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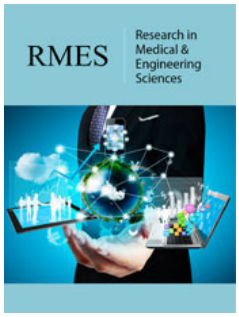
Mini Review

Artificial Intelligence in Dental Sciences: A Mini Review of Current Applications and Future Directions

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Abstract

Artificial intelligence (AI) has moved rapidly from an experimental concept to a practical tool across the dental specialties. Machine learning and deep learning models are now being applied to radiographic interpretation, caries and periodontal disease detection, orthodontic diagnosis, endodontic anatomy assessment, and prosthodontic planning, often matching or approaching clinician-level performance on narrow, well-defined tasks. This mini review summarizes recent developments in AI applications across dentistry, highlights recurring methodological limitations reported in the literature, and outlines the ethical and regulatory considerations that will shape clinical adoption. While the evidence base is expanding quickly, most studies remain retrospective, single-center, and validated on limited datasets, underscoring the need for prospective, multi-center research before widespread clinical integration.

Keywords: Artificial intelligence; Dentistry; Deep learning; Diagnostic imaging; Machine learning

Introduction

Dentistry generates large volumes of structured and unstructured data, including radiographs, cone-beam computed tomography (CBCT) scans, intraoral photographs, and electronic health records, making it well suited to data-driven analysis. Interest in applying AI to this data has grown substantially over the past decade, paralleling advances in computer vision and deep neural network architectures. Recent narrative and systematic reviews describe AI applications spanning nearly every dental subspecialty, including periodontology, endodontics, orthodontics, restorative dentistry, prosthodontics, and oral pathology, with the majority of published work concentrated in diagnostic imaging and disease detection tasks [1,2].

This review summarizes recent evidence on AI applications in dentistry, organized by clinical domain, and considers the practical and ethical barriers that remain before such tools can be reliably integrated into routine clinical workflows.

AI in diagnostic imaging and anomaly detection

Detection of dental anomalies in number, morphology, size, position, and structure is one of the most active areas of dental AI research, since such anomalies can be subtle and are sometimes missed on routine radiographic review. Convolutional neural network-based models trained on panoramic radiographs, periapical films, and CBCT datasets have been developed to flag anomalies for clinician review, with recent focused reviews cataloguing the range of imaging modalities and model architectures used for this purpose and identifying gaps in external validation as a priority for future work [3].

Beyond anomaly detection, AI-assisted image analysis has been applied to caries detection, alveolar bone loss assessment, and root canal morphology classification, with

several studies reporting sensitivity and specificity comparable to experienced clinicians on curated test sets [3,4].

AI in endodontics

In endodontics, AI has been explored for working length estimation, root canal system classification, detection of periapical lesions, and prediction of treatment outcomes. Comprehensive reviews of the endodontic literature describe steady growth in the number of published models over the past several years, while also noting that most studies to date rely on retrospective, single-institution image sets that limit generalizability across different imaging equipment and patient populations [2].

AI in orthodontics, prosthodontics, and restorative dentistry

Cephalometric landmark identification has been one of the earliest and most successful applications of AI in orthodontics, with automated landmarking systems reducing the time required for cephalometric analysis while maintaining accuracy close to manual tracing by experienced orthodontists. In prosthodontics and restorative dentistry, AI-assisted design tools are being integrated into digital workflows for crown and denture design, shade matching, and treatment planning, reflecting a broader shift toward digital dentistry. Systematic reviews of digital dentistry report that AI-based tools are increasingly embedded within CAD/CAM pipelines, though clinical outcome data comparing AI-assisted and conventional workflows remain limited [5,6].

Clinical utility, validation, and ethical considerations

Despite promising diagnostic performance, recent narrative reviews caution that the clinical relevance of many AI systems in dentistry has not been rigorously established, and that ethical implications require ongoing critical evaluation as these tools move toward implementation. Variability in data sources, model architectures, and evaluation methods across studies limits comparability and generalizability of reported findings, and the field lacks consensus guidelines and standardized validation protocols. Recurrent concerns raised in the literature include dataset bias (models trained predominantly on data from a single population or imaging system), the 'black box' nature of deep learning predictions, data privacy in the handling of patient imaging, and the medico-legal responsibility for AI-assisted diagnostic errors [2,6].

There is broad agreement that responsible integration of AI into dental practice should be guided by clinical judgment and ethical oversight, positioning these tools as decision-support aids rather than autonomous diagnostic authorities.

Future directions

Priorities identified across recent reviews include prospective multi-center validation studies, standardized reporting frameworks for dental AI research, greater dataset diversity to reduce bias, and closer integration of AI tools into dental education and training pipelines so that future clinicians are equipped to critically appraise and use these systems. Expanding AI's role beyond diagnosis into treatment planning, outcome prediction, and patient communication is also an active area of interest, alongside its emerging use as a research and literature-synthesis tool within dental science itself [7,8].

Conclusion

Artificial intelligence is increasingly embedded across the dental specialties, with the strongest evidence currently supporting its use in image-based diagnostic tasks. However, the field remains at an early stage of clinical maturity: most published models are validated on limited, single-source datasets, and methodological heterogeneity makes cross-study comparison difficult. Realizing the clinical potential of dental AI will depend on prospective validation, standardized evaluation protocols, and sustained attention to the ethical and regulatory questions that accompany its adoption.

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