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Photogrammetry-Based Digital Scanning in Implant Dentistry and Edentulous Arch Rehabilitation: A Case-Based Review

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Abstract
Digital dentistry has rapidly evolved with the integration of computer-aided design and computer-aided manufacturing (CAD-CAM) technologies. Accurate digital impressions are essential for the fabrication of implant-supported prostheses and complete dentures, particularly in edentulous arches where conventional intraoral scanners (IOSs) often demonstrate limitations. Photogrammetry has emerged as a promising technique capable of improving the accuracy of implant position recording. This review article presents a case-based analysis evaluating the role of photogrammetry and related technologies, such as light detection and ranging (LiDAR), in digital implant dentistry. Evidence from clinical studies, systematic reviews, and experimental investigations indicates that photogrammetry provides superior trueness and precision compared with intraoral scanning, especially in full-arch implant rehabilitation. However, limitations such as soft tissue recording and workflow complexity remain. Further clinical studies are required to optimize these technologies for routine prosthodontic practice.

Keywords: Photogrammetry, digital dentistry, intraoral scanner, implant prosthesis, CAD-CAM, edentulous arch.

INTRODUCTION

The transition from conventional impression techniques to digital workflows has significantly transformed modern prosthodontics. Traditional impression materials such as polyvinyl siloxane and elastomers may exhibit dimensional instability and polymerization shrinkage, potentially affecting the accuracy of the final prosthesis (1).

Digital impression techniques using intraoral scanners (IOSs) have improved patient comfort, reduced

clinical time, and facilitated integration with CAD-CAM manufacturing systems (2). However, capturing accurate digital impressions in edentulous arches remains challenging due to the absence of anatomical landmarks, the presence of saliva, and potential scanning errors caused by reflective surfaces (1,3). Photogrammetry has recently emerged as a promising digital alternative for recording implant positions. This technique reconstructs three-dimensional structures from multiple overlapping two-dimensional images taken from different angles (3). The spatial coordinates of implants can therefore be calculated with high accuracy, improving the passive fit of implant-supported prostheses (4). This review aims to analyze current evidence regarding photogrammetry-based scanning systems and their application in the rehabilitation of edentulous patients through a case-based perspective.

CASE SCENARIO

A 65-year-old edentulous patient presented with instability of mandibular dentures and difficulty in mastication. The treatment plan involved the placement of four implants in the mandibular arch to support a screw-retained fixed prosthesis.Accurate recording of implant positions was required for CAD-CAM fabrication of the prosthesis. Three digital impressio methods were evaluated:

1. Conventional intraoral scanning (IOS)
2. Photogrammetry-based implant scanning
3. Photogrammetry combined with LiDAR-assisted digital reconstruction

The objective was to determine which method would provide the most accurate digital impression for prosthetic fabrication.

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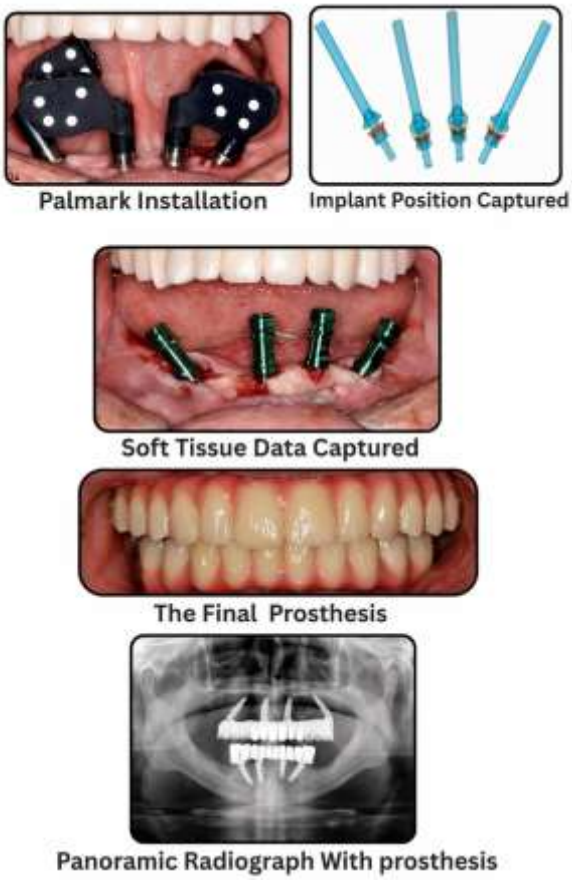

Photogrammetry-Based Digital Scanning in Implant Dentistry

REVIEW OF EVIDENCE

Photogrammetry in Implant Dentistry

Photogrammetry technology has been used in dentistry for measuring implant coordinates, evaluating prosthetic framework fit, and detecting implant impression errors (4). The technique relies on capturing images of specialized optical markers attached to implants, allowing software algorithms to calculate their spatial coordinates (4).

Several systematic reviews have reported that photogrammetry systems provide reliable implant position transfer with high accuracy and minimal distortion (3,4). Because the technique does not rely on sequential scanning or image stitching, it can avoid cumulative errors commonly associated with intraoral scanners (3).

Accuracy Compared with Intraoral Scanners

The accuracy of intraoral scanners decreases as the scanning span increases, particularly in complete-arch implant restorations (5). Errors may accumulate due to the stitching of sequential images, resulting in distortions of implant positions (6).

A systematic review and meta-analysis comparing photogrammetry with intraoral scanners demonstrated significantly greater trueness and precision for photogrammetry systems in recording implant positions (3). Similarly, a clinical study reported mean Euclidean deviations of 30.7 µm for intraoral photogrammetry scanners compared with 59.8 µm for conventional intraoral scanners, indicating superior accuracy for photogrammetry (5).

These findings suggest that photogrammetry may improve the predictability of full-arch implant-supported prostheses.

Photogrammetry Combined with LiDAR

Recent technological advancements have introduced the use of LiDAR sensors in combination with photogrammetry for digital dental scanning. LiDAR technology measures distances using laser pulses, allowing precise surface mapping (1).

An experimental study demonstrated that combining photogrammetry with LiDAR technology enabled accurate three-dimensional reconstruction of edentulous mandibular models using smartphone cameras, even in the presence of artificial saliva (1). This hybrid method may overcome several limitations of intraoral scanners, particularly in edentulous arches.

Functional Outcomes in Edentulous Rehabilitation

Although digital impression accuracy is essential for prosthetic success, patient adaptation to new prostheses also plays a significant role in treatment outcomes. Studies evaluating adaptation to complete dentures have shown that masticatory performance improves over time as the neuromuscular system adapts to the prosthesis (7). Electromyographic studies indicate that muscle activity may initially decrease after insertion of new dentures but gradually return to baseline after an adaptation period of approximately three months (7). Therefore, both prosthetic accuracy and neuromuscular adaptation should be considered in prosthodontic rehabilitation.

DISCUSSION

Digital dentistry continues to evolve as advanced scanning technologies advance. Intraoral scanners have become widely used due to their convenience and integration with CAD-CAM workflows. However, their accuracy may be limited in full-arch implant cases because of cumulative scanning errors and a lack of anatomical reference points (6).

Photogrammetry offers a promising alternative because it directly records implant coordinates without relying on sequential scanning. Several studies have demonstrated the superior accuracy of photogrammetry compared with intraoral scanners in full-arch implant restorations (3,5,8).
The integration of LiDAR technology may further enhance the accuracy of photogrammetry-based scanning systems. particularly in edentulous arches where conventional scanning methods struggle (1). Despite these advantages, photogrammetry systems often require additional scans to capture soft tissue morphology and adjacent teeth, which may Case-Based Review | Digital Dentistry & Implant Prosthetics J Prosthet Dent | 2025
Photogrammetry-Based Digital Scanning in Implant Dentistry complicate the clinical workflow.
Future research should focus on integrating photogrammetry with intraoral scanning technologies to create comprehensive digital workflows capable of capturing both implant coordinates and soft tissue anatomy.

CONCLUSION

Photogrammetry is a promising digital technology for recording implant positions and fabricating implant-supported prostheses in edentulous arches. Evidence suggests that photogrammetry provides greater trueness and precision than conventional intraoral scanners, particularly in complete-arch implant restorations. The addition of LiDAR technology may further improve scanning accuracy and overcome challenges associated with edentulous arches. Nevertheless, limitations related to soft tissue capture and workflow integration remain. Further clinical studies are required to establish standardized protocols for the routine use of photogrammetry in implant dentistry.

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