Artificial Intelligence in Oral Diagnosis: Scope and Limitations for General Dental Practitioners

Nandini Yadav[1]
[1]*ITS Dental College Hospital & Research Centre, Greater Noida - 201310.*

Corresponding Author:
Nandini Yadav
E-mail ID: nandiniyadavwork@gmail.com

Submission: 20.01.2026 Acceptance: 25.04.2026 Publication: 07.05.2026

https://www.doi.org/10.63778/CJID-DRJPL/2026_07518

Abstract

Introduction: Artificial intelligence (AI) is rapidly transforming the landscape of modern dentistry, with particular impact on diagnostic processes. Dental radiography has long served as a cornerstone of oral diagnosis, enabling the identification of carious lesions, periapical pathology, cystic formations, and neoplastic changes that are not appreciable on clinical examination alone. The integration of AI — particularly deep learning and convolutional neural network (CNN) architectures — into dental imaging workflows offers the potential to automate, standardise, and enhance diagnostic accuracy, while simultaneously reducing dependence on specialist interpretation.

Observations: AI-powered diagnostic systems demonstrate the capacity to analyse radiographic and photographic imaging data with high sensitivity and specificity. Convolutional neural networks applied to panoramic and periapical radiographs have successfully detected carious lesions, periapical pathologies, and alveolar bone loss with performance metrics comparable to experienced dental specialists. Fluorescence-based optical imaging technologies, such as VELscope, represent a complementary application that enhances detection of potentially malignant oral mucosal changes at subclinical stages. Comparative analysis of AI-based versus traditional diagnostic methods reveals consistent advantages of AI in speed, reproducibility, early detection capability, and reduced inter-examiner variability. Key limitations include the requirement for large, high-quality annotated training datasets, concentration-dependent algorithmic performance, patient concerns regarding diagnostic transparency, and the absence of universally standardised regulatory frameworks governing clinical AI deployment.

Discussion (including Conclusions): The evidence collectively supports AI as a diagnostically valid and clinically valuable adjunct for general dental practitioners, particularly in the fields of oral radiology and oral pathology. AI multimodal deep learning systems hold particular promise for democratising access to specialist-level diagnostic support in primary care dental settings. However, the prospect of AI displacing specialist dental roles — including oral radiologists — raises significant professional and ethical considerations that must be addressed through transparent policy development, practitioner education, and robust clinical validation. AI should be regarded as an intelligent diagnostic assistant rather than a replacement for clinical expertise. Widespread clinical adoption requires investment in practitioner AI literacy, validated large-scale training datasets, and the development of ethical frameworks governing patient data use and algorithmic accountability.

Keywords: artificial intelligence; oral diagnosis; dental radiology; machine learning; deep learning

Introduction

The practice of contemporary dentistry is increasingly shaped by technological innovation, and among recent developments, artificial intelligence (AI) has emerged as one of the most consequential. AI encompasses computational systems designed to perform tasks that traditionally require human cognitive ability - including pattern recognition, decision-making, and diagnostic inference. In the clinical dental context, AI most commonly manifests as machine learning (ML) and deep learning (DL) algorithms applied to imaging data, clinical records, and patient histories to support or automate diagnostic processes[4,7].

Dental radiography occupies a foundational role in oral diagnosis. Periapical, bitewing, and panoramic radiographs allow clinicians to visualise tooth morphology, detect interproximal and occlusal carious lesions, assess alveolar bone levels, identify periapical pathoses, and evaluate impacted or developing teeth - structures and pathologies that are entirely inaccessible to visual clinical examination. The interpretive accuracy of radiographic diagnosis is, however, subject to variability attributable to clinician experience, fatigue, viewing conditions, and image quality[1,5].

AI-powered image analysis systems — particularly convolutional neural networks (CNNs) — have demonstrated the capacity to process large volumes of radiographic data rapidly and reproducibly, generating diagnostic outputs with sensitivity and specificity comparable to those of trained dental specialists. Tuzoff et al. reported that CNN-based systems achieved accurate tooth detection and numbering in panoramic radiographs, illustrating the precision achievable with appropriately trained deep learning models[8]. Beyond radiography, fluorescence imaging technologies such as VELscope have extended AI-assisted detection to oral mucosal pathology, enabling the identification of potentially malignant lesions at subclinical stages before they present overtly on clinical examination[3].

Despite this progress, the integration of AI into general dental practice is accompanied by legitimate concerns regarding data requirements, algorithmic transparency, patient acceptability, and the broader professional and ethical implications of automated diagnosis. This article reviews the current scope, applications, advantages, limitations, and future directions of AI as a diagnostic tool for general dental practitioners, with particular focus on oral radiology and multimodal diagnostic systems.

Discussion

AI Workflow in Oral Diagnosis

The operational framework of an AI-assisted oral diagnostic system encompasses several sequential stages: data acquisition, image pre-processing, feature extraction, algorithmic pattern analysis, and output generation. In the radiographic context, raw digital imaging data — from intraoral sensors, photostimulable phosphor plates, or cone-beam computed tomography (CBCT) units — serves as the primary input. Deep learning models, typically CNNs trained on large annotated datasets, extract hierarchical features from these images that are not discernible to the human eye, identifying patterns associated with specific pathological entities[5,7].

This automated analytical pipeline reduces the cognitive burden on the clinician, offers decision support at the point of care, and generates quantifiable, reproducible outputs. Importantly, the diagnostic quality of AI systems is directly proportional to the volume, diversity, and annotation quality of the training data. Systems trained on limited, homogeneous, or poorly annotated datasets exhibit significantly reduced generalisation capability and diagnostic accuracy in real-world clinical settings[4].

Clinical Applications in Oral Radiology and Pathology

The most extensively validated clinical application of AI in dentistry is the automated detection and classification of dental caries on bitewing and periapical radiographs. ML-based systems have demonstrated sensitivity and specificity for caries detection that are equivalent to, and in some studies superior to, those of general dental practitioners, while maintaining consistency that is independent of examiner fatigue or experience level[1,5]. Periapical pathology detection, alveolar bone loss quantification, and furcation involvement assessment represent additional radiographic applications where AI models have demonstrated strong performance[8].

In the field of oral pathology, AI-assisted analysis of histopathological whole-slide images offers the potential to support pathologists in the classification of oral epithelial dysplasia and oral squamous cell carcinoma. Optical fluorescence imaging exemplified by VELscope, an FDA approved fluorescence visualisation device enables real time detection of abnormal mucosal tissue autofluorescence patterns associated with dysplastic or malignant change, facilitating earlier diagnosis and intervention at a stage when the prognosis for patients is substantially more favourable[3,6].

Multimodal deep learning systems that integrate data from multiple imaging modalities — radiographic, photographic, optical, and clinical — represent the next frontier in AI-assisted oral diagnosis. Such systems have the potential to provide holistic, cross-validated diagnostic outputs that reflect the full complexity of oral pathological presentations, improving both diagnostic sensitivity for complex cases and the clinical confidence of general practitioners operating without immediate specialist support[4,7].

Comparison with Traditional Diagnostic Methods

A systematic comparison of AI-based and traditional diagnostic approaches reveals several consistent patterns. In terms of diagnostic accuracy, AI systems trained on sufficiently large datasets demonstrate reduced susceptibility to the inter-examiner variability and cognitive bias that characterise human diagnostic performance. AI-generated outputs are reproducible and time-efficient, and models can be updated continuously as new evidence becomes available — a significant adaptability advantage over traditional approaches that require formal clinician retraining[2,5]. Table 1 presents a structured comparative analysis of AI and traditional diagnostic methods across key clinical parameters.

Table 1. Comparison of AI-Based and Traditional Diagnostic Methods in Oral Diagnosis

Criteria	Traditional Methods	AI-Based Methods
Diagnostic Accuracy	Dependent on clinician experience; susceptible to inter-examiner variability	High accuracy through advanced algorithms and large-dataset training
Speed	Time-consuming; requires sequential manual interpretation	Rapid automated analysis enables faster clinical decision-making
Early Detection	Limited to clinically visible symptoms; reliant on examiner acuity	Predictive pattern recognition enables detection of subclinical lesions
Cost	Ongoing specialist consultation and repeat imaging costs	High initial setup cost; cost-effective at scale with reduced specialist dependency
Error Rate	Higher; attributable to fatigue, subjectivity, and cognitive bias	Lower; machine learning models exhibit consistent, reproducible outputs
Adaptability	Requires formal clinician retraining for new diagnostic protocols	Models can be continuously updated with new data without retraining end-users
Patient Comfort	May involve invasive or uncomfortable diagnostic procedures	Non-invasive imaging technologies improve the patient diagnostic experience

AI = artificial intelligence; CNN = convolutional neural network.

Artificial Intelligence in Oral Diagnosis | Page 5Notwithstanding these advantages, the cost of establishing AI-integrated diagnostic infrastructure remains a substantial barrier for smaller and resource-limited general dental practices. While the long-term cost-benefit ratio of AI implementation is favourable — through reduced specialist referrals, earlier disease interception, and streamlined workflows — the initial capital investment required may preclude adoption in primary care settings where it is most needed[4].

Limitations, Ethical Considerations, and Regulatory Challenges

The principal technical limitation of AI diagnostic systems is their dependence on large, high-quality, and representative annotated training datasets. Systems trained on data that is geographically or demographically non-representative may exhibit systematic diagnostic biases when deployed in clinical populations that differ from the training cohort. The absence of internationally standardised protocols for the development, validation, and clinical deployment of dental AI systems further complicates cross-study comparison and regulatory approval processes[6,7].

Ethical dimensions of AI in oral diagnosis encompass patient autonomy, informed consent, data privacy, and algorithmic accountability. Patients have a legitimate interest in understanding whether and how AI systems contribute to their diagnosis, and clinicians bear a professional and medicolegal responsibility to exercise informed oversight of AI-generated outputs rather than accepting them uncritically[6]. Mahdi et al. emphasised that transparency in AI decision-making processes is a prerequisite for patient trust and clinical adoption, and that ethical frameworks governing the use of patient data in AI training and deployment must be developed in parallel with the technology itself[4].

The prospect of AI assuming diagnostic functions traditionally performed by specialist practitioners — including oral radiologists and oral pathologists — raises important workforce and professional identity questions for the dental profession. While AI clearly has the potential to reduce dependence on specialist interpretation for routine cases, it is neither clinically appropriate nor professionally tenable to regard AI as a substitute for specialist expertise in complex, ambiguous, or high-stakes diagnostic scenarios. The appropriate framing positions AI as an intelligent decision-support tool that augments the capabilities of the general dental practitioner, rather than as a replacement for the diagnostic specialist[2,7].

Conclusion

Artificial intelligence represents a transformative and clinically validated advancement in oral diagnosis that is already reshaping the practice of dentistry for general dental practitioners. AI-powered image analysis systems demonstrate diagnostic accuracy, speed, and reproducibility that compare favourably with — and in standardised settings exceed — conventional human diagnostic performance across multiple radiographic and optical imaging applications. The potential of AI to democratise access to specialist-level diagnostic support in primary care dental settings carries significant implications for improving oral health outcomes, particularly for underserved and geographically remote patient populations.

However, realising this potential responsibly requires careful attention to the limitations of current AI systems — principally their dataset dependency, lack of standardisation, and unresolved ethical and regulatory status. The dental profession must actively engage in the development of evidence-based frameworks for AI validation, transparent clinical deployment, and practitioner education. AI should be embraced as a powerful adjunct to clinical expertise, not as a replacement for it, and its integration into general dental practice should proceed in parallel with the establishment of the governance structures necessary to ensure patient safety, professional accountability, and equitable access to its benefits[1,4,7].

Source of Support: Nil

Conflict of Interest: Nil

References

1. Bhatt, K., Bhatt, N., & Trivedi, G. (2023). Artificial intelligence in dentistry: A comprehensive review. European Journal of General Dentistry, 12(3), 135–137. https://doi.org/10.1055/s-0043-1772565.
2. Grischke, J., Johannsmeier, L., Eich, L., Griga, L., & Haddadin, S. (2020). Dentronics: Towards robotics and artificial intelligence in dentistry. Dental Materials, 36(6), 765–778. https://doi.org/10.1016/j.dental.2020.03.021.
3. Hung, M., Hon, E. S., & Lauren, E. (2020). Improving AI-based oral disease diagnosis accuracy through machine learning. Journal of Dental Research, 99(4), 406–411. https://doi.org/10.1177/0022034520902177.
4. Mahdi, S. S., Battineni, G., Khawaja, M., Allana, R., Siddiqui, M. K., & Agha, D. (2023). How does artificial intelligence impact digital healthcare initiatives? A review of AI applications in dental healthcare. International Journal of Information Management Data Insights, 3(1), 100144. https: // doi.org / 10.1016/j.jjimei.2023.100144.
5. Martins, M. V., Baptista, L., Luís, H., Assunção, V., Araújo, M. R., & Realinho, V. (2023). Machine learning in X-ray diagnosis for oral health: A review of recent progress. Computation, 11(6), 115. https: // doi.org / 10.3390/computation11060115.
6. Mörch, C. M., Atsu, S., Cai, W., Li, X., Madathil, S. A., Liu, X., Mai, V., & Tamimi, F. (2021). Artificial intelligence and ethics in dentistry: A scoping review. Journal of Dental Research, 100(13), 1452–1460. https://doi.org/10.1177/00220345211013808.
7. Schwendicke, F., Chaurasia, A., Wiegand, T., Uribe, S. E., Fontana, M., Akota, I., & Krois, J. (2021). Artificial intelligence for oral and dental healthcare: Core education curriculum. Journal of Dentistry, 128, 104430. https://doi.org/10.1016/j.jdent.2023.104430.
8. Tuzoff, D. V., Tuzova, L. N., Bornstein, M. M., Krasnov, A. S., Kharchenko, M. A., Nikolenko, S. I., Sveshnikov, M. M., & Bednenko, G. B. (2019). Tooth detection and numbering in panoramic radiographs using convolutional neural networks. Dentomaxillofacial Radiology, 48(4), 20180051. https://doi.org/10.1259/dmfr.20180051.