

DIGITAL DENTISTRY WORKFLOWS – FROM SCAN TO FINAL DENTAL PROSTHESIS

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ABSTRACT

Aim of the study. Digital dentistry has revolutionized contemporary prosthodontic practice by integrating intraoral scanning, computer-aided design (CAD), and computer-aided manufacturing (CAM) technologies into highly efficient clinical workflows. The purpose of this review is to analyze the current digital workflow from data acquisition to the delivery of the final dental prosthesis and to evaluate its clinical applications, advantages, limitations, and future perspectives.

Material and methods. A narrative review of the literature published between 2019 and 2025 was conducted using PubMed, Scopus, Web of Science, and Google Scholar databases. Relevant studies focusing on intraoral scanning, CAD/CAM systems, additive manufacturing, artificial intelligence, and digital prosthodontics were analyzed.

Results. Digital workflows demonstrated improved accuracy, reduced treatment time, enhanced patient comfort, and superior communication between clinicians and dental laboratories. Recent advancements in scanner technology, CAD software, artificial intelligence, and three-dimensional printing have significantly increased treatment predictability and restorative quality.

Conclusions. Digital dentistry is progressively becoming the standard of care in prosthodontics. Fully digital workflows improve clinical efficiency, patient satisfaction, and restorative outcomes while supporting evidence-based and minimally invasive treatment approaches.

Keywords: digital dentistry, CAD/CAM, intraoral scanner, prosthodontics, digital workflow, dental prosthesis

INTRODUCTION

The digital transformation of dentistry represents one of the most significant technological revolutions in modern healthcare. During the last two decades, rapid advancements in imaging systems, computer technologies, and manufacturing processes have fundamentally changed the diagnosis, planning, and treatment of dental patients.

Traditional prosthodontic workflows rely on elastomeric impressions, stone casts, articulators, and manual laboratory procedures. Although these techniques have been successfully used for decades, each step introduces potential inaccuracies that may compromise the final restoration. Errors associated with impression materials, cast expansion, laboratory processing, and technician-

dependent procedures can accumulate throughout the workflow.

The introduction of digital dentistry has provided an alternative approach based on virtual data acquisition, digital design, and computer-assisted manufacturing. Intraoral scanners, CAD software, and CAM technologies have enabled clinicians to streamline clinical procedures while improving treatment precision and predictability.

Today, digital workflows are routinely applied in fixed prosthodontics, implant dentistry, removable prosthodontics, orthodontics, maxillofacial rehabilitation, and aesthetic dentistry. The increasing accessibility of digital systems has accelerated their adoption worldwide, making digital dentistry one of the fastest-growing areas in dental practice.

A complete digital workflow generally consists of four fundamental stages:

1. Digital data acquisition.
2. Virtual treatment planning and design.
3. Computer-assisted manufacturing.
4. Clinical delivery and maintenance.

The objective of this review is to provide a comprehensive overview of contemporary digital workflows in prosthodontics, emphasizing current technologies, clinical applications, advantages, limitations, and future developments.

MATERIAL AND METHODS

A narrative review was performed using PubMed, Scopus, Web of Science, and Google Scholar databases. Scientific articles published between January 2019 and March 2025 were considered.

The search strategy included combinations of the following keywords:

- Digital dentistry
- CAD/CAM
- Intraoral scanning
- Digital workflow
- Prosthodontics
- Dental prosthesis
- Artificial intelligence
- Additive manufacturing
- 3D printing
- Implant prosthodontics

Studies were selected based on their relevance to digital workflows in restorative and prosthetic dentistry. Review articles, systematic reviews, randomized clinical trials, and observational studies were included.

The collected evidence was categorized according to the principal stages of digital prosthodontic workflows:

- Data acquisition
- Digital design
- Manufacturing technologies
- Clinical applications
- Future innovations

RESULTS AND DISCUSSIONS

Evolution of Digital Dentistry

The development of digital dentistry began with the introduction of CAD/CAM systems during the 1980s. Early systems were limited by computational power and material availability. However, technological improvements have dramatically expanded their clinical applicability.

The digital revolution has been driven by several factors:

- Increased computing power
- Improved optical scanning technologies
- Advances in biomaterials
- Development of artificial intelligence
- Growth of additive manufacturing

Today, clinicians can manage complete rehabilitations using fully digital protocols, reducing treatment complexity and improving communication among team members.

Intraoral Scanning Technologies

Digital workflows begin with the acquisition of accurate three-dimensional data.

Intraoral scanners (IOS) capture thousands of images every second and reconstruct digital models through sophisticated software algorithms. Several optical principles are currently employed:

- Confocal microscopy
- Structured light projection
- Active triangulation
- Optical coherence technologies

Modern scanners offer remarkable accuracy for:

- Single crowns
- Fixed partial dentures
- Implant-supported restorations
- Orthodontic treatment planning
- Digital smile design

One of the major advantages of digital impressions is improved patient comfort. Conventional impression materials often trigger gag reflexes and discomfort, whereas intraoral scanning is generally better tolerated.

Table 1. Comparison between conventional and digital impressions

Parameter	Conventional Impression	Digital Impression
Patient comfort	Moderate	Excellent
Treatment acceptance	Moderate	High
Chairside time	Longer	Shorter
Storage requirements	Physical casts	Digital files
Communication with laboratory	Indirect	Direct
Immediate verification	Not possible	Possible
Repeatability	Limited	High
Environmental impact	Higher	Lower

Clinical studies consistently report excellent accuracy for digital impressions in short-span prosthetic restorations. However, full-arch scanning remains technically challenging due to cumulative stitching errors.

CAD Systems and Virtual Prosthetic Design

Following data acquisition, digital files are imported into CAD software.

The virtual environment allows clinicians and technicians to analyze:

- Preparation margins
- Occlusal relationships
- Interproximal contacts
- Emergence profiles
- Aesthetic parameters

Contemporary CAD software integrates extensive anatomical databases and automated design tools.

The principal advantages of virtual design include:

- Greater precision
- Improved communication
- Reduced laboratory errors
- Better treatment predictability

Digital smile design has become an essential component of modern aesthetic dentistry. Through the integration of facial photographs, videos, and intraoral scans, clinicians can simulate treatment outcomes before initiating therapy.

Such visualization enhances patient understanding and facilitates informed consent.

Computer-Assisted Manufacturing (CAM) After completion of restorations are manufactured using CAM technologies. Two principal manufacturing approaches are available: **Subtractive Manufacturing** Subtractive manufacturing involves milling restorations from prefabricated blocks. Common materials include:

- Zirconia
- Lithium disilicate
- Hybrid ceramics
- Composite resins
- PMMA

Milling technology offers excellent precision and material homogeneity but produces significant material waste.

Additive Manufacturing

Additive manufacturing, commonly known as 3D printing, builds objects layer by layer.

Applications include:

- Surgical guides
- Diagnostic casts
- Temporary restorations
- Denture bases
- Orthodontic appliances
- Custom trays

Recent developments have expanded the use of 3D printing to definitive prosthetic restorations.

Table 2. Comparison between milling and 3D printing

Parameter	Milling	3D Printing
Accuracy	Excellent	Very good
Material waste	High	Minimal
Manufacturing complexity	Moderate	High
Production speed	Moderate	Fast
Cost efficiency	Moderate	High
Surface finish	Superior	Requires post-processing
Complex geometries	Limited	Excellent

Both technologies play complementary roles in contemporary prosthodontics.

Digital Workflows in Fixed Prosthodontics

Fixed prosthodontics represents the most common application of digital workflows.

The digital workflow typically includes:

1. Tooth preparation
2. Intraoral scanning
3. CAD design
4. CAM manufacturing
5. Finishing procedures
6. Clinical delivery

Numerous studies have reported excellent marginal adaptation for CAD/CAM restorations.

Clinical benefits include:

- Reduced treatment time
- Improved precision
- Enhanced patient comfort
- Better documentation

Chairside CAD/CAM systems permit same-day restorations, eliminating temporary crowns and additional appointments.

Table 3. Advantages of digital fixed prosthodontic workflows

Clinical Parameter	Reported Benefit
Marginal adaptation	Improved
Chairside time	Reduced
Patient comfort	Increased
Communication	Enhanced
Remake rate	Reduced
Documentation	Simplified
Treatment predictability	Improved

Digital Implant Prosthodontics

Implant dentistry has experienced remarkable growth through digital technologies.

The integration of CBCT imaging and intraoral scanning enables prosthetically driven implant planning.

Digital implant workflows improve:

- Surgical precision
- Implant positioning
- Prosthetic outcomes
- Long-term maintenance

Guided surgery protocols allow virtual planning to be transferred accurately into clinical reality through the use of surgical guides.

Following implant placement, scan bodies facilitate digital impression procedures.

Advantages include:

- Reduced treatment complexity
- Improved accuracy
- Better patient experience
- Enhanced interdisciplinary collaboration

Several systematic reviews report comparable or superior outcomes for digital implant workflows compared with conventional approaches.

Artificial Intelligence in Prosthodontics

Artificial intelligence (AI) represents one of the most exciting developments in digital dentistry.

Current applications include:

- Automated caries detection
- Radiographic interpretation

- Orthodontic diagnosis
- Prosthetic design optimization
- Treatment planning support

Machine learning algorithms continuously improve through exposure to large datasets.

Potential future applications include:

- Automated restoration design
- Occlusal optimization
- Predictive treatment simulation
- Personalized prosthetic recommendations
- Automated quality control

Table 4. Current and future applications of AI in digital dentistry

Current Applications	Future Applications
Caries detection	Fully automated crown design
Radiographic analysis	Predictive prosthetic simulations
Orthodontic planning	Personalized prosthetic recommendations
Implant planning	Automated occlusal adjustment
Restoration design assistance	Autonomous quality control

Although AI will not replace clinicians, it is expected to become an essential decision-support tool.

Patient Satisfaction and Clinical Outcomes

Patient satisfaction remains a critical indicator of treatment success.

Digital workflows contribute positively through:

- Improved comfort
- Faster treatment
- Better communication
- Enhanced visualization of outcomes

Patients increasingly appreciate the ability to visualize treatment results before therapy begins.

Furthermore, digital documentation allows easier monitoring and long-term follow-up.

Several clinical studies have reported significantly higher patient satisfaction scores for digital impression techniques compared with conventional impressions.

Limitations of Digital Dentistry

Despite numerous advantages, digital workflows still present challenges.

Major limitations include:

- High initial equipment costs
- Learning curve requirements
- Software compatibility issues
- Scanner limitations in edentulous arches
- Frequent technological updates

Smaller dental practices may encounter financial barriers when implementing comprehensive digital systems.

Furthermore, complete digital workflows remain less predictable in extensive edentulous rehabilitations compared with conventional methods.

Nevertheless, technological improvements continue to address these limitations.

Future Perspectives

The future of digital dentistry appears exceptionally promising.

Emerging technologies include:

- Artificial intelligence integration
- Cloud-based treatment planning
- Digital patient twins
- Augmented reality
- Robotic manufacturing
- Advanced printable biomaterials

These innovations are expected to further improve treatment precision, efficiency, and accessibility.

The concept of a completely integrated digital ecosystem is rapidly becoming a clinical reality.

Future workflows may permit definitive prosthesis fabrication within hours while maintaining exceptional functional and aesthetic outcomes.

CONCLUSIONS

1. Digital dentistry has fundamentally transformed modern prosthodontic workflows.
2. Intraoral scanners provide highly accurate digital impressions while improving patient comfort.
3. CAD software facilitates precise virtual planning and enhanced communication between clinicians and technicians.
4. Milling and additive manufacturing technologies offer reliable solutions for prosthesis fabrication.
5. Digital workflows improve efficiency, predictability, and restorative quality.
6. Artificial intelligence is expected to play an increasingly important role in diagnosis, treatment planning, and prosthetic design.
7. Despite existing limitations, digital dentistry is progressively becoming the standard of care in contemporary prosthodontics.
8. Continued technological innovation will further expand the clinical applications of fully digital workflows.

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