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ARTIFICIAL INTELLIGENCE IN PERIODONTICS: TRANSFORMING DIAGNOSIS, RISK PREDICTION, AND CLINICAL DECISION-MAKING

Periodontology

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ABSTRACT

Background: Periodontitis is a multifactorial inflammatory disease requiring accurate diagnosis, risk assessment, and long-term maintenance. Recent advances in artificial intelligence (AI) have introduced innovative tools capable of assisting clinicians in diagnosis, prognosis, and treatment planning. **Objective:** To review the current applications of AI in periodontics, discuss existing limitations, and highlight future opportunities for its integration into clinical practice. **Methods:** A narrative review of published literature was performed using PubMed, Scopus, and Web of Science. English-language articles published between 2010 and 2025 addressing AI applications in periodontal diagnosis, risk prediction, treatment planning, and patient management were evaluated. **Results:** Deep learning and machine learning algorithms have demonstrated high diagnostic accuracy for detecting alveolar bone loss, periodontal disease progression, tooth prognosis, and treatment planning. AI also supports patient education and personalized periodontal care. However, widespread clinical implementation remains limited because of small datasets, lack of external validation, ethical concerns, regulatory issues, and poor integration into routine clinical workflows. **Conclusion:** Artificial intelligence has the potential to transform periodontal practice by improving diagnostic precision and clinical decision-making. Nevertheless, AI should serve as an adjunct rather than a replacement for clinician expertise. Future research should focus on multicentre validation, explainable AI, ethical governance, and seamless integration into periodontal practice.

KEYWORDS

Artificial Intelligence, Periodontics, Machine Learning, Deep Learning, Periodontal Diagnosis

INTRODUCTION

Periodontal disease remains one of the most prevalent chronic oral diseases worldwide and continues to be a major cause of tooth loss among adult.(1,2,3)Conventional periodontal diagnosis depends on clinical examination and radiographic interpretation, both of which are susceptible to examiner variability and subjective judgment. Early identification of disease activity and prediction of future progression therefore remain significant clinical challenges.

Artificial intelligence (AI) has emerged as an important technological advancement capable of analysing large clinical datasets, identifying complex disease patterns, and supporting evidence-based decision-making. Machine learning (ML), deep learning (DL), convolutional neural networks (CNNs), and natural language processing (NLP) have demonstrated promising applications in periodontology, including automated radiographic interpretation, periodontal risk prediction, treatment planning, and patient education.(4-9)

Despite encouraging results, most AI applications remain in the proof-of-concept stage. Limited external validation, small study populations, ethical concerns, regulatory uncertainty, and inadequate integration with routine clinical workflows continue to restrict widespread clinical adoption. Therefore, a critical appraisal of current evidence is essential to understand both the opportunities and limitations of AI in periodontal practice.

The purpose of this review is to summarize the current role of artificial intelligence in periodontal diagnosis, risk prediction, and clinical decision-making while highlighting the major challenges and future directions for its successful implementation.(10-12)

METHODOLOGY

This narrative review was prepared using literature retrieved from PubMed, Scopus, and Web of Science databases. Articles published in English between 2010 and 2025 concerning artificial intelligence, machine learning, deep learning, periodontal diagnosis, periodontal imaging, and predictive modelling were reviewed. Original research articles and systematic reviews with significant clinical relevance were included. The available evidence was critically analysed under four major domains: periodontal diagnosis, risk prediction, treatment planning, and future clinical applications.

AI Applications in Periodontics

Artificial intelligence has rapidly evolved from a research concept to a valuable adjunct in periodontal practice. Current applications primarily focus on disease diagnosis, prediction of disease progression, treatment planning, and patient management. Although most systems remain under clinical evaluation, they demonstrate considerable potential to improve accuracy, consistency, and efficiency in periodontal care.

1. AI in Periodontal Diagnosis

Radiographic interpretation is fundamental for periodontal diagnosis; however, manual assessment is often subjective. Deep learning models, particularly convolutional neural networks (CNNs), have shown excellent performance in detecting alveolar bone loss on periapical radiographs, bitewings, panoramic radiographs, and CBCT images. Several studies have reported diagnostic accuracies exceeding 90%, allowing early disease detection and reducing observer variability. AI can also identify periodontal ligament changes, furcation involvement, and calculus deposits while simultaneously analysing large numbers of radiographs within seconds.

2. AI in Risk Prediction

Periodontitis results from interactions among microbial, environmental, behavioural, and systemic factors. Machine learning algorithms such as Random Forests, Support Vector Machines, and Logistic Regression integrate multiple clinical variables, including age, smoking status, diabetes, probing depth, and attachment loss, to estimate disease progression and tooth survival. These predictive models support individualized maintenance schedules and early preventive interventions. However, most currently available models require validation using larger multicentre datasets before routine clinical implementation.

3. AI in Clinical Decision-Making

Artificial intelligence has expanded beyond diagnosis into clinical decision support. AI-assisted software can recommend treatment approaches based on patient-specific clinical findings, estimate implant prognosis, and predict peri-implant disease risk. Mobile health applications powered by AI also encourage patient compliance through personalized reminders and oral hygiene monitoring. Despite these advances, treatment decisions should continue to rely on clinician expertise, with AI serving as an adjunctive tool rather than an independent decision-maker. (Table 1,2)

Table 1. Current Applications of Artificial Intelligence in Periodontics

Clinical Area	AI Application	Clinical Benefit
Diagnosis	CNN-based radiographic analysis	Early detection of bone loss
Risk Prediction	Machine learning algorithms	Individualized prognosis

Treatment Planning	Clinical decision-support systems	Standardized treatment planning
Implantology	Predictive analytics	Improved implant prognosis
Patient Care	AI chatbots and mobile applications	Better compliance and maintenance

Table 2. Advantages of AI in Periodontal Practice

Application	Clinical Advantage
Radiographic interpretation	Increased diagnostic accuracy
Risk assessment	Early identification of high-risk patients
Decision support	Reduced treatment variability
Digital monitoring	Improved patient follow-up
Data analysis	Faster processing of large datasets

Challenges and Future Perspectives

Despite encouraging results, significant barriers continue to limit the routine use of AI in periodontology. Most published studies are retrospective, single-centre investigations with relatively small sample sizes, reducing their generalizability. Differences in imaging techniques, disease presentation, and patient demographics further affect model performance. Additionally, many AI algorithms function as "black boxes," making it difficult for clinicians to understand how diagnostic decisions are reached. Ethical concerns related to patient privacy, data security, algorithmic bias, and medico-legal responsibility remain unresolved.

Future research should prioritize multicentre datasets, prospective clinical trials, explainable AI models, and integration with electronic health records. The incorporation of genomics, salivary biomarkers, microbiome analysis, and wearable technologies may facilitate precision periodontology and personalized treatment planning. Collaboration between periodontists, data scientists, engineers, and regulatory authorities will be essential to ensure safe and effective implementation of AI in routine clinical practice.(Table 3)

Table 3. Major Challenges and Future Directions

Current Challenges	Future Directions
Small datasets	Multicentre validation studies
Poor generalizability	Standardized databases
Black-box algorithms	Explainable AI models
Privacy and ethical concerns	Robust regulatory frameworks
Limited clinical integration	Integration with EHR and chairside software

CONCLUSION

Artificial intelligence is transforming periodontics by enhancing diagnostic accuracy, facilitating risk prediction, and supporting evidence-based clinical decision-making. Deep learning and machine learning models have demonstrated considerable promise in radiographic interpretation, prognosis, and treatment planning. However, current evidence is primarily exploratory, and significant challenges remain regarding validation, interpretability, ethics, and regulatory approval. AI should therefore complement rather than replace clinical expertise. With rigorous validation, transparent algorithms, and multidisciplinary collaboration, AI has the potential to become an indispensable component of precision periodontal care.

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