International Journal of Science and Research (IJSR)
ISSN: 2319-7064
Impact Factor 2025: 7.089

Accuracy of Complete-Arch Digital Implant Impressions using Intraoral Optical Scanning versus Stereophotogrammetry: A Systematic Review

Dr. Rasika Bansode[1], Dr. Kishor Mahale[2], Dr. Smita Khalikar[3], Dr. Rasika Bansode[4]

[1] Post Graduate Student, Department of Prosthodontics, Government Dental College Chh. Sambhajinagar

[2] Professor and Head of the Department, Department of Prosthodontics Government Dental College Chh. Sambhajinagar

[3] Professor, Department of Prosthodontics Government Dental College Chh. Sambhajinagar

[4] Post Graduate Student, Department of Prosthodontics, Government Dental College Chh. Sambhajinagar

Abstract: ***Objective: To compare the accuracy of complete-arch digital implant impressions obtained using intraoral optical scanning (IOS) and stereophotogrammetry (SPG). Materials and Methods: This systematic review was conducted following PRISMA guidelines and registered in PROSPERO (CRD42024628356). Electronic searches of PubMed/MEDLINE, Cochrane Library, Web of Science, and manual searches were performed up to April 25, 2025. In vivo and in vitro studies evaluating the accuracy, trueness, and precision of complete-arch implant impressions using IOS and/or SPG were included. Risk of bias was assessed using the ROBINS-I tool. Results: Ten studies (one in vivo and nine in vitro) met the inclusion criteria. Most studies demonstrated superior trueness and precision for SPG compared with IOS, particularly in linear, 3D, and angular deviations for edentulous full-arch implant scenarios. IOS accuracy decreased with increasing inter-implant distance and implant number, likely due to cumulative stitching errors. Although some studies reported comparable or superior performance of conventional impressions or laboratory scanners, SPG consistently showed reduced angular deviation and higher reproducibility in most experimental setups. Conclusion: Within the limitations of the included studies, stereophotogrammetry demonstrates superior accuracy compared with intraoral optical scanning for complete-arch digital implant impressions. SPG appears particularly advantageous in full-arch rehabilitations involving multiple implants. Further well-designed clinical trials are required to validate these findings under routine clinical conditions.***

Keywords: Digital impressions; intraoral optical scanner; stereophotogrammetry; complete-arch implants; accuracy; trueness; precision

1. Introduction

Digital technologies have become integral to contemporary prosthodontic workflows, particularly in implant dentistry (5,10). Digital impression techniques offer several clinical advantages over conventional analog methods, including improved patient comfort, reduced chairside time, and enhanced integration with computer-aided design and manufacturing (CAD/CAM) systems (5,7). In complete-arch implant rehabilitations, the accuracy of impression procedures is critical to achieving passive fit of the superstructure and minimizing mechanical and biological complications (1,3,4,27).

Conventional impression techniques using elastomeric materials have historically been regarded as the reference standard for recording implant positions (12,20,25). However, these methods are associated with potential inaccuracies arising from impression material distortion, cast expansion, and errors during laboratory digitization. Intraoral optical scanning (IOS) has been proposed as an alternative approach, enabling direct digital acquisition of implant positions (7,9,11). While IOS has demonstrated acceptable accuracy for single-unit and short-span restorations, its reliability for complete-arch implant impressions remains controversial (8,21,22). The absence of anatomical landmarks in edentulous arches, extended scanning paths, and cumulative stitching errors may compromise accuracy as the span length increases.

Stereophotogrammetry (SPG) represents a fundamentally different digital impression concept (1,15,17). By simultaneously capturing the spatial coordinates of multiple implants using extraoral stereo cameras and triangulation algorithms, SPG eliminates the need for sequential image stitching. Previous investigations have suggested that this characteristic may confer superior accuracy for complete-arch implant impressions (16,18,23,24). Nevertheless, SPG systems do not capture soft tissue morphology and therefore require integration with IOS or conventional scans for prosthetic design.

Given the expanding clinical adoption of digital workflows and the potential consequences of impression inaccuracies on long-term implant success, a systematic evaluation of IOS and SPG for complete-arch implant impressions is warranted. Therefore, the purpose of this systematic review was to compare the accuracy of complete-arch digital implant impressions obtained using intraoral optical scanning and stereophotogrammetry.

2. Material and Methods

Protocol and Registration

This systematic review was conducted according to PRISMA guidelines and registered in the PROSPERO database (CRD42024628356).

Focused Question and PICO Framework

The focused research question was: *Is there a difference in*

the accuracy and trueness of complete-arch implant impressions obtained using intraoral optical scanning and stereophotogrammetry?

- Population: Patients or models with dental implants
- Intervention: Intraoral optical scanning (IOS)
- Comparison: Stereophotogrammetry (SPG) and/or conventional impressions
- Outcome: Linear, 3D, and angular deviations; trueness and precision

Eligibility Criteria

Inclusion criteria: Randomized and non-randomized clinical trials, in vitro studies, and cohort studies published in English. Exclusion criteria: Case reports, case series, animal studies, reviews, and studies without clearly defined outcome measures.

Search Strategy

Electronic searches were performed in PubMed/MEDLINE, Cochrane Library, and Web of Science databases up to April 25, 2025. Manual searches of institutional library journals were also conducted. Search terms were derived from MeSH and free-text keywords related to dental implants, complete-arch impressions, intraoral scanners, stereophotogrammetry, accuracy, and trueness.

Study Selection

Two calibrated reviewers independently screened titles, abstracts, and full texts. Disagreements were resolved through discussion or consultation with a third reviewer. Ten studies met the inclusion criteria and were included in the qualitative synthesis.

Data Extraction

Data extraction was performed using standardized forms, collecting information on study design, sample characteristics, impression techniques, outcome measures, and key findings.

Risk of Bias Assessment

Risk of bias was assessed using the ROBINS-I tool for non-randomized studies. All included studies demonstrated an overall low risk of bias.

3. Results and Discussion

Study Characteristics

A total of ten studies published between 2005 and 2024 were included, comprising one in vivo clinical study and nine in vitro investigations. The majority evaluated linear, 3D, and angular deviations, as well as trueness and precision of IOS and SPG techniques.

Accuracy Outcomes

Most studies reported superior trueness and precision for SPG compared with IOS. The in vivo study by Pozzi et al. demonstrated significantly lower 3D and angular deviations for SPG. In vitro studies consistently showed increased errors for IOS with increasing implant number and inter-implant distance. Some variability in SPG performance was noted depending on device type and experimental setup.

The findings of this systematic review indicate that stereophotogrammetry generally provides higher accuracy than intraoral optical scanning for complete-arch digital implant impressions (18, 21–24). The principal advantage of SPG lies in its ability to capture implant positions simultaneously, thereby avoiding cumulative stitching errors inherent to IOS systems (9,19,21).

The in vivo evidence, although limited, supports the superior performance of SPG under clinical conditions (23,24). In vitro studies further corroborate these findings, particularly for full-arch rehabilitations involving multiple implants or unfavorable implant distributions (18,21,22). Nevertheless, discrepancies among studies highlight the influence of scanner type, scan bodies, implant angulation, and reference standards on reported outcomes.

Despite its advantages, SPG has limitations, including inability to capture soft tissue contours and higher equipment costs. Therefore, hybrid workflows combining SPG for implant position capture and IOS for soft tissue recording may represent a pragmatic clinical solution (16,17,23).

The predominance of in vitro studies and heterogeneity in methodologies limit direct quantitative comparisons. Additionally, variations in reference standards and outcome metrics precluded meta-analysis.

4. Conclusions

Within the limitations of the available evidence, stereophotogrammetry demonstrates superior accuracy compared with intraoral optical scanning for complete-arch digital implant impressions. SPG appears particularly advantageous for full-arch implant-supported prostheses, although further high-quality clinical trials are necessary to confirm these findings.

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