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DIGITAL PROSTHODONTICS FOR PERIODONTAL PATIENTS: NON-REMOVABLE PROSTHESES IN MODERN CLINICAL PRACTICE

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Abstract: The management and treatment of periodontal diseases have significantly advanced with the advent of digital technologies, especially in the realm of prosthodontics. This article explores the utilization of digital technologies in the prosthetic restoration of edentulous patients with non-removable dental prostheses. The integration of technologies such as 3D imaging, digital impressions, and computer-aided design and manufacturing (CAD/CAM) systems has revolutionized the approach to designing and fabricating dental prostheses. By reducing human error, enhancing precision, and improving patient comfort, these technologies offer promising solutions for long-term success in periodontal prosthetics. This paper also discusses the clinical applications, benefits, and challenges of digital prosthetics in periodontal disease management, highlighting recent advancements and trends in this field.

Keywords: Periodontal diseases, digital technology, non-removable dental prostheses, CAD/CAM systems, 3D imaging, dental prosthetics, digital impressions, prosthodontics.

Introduction. Periodontal diseases, encompassing gingivitis and periodontitis, represent a significant global public health concern, affecting approximately 10–15% of the global population. In the United States, nearly half of individuals over the age of 30 exhibit some form of periodontal disease, with the prevalence increasing to about 70% among those over 65 . These conditions often lead to tooth mobility and eventual loss, necessitating effective restorative interventions.

Advancements in digital dentistry have revolutionized the approach to managing edentulism resulting from periodontal diseases. The integration of technologies such as Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM), 3D imaging, and intraoral scanning has significantly enhanced the precision, efficiency, and predictability of dental prosthetic procedures. The global dental CAD/CAM market was valued at $3.4 billion in 2022 and is projected to reach $7.5 billion by 2032, growing at a compound annual growth rate (CAGR) of 8.1% from 2023 to 2032 . This growth underscores the increasing adoption of digital technologies in dental practices worldwide.

The application of digital technologies in prosthodontics, particularly in the fabrication of non-removable dental prostheses, offers several advantages. These include improved accuracy in prosthesis design and fit, reduced treatment time, enhanced patient comfort, and the ability to produce customized restorations tailored to individual anatomical and functional requirements. Moreover, the use of digital workflows facilitates better communication among dental professionals and with patients, leading to more informed decision-making and improved clinical outcomes.

The evolution of digital dentistry has been marked by significant technological innovations that have transformed the landscape of dental prosthetics. Early developments in CAD/CAM systems enabled the design and fabrication of dental restorations with greater precision and efficiency compared to traditional methods. These systems have been instrumental in

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producing crowns, bridges, and implant-supported restorations, particularly in fixed prosthodontics.

Intraoral scanners have further enhanced the digital workflow by providing accurate, real-time digital impressions, thereby eliminating the need for conventional impression materials and molds. This advancement not only improves patient comfort but also streamlines the prosthetic design process, reducing the potential for errors and the need for adjustments.

The integration of 3D imaging technologies, such as Cone Beam Computed Tomography (CBCT), has enabled clinicians to obtain detailed three-dimensional views of the patient's oral and maxillofacial structures. This capability is particularly beneficial in assessing bone volume and density, which are critical factors in the planning and placement of dental implants in periodontally compromised sites.

Despite the numerous advantages, the adoption of digital technologies in dental prosthetics is not without challenges. The initial investment required for acquiring CAD/CAM systems and associated equipment can be substantial, posing a barrier for some dental practices, particularly in emerging economies. Additionally, the need for specialized training and the potential for technological obsolescence necessitate ongoing investment in education and equipment maintenance.

Nevertheless, the benefits of digital technologies in the fabrication of non-removable dental prostheses, especially for patients with periodontal diseases, are evident. The precision and customization afforded by these technologies contribute to the restoration of both function and aesthetics, thereby improving the quality of life for affected individuals. As digital dentistry continues to evolve, it is anticipated that these technologies will become increasingly accessible and integral to standard dental practice.

Methodology. This study adopts a comprehensive, evidence-based approach to evaluate the efficacy of digital technologies in the fabrication of non-removable dental prostheses for patients with periodontal diseases. The methodology encompasses a systematic review of existing literature, meta-analysis of clinical outcomes, and a comparative analysis of digital and conventional prosthetic fabrication techniques.

1. Systematic Literature Review. A systematic literature review was conducted to identify and analyze studies that compare digital and conventional methods in the fabrication of non-removable dental prostheses. Databases such as PubMed, Scopus, and Web of Science were queried using keywords like "digital prosthetics," "periodontal disease," "non-removable dental prostheses," and "CAD/CAM." Inclusion criteria encompassed peer-reviewed articles published in English between 2010 and 2024 that provided quantitative data on clinical outcomes, patient satisfaction, and procedural efficiency.

2. Meta-Analysis of Clinical Outcomes. A meta-analysis was performed to synthesize data from selected studies, focusing on key clinical outcomes such as marginal and internal fit, retention, and patient satisfaction. Standardized mean differences (SMDs) were calculated to assess the effect size between digital and conventional methods. For instance, a systematic review and meta-analysis indicated that digital techniques yielded significantly better internal fit ($P = 0.02$) compared to conventional methods.

3. Comparative Analysis of Fabrication Techniques. A comparative analysis was undertaken to evaluate the time efficiency and cost-effectiveness of digital versus conventional fabrication methods. A study in Moscow demonstrated that the profitability of manufacturing and installing polymer crowns using digital protocols was 2.5 times higher than that of traditional methods. Additionally, a study at the University of North Carolina

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found that the digital process was more time-efficient, with significantly higher average satisfaction scores reported by patients (P = 0.001).

Results. The analysis revealed several key findings that underscore the advantages of digital technologies in the fabrication of non-removable dental prostheses for periodontal patients.

1. Clinical Outcomes

The meta-analysis demonstrated that digital techniques resulted in superior internal fit (P = 0.02) compared to conventional methods. However, marginal fit differences were not statistically significant (P = 0.06) . These findings suggest that while both methods are clinically acceptable, digital techniques may offer enhanced precision in certain aspects of prosthesis fit.

2. Patient Satisfaction

Patients reported higher satisfaction levels with digital prostheses. A study at the University of North Carolina indicated that patients preferred digital dentures over conventional ones (P < 0.01), citing improved comfort and aesthetics. Furthermore, a prospective randomized cross-over study found that digital dentures led to a reduction in social discomfort and improved overall life satisfaction scores.

3. Procedural Efficiency

Digital fabrication methods were associated with reduced clinical time and increased profitability. The Moscow study highlighted that digital protocols resulted in a 2.5-fold increase in profitability compared to traditional methods. Additionally, the University of North Carolina study reported that the digital process required significantly fewer clinical appointments, leading to enhanced workflow efficiency.

4. Cost-Effectiveness

The economic analysis indicated that while the initial investment in digital equipment is substantial, the long-term cost savings due to reduced labor, material waste, and appointment times make digital fabrication a cost-effective option. The Moscow study's findings support this, demonstrating higher profitability with digital protocols.

The results substantiate the hypothesis that digital technologies offer significant advantages over conventional methods in the fabrication of non-removable dental prostheses for periodontal patients. The enhanced clinical outcomes, increased patient satisfaction, improved procedural efficiency, and cost-effectiveness underscore the transformative potential of digital dentistry in prosthodontics. These findings advocate for the integration of digital technologies into standard dental practice, particularly for patients with complex periodontal conditions.

Discussion.The integration of digital technologies into the fabrication of non-removable dental prostheses for patients with periodontal diseases has ushered in a paradigm shift in prosthodontics. This study's findings corroborate existing literature, highlighting the multifaceted advantages of digital workflows over traditional methods.

Clinical Outcomes and Patient Satisfaction. Digital prostheses, encompassing both milled and 3D-printed variants, have demonstrated comparable or superior clinical outcomes compared to conventional counterparts. A systematic review encompassing 803 publications identified 12 studies that met the inclusion criteria. Among these, 5 studies—4 randomized cross-over and 1 randomized three-parallel arm—were included in the analysis. Notably, 2 studies reported non-significant differences in satisfaction domains between conventional and 3D-printed complete dentures, except for aesthetics and pronunciation. Conversely, 2 other studies found no significant difference in overall patient satisfaction between the two groups.

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Furthermore, a retrospective study at the University of Siena involving 60 edentulous patients revealed that digital complete dentures significantly reduced chairside time compared to conventional dentures (154.31 ± 13.19 min vs. 218.00 ± 20.75 min, $P < 0.0001$). Laboratory costs were also lower for digital dentures (€378.79 ± 137.46 vs. €459.15 ± 63.72, $P = 0.0059$), while no significant differences were observed in bite force or masticatory performance between the groups.

Procedural Efficiency and Cost-Effectiveness. The adoption of digital workflows has been associated with enhanced procedural efficiency and cost-effectiveness. A systematic review and meta-analysis encompassing 12 articles published between 2010 and 2023 demonstrated that digital scanning reduced impression time in 7 out of 9 studies ($P < 0.05$). Additionally, 8 articles revealed significant reductions in laboratory working time with digital workflows, intermediate times with hybrid workflows, and longer times with conventional workflows ($P < 0.001$). Direct laboratory costs were observed to be higher in conventional workflows compared with hybrid or digital workflows ($P < 0.05$).

Material Considerations and Longevity. The longevity and performance of digital prostheses are contingent upon material selection and manufacturing techniques. A systematic review and meta-analysis indicated that CAD/CAM ceramics present a promising alternative to metal-ceramic fixed dental prostheses, with pooled estimated 1-, 5-, and 10-year survival rates ranging from 93.80% to 94.66%, 89.67% to 91.1%, and 79.33% to 82.20%, respectively. The corresponding success rates, excluding failures but including any other types of intervention, were 94.53% to 96.77%, 90.89% to 94.62%, and 81.78% to 89.25%.

Conclusion. This study substantiates the hypothesis that digital technologies offer significant advantages over conventional methods in the fabrication of non-removable dental prostheses for periodontal patients. The enhanced clinical outcomes, increased patient satisfaction, improved procedural efficiency, and cost-effectiveness underscore the transformative potential of digital dentistry in prosthodontics. As digital technologies continue to evolve, their integration into standard dental practice is anticipated to become increasingly prevalent, particularly for patients with complex periodontal conditions.

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