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ORIGINAL ARTICLE

Digital Technologies in Prosthodontics: Clinical Applications and Treatment Outcomes

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Abstract

The rapid development of digital technologies has transformed modern prosthodontics by improving diagnostic accuracy, treatment planning, fabrication processes, and clinical outcomes. Digital dentistry integrates computer-aided design and computer-aided manufacturing (CAD/CAM), intraoral scanning, three-dimensional imaging, artificial intelligence, and additive manufacturing techniques into routine prosthodontic practice. These technologies facilitate highly precise restorations while reducing treatment time and enhancing patient comfort. The present study aimed to evaluate the clinical applications of digital technologies in prosthodontics and assess their influence on treatment outcomes. A total of 118 patients requiring prosthetic rehabilitation participated in the investigation. Digital workflows involving intraoral scanning, virtual treatment planning, CAD/CAM fabrication, and three-dimensional printing were utilized according to individual clinical indications. Clinical evaluation included assessment of restoration accuracy, treatment duration, patient satisfaction, marginal adaptation, occlusal stability, and prosthesis longevity. The findings demonstrated that digital technologies significantly improved clinical efficiency, reduced procedural errors, enhanced communication between clinicians and dental laboratories, and increased patient acceptance. Restorations produced through digital workflows exhibited excellent functional performance and favorable aesthetic outcomes. The study confirms that digital technologies represent an essential component of contemporary prosthodontics and contribute substantially to the optimization of patient-centered dental care.

Keywords: digital prosthodontics, CAD/CAM, intraoral scanning, digital dentistry, three-dimensional printing, prosthetic rehabilitation, virtual treatment planning, dental technology, restorative dentistry, clinical outcomes.

1. Introduction

The field of prosthodontics has experienced remarkable technological advancement over the last two decades. Traditional prosthetic procedures, which relied heavily on manual impressions, stone casts, and conventional laboratory techniques, are increasingly being supplemented or replaced by digital technologies. These innovations have significantly improved the precision, efficiency, and predictability of prosthetic treatment.

Digital dentistry encompasses a broad range of technologies designed to facilitate diagnosis, treatment planning, fabrication, and evaluation of dental restorations. Among the most influential developments are computer-aided design and computer-aided manufacturing systems, intraoral scanners, cone-beam computed tomography, virtual articulators, artificial intelligence applications, and additive manufacturing technologies. Together, these tools have established a fully digital workflow capable of enhancing every stage of prosthetic rehabilitation.

Accurate diagnosis and treatment planning are fundamental requirements for successful prosthodontic therapy. Conventional diagnostic procedures often involve multiple clinical appointments and extensive laboratory procedures. Digital technologies provide clinicians with detailed three-dimensional representations of oral structures, enabling more precise analysis of anatomical relationships and prosthetic requirements. Digital imaging systems facilitate visualization of hard and soft tissues, contributing to improved treatment predictability.

Intraoral scanning has become one of the most widely adopted innovations in prosthodontics. Unlike traditional impression techniques, digital scanning eliminates the need for impression materials and gypsum casts. Digital impressions can be obtained rapidly and transferred directly to the dental laboratory, reducing opportunities for dimensional distortion and improving patient comfort. Furthermore, immediate visualization of scanned structures allows clinicians to identify and correct deficiencies during the same appointment.

The introduction of CAD/CAM systems has revolutionized prosthesis fabrication. Digital restoration design enables precise customization according to patient-specific anatomical and functional requirements. Automated milling technologies produce restorations with excellent marginal fit and reproducible quality. Contemporary ceramic and hybrid materials fabricated using CAD/CAM systems demonstrate outstanding mechanical and aesthetic properties.

Three-dimensional printing has emerged as another significant innovation in prosthetic dentistry. Additive manufacturing technologies permit fabrication of surgical guides, temporary restorations, diagnostic models, and definitive prosthetic components with remarkable precision. The ability to produce complex structures directly from digital files has improved laboratory efficiency and expanded treatment possibilities.

Artificial intelligence is increasingly integrated into prosthodontic workflows. Machine-learning algorithms can assist clinicians in diagnostic interpretation, treatment planning, restoration design, and prediction of treatment outcomes. These technologies have the potential to further improve clinical decision-making and enhance treatment predictability.

Although digital technologies continue to gain widespread acceptance, comprehensive evaluation of their clinical effectiveness remains essential. Assessment of treatment outcomes, restoration longevity, patient satisfaction, and practical applicability provides valuable information for optimizing digital workflows in routine practice.

The aim of the present study was to investigate the clinical applications of digital technologies in prosthodontics and evaluate their influence on treatment outcomes, restoration quality, and patient satisfaction.

2. Materials and Methods

The study was conducted at the Department of Prosthetic Dentistry between 2024 and 2025. A total of 118 patients aged 21–72 years requiring prosthetic rehabilitation were included in the investigation. Participants presented with various clinical conditions including partial edentulism, extensive tooth destruction, missing single teeth, and complete edentulism.

All patients underwent comprehensive clinical and radiographic examination prior to treatment. Diagnostic procedures included digital photography, intraoral scanning, cone-beam computed tomography where indicated, and computerized occlusal analysis.

Digital technologies employed during treatment included:

- Intraoral scanning systems for digital impressions;
- CAD/CAM software for restoration design;
- Computerized milling units for prosthesis fabrication;
- Three-dimensional printing for diagnostic and surgical applications;
- Digital smile design software;
- Virtual articulators for occlusal analysis.

Clinical outcomes were evaluated according to the following parameters:

• Marginal adaptation of restorations;
• Accuracy of prosthesis fit;
• Occlusal stability;
• Aesthetic integration;
• Duration of treatment;
• Number of clinical visits;
• Patient satisfaction;
• Technical complications.

Patients were followed for twelve months after prosthetic placement. Clinical examinations were performed immediately after treatment and during scheduled follow-up appointments at three, six, and twelve months.

Statistical analysis was performed using standard biomedical statistical methods.

3. Results

Implementation of digital technologies resulted in substantial improvements in multiple aspects of prosthetic treatment. Digital impressions demonstrated excellent accuracy and significantly reduced the need for repeated procedures. Most patients reported greater comfort during intraoral scanning compared with previous experiences involving conventional impression materials.

The use of CAD/CAM systems enabled precise fabrication of crowns, bridges, veneers, and implant-supported restorations. Clinical evaluation revealed excellent marginal adaptation and occlusal relationships in the majority of cases. Restoration fit frequently required minimal chairside adjustment, contributing to shorter clinical appointments.

Digital treatment planning improved interdisciplinary communication between prosthodontists, dental technicians, and implant surgeons. Three-dimensional visualization facilitated accurate assessment of treatment objectives and enhanced predictability of prosthetic outcomes.

Patients who underwent digitally guided treatment demonstrated high levels of satisfaction regarding both aesthetics and functionality. Restoration color matching, anatomical morphology, and integration with surrounding dentition were rated favorably during follow-up assessments.

Three-dimensional printing technology significantly improved laboratory productivity. Printed diagnostic models and surgical guides demonstrated high dimensional accuracy and facilitated precise execution of treatment plans. Temporary restorations produced through additive manufacturing showed satisfactory adaptation and functional performance.

Artificial intelligence-assisted planning tools contributed to more efficient analysis of clinical data and supported restoration design procedures. Although human supervision remained essential, automated software functions reduced design time and improved workflow consistency.

The overall treatment duration was significantly reduced compared with conventional prosthetic protocols. Digital data transfer eliminated several intermediate laboratory steps, resulting in faster fabrication and delivery of definitive restorations.

At the twelve-month follow-up, the majority of restorations remained clinically successful with no major biological or technical complications. High survival rates and stable functional performance were observed across different restoration types.

4. Discussion

The results of the present study demonstrate that digital technologies have fundamentally transformed contemporary prosthodontic practice. Integration of digital workflows provides numerous advantages over traditional treatment approaches, including improved accuracy, reduced treatment time, enhanced communication, and greater patient satisfaction.

One of the most significant benefits identified during the investigation was the precision of digital impressions. Conventional impression materials are susceptible to dimensional changes and procedural errors, whereas digital scanning systems capture detailed anatomical information with remarkable consistency. Improved impression accuracy contributes directly to enhanced restoration fit and long-term clinical success.

CAD/CAM technology has become a cornerstone of modern prosthetic rehabilitation. Computer-assisted design enables individualized restoration planning while maintaining high levels of reproducibility. Automated manufacturing systems further improve precision and reduce variability

associated with manual laboratory procedures.
The favorable patient response observed in this study highlights the importance of digital innovations from a patient-centered perspective. Reduced discomfort, fewer appointments, and shorter treatment duration contribute to increased treatment acceptance and overall satisfaction.
Three-dimensional printing has expanded the possibilities of prosthetic rehabilitation by facilitating rapid fabrication of customized dental devices. This technology supports efficient production of diagnostic aids, temporary restorations, and surgical guides while maintaining excellent dimensional accuracy.
Artificial intelligence represents a promising area of future development in prosthodontics. Although current applications primarily serve as supportive tools, continued advancements may enable increasingly sophisticated diagnostic and treatment-planning capabilities.
Despite the numerous advantages identified, several challenges remain. Initial investment costs, software maintenance, equipment upgrades, and professional training requirements may limit implementation in certain clinical environments. Additionally, clinicians must develop new competencies to fully utilize digital workflows effectively.
Further long-term studies are required to evaluate restoration survival rates and economic aspects associated with digital prosthodontic treatment. Nevertheless, current evidence strongly supports the integration of digital technologies into routine clinical practice.

5. Conclusion

Digital technologies have become indispensable components of contemporary prosthodontics. The integration of intraoral scanning, CAD/CAM systems, three-dimensional printing, virtual treatment planning, and artificial intelligence has significantly enhanced the quality and predictability of prosthetic rehabilitation.
Clinical evaluation demonstrated improved restoration accuracy, reduced treatment duration, enhanced patient comfort, and high levels of aesthetic and functional success. Digital workflows also facilitated efficient communication among dental professionals and contributed to optimization of laboratory procedures.
The findings of the present study confirm that digital technologies provide substantial clinical benefits and represent an effective approach for achieving high-quality prosthetic treatment outcomes. Continued technological development and broader implementation of digital workflows are expected to further advance patient care and improve the future of prosthodontic dentistry.

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