

# Artificial Intelligence in Prosthodontics: Current Applications, Challenges, and Future Perspectives

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## Abstract

Artificial intelligence (AI) is becoming an important part of modern dentistry. It is being used in different areas of prosthodontics such as diagnosis, treatment planning, implant dentistry, removable and fixed prosthodontics, maxillofacial prosthetics, and digital workflows. AI helps clinicians analyze large amounts of data and make better clinical decisions. It can improve accuracy, reduce treatment time, and increase efficiency. The combination of AI with technologies such as cone beam computed tomography (CBCT), computer-aided design/computer-aided manufacturing (CAD/CAM), intraoral scanners, and three-dimensional (3D) printing has changed the way prosthodontic treatment is planned and delivered. Despite its advantages, AI also has some limitations including high cost, lack of standardization, data privacy concerns, and the need for further clinical validation. This review discusses the current applications of artificial intelligence in prosthodontics, its benefits and challenges, and future developments that may influence prosthodontic practice.

**Keywords:** Artificial Intelligence, Prosthodontics, Digital Dentistry, CAD/CAM, Implant Dentistry, Machine Learning, Maxillofacial Prosthetics

## Introduction

Artificial intelligence refers to the ability of computer systems to perform tasks that normally require human intelligence. These tasks include learning, problem solving, image recognition, and decision making. AI has become one of the fastest growing technologies in healthcare and is increasingly being used in dentistry. Prosthodontics is a dental specialty concerned with the restoration and replacement of missing teeth and oral structures. The introduction of digital technologies such as intraoral scanners, CBCT imaging, CAD/CAM systems, and 3D printing has created large amounts of digital data. AI can analyze this data and provide useful information that supports clinical decision making. The use of AI in prosthodontics aims to improve diagnosis, treatment planning, prosthesis design, and patient outcomes. Although AI cannot replace the knowledge and

experience of a prosthodontist, it can serve as a valuable tool to support clinical practice.

## Artificial Intelligence in Prosthodontics

AI in prosthodontics mainly works through machine learning and deep learning algorithms. These systems learn from large amounts of clinical data and identify patterns that can help in diagnosis and treatment planning. Modern AI systems can analyze radiographs, CBCT scans, digital impressions, facial scans, and clinical photographs. Based on this information, they can assist clinicians in making more accurate and predictable treatment decisions.

## Current Applications of Artificial Intelligence in Prosthodontics

### 1. Diagnosis and Treatment Planning

Diagnosis and treatment planning are the first steps in any prosthodontic treatment. AI can help clinicians by

analyzing radiographs, CBCT scans, intraoral scans, and photographs. These systems can identify missing teeth, evaluate bone levels, detect pathology, and assess oral structures. AI can also combine information from different records and suggest suitable treatment options. In implant dentistry, for example, AI can evaluate bone quantity and quality and assist in selecting the most appropriate implant position and size. The use of AI in treatment planning helps improve accuracy and reduces the possibility of human error. It also allows clinicians to provide more personalized treatment plans based on individual patient needs.

## 2. Fixed Prosthodontics

AI is increasingly used in fixed prosthodontics for the design and fabrication of crowns, bridges, veneers, and implant-supported restorations. When combined with CAD/CAM systems, AI can automatically identify preparation margins and generate restoration designs. It analyzes the shape of adjacent teeth and creates restorations that are functional and aesthetically pleasing. AI also helps reduce laboratory errors and shortens the time needed for designing and manufacturing restorations. As a result, patients can receive treatment more quickly and efficiently.

## 3. Removable Prosthodontics

The fabrication of complete and removable partial dentures traditionally requires several clinical and laboratory procedures. AI can simplify many of these steps. Digital denture systems use AI to analyze ridge anatomy, facial appearance, and jaw relationships. Based on this information, the software can suggest tooth arrangement and denture design. AI-assisted denture fabrication improves consistency and reduces the number of clinical appointments. It also helps in achieving better aesthetic and functional outcomes.

## 4. Implant Prosthodontics

Implant dentistry is one of the most important areas where AI is being used. AI systems can analyze CBCT images and identify important anatomical structures such as the mandibular canal, maxillary sinus, and mental foramen. This helps clinicians avoid complications during implant placement. AI can assist in implant planning by recommending implant size, angulation, and position. Machine learning models can also predict the risk of implant failure by analyzing factors such as bone quality, smoking habits, systemic diseases, and oral hygiene. These applications improve treatment predictability and increase the chances of long-term implant success.

## 5. Maxillofacial Prosthetics

Patients with facial defects caused by trauma, congenital conditions, or cancer surgery often require maxillofacial prostheses. AI combined with digital imaging technologies can assist in the design and fabrication of facial prostheses. Digital scans are used

to create accurate three-dimensional models of the defect area. For unilateral defects, AI can use the unaffected side of the face as a reference and create a symmetrical prosthesis. This improves aesthetics and patient satisfaction. AI also supports the use of 3D printing technology, which allows faster and more accurate fabrication of maxillofacial prostheses.

## 6. Facial Prosthodontics and Smile Design

Facial appearance plays an important role in prosthodontic treatment. AI-based smile design software can analyze facial proportions, lip position, smile line, and tooth display. The software creates a virtual image of the expected treatment outcome, allowing patients to visualize the final result before treatment begins. This improves communication between the dentist and patient and helps patients make informed treatment decisions.

## 7. Occlusal Analysis

Proper occlusion is important for the success of prosthodontic treatment. AI-based systems can evaluate occlusal contacts and identify interferences that may affect function. These systems help clinicians perform more accurate occlusal adjustments and improve prosthesis performance. Better occlusal balance can also increase patient comfort and prosthesis longevity.

## 8. Integration with CAD/CAM and Digital Workflow

The combination of AI and CAD/CAM technology has significantly improved digital dentistry. AI can assist in every stage of the digital workflow, including digital impressions, restoration design, manufacturing, and quality control. Information from intraoral scanners, facial scanners, and CBCT images can be combined into a single digital treatment plan. This integration reduces treatment time, improves communication between clinicians and laboratories, and enhances treatment accuracy.

## Benefits of Artificial Intelligence in Prosthodontics

AI offers several advantages in prosthodontic practice.

1. **Improved Accuracy-** AI systems can analyze large amounts of data and identify details that may be missed during manual evaluation. This improves diagnostic accuracy and treatment planning.
2. **Better Treatment Predictability-** AI helps clinicians predict treatment outcomes and identify potential complications before treatment begins.
3. **Increased Efficiency-** Automation of repetitive tasks reduces clinical and laboratory time, making treatment more efficient.
4. **Improved Prosthesis Quality-** AI-assisted design systems help produce restorations with better fit, function, and aesthetics.

5. Personalized Treatment- AI allows treatment plans to be tailored according to the needs and characteristics of individual patients.
6. Enhanced Patient Communication- Digital simulations and treatment previews help patients understand the proposed treatment and expected outcomes.

### Challenges and Limitations

Despite its advantages, AI has several limitations.

**Data Quality-** AI systems require large amounts of high-quality data for training. Poor-quality or incomplete data can reduce the accuracy of AI predictions.

**High Cost-** The implementation of AI technologies often requires expensive software, equipment, and training.

**Data Privacy and Security-** Patient records used in AI systems must be protected to maintain confidentiality and comply with ethical standards.

**Lack of Clinical Validation-** Many AI systems are still being evaluated and require further clinical studies before widespread adoption.

**Technical Limitations-** AI may not perform well in unusual or highly complex clinical situations. Human judgment is still necessary for final decision making.

**Ethical Concerns-** Questions regarding responsibility, transparency, and bias in AI algorithms remain important concerns in healthcare.

### Future Perspectives

The future of AI in prosthodontics is promising. Continued improvements in machine learning, digital imaging, and computing technology are expected to expand its applications. AI may become an important part of fully digital treatment workflows, from diagnosis to prosthesis delivery. Future systems may provide real-time clinical decision support and more accurate prediction of treatment outcomes. The combination of AI with robotics, augmented reality, virtual reality, and advanced 3D printing technologies may further improve treatment precision and efficiency. Personalized prosthodontics is also expected to grow, with AI helping clinicians develop treatment plans based on the specific characteristics of each patient. As technology continues to evolve, AI will likely become an integral part of routine prosthodontic practice.

### Conclusion

Artificial intelligence is changing the field of prosthodontics by improving diagnosis, treatment planning, prosthesis design, implant dentistry, and digital workflows. The technology has the potential to increase accuracy, efficiency, and treatment predictability while improving patient satisfaction. Although several challenges remain, including cost,

data security, and the need for clinical validation, the future of AI in prosthodontics appears promising. AI should be viewed as a tool that supports clinicians rather than replacing them. With further research and technological advancements, artificial intelligence is expected to play an increasingly important role in the future of prosthodontic care.

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