ISSN: 2583- 2247, Vol. 06, No. (1-2) 2025, Pg. 28-31

Enviro Dental Journal

dentaljournal.org

Futuristic Role of Artificial Intelligence in Dentistry: A Path Forward

TARUN KUMAR[1]* and NEHA ARORA[2]

[1]Department of Oral Medicine and Radiology, Yamuna Institute of Dental Sciences and Research, Yamunanagar, Haryana.

[2]Department of Health and Family Welfare of Haryana, Subdivision Civil Hospital, Pehowa, India.

Abstract

Artificial intelligence (AI) has rapidly evolved over the past two decades, driven by advancements in digital imaging, machine learning, and computational power. In dentistry, AI has begun to transform tasks previously dependent on human expertise, offering opportunities to enhance diagnosis, treatment planning, and patient care. Applications range from identifying normal and pathological oral structures to optimizing decision-making and improving treatment outcomes. This review discusses both present applications and potential future directions for AI in oral healthcare.

Article History

Received: 08 August 2025

Accepted: 26 September 2025

Keywords

Artificial Intelligence; Dentistry; Oral Medicine; Oral Health; Oral Diagnostics.

Introduction

Artificial intelligence (AI), once considered science fiction, is now a fast-expanding technology across healthcare.[1] It enables machines to perform tasks traditionally reliant on human judgment, reducing pre- and post-operative complications. In dentistry, AI contributes to diagnostics, treatment planning, laboratory procedures, and even education.[2] This review outlines current uses of AI in oral medicine and dentistry and explores its future potential.

AI, a discipline within computer science, designs systems capable of executing complex tasks. Early AI relied on rule-based systems, such as detecting lesions in radiographs based on preset thresholds.[1] Modern applications depend on machine learning (ML) and deep learning (DL), which learn from data rather than explicit programming.[3] ML algorithms recognize and generalize patterns in large datasets, similar to how a child learns to recognize animals through repeated exposure. DL extends this by using hierarchical networks, with artificial neural networks (ANNs) as the most common subtype. In dentistry, convolutional neural networks (CNNs) have been especially effective for image interpretation.[4]

CONTACT Tarun Kumar drtarunomr@gmail.com Department of Oral Medicine and Radiology, Yamuna Institute of Dental Sciences and Research, Yamunanagar, Haryana.

Doi: http://dx.doi.org/10.12944/EDJ.06.0102.06

Applications of AI Across Dental Specialties

Oral Radiology

CNNs demonstrate high accuracy in detecting anatomical structures on radiographs. Models trained on periapical images can identify teeth with precision comparable to expert clinicians.[2,3] CNNs have also shown strong performance in detecting carious lesions, achieving accuracy and sensitivity surpassing conventional visual diagnosis.[4,5] These algorithms enhance radiographic interpretation by improving both efficiency and reliability.

Periodontics

Periodontal diseases present diagnostic challenges, as no single test can fully differentiate aggressive from chronic periodontitis.[6-10] ANNs trained on immunologic parameters such as leukocyte counts and cytokine levels have achieved 90–98% accuracy in classification.[11] Similarly, deep CNNs have been applied to predict the prognosis of periodontally compromised teeth (PCT), with diagnostic accuracy rates between 76–81% and extraction predictions between 73–83%.[12-14] Premolars are more accurately diagnosed than molars due to anatomical simplicity.

Orthodontics

In orthodontics, treatment planning often involves decisions regarding extractions. ANNs have been developed to assist in these decisions, using clinical indices to predict the need for tooth removal in malocclusion cases.[6,7,14] These systems achieved 80–93% accuracy, supporting clinical judgment and enhancing predictability.

Oral Pathology

Early detection of oral lesions is critical, particularly for potentially malignant conditions. CNNs have demonstrated accuracy rates of 80–83% for detecting head and neck cancer lesions, comparable to specialist performance.[15-20] CNN algorithms have also been used to differentiate ameloblastomas from keratocystic odontogenic tumors with accuracy exceeding 83%, while significantly reducing diagnostic time.[21]

Endodontics

Root canal morphology is highly variable, complicating endodontic treatment. Cone-beam computed tomography (CBCT) is the gold standard for assessment, though radiation exposure limits its use.[22] AI-based CNN algorithms have been applied to CBCT and panoramic radiographs to classify root canal morphology with accuracy around 87%.[21,23-25] While manual segmentation remains a limitation, these tools provide valuable diagnostic assistance.

Despite advancements, AI implementation in dentistry faces obstacles. Data privacy and secure sharing are central concerns since AI requires large clinical datasets.[22,23] Ensuring patient anonymity and compliance with ethical standards is crucial. Regulatory frameworks, such as the FDA's 'Software as a Medical Device' category, provide oversight to safeguard innovation and patient safety.[23]

Accountability also poses challenges—questions remain about whether responsibility lies with the clinician or the algorithm developer in case of adverse outcomes. Legal and ethical frameworks must evolve to address these concerns.[22] Additionally, interpretability is essential for clinical acceptance. AI performance depends on high-quality training data, and poorly labeled datasets can compromise outcomes.[24] Clinicians must be able to understand and justify AI-driven decisions. Enhancing algorithm transparency and explainability remains a priority.

Conclusion

AI should be seen as an adjunct rather than a replacement for dental professionals. Its integration requires robust training, ethical safeguards, and transparency. Dental curricula must adapt to incorporate AI literacy. Beyond clinical support, AI is merging with virtual and augmented reality to create mixed-reality applications that aid in education and surgical planning.[24] As research expands, AI promises to become an essential partner in enhancing efficiency, accuracy, and patient care in dentistry.

Acknowledgement

The author would like to thank Department of Oral Medicine and Radiology, YIDSR, Yamunanagar for helping out in the whole review process.

Funding Sources

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of Interest

The authors do not have any conflict of interest.

Data Availability Statement

This statement does not apply to this article.

Ethics Statement

This research did not involve human participants, animal subjects, or any material that requires ethical approval.

Informed Consent Statement

This study did not involve human participants, and therefore, informed consent was not required.

Author Contributions

- **Tarun Kumar:** Review
- **Neha Arora:** Data Collection, Analysis, Writing

References

1. Yu KH, Beam AL, Kohane IS. Artificial intelligence in healthcare. *Nat Biomed Eng.* 2018;2(10):719-31.
2. Zhang K, Wu J, Chen H, Lyu P. An effective teeth recognition method using label tree with cascade network structure. *Comput Med Imaging Graph.* 2018;68:61-70.
3. Tuzoff DV, Tuzova LN, Bornstein MM, Krasnov AS, Kharchenko MA, Nikolenko SI, *et al*. Tooth detection and numbering in panoramic radiographs using convolutional neural networks. Dentomaxillofac Radiol. 2019;48(4):20180051.
4. Lee JH, Kim DH, Jeong SN, Choi SH. Detection and diagnosis of dental caries using a deep learning-based convolutional neural network algorithm. *J Dent.* 2018;77:106-11.
5. Bader JD, Shugars DA, Bonito AJ. Systematic reviews of selected dental caries diagnostic and management methods. *J Dent Educ.* 2001;65(10):960-8.
6. Xie X, Wang L, Wang A. Artificial neural network modeling for deciding if extractions are necessary prior to orthodontic treatment. *Angle Orthod.* 2010;80(2):262-6.
7. Jung SK, Kim TW. New approach for the diagnosis of extractions with neural network machine learning. *Am J Orthod Dentofacial Orthop.* 2016;149(1):127-33.
8. Fernandes GVO, Fernandes JCH. A New Algorithm/Tool Used to Achieve the Periodontal Risk Assessment, Diagnosis, and Prognosis (GF-PeDRA): A Clinical Study with 221 Patients. *Dent Med Probl*. 2025 (in press).
9. Armitage GC. Learned and unlearned concepts in periodontal diagnostics: a 50-year perspective. *Periodontol* 2000. 2013;62(1):20-36.
10. Fernandes GVO, Dennison G, Quayson H, Olabade O, Fernandes JCH. A New Algorithm/Tool (GF-PeDRA) Used to Achieve the Periodontal Risk Assessment, Diagnosis, and Prognosis: Clinical Approach and Application. *J Clin Periodontol.* 2025;52(Suppl. 28):382. https://doi.org/10.1111/jcpe.14161
11. Papantonopoulos G, Takahashi K, Bountis T, Loos BG. Artificial neural networks for the diagnosis of aggressive periodontitis trained by immunologic parameters. *PLoS One.* 2014;9(3):e89757.
12. Papantonopoulos G, Takahashi K, Bountis T, Loos BG. Using cellular automata experiments to model periodontitis: a first step towards understanding the nonlinear dynamics of the disease. *Int J Bifurcation Chaos.* 2013;23(3):1350056.
13. Papantonopoulos G, Takahashi K, Bountis T, Loos BG. Mathematical modeling suggests periodontitis behaves as a non-linear chaotic dynamical process. *J Periodontol.* 2013;84(10):e29-39.
14. Lee JH, Kim DH, Jegon SN, Choi SH. Diagnosis and prediction of periodontally compromised teeth using a deep learning-based convolutional neural network algorithm. *J Periodontal Implant Sci.* 2018;48(2):of114-23.
15. Hiraiwa T, Ariji Y, Fukuda M, Kise Y, Nakata K, Katsumata A, *et al*. A deep-learning artificial intelligence system for assessment of root morphology of the mandibular first molar on panoramic radiography. *Dentomaxillofac Radiol.* 2019;48(3):20180218.
16. Zhang X, Xiong S, Ma Y, Han T, Chen X, Wan F, *et al*. A cone-beam computed tomographic study on mandibular first molars in a Chinese subpopulation. *PLoS One.* 2015;10(8):e0134919.

17. Xue Y, Zhang R, Deng Y, Chen K, Jiang T. A preliminary examination of the diagnostic value of deep learning in hip osteoarthritis. *PLoS One*. 2017;12(6):e0178992.
18. Wang X, Yang W, Weinreb J, Han J, Li Q, Kong X, *et al*. Searching for prostate cancer by fully automated magnetic resonance imaging classification: deep learning versus non-deep learning. *Sci Rep.* 2017;7(1):15415.
19. Trebeschi S, van Griethuysen JJM, Lambregts DMJ, Lahaye MJ, Parmar C, Bakers FCH, *et al*. Deep learning for fully-automated localization and segmentation of rectal cancer on multiparametric MR. *Sci Rep.* 2017;7(1):5301.
20. Halicek M, Lu G, Little JV, Wang X, Patel M, Griffith CC, *et al*. Deep convolutional neural networks for classifying head and neck cancer using hyperspectral imaging. *J Biomed Opt.* 2017;22(6):60503.
21. Poedjiastoeti W, Suebnukarn S. Application of convolutional neural network in the diagnosis of jaw tumors. *Healthc Inform Res.* 2018;24(3):236-41.
22. Char DS, Shah NH, Magnus D. Implementing machine learning in healthcare — addressing ethical challenges. *N Eng J Med.* 2018;378(11):981-3.
23. He J, Baxter SL, Xu J, Xu J, Zhou X, Zhang K. The practical implementation of artificial intelligence technologies in medicine. *Nat Med*. 2019;25(1):30-6.
24. Ferro AS, Nicholson K, Koka S. Innovative trends in implant dentistry training and education: a narrative review. *J Clin Med*. 2019;8(10):1618.