

Artificial Intelligence in Clinical Dentistry: Case-Based Innovations Ethical Challenges and Future Prospects

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Abstract:

Background: Artificial intelligence (AI) has rapidly transitioned from theoretical promise to clinical reality in dentistry. Its applications span diagnostic imaging, predictive analytics and patient-centered care offering solutions to long-standing challenges such as diagnostic variability and delayed disease detection.

Objective: This manuscript synthesizes recent evidence case reports and systematic reviews to highlight AI's transformative role in clinical dentistry, focusing on diagnostic accuracy treatment planning and ethical considerations.

Methods: A narrative review of systematic reviews, meta-analyses, and case-based studies published between 2024–2025 was conducted. Case applications include radiographic interpretation oral cancer screening and restorative dentistry innovations.

Results: AI demonstrated diagnostic accuracy ranging from 82–95% across dental specialties [1,2]. Case reports reveal improved sensitivity in caries detection, predictive modeling of periodontal disease and enhanced oral cancer screening [3,4]. AI-assisted restorative procedures reduced variability and improved precision [5].

Conclusion: AI is reshaping dentistry by bridging academic research with clinical practice. Its integration promises equitable access to advanced diagnostics, improved patient outcomes and a redefined educational framework for future dental professionals.

Key words: artificial intelligence; dentistry; clinical case reports; digital diagnostics; oral healthcare transformation; predictive analytics

Introduction

Dentistry is undergoing a digital revolution, with AI at the forefront. Systematic reviews confirm AI's diagnostic accuracy across specialties, particularly in radiographic interpretation [1]. Case reports highlight its role in early disease detection, predictive modeling, and patient engagement [2]. This article explores these innovations, contextualizing them within clinical case applications, while addressing ethical and educational implications. The integration of AI into dentistry is not merely technological but philosophical: it redefines the clinician's role from reactive treatment provider to proactive health strategist. This paradigm shift requires careful evaluation of case-based evidence, ethical frameworks, and educational reforms.

Methodology

A narrative review was conducted using PubMed, Scopus, and Web of Science databases. Inclusion criteria:

- Publications between January 2024–March 2025.

- Case reports, systematic reviews, and meta-analyses on AI in dentistry.

- Clinical applications in diagnostics, treatment planning, or patient engagement.

Exclusion criteria included purely theoretical AI models without clinical validation and studies lacking peer review.

Case Applications

1. Caries Detection

AI-enhanced radiographs identified incipient lesions with higher sensitivity than conventional methods. A 2025 meta-analysis reported diagnostic accuracy of 92% compared to 78% for human clinicians [1]. Case reports demonstrated reduced false negatives particularly in early enamel lesions.

2. Periodontal Disease Prediction

Machine learning models predicted disease progression enabling preventive interventions. Case studies demonstrated predictive accuracy of 85% in identifying patients at risk [2]. This allowed clinicians to tailor preventive strategies reducing long-term morbidity.

3. Oral Cancer Screening

AI-driven image recognition systems detected precancerous lesions with high specificity in clinical settings. A multicenter trial in 2024 reported sensitivity of 93% [3]. Case reports highlighted AI's ability to detect subtle mucosal changes often missed by clinicians.

4. Restorative Dentistry

AI-assisted crown placement improved accuracy and reduced procedural variability. Case reports confirmed reduced chairside time and enhanced patient satisfaction [5]. Digital workflows integrated with AI algorithms ensured precision in prosthodontics.

Discussion

Clinical Impact

- Diagnostic Accuracy: AI reduces human error and inter-clinician variability.
- Efficiency: Shortens chairside time and enhances workflow.
- Patient Engagement: Builds trust through transparent, data-driven care.
- Education: Equips future dentists with digital competencies.

Ethical Considerations

- Data Privacy: Patient data must be safeguarded [6].
- Bias: Algorithms must be validated across diverse populations [7].
- Accountability: Clinicians remain responsible for final decisions.

Future Directions

- Multi-center trials to validate AI tools.

- Integration with hospital management systems.
- Equitable access in resource-limited settings.
- Development of AI curricula in dental education.

Conclusion

AI in dentistry represents a paradigm shift from reactive treatment to proactive, predictive care. Clinical case reports confirm its transformative potential, positioning AI as a cornerstone of modern dental practice. Future research should focus on multi-center trials, integration with hospital systems and equitable access.

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