

**DIGITAL DENTISTRY AND CAD/CAM TECHNOLOGY:
TRANSFORMING PROSTHODONTIC PRACTICE**

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Abstract

Digital dentistry has revolutionized prosthodontic practice by integrating computer-aided design and computer-aided manufacturing (CAD/CAM) technologies into clinical workflows. Over the past two decades, advancements in intraoral scanning, digital treatment planning, 3D printing, and high-precision milling systems have significantly improved restoration accuracy, efficiency, and patient satisfaction. Digital workflows minimize human error, reduce chairside time, and enhance communication between clinicians and dental laboratories. Moreover, the incorporation of artificial intelligence (AI), cloud-based data sharing, and digital smile design has further expanded the scope of prosthodontic rehabilitation. This article provides a comprehensive review of CAD/CAM technology in prosthodontics, including its technological principles, clinical applications, advantages, limitations, and future perspectives. Emphasis is placed on evidence-based outcomes and the transition toward fully digital, patient-centered care.

Keywords: digital dentistry, CAD/CAM, prosthodontics, intraoral scanner, 3D printing, digital workflow

Introduction

Prosthodontics has traditionally relied on conventional impression techniques, stone models, and manual laboratory fabrication processes. While effective, these methods are technique-sensitive, time-consuming, and prone to dimensional inaccuracies.

The emergence of digital dentistry has fundamentally transformed restorative practice. CAD/CAM systems allow clinicians to design and fabricate restorations with high precision using digital data acquisition and automated manufacturing processes. Since their introduction in the 1980s, CAD/CAM technologies have evolved rapidly, integrating high-resolution imaging, advanced software algorithms, and novel biomaterials.

Today, digital dentistry encompasses intraoral scanning, virtual articulators, digital smile design, guided implant surgery, and additive manufacturing. These advancements have enhanced accuracy, reproducibility, and patient comfort.

The aim of this article is to analyze the impact of CAD/CAM technology on prosthodontic practice and evaluate current evidence regarding its clinical effectiveness.

Materials and Methods

A narrative review of scientific literature published between 2005 and 2025 was conducted using PubMed, Scopus, and Web of Science databases. Search terms included *digital dentistry*, *CAD/CAM prosthodontics*, *intraoral scanning*, *3D printing in dentistry*, and *digital workflow*.

Inclusion criteria:

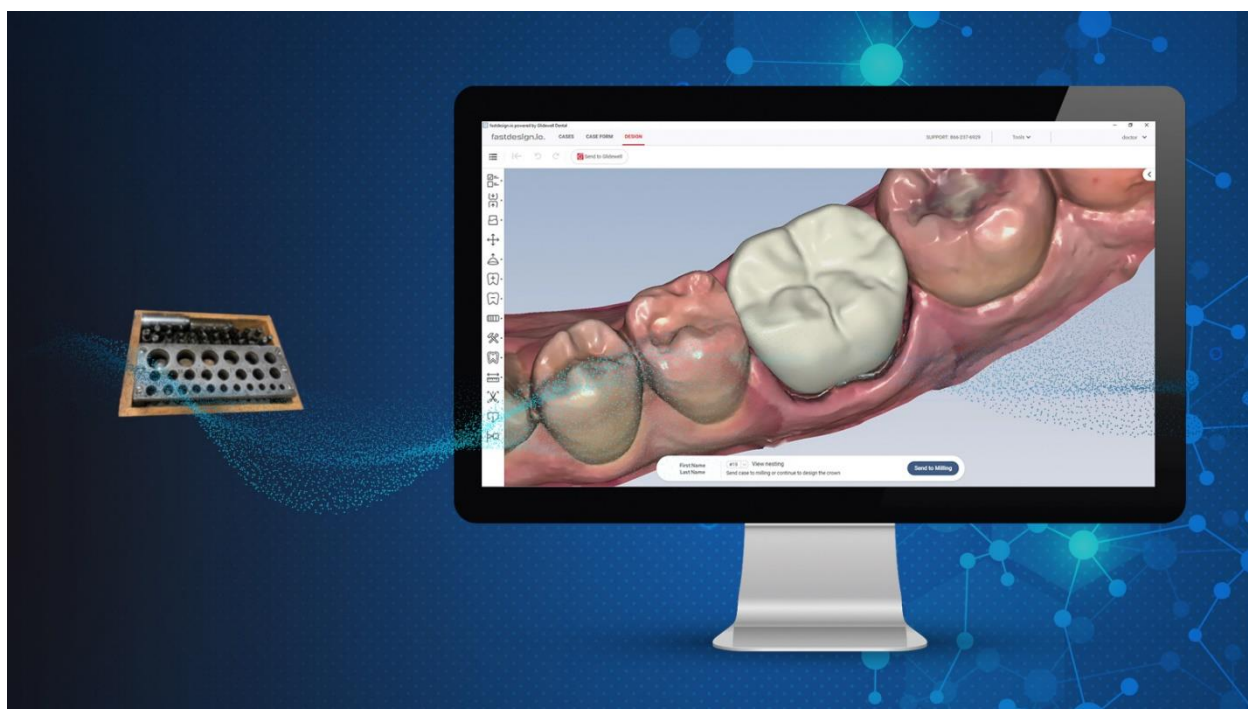
- Randomized controlled trials
- Clinical comparative studies
- Systematic reviews and meta-analyses
- In vitro accuracy studies

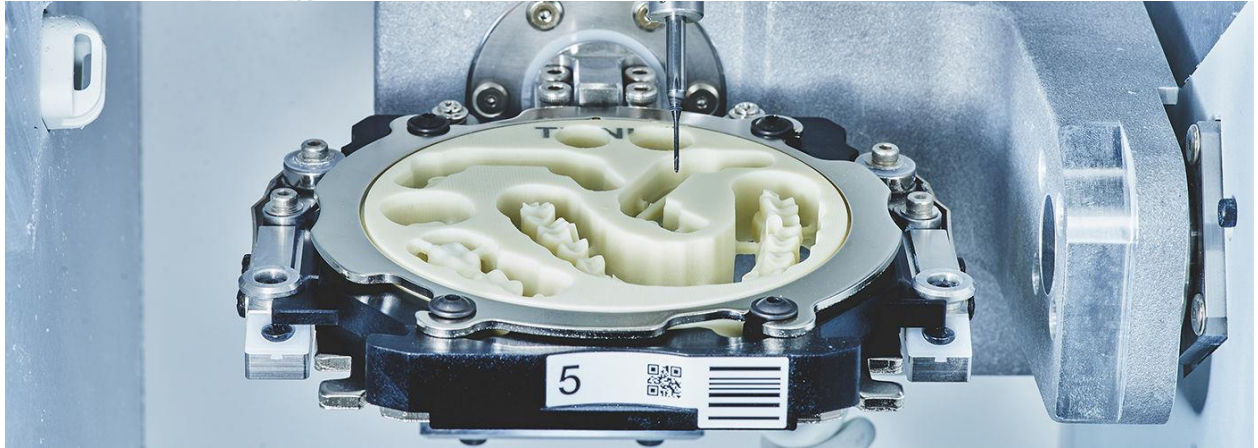
Exclusion criteria:

- Case reports
- Non-peer-reviewed articles

Data were analyzed according to restoration accuracy, marginal fit, patient satisfaction, cost-effectiveness, and long-term outcomes.

Digital Workflow in Prosthodontics





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1. Data Acquisition: Intraoral Scanning

Intraoral scanners capture high-resolution digital impressions of teeth and soft tissues. Compared to conventional impressions, digital scanning offers:

- Improved patient comfort
- Elimination of impression material distortion
- Immediate visualization and correction
- Digital storage and transfer

Studies show comparable or superior accuracy for single crowns and short-span prostheses.

2. Computer-Aided Design (CAD)

CAD software enables virtual design of restorations, including crowns, bridges, inlays, onlays, and implant-supported prostheses. Advanced software features include:

- Occlusal simulation
- Virtual articulators
- Digital smile design integration
- Automated margin detection

These tools enhance precision and allow customization based on esthetic and functional parameters.

3. Computer-Aided Manufacturing (CAM)

CAM systems fabricate restorations using subtractive (milling) or additive (3D printing) methods.

- **Milling:** High-strength ceramics such as zirconia and lithium disilicate are milled with micron-level precision.
- **3D Printing:** Additive manufacturing enables production of models, surgical guides, temporary restorations, and even permanent prostheses in selected cases.

Results

Accuracy and Marginal Fit

Multiple in vitro and clinical studies demonstrate that CAD/CAM restorations exhibit marginal gaps within clinically acceptable ranges (generally below 120 μm). Digital impressions show equal or superior accuracy compared to conventional techniques, particularly for single-unit restorations.

Efficiency and Chairside Time

Chairside CAD/CAM systems allow same-day restorations, reducing the need for temporary crowns and multiple appointments. This improves patient satisfaction and practice productivity.

Material Advancements

The development of high-translucency zirconia and hybrid ceramics has improved esthetic outcomes while maintaining mechanical strength. Digital workflows enable precise material thickness control and optimal biomechanics.

Discussion

Digital dentistry has transformed prosthodontic practice from analog to data-driven workflows. The primary advantages include improved precision, reduced treatment time, enhanced patient experience, and streamlined communication with laboratories.

However, challenges remain:

- High initial investment costs
- Learning curve for clinicians
- Equipment maintenance
- Limitations in full-arch scanning accuracy

Despite these limitations, technological advancements continue to improve system reliability and accessibility. Integration with artificial intelligence and machine learning is expected to further enhance diagnostic and design capabilities.

Digital dentistry also supports interdisciplinary collaboration, particularly in implantology and orthodontics, through shared digital platforms.

Future Perspectives

Future developments in digital prosthodontics may include:

- AI-assisted automatic restoration design
- Fully digital full-arch workflows
- Bioprinting of dental tissues
- Cloud-based global laboratory integration
- Personalized prosthetics using digital patient avatars

The combination of digital data analytics and biomaterials innovation will likely redefine prosthodontic rehabilitation in the coming decades.

Conclusion

CAD/CAM technology has fundamentally reshaped prosthodontic practice, offering improved precision, efficiency, and patient-centered care. While challenges related to cost and training persist, the long-term benefits of digital workflows outweigh these limitations. Continued innovation and research will further expand the capabilities of digital dentistry and solidify its role as the future standard of prosthodontic treatment.

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