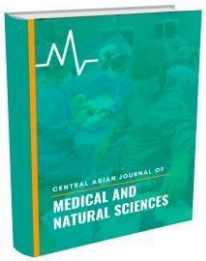

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Article

Photogrammetry For Implant Impressions: A Short Review

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Abstract: Because of stitching mistakes and a lack of anatomical landmarks, intraoral scanners (IOS) frequently have trouble taking precise full-arch implant impressions, which results in less than ideal prosthetic fit. An alternative is provided by photogrammetry, which uses specialized cameras and coded scan bodies to directly record implant positions. Reviewing photogrammetry applications for full-arch, implant-supported prostheses with an emphasis on technical constraints, user experience, workflow efficiency, and accuracy is the goal. Using searches in PubMed, Google Scholar, and the Wiley Online Library, a narrative review of ten important studies was carried out. These studies included systematic reviews, in vitro comparisons, and proof-of-concept reports. Clinical trials and comparative studies comparing photogrammetry with IOS and traditional impression techniques were the focus of the inclusion criteria. Compared to IOS and traditional techniques, photogrammetry consistently showed sub-50 μm trueness in full-arch implant impressions. The "one-shot" capture method improved patient and clinician satisfaction by cutting down on scan time and retakes. The majority of systems, however, demand a different scan for soft-tissue registration, and there are still obstacles in the form of expensive upfront costs and a dearth of extensive clinical trials. The accuracy and effectiveness of full-arch implant workflows are greatly improved by photogrammetry. Despite its promise, its routine clinical adoption will require additional large-scale, standardized clinical studies and integrated soft-tissue capture solutions.

Keywords: Photogrammetry, Full-Arch Implants, Intraoral Scanners, Digital Impression, Prosthetic Accuracy, Soft Tissue Registration, Clinical Workflow

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1. Introduction

Clinicians often face notable challenges when using intraoral scanners (IOS) to capture complete-arch implant impressions. Traditional IOS workflows depend on sequential stitching of overlapping images, which can accumulate alignment errors—especially over large spans involving multiple implants. These cumulative inaccuracies may result in poor prosthetic fit and require chairside adjustments, particularly problematic in edentulous arches with limited anatomical landmarks[1]

Various factors exacerbate this issue: scanning across multiple implants increases the risk of distortion, while soft tissue variability and operator technique influence the final scan precision. Consequently, IOS tends to be reliable for short-span restorations, but less so for full-arch cases where misalignment can exceed clinically acceptable limits[2]

These limitations have prompted the exploration of alternative digital approaches better suited for complex cases. One such advancement is photogrammetry, a technique that directly records implant positions using specialized camera systems and coded scan bodies, aiming to overcome the drawbacks of conventional digital scanning in edentulous

arches[3]. While initially introduced with limited clinical data, the method has seen a rise in both research interest and clinical application over recent years[4].

As the demand for efficient and precise full-arch rehabilitation grows, photogrammetry is emerging as a promising technology in digital implant dentistry. This review explores the development, clinical evidence, and potential role of photogrammetry in improving outcomes in implant-supported prosthodontics.

2. Materials and Methods

This narrative review was designed to map and synthesize the most relevant peer-reviewed research on photogrammetry for full-arch, implant-supported prostheses published in the last five years. We began by searching PubMed, Google Scholar and Wiley Online Library. Our search used combinations of the keywords photogrammetry, full-arch, dental implants, accuracy, and digital impression. Searches were limited to articles published from 2018 through mid-2025.

Then an inclusion criteria applied that focused strictly on: Clinical trials or in vitro comparative studies directly evaluating photogrammetry against conventional or intraoral-scanner methods in complete-arch implant impressions,

Systematic reviews and meta-analyses centered on photogrammetric techniques in implant dentistry, and Proof-of-concept studies examining new photogrammetry systems or workflows. Exclusion was done to opinion pieces, narrative reviews (unless they contained new primary data), and studies limited to single-unit or short-span restorations.

After initial screening of titles and abstracts, we retrieved full texts for all candidate papers. Two reviewers independently confirmed eligibility; disagreements were resolved through discussion. During extraction, we captured for each study: the photogrammetry systems used, study design (e.g. RCT, in vitro), sample context (patients vs. models), comparator methods, and outcomes (trueness, precision, scan time, user feedback). We also noted any reported strengths (e.g. sub-50 μm accuracy) and limitations (e.g. small sample size).

Table 1. summarizing the 10 selected studies.

Study No.	Full Reference (Year)	Journal / Source	Comparator	Key Outcome Reported
1	Photogrammetry technology in implant dentistry: A systematic review[5]. 2023.	Systematic Review	N/A	Validity and reliability of photogrammetry endorsed.
2	Photogrammetry in dentistry: a literature review [6]. 2022.	Literature Review	N/A	Highlights simplicity, affordability, high accuracy, contactless workflow, and need for more clinical validation.
3	Stereo-photogrammetry for impression of full-arch fixed dental prosthesis—an	Review Update	N/A	Overview of photogrammetry advances.

	update of the reviews. Prosthesis [7]. 2024.			
4	Photogrammetry as an alternative for acquiring digital dental models: A proof of concept. Med Hypotheses [8]. 2019.	Proof-of-Concept	N/A	Demonstrated feasibility of coded scan bodies.
5	Photogrammetry Versus Intraoral Scanning in Complete-Arch Digital Implant Impression: A Systematic Review and Meta-Analysis [9]. 2025.	Systematic Review & Meta-Analysis	Intraoral Scanner	Photogrammetry showed higher trueness in full-arch.
6	Accuracy, scanning time, and patient satisfaction of stereophotogrammetry systems for acquiring 3D dental implant positions: a systematic review[3]. 2023.	Systematic Review	Intraoral Scanner, Conventional	Reported sub-50 µm precision; scan time & satisfaction data.
7	Digital dental models: is photogrammetry an alternative to dental extraoral and intraoral scanners? [10] 2022.	Comparative Review	Extraoral Scanner, IOS	Summarized photogrammetry vs. scanners.
8	Photogrammetry technology in full arch implant-suppo	Systematic Review	Intraoral Scanner, Conventional	PG showed significantly better accuracy, unaffected by implant

	rted rehabilitations: a systematic review.[11] 2022.			position/angulation; calls for larger clinical studies.
9	Evaluation of the Accuracy of Digital Models Generated Using Photogrammetry[12]. 2024.	In Vitro Comparative	Conventional, IOS	Photogrammetry achieved clinically acceptable accuracy.
10	Photogrammetry technique for the 3D digital impression of multiple dental implants.[13] 2019.	Conference Paper	Intraoral Scanner, Conventional	Described workflow and initial accuracy data.

3. Results

The main findings of this short review is organized into four key themes: Accuracy & Trueness, Workflow Efficiency, User Experience, and Technical Limitations. Table 2 presents these themes alongside the study numbers and their core outcomes.

Table 2. Thematic Summary of Key Findings

Theme	Study Nos.	Key Findings
Accuracy & Trueness	1, 5, 6, 8, 9	Studies 1, 5, and 8 report mean trueness errors often < 50 μm, outperforming IOS and conventional methods; Study 6 confirms sub-50 μm precision; Study 9 demonstrates clinically acceptable accuracy.
Workflow Efficiency	4, 6, 8	Study 4 shows "one-shot" capture without stitching; Study 6 reports reduced scan times vs IOS; Study 8's RCT finds PG faster than IOS and conventional.
User Experience	6, 8	Study 6 notes high patient satisfaction and positive clinician feedback; Study 8 highlights simpler protocols and fewer retakes, boosting operator confidence.
Technical Limitations	2, 3, 7, 10	Studies 2 and 3 call for more clinical trials and standardization; Study 7 points out need for integrated soft-tissue capture; Study 10 notes equipment cost and learning curve.

Accuracy & Trueness

Multiple systematic reviews and in vitro studies demonstrate that photogrammetry provides superior spatial fidelity when capturing full-arch implant positions. Large reviews (Studies 1 and 5) report mean trueness deviations well below 50 μm—significantly better than intraoral scanning or conventional impressions for edentulous arches. Study 6 corroborates this, quantifying precision values under 50 μm across different photogrammetric systems. An in vitro comparison (Study 9) further confirms that digital models generated by photogrammetry meet or exceed clinical accuracy thresholds.

Workflow Efficiency

Proof-of-concept and comparative studies (Studies 4, 6, and 8) consistently note that photogrammetry reduces procedural steps. Instead of capturing multiple overlapping IOS images, photogrammetric systems record all implant positions in a single snap using coded scan bodies. This "one-shot" approach lowers scan time and decreases the number of retakes. Study 8's pilot RCT even found photogrammetry to be faster than both IOS and conventional techniques in a clinical setting.

User Experience

Patient comfort and clinician ease-of-use are important practical considerations. Study 6 reports that patients undergoing photogrammetric scanning experienced minimal discomfort, and clinicians rated the workflow positively for its simplicity. Study 8 adds that operators appreciated the reduced complexity and higher first-time accuracy, which boosted confidence in delivering full-arch prostheses.

Technical Limitations

Despite its strengths, photogrammetry has areas for improvement. The literature reviews (Studies 2 and 3) emphasize the need for larger clinical trials and standardized scanning protocols. Comparative reviews such as Study 7 note that photogrammetry currently captures only implant positions, requiring a separate IOS pass for soft-tissue details. Finally, early conference data (Study 10) remind us of initial equipment investment and the learning curve associated with new photogrammetric hardware and software.

4. Discussion

The data synthesized in this review consistently indicate that photogrammetry provides superior spatial fidelity, faster workflows, and high patient and clinician satisfaction when compared to traditional approaches.

The most consistent benefit of photogrammetry across studies is its high level of accuracy and trueness. Several in vitro and systematic reviews (e.g., studies 1, 5, 6, and 9) report deviation values well below 50 μm—comfortably within clinical acceptance thresholds for full-arch prostheses. This is a significant improvement over intraoral scanners (IOS), which often suffer from accumulated stitching errors when capturing large-span restorations (1,2).

Moreover, workflow efficiency is a major advantage. Instead of capturing a series of overlapping images like IOS, photogrammetry systems utilize coded scan bodies and stereo cameras to register all implant positions in a single capture. This "one-shot" mechanism reduces scan time and operator fatigue while minimizing retakes. Study 8 demonstrated that photogrammetry not only decreased procedure duration but also improved the first-attempt success rate.

In terms of user experience, photogrammetry presents a smoother experience for both the clinician and the patient. It requires no intraoral contact during image capture, improving patient comfort, and offers streamlined digital integration for the clinician. Study 6 reported high satisfaction scores in this regard.

Despite these benefits, photogrammetry is not without its limitations. The main concern is that most current systems can only register implant positions, not soft tissue morphology. This necessitates a second digital scan (typically via IOS) to capture gingival

contours, which adds complexity and potential for alignment errors. As noted in studies 7 and 10, the learning curve and cost of equipment remain barriers to widespread adoption.

Additionally, most clinical studies are limited in sample size and use non-standardized protocols, which restricts the generalizability of the results. Some reviews (2,3) have called for robust randomized clinical trials and long-term follow-ups to establish photogrammetry as a gold standard in digital implant workflows.

Different photogrammetric systems vary in workflow, image capture method, and integration with CAD/CAM pipelines. Common commercial systems include the PIC system (PIC Dental, Spain), iCam4D (Imetric, Switzerland). These devices vary in hardware, speed, and calibration needs, but most offer similar baseline precision [14, 15].

A recent development of note is the hybrid system released by Shining 3D (China), which integrates intraoral scanning and photogrammetry into a single device. Early reports suggest this may streamline soft-tissue capture and eliminate the need for multiple scan devices. While peer-reviewed data on this system is still limited, preliminary clinical evaluations show promise in improving both accuracy and efficiency in full-arch cases [16, 17]. As this system gains traction, future studies should evaluate its performance in comparison with dedicated photogrammetry setups.

Besides photogrammetry, other emerging technologies aim to improve full-arch scanning outcomes. One such method is structured light scanning, which uses projected light patterns and high-resolution sensors to capture 3D geometry. These systems can achieve high precision but are often sensitive to intraoral lighting and motion artifacts[18, 19].

Cone-beam CT (CBCT)-based workflows have also been proposed, especially in guided implant surgery, where existing radiographic data can be used to virtually model implant positions. However, this method typically lacks the surface resolution needed for accurate prosthesis fabrication and may expose patients to unnecessary radiation if used solely for impressions [20, 21]

Photogrammetry in dentistry is still an evolving field, with ongoing advancements in hardware, software, and clinical applications. Due to the continuous development and expansion of this technology, it is challenging to capture and review all available data comprehensively. However, this review attempted to highlight key trends, commonly reported benefits, and notable limitations within recent literature. The findings should be interpreted with this limitation in mind, and future reviews may be needed as the field matures and more clinical data becomes available.

5. Conclusion

Photogrammetry represents a significant advancement in the digital workflow for full-arch, implant-supported rehabilitations. By offering a direct and highly accurate method of capturing implant positions, photogrammetry addresses key limitations associated with intraoral scanning—particularly in edentulous or complex clinical scenarios. The reviewed evidence indicates that photogrammetry consistently outperforms conventional and IOS methods in terms of trueness, workflow efficiency, and clinician/patient satisfaction. However, the technology remains in a stage of clinical maturation. Limitations such as the inability to capture soft tissue morphology in a single scan, high initial costs, and a limited body of large-scale clinical trials still constrain its widespread adoption. As hybrid systems and integrated digital solutions evolve, photogrammetry may become an indispensable tool in implant prosthodontics, but ongoing validation and standardization are essential for broader clinical integration.

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