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Review Article

Current aspects of artificial intelligence in dental medicine — A brief review

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Abstract

Artificial Intelligence (AI) is revolutionizing the field of dental medicine by enhancing the precision, efficiency, and personalization of dental care. This review presents an in-depth examination of the diverse applications of AI in dental diagnostics, treatment planning, patient management, and education. Emphasis is placed on AI's contributions to diagnostic imaging, orthodontics, prosthodontics, periodontology, oral pathology, patient communication, and dental training. The review also discusses the benefits, challenges, ethical considerations, and future prospects of integrating AI technologies into clinical practice, underscoring its transformative potential in achieving predictive, preventive, and personalized dental care.

Keywords: Artificial Intelligence, Dentistry, Machine learning, Diagnostic imaging, AI Applications, Oral health, Digital Dentistry

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1. Introduction

Artificial Intelligence (AI) encompasses a branch of computer science that enables machines to mimic human intelligence processes such as learning, problem-solving, reasoning, and self-correction. In dental medicine, AI harnesses technologies including machine learning (ML), deep learning (DL), computer vision, and natural language processing (NLP) to improve clinical accuracy, reduce diagnostic errors, enhance workflow efficiency, and provide data-driven treatment recommendations. The digital transformation of dentistry, particularly in diagnostic radiology and patient care, is accelerating the adoption of AI tools that support decision-making, early diagnosis, and minimally invasive interventions.[1-3]

2. Applications of AI in Dental Medicine

2.1. Diagnostic imaging

AI has become integral to the interpretation and analysis of radiographic and 3D dental images.

1. **Caries Detection**: Convolutional Neural Networks (CNNs) accurately identify incipient and advanced carious lesions on bitewing and periapical radiographs.
2. **Periodontal Evaluation**: AI systems quantify alveolar bone loss and automatically measure distances such as the cement enamel junction (CEJ) to the alveolar crest.
3. **Detection of Periapical Lesions**: Automated classification of periapical radiolucencies facilitates early diagnosis and intervention.
4. **Oral Cancer Diagnosis**: Machine learning models screen for oral squamous cell carcinoma (OSCC) by analyzing lesion characteristics on imaging.

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5. **3D Imaging/CBCT Analysis**: AI enables automated segmentation and identification of structures in cone-beam computed tomography (CBCT), aiding implant planning and TMJ evaluation.

3. Orthodontics

AI applications in orthodontics include:

1. **Cephalometric Landmark Detection**: Automated landmark identification reduces examiner variability and accelerates analysis.
2. **Growth Prediction Models**: ML algorithms forecast craniofacial growth, supporting orthodontic treatment planning.
3. **Aligner Simulation**: AI designs customized aligner sequences for clear aligner therapy, enhancing treatment predictability and efficiency.[4-9]

4. Prosthodontics and Restorative Dentistry

1. **AI-Driven CAD/CAM Design**: AI algorithms recommend optimal crown, bridge, and veneer designs based on occlusal dynamics and esthetic parameters.
2. **Virtual Articulators**: AI simulates occlusal movements, aiding accurate prosthesis fabrication.
3. **Material Selection**: Predictive models suggest restorative materials based on functional and aesthetic requirements.

5. Periodontology

1. **Disease Classification**: AI differentiates between stages of gingivitis and periodontitis using clinical and radiographic data.
2. **Risk Assessment**: AI analyzes patient history, genetic profiles, and habits (e.g., smoking) to forecast disease progression.

6. Oral Pathology

1. **Histopathological Analysis**: DL algorithms classify tissue samples to distinguish malignant and benign lesions.
2. **Cytological Screening**: AI-assisted microscopy detects abnormal cells in exfoliative cytology for early diagnosis of precancerous conditions.

7. Patient Management and Communication

1. **AI Chatbots**: These virtual agents handle appointment scheduling, symptom triage, and patient education.
2. **Treatment Compliance Prediction**: Behavioral AI models assess likelihood of adherence to treatment plans.

8. Dental Education and Training

1. **AR/VR Simulators**: AI-based simulators allow students to practice procedures in a risk-free, immersive environment.
2. **Objective Assessments**: AI evaluates student performance and provides personalized feedback for continuous improvement.

9. Benefits of AI Integration in Dentistry

1. Enhanced diagnostic precision and early disease detection
2. Standardization of clinical protocols and treatment outcomes
3. Increased time efficiency through automation
4. Predictive analytics for individualized care
5. Long-term cost reduction via prevention and accuracy

10. Challenges and Limitations

1. **Data Privacy**: AI tools must comply with data protection regulations (e.g., GDPR, HIPAA).
2. **Bias in Training Datasets**: Inadequate dataset diversity can lead to skewed results and limited generalization.
3. **Ethical and Legal Implications**: Assigning accountability for AI-driven clinical errors remains complex.
4. **Integration Barriers**: Implementing AI in clinical settings requires infrastructure, training, and workflow changes.
5. **Economic Constraints**: High initial costs limit adoption, especially in resource-limited settings.

11. Future Prospects

1. AI-generated autonomous treatment protocols
2. AI-driven tele dentistry platforms for remote diagnostics
3. Integration of AI with genomics for personalized risk prediction
4. Robotic surgeries guided by AI for enhanced surgical precision.[10-11]

12. Conclusion

Artificial Intelligence is rapidly transforming dental medicine, offering unprecedented advancements in diagnostics, treatment planning, patient engagement, and education. While certain obstacles such as cost, integration, and ethical concerns persist, continued research, interdisciplinary collaboration, and policy development will pave the way for AI to become a fundamental component of high-quality, accessible, and personalized oral healthcare.

13. Source of Funding

None.

14. Conflict of Interest

None.

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