Artificial Intelligence in Endo, an Overview

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KEYWORDS

• AI • Education • Practice management • Diagnosis • Robotics • Prognosis • Ethics

KEY POINTS

- This article provides an overview of the multiple ways by which artificial intelligence (AI) impacts Endodontics.
- It introduces the reader to this issue of Dental Clinics of North America and guides the reader through the key elements of AI in endodontics.
- AI has the potential to enhance the accuracy, efficiency, and safety of endodontic procedures.
- As the technology matures, it will continue to play a pivotal role in making endodontic care more precise, minimally invasive, and outcome-driven.

There's nothing else in the world...not all the armies...is so powerful as an idea whose time has come

–Victor Hugo, The Future of Man

EVOLUTION OF ARTIFICIAL INTELLIGENCE IN DENTISTRY

The adoption of artificial intelligence (AI) in dentistry, including endodontics, has evolved steadily over the past few decades. Before the current millennium, early systems mimicking clinical decision making (such as MYCIN) showed promise and inspired similar interest in dental applications.[1] As digital technologies began entering dental practice, including digital radiography, intraoral cameras, electronic health records, and practice management software, interest in using computers for diagnostic support grew. Some rudimentary rule-based systems for diagnosing periodontal disease, pulpal status, and caries were explored.[2–4] This increase in interest led to the

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Dent Clin N Am 69 (2025) 473–477

https://doi.org/10.1016/j.cden.2025.05.009 dental.theclinics.com

0011-8532/25/

Abbreviations	
AI	artificial intelligence
ADA	American Dental Association
CBCT	cone-beam computed tomography
2D	2-dimensional
3D	3-dimensional

incorporation of algorithms into computer-aided dental technologies like computer-aided-design (CAD)/computer-aided-manufacturing (CAM), which laid the groundwork for AI applications.

In the early 2010s, large amounts of digital data, especially radiographic information, were available to train AI models in a process termed Machine Learning. This enabled computers to learn from data and make decisions or predictions without following explicit instructions. It involved algorithms that identified patterns in data and improved their performance over time through experience. AI models began to be trained on large data sets of dental radiographs to assist in detecting dental caries, periodontal bone loss, and periapical lesions with increasing accuracy. AI algorithms, especially convolutional neural networks, can achieve higher accuracy in interpreting panoramic radiographs, cone-beam computed tomography (CBCT) scans, and intraoral images.[5–8]

AI-powered applications designed to detect dental disease in radiographs usually start with automated segmentation, a process of outlining and delineating the boundaries of individual teeth. A query for "automated tooth segmentation" on PubMed identified 448 publications (Fig. 1). The sheer number of publications on tooth segmentation alone exemplifies the exponential growth in AI for dentistry. These include applications for panoramic radiographs, periapical radiographs as well as CBCT images. A systematic review and meta-analysis on the accuracy and time efficiency

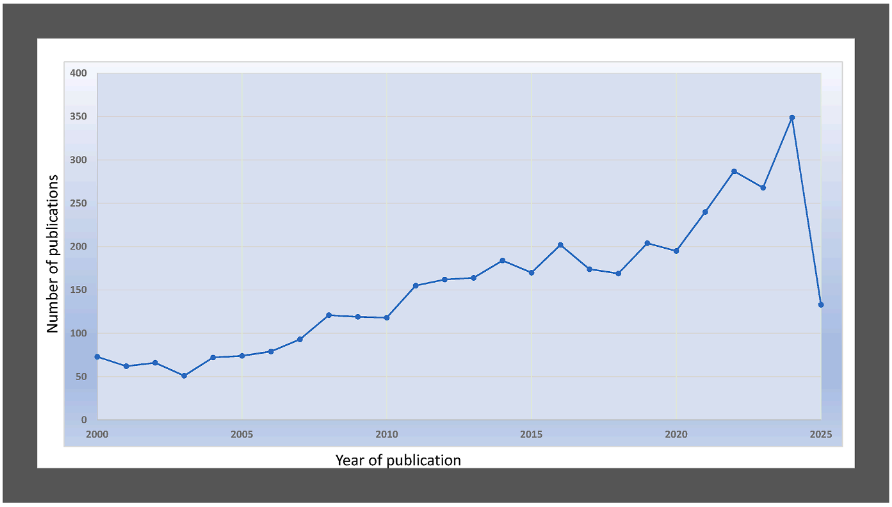

Fig. 1. PubMed indexed publications on tooth segmentation. A query was made in the PubMed database on April 30, 2025, using the terms "tooth segmentation NOT (review [publication type])". The search was limited to publications in the years 2000 to 2025. An exponential increase is seen in the number of publications on tooth segmentation. The apparent drop in numbers in 2025 is because the search was limited to the first 4 months of the year alone. (*Data from* Pubmed.)

for tooth segmentation in CBCT images reported that pooled Dice similarity coefficient score was 0.95 (95% CI, 0.94–0.96).[9] The time required for segmentation ranged from 1.5 seconds to 3.4 minutes.

From early diagnostic algorithms to today's advanced 3-dimensional (3D) imaging and predictive models, AI has revolutionized nearly every area of dentistry. Several AI-powered platforms are being developed for dental applications, such as automated caries and pathologic condition detection and periodontal disease assessment. As data availability and computing power continue to grow, AI is poised to become a central part of how dentists diagnose, plan, and deliver care—making dental treatments more *accurate, efficient, and personalized* than ever before.

ENDODONTICS AND ARTIFICIAL INTELLIGENCE

Endodontics deals with the diagnosis and treatment of diseases of the dental pulp and periapical tissues—often involving complex anatomic variations, subtle pathologic conditions, and high diagnostic demands. Traditional diagnostic methods, such as 2-dimensional (2D) periapical radiographs, clinical testing, and visual examination, have limitations in sensitivity and specificity. The emergence of AI and advanced imaging technologies (especially CBCT) has created opportunities for more precise diagnosis, improved treatment planning, and enhanced procedural outcomes in endodontics. As with patient care, this issue begins with an article on the role of AI in improving endodontic diagnosis written by Drs Thakkar and Mominkhan. They discuss the potential role of AI in improving the accuracy of clinical tests as well as the interpretation of 2D and 3D radiographs.

This role of AI-assisted interpretation is further discussed in the article titled "Cone-Beam Computed Tomography in Endodontics: Revolutionizing Endodontic Diagnosis and Treatment" by Drs Fayad and Villa-Machado. They discuss the use of AI E-VOLDXS, an AI system that allows for a more accurate interpretation of radiographic images. This is a promising approach to assist the busy clinician, especially given the increased incidence of cracked teeth.[10] The article also describes the use of 3D images to create stents for the orthograde location of calcified canals in nonsurgical endodontic treatment and surgical stents that allow more refined access to the root apex in an anatomically challenging area.

Another step is taken forward in the article, "Microrobotics in Endodontics: A Revolutionary Approach to Root Canal Treatment and Nanozymes," by Drs Jaruchotiratanasakul, Tran, Steager, Koo, and Karabucak. Biofilms and complex root canal anatomy continue to remain a challenge in the chemomechanical debridement of the root canal system. Magnetically actuated microbots show promise to navigate complex root canal anatomies. This coupled with nanoparticles that exhibit enzyme-like behavior to degrade biofilms has the potential to revolutionize the practice of endodontics.

Prognosis of endodontic treatment remains a concern for both the practitioner and the patient. The article by Drs Zebouni, Shirodkar, Ather, and Sarkis dives into the use of AI in predicting treatment outcomes. Perhaps this is an area that best elucidates the mechanisms of AI. Data-driven machine learning requires vast amounts of data for the program to sift through to come to a decision. The quality and amount of data are paramount to the outcome of the program. The use of AI in prognosis for case difficulty, caries management, regenerative procedures, surgical, nonsurgical, and even postoperative flare-ups is detailed.

The impact of AI is not limited to clinical endodontics alone. In the article titled "Practice Management: Artificial Intelligence in Marketing—An Application for Dental Practices," Ms FitzSimmons explains how AI can increase efficiency in dental offices. She presents the different ways by which AI improves marketing. It can be used to develop our marketing message, measure its effectiveness, and even modify the message for individual patients. Although it might seem counterintuitive, the use of AI can personalize patient care while automating tasks and thus reducing the administrative burden.

A major factor hindering broader AI adoption in dentistry is the limited availability of high-quality, structured, and comprehensive data. In the article on Artificial Intelligence and Ethics in Endodontics, Drs McCarthy and Elster discuss how crucial the source data are. There are also important ethical questions to be addressed, including those around data privacy, individual rights, and the need for human oversight. Although the American Dental Association (ADA) and other regulatory organizations are working on standards, there is no set of accepted standards addressing this issue. However, the ADA Code of Ethics does put a burden on practitioners.

The effective implementation of any new technology requires education on how to use it. This is covered in 2 articles titled, "Shaping the Clinician I: Virtual Reality and Augmented Reality Use in Teaching Endodontics" and "Shaping the Clinician II: Artificial Intelligence–Taught Endodontic Skills," by Drs Hsu, Iqbal, Zaman, Chatha, and Hebert. AI-based technology evolves very rapidly, and as a result, it is being learned by both educators and students simultaneously. These articles describe how AI can (and potentially will) be used in dental education. AI should allow for easier standardization of teaching methods and can allow for more personalized learning for the students. Interactive AI programs also allow instant feedback regardless of the time of day or availability of an instructor. Virtual reality allows for nonclinical education and the development of skills from a rudimentary level and readiness toward clinical care.

AI-based applications are now entering a phase of steep growth, and we are obligated to look forward. In their article titled, "On the Horizon: What's Next for Endodontics," Drs Isufi, Deriu, Shah, and Pasqualini delve into potential AI applications. The expansion of AI to its use in MRI and optical coherence tomography hold promise to further our ability to diagnose. Avatars also hold promise to test treatments before evaluating them in patients and to attain technical competence before treating patients. Robotics are also discussed, as they have the potential to make our procedures more efficient.

Dr Tung Bui takes the concept one step further and looks Beyond the Horizon. In this forward-thinking article, he explains how our recent advances may evolve into new and intriguing areas, such as augmented reality/virtual reality (AV/VR) technology, and regenerative and genetic technologies as well as robotics, neural operators, anti-USAG-1 therapy, and CRISPR-based gene editing.

SUMMARY

The AI revolution in health care is now entering a phase of steep exponential growth. AI in endodontics is no longer a far-in-the-future concept—it is actively transforming how clinicians diagnose, plan, and deliver care. By combining CBCT imaging, 3D rendering, navigation systems, and predictive models, AI has the potential to enhance the *accuracy, efficiency, and safety* of endodontic procedures. As the technology matures, it will continue to play a pivotal role in making endodontic care more *precise, minimally invasive, and outcome-driven*.

CLINICS CARE POINTS

- AI has the potential to impact all aspects of Endodontics including diagnosis, prognosis determination and treatment.

- AI also impacts practice management and will continue to play a greater role in increasing the efficiency of endodontic practices.
- AI will potentially impact dental education including both pre- and post-doctoral education.

FUNDING

Dr Khan: This work has been supported by The National Institutes of Health, under Project Number 2R44DE027574-02A1.

DISCLOSURE

S. Chogle and M.B. Desrosiers have no conflicts of interest to disclose. A.A. Khan has an ongoing collaboration with Kitware, Inc, on projects using AI to improve diagnoses.

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