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Short Communication

Artificial Intelligence in Prosthodontics: Revolutionizing Treatment Planning and Patient Care

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Abstract

Artificial intelligence (AI) is transforming prosthodontics by enhancing treatment planning, precision, and patient outcomes. AI-driven algorithms assist in diagnosing occlusal disorders, designing prostheses, and predicting treatment success. Machine learning models analyze large datasets to optimize material selection and improve patient-specific restorations. This article explores AI applications in prosthodontics, including digital impressions, CAD/CAM technology, deep learning in prosthesis fabrication, and AI-based diagnostic tools. AI enhances the efficiency and accuracy of prosthetic rehabilitation while reducing chairside time and human errors. However, challenges such as data privacy, regulatory constraints, and integration into clinical workflows remain. The future of AI in prosthodontics lies in interdisciplinary collaboration, continuous data refinement, and ethical considerations to ensure successful adoption in clinical practice.

Keywords: artificial intelligence; prosthodontics; machine learning; digital dentistry; cad/cam; deep learning; predictive analytics; personalized treatment; ai-based diagnostics

Introduction

Artificial intelligence has revolutionized healthcare, including dentistry, by introducing machine learning, deep learning, and predictive analytics for personalized patient care. Prosthodontics, which focuses on restoring oral function and aesthetics through artificial replacements, has greatly benefited from AI-driven automation and precision. AI enhances various aspects of prosthodontic treatment, from diagnostic accuracy to prosthesis fabrication, reducing errors and improving long-term success [1].

AI in Prosthodontic Diagnostics

AI algorithms analyze intraoral scans, radiographs, and CBCT images to detect abnormalities and assist in treatment planning. Deep learning-based image recognition has been widely adopted for:

Caries and Occlusal Wear Detection: AI enhances radiographic interpretation, improving the early detection of caries and occlusal discrepancies [2].

Temporomandibular Disorder (TMD) Analysis: AI-based motion tracking evaluates jaw function and predicts TMD risk [3].

Bone Density Assessment: AI-guided CBCT segmentation aids in implant planning by accurately assessing bone volume and density [4].

AI-Driven Prosthetic Design and Fabrication

AI significantly improves computer-aided design/computer-aided manufacturing (CAD/CAM) workflows by automating prosthetic design. Notable applications include:

AI in Crown and Bridge Design: Machine learning algorithms optimize marginal fit and occlusal balance in CAD software [5].

Deep Learning for Denture Fabrication: AI predicts optimal occlusal schemes and tooth positioning for complete and partial dentures [6].

Automated Occlusion Analysis: AI simulates dynamic occlusal forces to ensure functional prosthetic outcomes [7].

Predictive Analytics for Prosthodontic Success

AI-based predictive models assess treatment success and patient-specific risk factors, enhancing long-term prosthetic rehabilitation.

Implant Survival Prediction: AI evaluates peri-implant conditions, patient habits, and bone integration to predict implant longevity [8].

Material Performance Optimization: Machine learning analyzes wear resistance, fracture toughness, and longevity of prosthetic materials [9].

Personalized Prosthetic Recommendations: AI integrates patient data, including bite force and dietary habits, to suggest ideal prosthetic materials [10].

AI in Digital Impressions and Virtual Patients

AI-driven intraoral scanners enhance digital impressions, reducing manual errors. Virtual patients created using AI enable:

Dynamic Occlusion Simulation: AI models patient-specific jaw movements for accurate prosthesis adaptation [11].

Virtual Prosthesis Trials: AI generates 3D simulations, allowing dentists and patients to preview prosthetic outcomes before fabrication [12].

Challenges and Ethical Considerations

Despite its advantages, AI implementation in prosthodontics faces challenges:

Data Privacy and Security: Ensuring patient confidentiality in AI-driven cloud storage systems [13].

Regulatory Compliance: Standardizing AI-driven prosthodontic technologies for clinical approval [14].

Human-AI Collaboration: Maintaining the role of human expertise while integrating AI decision-making [15].

Future Prospects

AI continues to evolve in prosthodontics with innovations such as:

AI-Powered Robotics: Autonomous robotic systems for precise prosthesis placement.

Nano-AI Materials: Smart materials that adapt to oral conditions for enhanced longevity.

Augmented Reality (AR) Integration: AI-driven AR for real-time prosthetic adjustments.

Conclusion

AI is reshaping prosthodontics, enhancing precision, efficiency, and patient outcomes. From AI-assisted diagnostics to automated prosthetic design and predictive analytics, the technology is making prosthetic dentistry more accurate and personalized. While challenges remain in terms of data security, regulatory policies, and ethical considerations, AI's future in prosthodontics is promising. Interdisciplinary collaboration and continuous advancements will pave the way for widespread AI adoption in dental practice.

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