



## The Future of Artificial Intelligence in Specialty Dentistry: The Benefits, Challenges and Considerations of the Use of AI in Endodontics

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### Abstract

AI can be valuable in aiding endodontic procedures by analyzing dental imaging to accurately detect periapical lesions with active infections, identify complex root anatomy, quickly determine a correct working length measurements, predict any potential complications and ultimately improve treatment planning. This article explores the role of AI in endodontic treatment, how AI affects the prognosis, successful dental outcomes and the challenges faced by dental providers once this platform is further integrated into practice.

**Keywords:** Artificial Intelligence; Analyze Root Fractures; External Cervical Resorption; SSL; Ann Platforms

### Introduction

Since its emergence in the dental field, Artificial Intelligence (AI) has had a transforming effect on the diagnostic methods and treatment modalities in endodontics. Endodontics is a constantly evolving field and AI has proven to be highly beneficial in the analysis of root canal anatomy, detecting periapical lesions in early stages as well as providing accurate working-length determination [1]. Additionally, AI can also effectively predict the success of a treatment after the identification of a disease process, such as caries, pulpal inflammation and root fractures. AI has also had the ability to efficiently identify landmarks and neoplastic lesions in cone-beam computed tomography scans with excellent accuracy. Important to note, is that while AI has significantly assisted in the accuracy of endodontic procedures, confirming the reliability of AI for a broader use in daily clinical practice for all specialties in dentistry should be a priority in implementing its use. Additionally, issues of patient privacy, data security and potential biases to patients needs to be examined to ensure responsible implementation of this tool in dentistry.

### Discussion

Recently, the field of endodontics has witnessed revolutionary changes through the integration of AI in diagnosing complex dental conditions. It has been observed that AI can be useful in image analysis in endodontics and can accurately analyze cone-beam computed tomography (CBCT) scans to identify the number of canals present, and the presence of the curvature of roots. These two factors are crucial to dental providers when preparing canals for endodontic treatment and are indicative for a positive prognosis of an endodontic case [2].

AI presently have two computational models: Self Supervised Learning (SSL) and Artificial Neural Networks (ANN). The SSL model allows the AI to learn on its own, based on how much data it is exposed to, and with ANN platforms, the AI behaves similarly to our own brains, where data sets can grow once new tasks are mastered. When operating within an endodontic realm, AI algorithms can be used to detect signs of infection around the surrounding periodontium of teeth roots on radiographs, which allows for earlier diagnosis and treatment[3]. Additionally, where cracks and fractures can be missed by the human eye during routine examinations, AI has the ability to accurately identify these types of phenomena [3].

When considering working length determination, AI can automatically calculate the ideal depth needed in the canal preparation based on the image analysis, which can reduce the risk of procedural errors. Predicting case difficulty is another benefit of AI, as patient data can be identified and the complexity of the root canal procedure predicted. This can allow for better informed treatment decisions by providers and allow patients to understand better what their specific case entails. Real-time feedback on instrument location when in canals during treatment is also possible with AI, which offers guidance to additionally reduce errors in rendering endodontic treatment. AI also has the ability to analyze the forces applied during canal preparation, which can alert dental providers on the possibility of tissue damage, vertical root fractures and instrument breakage [3-5].

When looking at how AI can enhance the detection of endodontic infections, dental providers traditionally evaluate the surrounding periodontium radiographically to diagnose pulpal pathoses. Radiographic evaluations usually are performed with a focus on external cervical resorption (ECR) which presents as an invasive type of resorption originating from periodontium that can progress through a non-linear pattern at a slow pace [4]. Differentiating ECR from other pathologies such as periodontal disease or caries on radiographs can be challenging. Its asymptomatic nature, variability in its physical symptoms with affected patients and difficulty in its detection has made ECR a focal point for applying AI technologies [4].

**Challenges: Data availability, interpretation and regulatory and ethical considerations**

The potential for AI to single handedly revolutionize endodontic practice is far reaching. This continued integration of AI into

endodontics presents several challenges that must be considered. These hurdles are complicated and encapsulate technical, ethical, regulatory and larger domains such as government.

**Data availability**

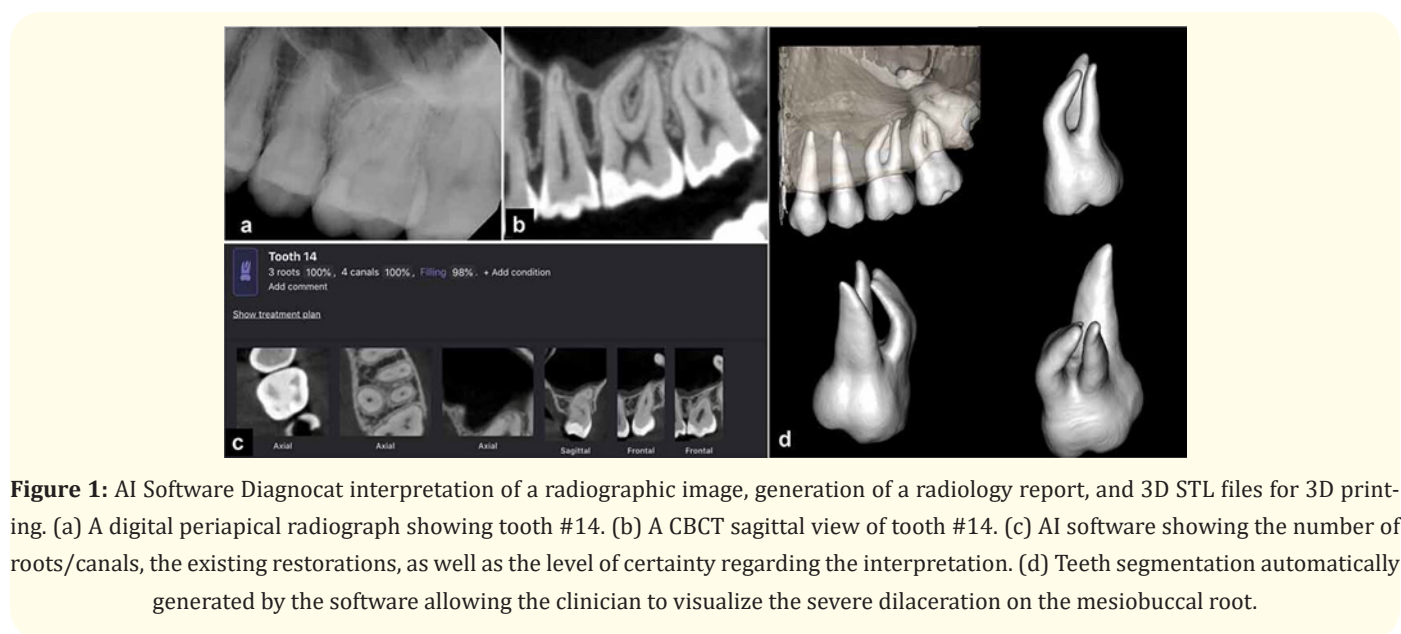
A tenet of effective AI models lies in the availability of well-established, varied and large datasets. In endodontics, when looking at conditions such as ECR, having enough labeled data available for access to dental providers poses significant challenges. The process of acquiring and harvesting data sets is costly and very time consuming [6].

**Interpretation**

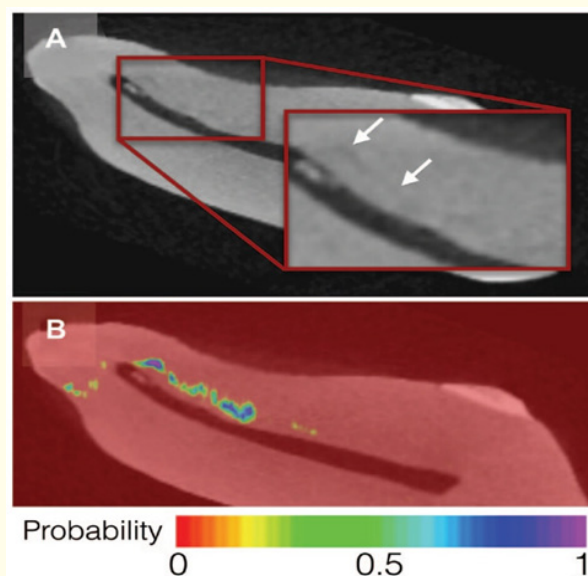
Another challenge lies in the interpretation of AI of datasets. For dental providers to trust information from AI platforms, they must first understand that AI uses algorithms from several models to produce the information that is relayed to dental providers during treatment. These outputs of information are used in the decision-making process of the AI during dental treatment. AI models must strive to excel not just in performance, but also be capable to explain their reasoning in terms that dental providers can clearly understand [7].

**Regulatory and ethical considerations**

Complex regulatory and ethical considerations arise with the use of AI in dental practice. Dental providers must ensure patient safety and privacy of their health information, obtain informed consent for the use of patient data sets and navigate regulatory approvals for the use of AI in diagnoses of dental treatment. When there is uncertainty or errors in dental treatment, the ethical implications for AI use must be addressed to ensure that patient care remains the priority of the use with any AI platform [8].



**Figure 1:** AI Software Diagnocat interpretation of a radiographic image, generation of a radiology report, and 3D STL files for 3D printing. (a) A digital periapical radiograph showing tooth #14. (b) A CBCT sagittal view of tooth #14. (c) AI software showing the number of roots/canals, the existing restorations, as well as the level of certainty regarding the interpretation. (d) Teeth segmentation automatically generated by the software allowing the clinician to visualize the severe dilaceration on the mesiobuccal root.



**Figure 2:** Crack detection with AI: the probability of a crack present. (A) Original tooth volume. A strong crack (left) and a subtle crack (right) are indicated by 2 arrows. (B) Probability map overlay. Values are interpolated from 0 (red) to 1 (purple). The larger crack shown in purple indicates a strong probability (value = 1), while the subtle crack is shown in green (value = 0.6).

## Conclusion

The future of endodontics is promising, with AI transforming dental care characterized by precision, efficiency, and innovation. Consider a future where AI algorithms easily analyze radiographs and CBCT scans, not only identifying complex root canal anatomy and treatment challenges but also flagging radiographic defects such as ECR or dilacerated roots that can be overlooked by the clinician due to difficulty in their detection. This advanced diagnostic support allows endodontists to adapt approaches for each unique endodontic case.

AI with different models and algorithms can assist dental providers diagnose endodontic infections with greater accuracy and identify anatomic anomalies easily. In saying this, it must be stressed that more emphasis on the use of AI, and provision of evidence-based guidelines along with AI models that other endodontists can easily implement into their practices is still needed [9]. AI presents an improvement to patient care that exponentially improves how dentists can treatment plan and customize outcomes for their patients with the ability of AI platforms to predict the likelihood of post-operative pain, allowing for better pain management strategies. The principal function of AI when it was designed was for it to serve as a tool to supplement human capa-

bilities, and not replace them altogether. In endodontics, AI has the unique ability to automate mundane tasks, enhance diagnostic accuracy and predict success rates of endodontic cases. But these advancements are reliant on the integration of high-quality data sets from thorough research, unique algorithms and most importantly, the inclusion of the knowledge and expertise of the endodontic dental provider. Therefore, it is of supreme importance for practicing endodontists to be part of robust research and development of AI platforms for future integration into practice [10].

With the emergence of AI into practice, there has been a significant shift towards artificial and data-driven decision-making in the field of endodontics. By utilizing high quality datasets and progressively learning from each interaction, AI can identify patterns in endodontic conditions that could escape the most experienced practitioner. In research, AI opens new avenues for innovation and can guide endodontic dental providers to produce more efficient treatment for their patients. As we continue to learn more about this phenomenon of artificial intelligence and how it can function within the context of endodontic treatment delivery, AI should be seen as a valuable tool to enhance clinical decision-making, not replace the expertise of the endodontist.

### Declaration of Patient Consent

The authors of this article certify that they have obtained all appropriate patient consent forms. In the form the patient has given consent to the use of their images and other clinical information that has been used. All names and initials will not be published and appropriate measures were taken to conceal identifying information.

### Conflicts of Interest

None

### Financial Support

Nil.

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### Figures

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