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Digital Workflow Accuracy in Prosthodontics: Comparison of Intraoral and Conventional Impression Techniques

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Annotation: The accuracy of prosthodontic restorations relies heavily on precise impressions, as discrepancies may lead to poor marginal fit, occlusal errors, and compromised long-term clinical outcomes. The introduction of digital workflows, including intraoral scanning, has revolutionized prosthodontics by offering potential improvements in accuracy, efficiency, and patient comfort compared to conventional impression techniques such as polyvinyl siloxane or polyether impressions. This article evaluates the comparative accuracy of intraoral digital impressions and conventional analog techniques, examining linear and volumetric deviations, marginal adaptation, prosthesis fit, and clinical feasibility. Clinical studies and laboratory evaluations are analyzed to assess the influence of material properties, scanning protocols, operator experience, and software algorithms on the precision of digital impressions. Evidence demonstrates that intraoral scanning offers comparable or superior trueness and reproducibility in single-unit and short-span restorations, while conventional impressions maintain advantages in edentulous or complex full-arch cases. Proper material selection, scanning strategy, and post-processing protocols are critical to maximize digital workflow accuracy and achieve predictable prosthodontic outcomes.

Keywords: Digital prosthodontics, Intraoral scanning, Conventional impressions, Accuracy, Marginal fit, Restoration precision, Workflow efficiency, Material selection, Trueness, Reproducibility.

Introduction: Accurate impressions are a cornerstone of successful prosthodontic treatment, influencing marginal adaptation, occlusion, and prosthetic longevity. Conventional impression techniques, including polyvinyl siloxane, polyether, and irreversible hydrocolloid materials, have long been considered the standard due to their dimensional stability, fine detail reproduction, and clinical versatility. However, conventional methods are time-consuming, technique-sensitive, and may cause patient discomfort, gag reflex, or cross-contamination risk. Intraoral digital impressions provide a non-invasive alternative, capturing three-dimensional data using optical scanning technologies and producing virtual models suitable for computer-aided design and manufacturing. Digital workflows promise reduced chairside time, elimination of material distortions, and immediate evaluation of scan quality. Despite these advantages, clinical adoption depends on demonstrated accuracy, reproducibility, and reliability, particularly in complex prosthodontic cases. Variations in scanner type, operator skill, software algorithms, and arch morphology may influence digital impression fidelity. Comparative evaluations of intraoral and conventional methods are essential to guide evidence-based clinical decision-making and optimize prosthetic outcomes across diverse restorative scenarios.

Materials and Methods: This study is based on a systematic review of current literature comparing intraoral scanning with conventional impression techniques in prosthodontics. Inclusion criteria consisted of clinical trials, in vitro studies, and systematic reviews analyzing accuracy, marginal adaptation, linear and volumetric deviations, and prosthetic fit. Both single-unit and full-arch restorations were included. Conventional impressions included polyvinyl siloxane, polyether, and hydrocolloid materials, while digital techniques utilized widely available intraoral scanners employing confocal, triangulation, or structured light technologies. Parameters assessed included trueness, precision, marginal gap measurements, surface detail reproduction, and operator-dependent factors. Data on material handling, storage, and compatibility with digital workflows were also reviewed to identify best practices and optimize clinical performance.

Materials: 1. Polyvinyl siloxane (PVS) impression material exhibits high dimensional stability, excellent tear strength, and precise detail reproduction, essential for conventional prosthodontic impressions. Storage should avoid heat and moisture to maintain accuracy. 2. Polyether impression material provides excellent wettability, high flow, and rigidity, ideal for capturing fine details in fixed prosthodontics; storage in cool, dry conditions preserves material integrity. 3. Alginate (irreversible hydrocolloid) is low-cost and fast-setting, suitable for preliminary impressions, but susceptible to dimensional changes if not poured promptly; storage should prevent dehydration. 4. Intraoral scanners (confocal, structured light, or triangulation) capture digital impressions efficiently, allowing immediate evaluation and CAD/CAM integration; components should be kept clean, calibrated, and stored according to manufacturer recommendations. 5. Scanning powder or spray may be used with some intraoral scanners to reduce reflections; it should be applied minimally and stored in sealed containers. 6. CAD software enables digital model manipulation, margin design, occlusion analysis, and prosthesis fabrication; data should be backed up and maintained on secure digital storage systems. 7.

Milling blocks or discs (zirconia, PMMA, or composite) provide raw material for prosthetic fabrication; storage in temperature-controlled environments prevents moisture uptake and dimensional instability. 8. Resin-based 3D printing materials are used for temporary restorations and digital models; they require protection from UV light and high temperatures to preserve mechanical properties. 9. Articulators compatible with digital models allow occlusal analysis and functional evaluation; mechanical components should be kept calibrated and free from contamination. 10. Model disinfectants and storage solutions are used to maintain biosecurity without compromising dimensional stability; solutions must be compatible with both conventional and digital impression materials.

Results: Comparative studies indicate that intraoral scanning provides trueness and precision comparable to or exceeding conventional impressions for single-unit and short-span prostheses. Marginal adaptation of restorations fabricated using digital workflows often shows reduced discrepancies compared to stone casts from conventional impressions. Volumetric deviations are minimal in posterior quadrants for digital scans, although full-arch scans may exhibit cumulative errors, particularly in edentulous patients or when soft tissue mobility is high. Conventional impressions demonstrate reliable accuracy in full-arch or complex edentulous cases but are susceptible to material deformation, pouring errors, and operator-dependent inconsistencies. Digital workflows reduce patient discomfort, chairside time, and cross-contamination risk, while conventional methods remain cost-effective and widely accessible. Material handling, storage, and scanning protocol adherence significantly influence clinical outcomes. Proper integration of both techniques allows clinicians to maximize accuracy, efficiency, and patient satisfaction across diverse prosthodontic scenarios.

Discussion: The findings suggest that digital impressions offer predictable accuracy for fixed prosthodontic restorations and limited-span bridges, with benefits in patient comfort, workflow efficiency, and immediate evaluation. Full-arch and edentulous cases remain challenging for intraoral scanning due to soft tissue movement, saliva management, and potential cumulative stitching errors, where conventional impressions may still provide superior dimensional stability. Material selection and handling are critical for both digital and conventional workflows; improper storage or contamination can compromise accuracy. Operator experience, scanning strategy, and software calibration influence digital scan fidelity, while impression technique, tray selection, and pour timing affect conventional outcomes. Hybrid approaches combining intraoral scans for single units and conventional impressions for full-arch cases may optimize clinical efficiency and restorative precision. Future developments in scanner technology, AI-assisted stitching, and material science are expected to further enhance the reliability of fully digital workflows in complex prosthodontic cases.

Conclusion: Intraoral digital impressions offer comparable or superior accuracy to conventional techniques for single-unit and limited-span prosthodontic restorations, with additional advantages in efficiency, patient comfort, and workflow integration. Conventional impressions remain valuable for full-arch, edentulous, or highly mobile soft tissue cases, ensuring dimensional stability and predictable outcomes. Proper material selection, handling, and storage are essential for both workflows to maintain precision, biological safety, and prosthesis longevity. Clinicians should consider patient-specific factors, arch morphology, and procedural complexity when selecting impression techniques, and hybrid approaches may offer optimal accuracy and clinical efficiency. Integration of digital workflows in prosthodontics enhances restoration precision, reduces procedural errors, and contributes to improved long-term patient satisfaction.

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