ISSN: 2835-0448

International Journal of Dental Science and Dentistry Research (IJDSDR)

IJDSDR : Dental Publication

Available Online at: www.ijdsdr.com

Volume – 5, Issue – 2, March – April – 2026, Page No. : 01 – 05

Integration of Artificial Intelligence in Oral Health Practice

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How to Cite This Article: Reem E. Siddig, Ammar Yassir Yassin, "Integration of Artificial Intelligence in Oral Health Practice", IJDSDR – March – April – 2026, Vol. – 5, Issue – 2, P. No. 01 – 05.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Artificial intelligence (AI) is changing modern dentistry by improving diagnoses, treatment plans, and patient care. AI can detect issues like cavities and oral cancer early. It also creates personalized treatment plans and streamlines administrative tasks. However, AI faces challenges like high costs and data privacy concerns. Despite these challenges, AI can revolutionize dentistry by making it more accurate and patient-centered.

Keywords: Oral Health, Artificial Intelligence, Imaging, Diagnosis, Machine Learning.

Introduction

"Artificial intelligence" describes a computer's capability to mimic cognitive functions such as "learning and problem-solving," which are typically linked to human intelligence. AI techniques have been thoroughly researched as tools for clinical trials, especially to enhance prognostic assessments and decision-making predictions, along with all phases of diagnosis and treatment planning.[1]

Dartmouth College in New Hampshire hosted the eight-week Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI) in 1956, led by John McCarthy and Marvin Minsky. This workshop brought together individuals who would later be recognized as the pioneers of AI, marking the beginning of the AI Spring.[2]

AI is making notable strides in dentistry, particularly in areas such as radiographic image interpretation, predicting post-treatment outcomes, and optimizing orthodontic and prosthetic aligners. With advancements in machine learning AI is proving to be a valuable tool for dental professionals in decision-making and management.[3]

Currently, there are limited AI applications in the dental sector. However, the advancement of these technologies has positively impacted caries detection, radiography and pathology, robotic assistance, dental imaging diagnostics, and computerized recordkeeping. As other dental specialties have progressed, research in endodontic artificial intelligence has also advanced.[4]

AI-enhanced dental tools face challenges like ethics and data security. Developers aim to make AI assist dental professionals, not replace them.[1]

This commentary aims to outline the current state of AI integration in dentistry, identify the key ethical, legal, and technological barriers to clinical adoption, and propose evidence-based strategies for further research, standardization, and interdisciplinary collaboration.

Current AI Applications in Oral Medicine

- **AI in diagnostic imaging**

AI has transformed oral medicine diagnostics by effectively analyzing dental radiographs, intraoral photos, and CBCT scans. These AI systems utilize Deep Learning (DL) and Machine Learning (ML) algorithms to classify and identify periodontal diseases, periapical conditions, and cavities. [5] AI drives progress in image processing and analysis. To enhance CBCT resolution, these methods utilize AI-powered super-resolution processing, allowing clinicians to visualize microscopic structures. AI is integrated into CBCT imaging, enabling the creation of high-fidelity 3D simulations for orthodontic, prosthetic, and surgical procedures using CBCT data.[6]

- **AI in treatment planning**

To enhance decision-making and improve patient outcomes, predictive analysis is utilized to optimize dental treatment planning through AI, machine learning (ML), and big data analysis. [7] AI provides automated insights into disease progression and suggests tailored care plans for each patient. The algorithms enable the selection of the most suitable approaches for surgical interventions, orthodontic adjustments, and prosthetic rehabilitation.[7]

- **AI in patient care**

AI-powered virtual assistants help with appointment scheduling, patient education, and answering questions. They also analyze patient feedback and automate tasks like documentation and scheduling, freeing clinicians to focus on patient care.[8]

- **Disease detection**

AI algorithms analyze dental images to detect oral issues like periodontal disease and cavities. They also anticipate disease progression to support personalized care planning and improve patient outcomes.[9]

- **Virtual consultations and Teledentistry**

Teledentistry services enhance the accessibility and convenience of dental care by incorporating AI chatbots and virtual assistants to address patient inquiries, provide personalized oral health advice, and streamline the scheduling of in-person appointments.[10]

- **AI in Workflow Automation**

Dental professionals spend more time with patients and have less work to perform because AI-facilitated automation streamlines procedures like patient record management, care workflows, and documentation. AI-enabled solutions improve data entry, scheduling, and reporting accuracy and efficiency, creating a more productive and ideal healthcare setting.[11]

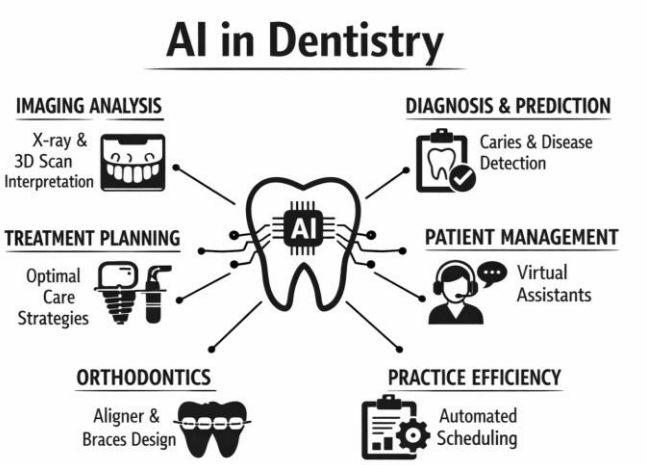

Figure 1: A diagram illustrating various ways artificial intelligence is applied in dentistry

Benefits of AI Application in dentistry

AI is revolutionizing dentistry by providing several key advantages that enhance patient care. It improves diagnostic accuracy, leading to more effective treatments, while personalized treatment planning allows dentists to customize care for each patient's unique needs.[12]

Additionally, streamlined administrative workflows reduce costs and enhance efficiency, and predictive analytics facilitate the early detection of potential oral health issues, enabling timely prevention. Faster image analysis contributes to quicker and more accurate diagnoses, while effective management of large datasets helps dentists make informed decisions. Collectively, these advancement result in better patient outcomes and increasing access to high-quality dental care for a wider population.[13]

Limitations for Implementation of AI in Dentistry

Ethical and Legal Concerns

AI in dentistry introduces important ethical and legal challenges, particularly regarding data privacy, informed consent, and accountability. The use of large datasets, including patient records and images, increases the risk of data breaches, making it essential for patients to be informed about how their information is used.[14]

Patients must also understand the role of AI in their care, ensuring it supports rather than replaces clinical judgment. Additionally, biased training data can lead to unfair outcomes and inaccurate diagnoses for certain groups, highlighting concerns about equity in care. Finally, the use of AI raises complex legal questions about responsibility, as accountability may be shared among clinicians, developers, and institutions, potentially increasing legal risks and hesitancy in adoption.[15]

Integration Barriers

Technical infrastructure limitations remain a significant barrier to the adoption of AI in dentistry, as many clinics lack the advanced digital systems required for effective implementation. Additionally, issues with data standardization reduce the reliability of AI systems, since variations in datasets and imaging protocols can affect performance, highlighting the need for broader validation before widespread use.[15]

High implementation costs further restrict adoption, particularly for smaller practices that may not have the financial capacity to invest in such technologies. Moreover, a lack of training and professional readiness contributes to hesitation among dental professionals, who often require structured education to build confidence and competence in using AI tools. Finally, fragmented clinical workflows pose another challenge, as many AI systems are not well integrated into existing dental software, leading to inefficiencies that limit their full potential in clinical practice.[16]

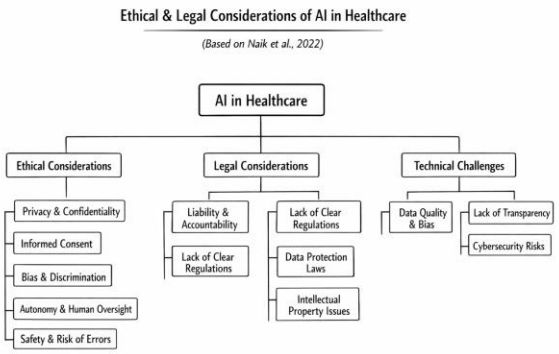

Figure 2 : Ethical and Legal Considerations of AI in Healthcare By Naik et al. (2022)[17]

Future Perspectives

- It's important to evaluate the long-term effects of AI to ensure its effectiveness.
- Educational programs are needed to enhance AI literacy among clinicians, students, and academic institutions.
- Fostering collaborations among stakeholders can facilitate the integration of AI in dentistry.
- Ethical frameworks should focus on safeguarding patient privacy.
- Investment in tele-dentistry platforms that utilize AI is crucial for areas with limited access to dental care.
- Research by governments and NGOs is essential to create affordable AI resources.

Conclusion

Dental practitioners leverage AI to streamline their workload and enhance the precision of diagnoses, decisions, and treatment plans. AI systems are designed for various dental specialties driving the advancement of dentistry forward with significant potential.

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