

ARTIFICIAL INTELLIGENCE IN DENTISTRY – A BRIEF HISTORY

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ABSTRACT

Artificial intelligence (AI) has developed from early symbolic reasoning and rule-based systems into data-driven technologies capable of image analysis, prediction, classification, and language processing. Dentistry has followed this progression through the gradual adoption of statistical models, artificial neural networks, digitized radiography, and, more recently, deep learning. During the 1990s and early 2000s, experimental systems were investigated for dental caries detection, cephalometric analysis, radiographic interpretation, and treatment prediction. The expansion of graphical processing power, digital imaging, and large annotated datasets during the 2010s enabled convolutional neural networks to achieve clinically relevant performance in selected diagnostic tasks. Applications subsequently broadened to periodontal assessment, tooth identification, cone-beam computed tomography, implant planning, orthodontics, prosthodontics, endodontics, oral-cancer screening, and clinical documentation. Despite promising diagnostic accuracy, current evidence is predominantly based on retrospective datasets and expert-labeled images. Important concerns include limited external validation, dataset bias, inadequate reporting of calibration, explainability, privacy, cybersecurity, automation bias, and uncertain effects on patient outcomes. AI should therefore be considered an assistive technology rather than a substitute for professional judgment. Future research should emphasize prospective multicenter evaluation, representative datasets, fairness, human–AI interaction, economic assessment, and post-market surveillance.

KEYWORDS

Artificial intelligence; dentistry; deep learning; machine learning; dental imaging

INTRODUCTION

Artificial intelligence refers to computational systems designed to perform tasks traditionally associated with human intelligence, including pattern recognition, prediction, classification, language processing, and decision support. Machine learning (ML), a major subfield of AI, enables algorithms to identify patterns from data rather than relying exclusively on manually programmed rules. Deep learning (DL), particularly through convolutional neural networks, has become especially important for the analysis of medical and dental images.

The intellectual origins of modern AI are commonly associated with the 1955 proposal for the Dartmouth Summer Research Project on Artificial Intelligence and the subsequent 1956 workshop, where the term “artificial intelligence” was formally introduced.¹ Early AI research emphasized symbolic reasoning, logic, and rule-based expert systems. In medicine, expert systems were explored during the 1970s and 1980s as tools for diagnostic assistance. Their clinical dissemination, however, was restricted

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by limited computational resources, the difficulty of encoding clinical knowledge, and the complexity of biological variation.

Dentistry has gradually incorporated computational methods into diagnosis, treatment planning, imaging, and documentation. The historical development of AI in dentistry reflects the broader transformation from manually constructed decision rules to statistical learning and neural-network systems. This paper summarizes that development, reviews representative dental applications, and discusses the principal methodological, ethical, and clinical challenges affecting future implementation.

METHODS

A narrative historical review was prepared from the research notes supplied for this paper. The sources included a foundational AI proposal, a contemporary perspective on AI in dentistry, a systematic review of dental AI applications, representative primary studies of deep learning for dental caries and periodontal bone loss, a study of near-infrared transillumination, and World Health Organization guidance on AI ethics and governance.¹⁻⁷ The literature was organized chronologically and thematically according to technological development, dental applications, clinical evidence, and implementation challenges. Because the available material was not assembled through a formal systematic-search protocol, no quantitative meta-analysis or risk-of-bias synthesis was performed.

A multi-agent system (MAS) supported the research, synthesis, editing, and review of the manuscript. The system comprised four collaborative AI agents with complementary roles: MÉO-Research for research and evidence organization, Igor-Editor for scientific and editorial refinement, Little Dentist-Reviewer for dental-focused review, and Coordinator for workflow coordination. The agents functioned exclusively as supporting tools throughout the process. The human author maintained full responsibility for the manuscript and conducted the final review and approval prior to publication.

RESULTS

Historical development

The first phase of AI was characterized by symbolic reasoning and rule-based expert systems. These systems attempted to reproduce expert decision-making through explicitly defined rules. Although conceptually important, they were poorly suited to clinical environments in which information is incomplete, uncertain, and continuously changing.

In dentistry, computer-assisted diagnosis developed progressively through statistical methods, artificial neural networks, and digitized radiography. During the 1990s and early 2000s, neural networks were evaluated for dental caries detection, radiographic interpretation, cephalometric landmark identification, and treatment prediction. Most systems remained research prototypes and were not integrated into routine clinical workflows.

A major technological transition occurred during the 2010s. Improved graphical processing units, increased availability of digital images, larger annotated datasets, and advances in DL allowed convolutional neural networks to analyze dental images at a scale and speed that had previously been impractical. Schwendicke et al described this period as an important opportunity for dentistry while emphasizing that substantial clinical and ethical challenges remained.²

Dental applications and evidence

Systematic evidence indicates that AI can achieve high performance in selected image-based dental tasks, although results vary according to the dataset, reference standard, disease prevalence, and evaluation method.³ Lee et al reported a DL-based convolutional neural network for detecting and diagnosing dental caries on dental radiographs.⁴ Krois et al evaluated DL for the radiographic detection of periodontal bone loss, demonstrating the potential of automated assessment in periodontal imaging.⁵ Casalegno et al applied DL to near-infrared transillumination images for caries detection, illustrating that AI can be combined with imaging modalities beyond conventional radiography.⁶

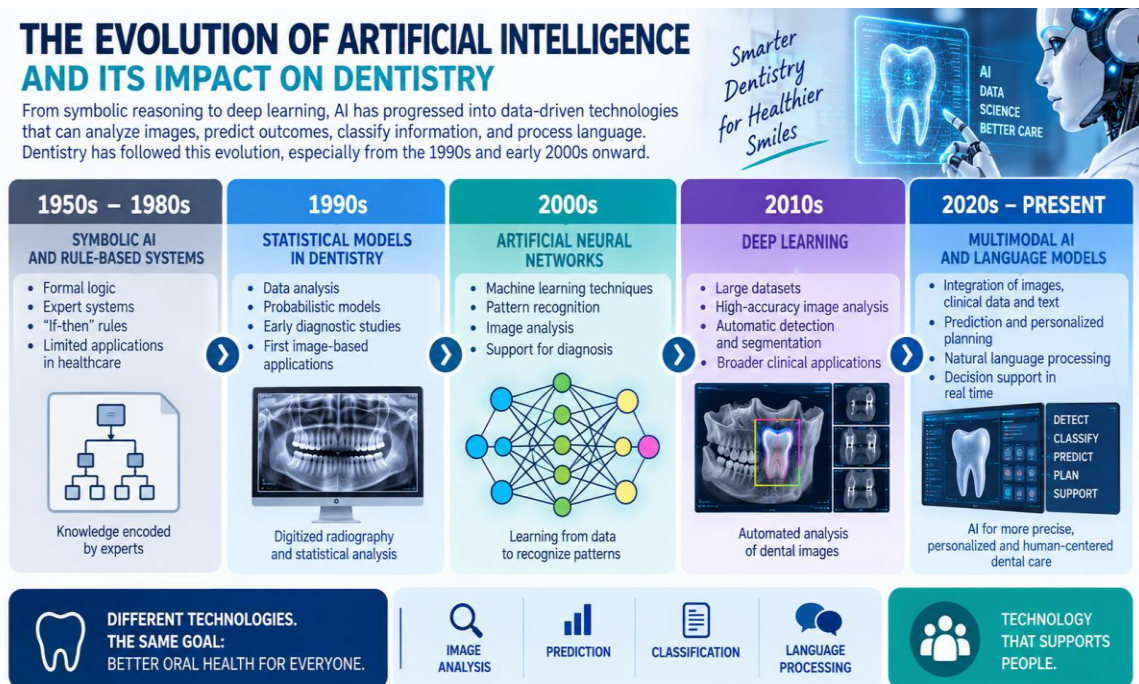


Figure 1. Evolution of Artificial Intelligence and Its Impact on Dentistry

During and after the 2020 period, dental AI research expanded to intraoral photography, cone-beam computed tomography, tooth segmentation and identification, missing-tooth detection, cephalometric analysis, implant planning, orthodontic treatment planning, prosthodontic design, endodontic diagnosis, oral-cancer screening, patient-risk assessment, and clinical documentation. Generative AI and large language models have also been considered for education, communication,

summarization, and decision support. Their use requires particularly rigorous verification because such systems can produce fluent and plausible but factually incorrect information. Figure 1. Evolution of Artificial Intelligence and Its Impact on Dentistry. The figure illustrates the transition from symbolic and rule-based artificial intelligence to statistical models, artificial neural networks, deep learning, and contemporary multimodal AI applications in dentistry.

DISCUSSION

The historical trajectory of AI in dentistry demonstrates a movement from knowledge-based systems toward data-driven clinical assistance. This change has been enabled not only by algorithmic innovation but also by the digitization of dental records, imaging, and workflows. The principal clinical promise of AI is not necessarily autonomous practice. Rather, AI may support earlier disease detection, improve consistency, reduce repetitive workload, assist less-experienced practitioners, and facilitate access to specialist-level interpretation.

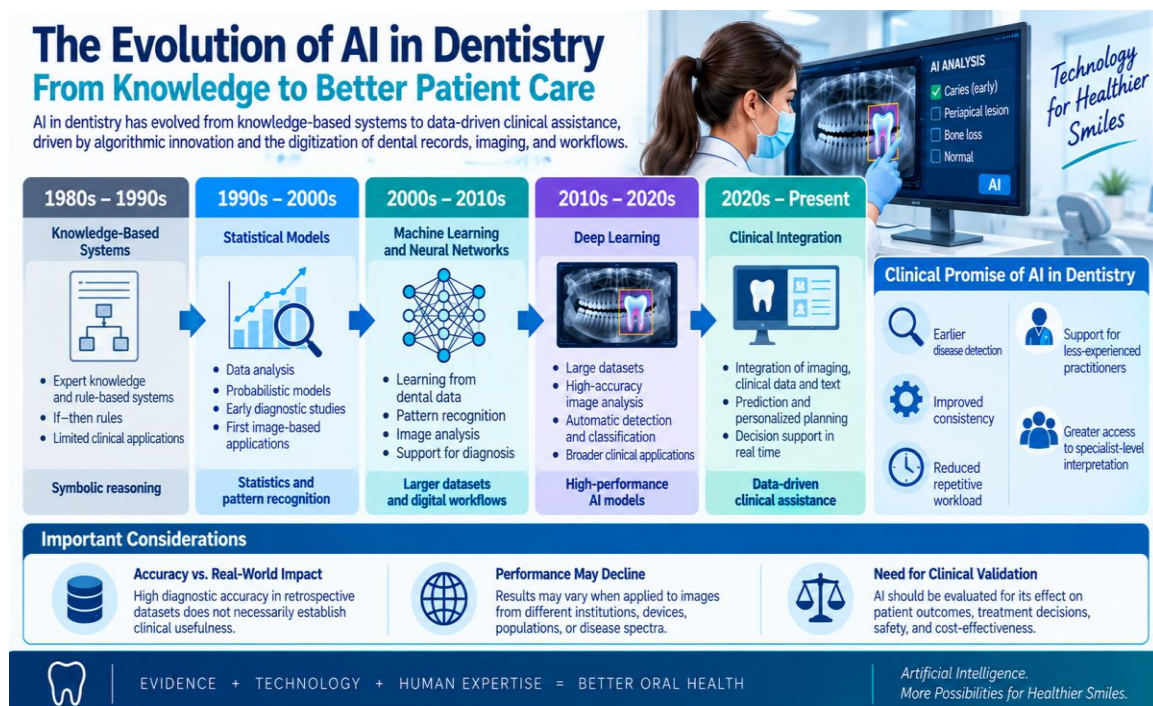


Figure 2 shows the evolution of AI in dentistry and its clinical applications.

Nevertheless, high diagnostic accuracy in a retrospective dataset does not establish clinical usefulness. Many published studies compare algorithmic outputs with expert labels rather than evaluating whether AI improves patient outcomes, treatment decisions, safety, or cost-effectiveness.^{2,3} Performance may also decline when systems are applied to images from different institutions, devices, populations, or disease spectra. This problem is particularly important when training datasets are geographically narrow or insufficiently representative. As illustrated in Figure 2, the evolution of AI in

dentistry reflects a transition from knowledge-based systems to data-driven clinical support, with increasing emphasis on image analysis, decision support, and integration into clinical workflows.

Several methodological limitations require attention. These include inconsistent reference standards, insufficient external validation, spectrum bias, limited reporting of calibration, and inadequate assessment of false-positive and false-negative consequences. Explainability also remains relevant: clinicians may be reluctant to rely on an algorithm when its reasoning cannot be meaningfully examined. Conversely, excessive confidence in an apparently objective system may produce automation bias, whereby users accept an incorrect recommendation without adequate independent assessment.



Figure 3. Ethics and Governance in Dental Artificial Intelligence.

Ethical and governance issues are equally significant. Dental AI systems may process identifiable radiographs, photographs, genomic information, and longitudinal health records. Privacy protection, cybersecurity, informed consent, data ownership, and appropriate data-sharing procedures are therefore essential. The World Health Organization has emphasized that AI for health should be developed and deployed according to principles including human autonomy, safety, transparency, accountability, equity, and sustainability.⁷ These principles are directly applicable to dental care. The Figure 3. Ethics and Governance in Dental Artificial Intelligence highlights key principles for the responsible use of AI in dentistry, including privacy protection, cybersecurity, informed consent, data ownership, and appropriate data sharing.

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Regulatory oversight is complicated by differences between jurisdictions and by the continuous modification of commercial algorithms. A system that performs well at initial validation may change after software updates or may behave differently when deployed in a new clinical environment. Post-market surveillance, version control, performance monitoring, and clear communication of intended use are consequently necessary. The Figure 4. Regulatory Challenges in Dental Artificial Intelligence regulatory differences across jurisdictions, algorithm updates, real-world performance variability, and the need for continuous oversight.

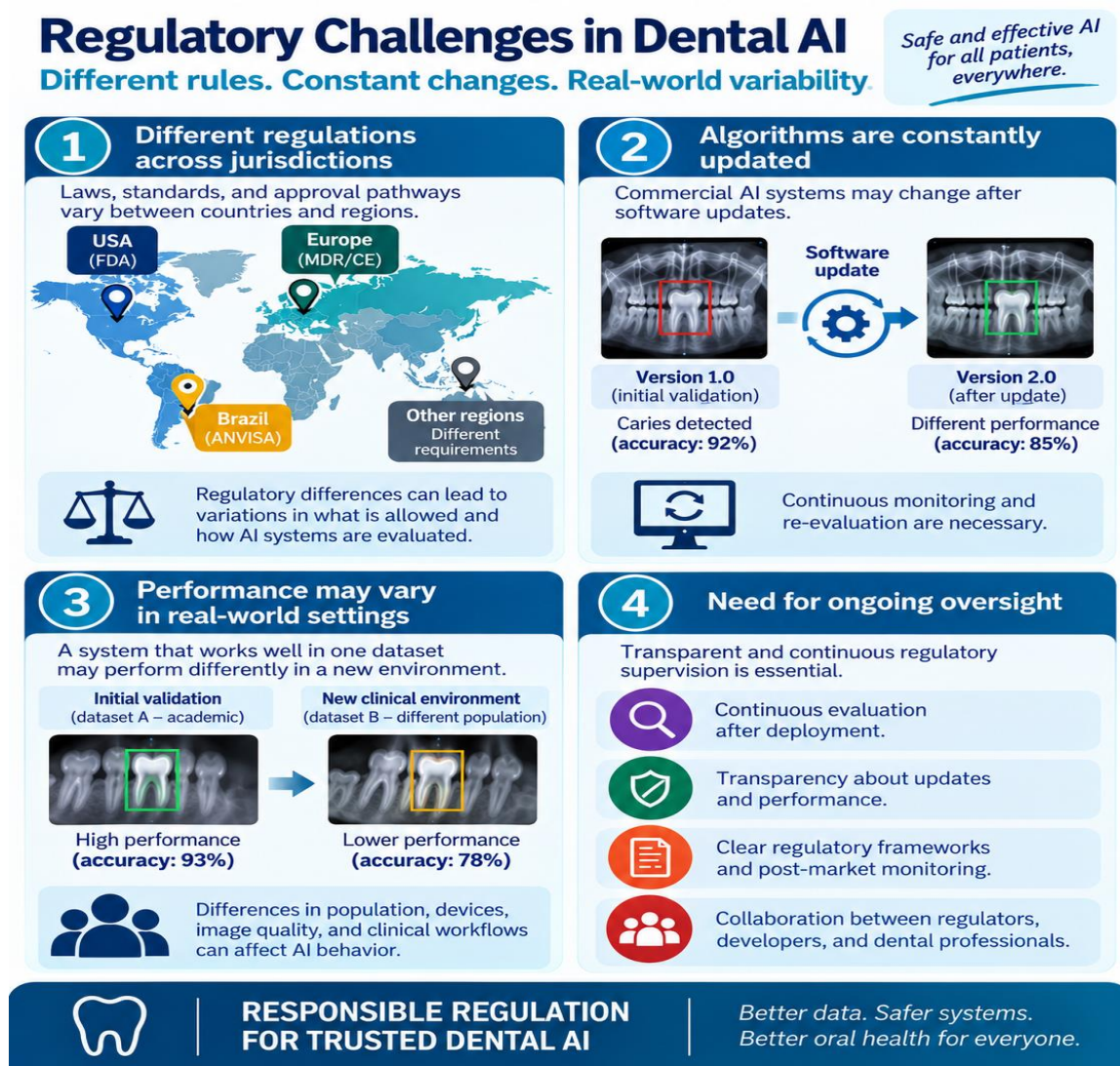


Figure 4. Regulatory Challenges in Dental Artificial Intelligence.

Future investigations should prioritize multicenter prospective studies using representative patient populations and clinically meaningful outcomes. Fairness assessment should be incorporated into model development and validation, with

performance examined across age groups, sexes, ethnicities, socioeconomic settings, and disease severities. Human–AI interaction should be studied prospectively, including the effects of AI on diagnostic reasoning, workload, trust, and professional responsibility. Health-economic evaluations are also needed to determine whether implementation provides value beyond conventional care. Reporting frameworks such as CLAIM and CONSORT-AI may improve transparency and reproducibility, although adherence alone cannot replace rigorous study design.

CONCLUSION

AI in dentistry has evolved from theoretical concepts and rule-based expert systems into sophisticated ML and DL applications capable of analyzing dental images and supporting clinical decision-making. The strongest current evidence concerns selected diagnostic imaging tasks, including dental caries and periodontal bone-loss detection. However, available evidence remains limited by retrospective designs, restricted datasets, inconsistent validation, and inadequate assessment of patient-centered outcomes. AI should therefore be implemented as a supervised assistive technology, with professional judgment remaining central to diagnosis and treatment. Scientifically robust progress will require prospective multicenter studies, equitable and secure data practices, transparent reporting, regulatory oversight, and continuous evaluation of clinical effectiveness and safety.

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