

The Impact of Artificial Intelligence on Diagnostic Accuracy and Treatment Planning in Dentistry

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ABSTRACT

The use of AI in dentistry is revolutionizing the field of dentistry by enhancing the accuracy of diagnosis and treatment. This research explores the impact of AI in dental care, focusing on its applications in diagnosis, treatment planning, and patient engagement, which contribute to improving the accuracy of diagnosis, treatment planning, and patient-doctor interaction. The application of AI in dentistry includes X-ray analysis, early diagnosis of oral diseases, improved patient care, and effective treatment planning based on accurate data. In addition, AI helps improve collaboration between different disciplines in treating patients and achieving better outcomes. However, the use of AI in dentistry raises some ethical and regulatory issues such as privacy protection, bias in algorithms, and legal regulations that professionals must keep up with. With the continuous advancement of AI technologies, major transformations are expected in diagnostic and treatment methods in dentistry, contributing to improving the patient's experience and treatment outcomes.

KEYWORDS: Artificial intelligence, dentistry, Diagnostic, x-rays, treatment planning, oral health.

1. Introduction

Dental caries is a global health problem that affects most of the population, and the increasing incidence of oral diseases is a global burden on healthcare systems [1]. This requires early detection, therapeutic and preventive interventions to reduce the risk of tooth decay and reduce treatment costs [1,2].

The technological revolution that our current era is witnessing and the use of digital

technology in all areas of life, including dentistry [3]. Artificial intelligence is one of the most important and prominent digital technologies in the world of modern dentistry through developments that affect the accuracy of diagnosis, treatment planning and interaction with patients [3,4].

Artificial intelligence (AI) is the ability of machines to perform human-like tasks that usually require human intelligence, including machine learning techniques that identify patterns in data for prediction [5]. Artificial intelligence (AI) is usually employed in dentistry by analyzing dental x-rays, photographs and other diagnostic records, which are performed by artificial intelligence with unprecedented accuracy [6]. Artificial intelligence contributes to the early detection of tooth decay, gum disease and other diseases and health problems related to the mouth at early stages [7], due to advanced machine learning algorithms and the ability to process huge amounts of data using artificial intelligence.

Moharrami et al., (2024) indicate that the application of different AI models in diagnosis provides higher levels of accuracy than traditional methods that rely on the dentist's experience, especially in complex cases and early detection of oral health problems [8].

In addition to diagnosis and treatment, AI applications in dentistry enhance the interaction between patients and dentists through interactive robots in providing immediate information to patients about treatments and post-procedure care, and simplifying administrative processes such as scheduling and follow-up, which contributes to the quality of service, increases patient satisfaction, and improves adherence to dental care appointments [9,10].

Therefore, this review seeks to investigate the implications of using artificial intelligence in diagnosis and planning dental treatment, and to provide comprehensive insights into the potential future of artificial intelligence in dentistry, focusing on recent innovations in the field of artificial intelligence that contribute to the advancement of dentistry.

Artificial intelligence Techniques in dentistry

Artificial intelligence is a branch of computer science that aims to create and develop machines and systems that simulate human tasks that require intelligence such as learning, problem solving, and decision making. AI is the most important pillar of the modern technological revolution, which has proven its effectiveness in all fields, including dentistry [11].

Artificial intelligence contributes to improving the ability and accuracy of early diagnosis in dentistry, and the efficiency of optimal treatment planning. The main applications of artificial intelligence in dentistry depend on two main technologies: (1) Machine Learning (ML), which contributes to the analysis of radiological images, early diagnosis of dental disorders, treatment planning, and predictive modeling that contributes to improving treatment outcomes and achieving a faster professional response [12]; (2) Natural Language Processing (NLP), which has the ability to understand and analyze human language, which facilitates interaction between doctors and patients, patient correspondence via digital communication

platforms, and providing accurate responses that support the process of making therapeutic decisions [13].

The use of artificial intelligence technologies in dentistry has led to a radical change in diagnosis and treatment methods due to advanced tools that support accurate clinical decision-making.

Artificial intelligence in dental diagnosis

In dentistry, accurate diagnosis is the foundation of dental treatment. AI enables dentists to diagnose teeth and gum disease through:

Dental Imaging and Radiography:

Artificial intelligence technologies contribute to dentistry and radiology, as they enhance the quality of radiological images that help reveal all the fine details that traditional images cannot, which helps dentists see the details accurately and thus accurately diagnose dental problems and gum diseases in the early stages [14]. In addition, artificial intelligence can analyze radiological images and identify many problems such as caries, impacted teeth, gum infections, and others, which enhances the accuracy and speed of diagnosis and contributes to improving treatment results [15]. It also contributes to many operations related to radiological images such as determining the position of the device and improving the accuracy of the quality of radiological images, thus reducing the burden on the dentist and reducing human errors [16].

Computer-Aided Detection and Diagnosis of Dental Conditions

Computer-aided artificial intelligence in dentistry is characterized by its ability to accurately and early detect and measure tooth decay before it becomes visible to the naked eye or conventional X-rays, which helps in early intervention and treatment before the problem worsens [17]. In addition, it helps in detecting gum diseases by analyzing radiographic images and clinical data of patients, thus providing a more comprehensive and accurate assessment of gum health [18]. It also contributes to analyzing images of oral lesions, tissue discoloration or irregularity using artificial intelligence, which enhances the chances of early treatment and saving patients' lives [19].

Early Detection and Prevention of Dental Diseases

Artificial intelligence in dentistry enhances early detection and prevention of dental diseases in several effective ways, such as analyzing patient medical records, identifying factors that may affect oral health, and discovering patterns that may not be apparent using traditional methods [20]. In addition, AI-powered predictive models provide accurate estimates of the progression of dental diseases based on historical patient data [21]. AI tools also play an important role in educating patients, by providing personalized information and recommendations that encourage them to follow preventive measures and adhere to dentists' instructions, and answering patients' inquiries, which enhances health awareness and motivates patients to participate more in maintaining their oral health [22].

Artificial intelligence in dental treatment

AI technologies in dentistry are helping to predict potential complications, thereby enhancing the opportunity for dentists to proactively address potential risks and design treatment plans based on each patient's unique needs.

Treatment Planning and Decision Support

Analyzing patients' medical records and radiological images using artificial intelligence techniques contributes to good treatment planning and determining the most appropriate treatment options for each patient based on their condition, medical history, and success rates of previous treatments [4]. Artificial intelligence also relies on algorithms that enable it to benefit from clinical data and research and keep pace with the latest developments and research in dentistry to make recommendations, which contributes to developing treatment strategies that are consistent with best practices and evidence-based clinical guidelines [22]. In addition, artificial intelligence provides real-time support that enhances the acquisition of accurate information while dealing with patients and making treatment decisions [23].

Predictive Analytics in Dental Treatment

Artificial intelligence is characterized by its ability to estimate the potential outcomes of a treatment plan, thus enhancing the ability of dentists to make effective decisions in planning treatment [24]. In addition to the ability to predict the development of diseases over time, especially in gum diseases and oral cancer, and thus take preventive measures. It also helps in evaluating the effectiveness of treatments by tracking the condition and progress of treatment, which allows for correcting treatment plans in real time to ensure the best results and reduce risks [25].

Multidisciplinary collaboration in Dental Treatment

Some cases require interventions from different dental specialties, where artificial intelligence facilitates cooperation between different specialties by exchanging information and facilitating communication between them, ensuring effective coordination in all aspects of the treatment plan [26]. Collaboration between different specialties leads to the patient receiving care efficiently and effectively by benefiting from the expertise of dentists, thus providing an integrated approach to treatment [27].

Ethical and Regulatory Considerations in the Use of Artificial intelligence in Dentistry

The use of artificial intelligence in dentistry raises ethical and regulatory issues, especially with the increasing integration of AI into dental practices due to its benefits in early detection of dental and oral health problems and developing effective treatment plans. These considerations include:

- **Data Privacy:** Dental AI relies on patient data, so dentists must maintain the confidentiality of patient data, use encryption techniques when transferring patient data to AI systems, and obtain patient consent to collect and analyze their data [28].
- **Algorithm Bias:** Analyzing patient data using AI requires addressing potential biases in algorithms that arise due to poor algorithm design or biased

training data, requiring dentists to ensure that algorithms are free of bias and to conduct regular audits to identify and correct any deviations that may appear in the algorithms [29].

- **Regulatory Considerations:** Dentists should keep up to date with applicable legislation and regulations, such as those imposed by regulatory bodies such as the FDA or MHRA. Professionals should also stay informed of future legislative developments that may impact the application of AI in dentistry [28].

Future directions in Artificial intelligence in dentistry

The advancement in the use of artificial intelligence technologies in the field of dentistry is still promising, and artificial intelligence is expected to radically change dental practices to improve patient experience and treatment outcomes.

- **Advanced Image Analysis:** AI-based algorithms are expected to become more advanced in analyzing medical images, enabling the detection of complex dental conditions, including caries and oral cancer, with greater accuracy and efficiency, leading to early intervention and improved patient outcomes [8].

- **Teledentistry:** AI-powered teledentistry platforms will become more advanced, allowing remote consultations, online treatment plans and follow-ups [30].

- **Personalized Treatment:** AI will be able to design personalized treatment plans based on each patient's genetics and lifestyle, enhancing the effectiveness of treatments and reducing potential risks and side effects [31].

- **Dental Assisting Robots:** The future is expected to witness the development of AI-powered robots that can perform some dental procedures with high accuracy. This will enhance doctors' capabilities and reduce the physical stress caused by surgical procedures and frequent examinations [31].

- **Leveraging Big Data:** AI will be able to analyze massive oral health data to uncover new patterns and gain a deeper understanding of disease mechanisms and the body's response to treatments [32].

- **Enhancing patient communication:** Smart tools such as chatbots and virtual assistants will become more capable of interacting with patients, providing them with medical information, and facilitating appointment booking and treatment follow-up.

- **Improving administrative efficiency:** AI will be able to automate many administrative tasks that occupy doctors and dental clinic staff, such as scheduling appointments, which reduces the administrative burden and contributes to improving the efficiency of workflow within clinics [32].

2. Conclusion:

Artificial intelligence provides accurate tools that contribute to the early diagnosis of dental and oral lesions, which improves dental practices, contributes to improving patient outcomes, and reduces treatment costs. Artificial intelligence technologies are

still advancing, and significant developments are expected in diagnostic methods, treatment planning, and patient-doctor interactions. However, this progress must be accompanied by consideration of ethical and regulatory issues to ensure the safe and effective use of artificial intelligence technologies. Future trends in artificial intelligence in dentistry are promising, including improved image analysis, remote fluorescence applications, and the development of intelligent robots that help provide effective and accurate healthcare.

References

- O'Brien KJ, Forde VM, Mulrooney MA, Purcell EC, Flaherty GT. Global status of oral health provision: identifying the root of the problem. *Public Health Challenges*. 2022;1:e6.
- Spatafora, G.; Li, Y.; He, X.; Cowan, A.; Tanner, A.C.R. The Evolving Microbiome of Dental Caries. *Microorganisms* 2024, 12, 121. <https://doi.org/10.3390/microorganisms12010121>
- Schwendicke, F.A.; Samek, W.; Krois, J. Artificial intelligence in dentistry: Chances and challenges. *J. Dent. Res.* 2020, 99, 769–774.
- Gracco A, De Stefani A, Bruno G. Influence of New Technology in Dental Care: A Public Health Perspective. *Int J Environ Res Public Health*. 2023 Apr 3;20(7):5364. doi: 10.3390/ijerph20075364. PMID: 37047978; PMCID: PMC10093858.
- Bogdan, C.; Ivan, V.M.; Apostol, A.; Sandu, O.E.; Maralescu, F.-M.; Lighezan, D.F. Hypothyroidism and Heart Rate Variability: Implications for Cardiac Autonomic Regulation. *Diagnostics* 2024, 14, 1261. <https://doi.org/10.3390/diagnostics14121261>
- Azhari AA, Helal N, Sabri LM, Abduljawad A. Artificial intelligence (AI) in restorative dentistry: Performance of AI models designed for detection of interproximal carious lesions on primary and permanent dentition. *Digit Health*. 2023 Nov 30;9:20552076231216681. doi: 10.1177/20552076231216681. PMID: 38047163; PMCID: PMC10693222.
- Al-Khalifa, K.S.; Ahmed, W.M.; Azhari, A.A.; Qaw, M.; Alsheikh, R.; Alqudaihi, F.; Alfaraj, A. The Use of Artificial Intelligence in Caries Detection: A Review. *Bioengineering* 2024, 11, 936. <https://doi.org/10.3390/bioengineering11090936>
- Moharrami M, Farmer J, Singhal S, Watson E, Glogauer M, Johnson AEW, Schwendicke F, Quinonez C. Detecting dental caries on oral photographs using artificial intelligence: a systematic review. *Oral Dis*. 2024;30(4):1765–83.
- Ayad N, Schwendicke F, Krois J, van den Bosch S, Bergé S, Böhner L, Hanisch M, Vinayahalingam S. Patients' perspectives on the use of artificial intelligence in dentistry: a regional survey. *Head Face Med*. 2023 Jun 22;19(1):23. doi: 10.1186/s13005-023-00368-z. PMID: 37349791; PMCID: PMC10288769.
- Thorat V, Rao P, Joshi N, et al. Role of Artificial Intelligence (AI) in Patient Education and Communication in Dentistry. (May 07, 2024) *Cureus* 16(5): e59799. DOI 10.7759/cureus.59799
- Mahesh Batra A, Reche A . A New Era of Dental Care: Harnessing Artificial Intelligence for Better Diagnosis and Treatment. (November 23, 2023) *Cureus* 15(11): e49319. doi:10.7759/cureus.49319
- Arsiwala-Scheppach LT, Chaurasia A, Müller A, Krois J, Schwendicke F: Machine learning in dentistry: a scoping review. *J Clin Med*. 2023, 12:937. 10.3390/jcm12030937
- Pethani F, Dunn AG: Natural language processing for clinical notes in dentistry: a systematic review. *J Biomed Inform*. 2023, 138:104282. 10.1016/j.jbi.2023.104282
- Anil S, Porwal P, Porwal A: Transforming dental caries diagnosis through artificial intelligence-based techniques. *Cureus*. 2023, 15:e41694. 10.7759/cureus.41694
- Patil S, Albogami S, Hosmani J, et al.: Artificial intelligence in the diagnosis of oral diseases:

- applications and pitfalls. *Diagnostics* (Basel). 2022, 12:1029. 10.3390/diagnostics12051029
- Hardy M, Harvey H: Artificial intelligence in diagnostic imaging: impact on the radiography profession. *Br J Radiol*. 2020, 93:20190840. 10.1259/bjr.20190840
- Bhattacharjee N: Automated dental cavity detection system using deep learning and explainable AI. *AMIA Jt Summits Transl Sci Proc*. 2022, 2022:140-8.
- Cholan P, Ramachandran L, Umesh SG, PS, Tadeipalli A: The impetus of artificial intelligence on periodontal diagnosis: a brief synopsis. *Cureus*. 2023, 15:e43583. 10.7759/cureus.43583
- García-Pola M, Pons-Fuster E, Suárez-Fernández C, Seoane-Romero J, Romero-Méndez A, López-Jornet P: Role of artificial intelligence in the early diagnosis of oral cancer. A scoping review. *Cancers* (Basel). 2021, 13:4600. 10.3390/cancers13184600
- Huang H, Zheng O, Wang D, et al.: ChatGPT for shaping the future of dentistry: the potential of multi-modal large language model. *Int J Oral Sci*. 2023, 15:29. 10.1038/s41368-023-00239-y
- Artificial intelligence in dentistry. (2023). Accessed: September 13, 2023: <https://www.dental-tribune.com/news/artificial-intelligence-in-dentistry/>.
- Anil S, Sudeep K, Saratchandran S, Sweety VK: Revolutionizing dental caries diagnosis through artificial intelligence. *IntechOpen*. 2023, 10.5772/intechopen.112979
- Mahdi SS, Battineni G, Khawaja M, Allana R, Siddiqui MK, Agha D: How does artificial intelligence impact digital healthcare initiatives? A review of AI applications in dental healthcare. *Int J Inf Manag Data Insights*. 2023, 3:100144. 10.1016/j.jjimei.2022.100144
- Schwendicke F, Samek W, Krois J: Artificial intelligence in dentistry: chances and challenges. *J Dent Res*. 2020, 99:769-74. 10.1177/0022034520915714
- Fatima A, Shafi I, Afzal H, et al.: Advancements in dentistry with artificial intelligence: current clinical applications and future perspectives. *Healthcare* (Basel). 2022, 10:2188. 10.3390/healthcare10112188
- Johnson KB, Wei WQ, Weeraratne D, et al.: Precision medicine, AI, and the future of personalized health care. *Clin Transl Sci*. 2021, 14:86-93. 10.1111/cts.12884
- Scott J, Biancardi AM, Jones O, Andrew D: Artificial intelligence in periodontology: a scoping review. *Dent J* (Basel). 2023, 11:43. 10.3390/dj11020043
- Johnson KB, Wei WQ, Weeraratne D, et al.: Precision medicine, AI, and the future of personalized health care. *Clin Transl Sci*. 2021, 14:86-93. 10.1111/cts.12884
- Norori N, Hu Q, Aellen FM, Faraci FD, Tzovara A. Addressing bias in big data and AI for health care: A call for open science. *Patterns* (N Y). 2021 Oct 8;2(10):100347. doi: 10.1016/j.patter.2021.100347. PMID: 34693373; PMCID: PMC8515002.
- Fricton J, Chen H: Using teledentistry to improve access to dental care for the underserved. *Dent Clin North Am*. 2009, 53:537-48. 10.1016/j.cden.2009.03.005
- Liu L, Watanabe M, Ichikawa T: Robotics in dentistry: a narrative review. *Dent J* (Basel). 2023, 11:62. 10.3390/dj11030062
- Zhang, P.; Kamel Boulous, M.N. Generative AI in Medicine and Healthcare: Promises, Opportunities and Challenges. *Future Internet* 2023, 15, 286. <https://doi.org/10.3390/fi15090286>