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APPLICATION OF ARTIFICIAL INTELLIGENCE IN DENTISTRY SCIENTIFIC AND PRACTICAL PERSPECTIVES

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Abstract

Artificial intelligence has become an essential component of digital transformation in modern dentistry. The application of AI-based technologies has significantly improved diagnostic accuracy, treatment planning, and clinical workflow efficiency. This article examines the scientific foundations and practical applications of artificial intelligence in dentistry, with particular emphasis on machine learning and deep learning algorithms used in dental imaging, orthodontics, prosthodontics, and implantology. The study is based on a systematic analysis of scientific literature and clinical research, evaluating the effectiveness, benefits, and limitations of AI-assisted dental systems. The findings demonstrate that artificial intelligence enhances evidence-based decision-making, reduces diagnostic variability, and supports personalized dental care. However, challenges related to data quality, ethical considerations, and clinical integration remain critical issues for future research. Overall, artificial intelligence is shown to be a promising tool for advancing the quality and efficiency of dental healthcare.

Keywords: Artificial intelligence, dentistry, machine learning, deep learning, dental diagnostics, digital dentistry

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Introduction

The rapid advancement of artificial intelligence (AI) technologies has become one of the most transformative forces shaping modern healthcare systems. In recent years, the integration of AI into medical practice has significantly influenced diagnostic accuracy, clinical decision-making, and treatment personalization. Dentistry, as a technologically intensive and data-driven medical discipline, has emerged as one of the most promising fields for the application of artificial intelligence.

Dentistry relies heavily on visual diagnostics, radiographic imaging, and precise interpretation of complex anatomical and pathological data. Traditional diagnostic approaches, while clinically effective, are often dependent on the practitioner's experience, subjective judgment, and workload-related limitations. These factors may lead to diagnostic variability, delayed disease detection, and suboptimal treatment planning. In this context, artificial intelligence offers a novel paradigm by enabling automated, objective, and highly accurate analysis of dental data. Artificial intelligence is broadly defined as the ability of computational systems to simulate human cognitive functions, including learning, reasoning, pattern recognition, and adaptive decision-making. Within dentistry, AI is predominantly implemented through machine learning (ML) and deep learning (DL) algorithms, particularly convolutional neural networks (CNNs), which are capable of processing large volumes of dental images such as panoramic radiographs, cone-beam computed tomography (CBCT) scans, intraoral photographs, and digital impressions. The growing availability of digital dental records and imaging datasets has facilitated the training of AI systems to detect caries, periodontal diseases, periapical lesions, temporomandibular joint disorders, and oral malignancies with a level of accuracy comparable to, and in some cases exceeding, that of experienced clinicians. Moreover, AI-driven tools contribute to early disease detection, which is critical for improving prognosis, reducing treatment costs, and enhancing patient quality of life. Another

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significant factor driving the adoption of artificial intelligence in dentistry is the global shift toward personalized and predictive medicine. AI-based systems enable individualized treatment planning by analyzing patient-specific anatomical, physiological, and behavioral data. This is particularly relevant in orthodontics, prosthodontics, and implantology, where precise biomechanical calculations and long-term outcome predictions are essential for clinical success. In this regard, the present article aims to analyze the theoretical foundations and practical applications of artificial intelligence in dentistry, assess its impact on diagnostic and therapeutic processes, and identify перспективal directions for future research and clinical implementation.

Methodology

The methodological approach of this study is based on a comprehensive analytical review of scientific research devoted to the application of artificial intelligence in dentistry. The research methodology integrates principles of evidence-based medicine, medical informatics, and digital health technologies in order to evaluate the effectiveness, reliability, and clinical relevance of AI-based systems in dental practice. The study relies on qualitative and comparative analysis of existing scientific data rather than experimental intervention, allowing for a broad and objective assessment of current trends and technological advancements. Scientific sources were selected from peer-reviewed medical and technological journals, conference proceedings, and academic publications that focus on artificial intelligence, machine learning, and deep learning applications in dentistry. Priority was given to studies that provided clear methodological descriptions, validated datasets, and measurable clinical outcomes. Publications lacking sufficient methodological rigor, statistical validation, or clinical relevance were excluded to ensure the scientific reliability of the analysis. The analytical process involved systematic examination of AI algorithms used in dental diagnostics and treatment planning, with particular attention to machine learning

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and deep learning models such as convolutional neural networks. These models were evaluated based on their training procedures, data preprocessing methods, validation strategies, and performance indicators, including diagnostic accuracy, sensitivity, specificity, and predictive consistency. Comparative analysis was conducted to assess differences between AI-assisted and conventional diagnostic approaches.

The methodology included assessment of the practical implementation of artificial intelligence in clinical dentistry. Reported applications were analyzed across various dental specialties, including radiographic image interpretation, orthodontic treatment planning, prosthetic design, and implant positioning. The study also considered ethical, legal, and data protection aspects related to the clinical use of artificial intelligence, emphasizing the importance of patient data security and algorithmic transparency. The synthesis of collected data was performed using descriptive and interpretative methods, enabling identification of common patterns, advantages, and limitations associated with artificial intelligence technologies in dentistry. This integrated methodological framework provides a solid scientific basis for evaluating the current state and future potential of AI-driven solutions in dental healthcare.

The analysis of scientific literature and clinical studies demonstrates that artificial intelligence technologies have a significant positive impact on diagnostic accuracy and clinical efficiency in dentistry. The reviewed studies consistently report that AI-based systems, particularly those utilizing deep learning algorithms, achieve high levels of accuracy in the detection and classification of dental pathologies. In radiographic diagnostics, convolutional neural networks have shown superior performance in identifying dental caries, periapical lesions, periodontal bone loss, and impacted teeth when compared to conventional visual assessment methods. The results indicate that AI-assisted interpretation of panoramic radiographs and cone-beam computed tomography images reduces diagnostic variability and minimizes the influence of subjective human factors.

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Several studies report sensitivity and specificity values exceeding those of traditional diagnostic approaches, especially in early-stage disease detection. This improvement is particularly evident in the identification of initial carious lesions and subtle periodontal changes, which are often overlooked in routine clinical examinations. In orthodontics, artificial intelligence-based systems have demonstrated high reliability in automated cephalometric analysis and treatment outcome prediction. The findings reveal that AI tools significantly decrease the time required for orthodontic measurements while maintaining or improving accuracy. Similarly, in prosthodontics and implantology, AI-driven software has shown effectiveness in optimizing prosthetic design and implant positioning by analyzing anatomical constraints and biomechanical factors, leading to improved functional and aesthetic outcomes. The results further show that the integration of artificial intelligence enhances clinical workflow efficiency. Automated data processing and decision-support systems reduce the workload of dental practitioners, allowing more time for patient-centered care. AI-assisted treatment planning contributes to more consistent and standardized clinical decisions, which is particularly beneficial in complex or multidisciplinary cases. The analysis also reveals certain limitations associated with AI implementation in dentistry. The performance of AI models is highly dependent on the quality and diversity of training datasets. Inadequate data representation may result in reduced accuracy when applied to different populations or clinical settings. Additionally, the lack of transparency in some AI algorithms poses challenges for clinical interpretability and acceptance among dental professionals.

Conclusion

The findings of this study indicate that artificial intelligence represents a transformative technological advancement in modern dentistry, offering substantial improvements in diagnostic accuracy, treatment planning, and clinical efficiency. The integration of AI-based systems enables objective and data-driven

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analysis of dental images and clinical information, thereby reducing diagnostic subjectivity and enhancing early detection of oral diseases. In conclusion, artificial intelligence holds considerable potential to reshape the future of dentistry by improving the quality, accessibility, and efficiency of oral healthcare services. Its responsible and scientifically grounded integration into clinical practice will play a key role in advancing digital dentistry and enhancing patient outcomes.

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