-Vercher S, Peñarrocha-Diago M. Stereophotogrammetry for recording the position of multiple implants: Technical description. *Int J Prosthodontics.* 2015 ;28(6) :631-636. [DOI: 10.11607/ijp.4146] [PMID]
 32. Lavorgna L, Cervino G, Fiorillo L, Di Leo G, Troiano G, Ortensi M, et al. Reliability of a virtual prosthodontic project realized through a 2D and 3D photographic acquisition: An experimental study on the accuracy of different digital systems. *Int J Environ Res Public Health.* 2019;16(24):5139. [DOI: 10.3390/ijerph16245139] [PMID] [PMCID]
 33. Sánchez-Monescillo A, Sánchez-Turrión A, Vellon-Domarco E, Salinas-Goodier C, Prados-Frutos JC. Photogrammetry impression technique: A case history report. *Int J Prosthodont.* 2016;29(1):71-73. [DOI: 10.11607/ijp.4287] [PMID]
 34. Pradies 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(4):338-344. [DOI: 10.14219/jada.2013.45] [PMID]
 35. Molinero-Mourelle P, Lam W, Cascos-Sánchez R, Azevedo L, Gómez-Polo M. Photogrammetric and intraoral digital impression technique for the rehabilitation of multiple unfavorably positioned dental implants: A clinical report. *J Oral Implantol.* 2019;45(5):398-402. [DOI: 10.1563/aaid-joi-D-19-00140] [PMID]
 36. Gómez-Polo M, Gómez-Polo C, del Río J, Ortega R. Stereophotogrammetric impression making for polyoxymethylene, milled immediate partial fixed dental prostheses. *J Prosthetic Dent.* 2018;119(4):506-510. [DOI: 10.1016/j.prosdent.2017.04.029] [PMID]
 37. Fu X, Peng C, Li Z, Liu S, Tan M, Song J. The application of multi-baseline digital close-range photogrammetry in three-dimensional imaging and measurement of dental casts. *PloS One.* 2017;12(6): e0178858. [DOI: 10.1371/journal.pone.0178858] [PMID] [PMCID]
 38. Wong JY, Oh AK, Ohta E, Hunt AT, Rogers GF, Mulliken JB, et al. Validity and reliability of craniofacial anthropometric measurement of 3D digital photogrammetric images. *Cleft Palate-Craniofac J.* 2008;45(3):232-239. [DOI: 10.1597/06-175] [PMID]
 39. 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; 21:1-9. [DOI: 10.1186/s12903-021-02005-0] [PMID] [PMCID]