Review Article

Artificial Intelligence In The Diagnosis And Treatment Of Dental Root Diseases; A Narrative Review

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Abstract

This narrative review explores the transformative impact of Artificial Intelligence (AI) on the diagnosis and treatment of dental root diseases. While AI models have yet to directly perform therapeutic procedures, their significant influence is witnessed across various dimensions of dental care. Focusing on endodontics, the integration of AI is examined, encompassing predictive capabilities for postoperative discomfort, enhanced diagnostic precision, and refined treatment planning. Neural network models exemplify the potential of AI to revolutionize dental diagnosis. Beyond predicting pain, AI's broader applications in patient management, diagnostic dentistry, and surgical interventions are discussed, promising to reshape the landscape of dental healthcare. The continuous evolution of AI models tailored for health sciences highlights their potential to elevate dental care standards, presenting a path toward enhanced patient outcomes and innovations in dental diagnostics and treatments.

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Introduction

Endodontics, the branch of dentistry focusing on tooth pulp and surrounding tissues, has undergone transformative changes propelled by technological advancements. Instrumentation innovations, such as rotary endodontics and improved instrument designs, have significantly enhanced efficiency in treating challenging root canals (1). The development of obturation techniques ensures thorough sealing of root canals, contributing to the success of endodontic treatments. Visualization technologies, including magnification tools, play a pivotal role in precise diagnosis and treatment planning (2). The integration of 3D printing technology has revolutionized treatment planning and execution. Additionally, artificial intelligence (AI) applications have emerged to enhance diagnostic accuracy, optimize treatment planning, and improve overall efficiency within the field of endodontics. Collectively, these technological strides have reshaped the landscape of endodontic practice, leading to improved clinical outcomes and patient care (3,4). Root canal diseases, including apical periodontitis and post treatment apical periodontitis, exhibit varying global prevalence. Apical periodontitis is reported to range widely from 7% to 86%, while post treatment apical periodontitis, occurring after root canal treatment, has a prevalence between 10% and 62% (5). A systematic review suggests that approximately 10% of all teeth have undergone root canal treatment (6). The calculated worldwide prevalence of root canal treatment is estimated to be 8.2%. Age-related patterns indicate that patients under 40 years old may show a higher prevalence of pulp disease, while those over 50 years may be more affected by periarticular diseases (7,8). The integration of AI in endodontics has marked a transformative journey. Computer-aided design (CAD) has a longer historical background compared to AI and was used in the therapeutic and diagnostic domains, including dentistry, at an earlier stage (9). In 1989, Mormann & Brandestinni introduced CAD/CAM (computer-aided-design and computer-aided-manufacturing) technology to endodontics in Germany, focused on in-office manufacturing. Over time, the technique was used in endodontics to construct unique posts and cores (10). As technology advanced, CAD/CAM systems combined 3D imaging for accurate treatment planning and specialized endodontic devices, improving root canal procedures (11). The technology helped develop and fabricate endodontic microsurgery surgical guides, making them more precise and less invasive (12). Today, endodontics' digital workflow includes CAD/CAM technology, which improves treatment results, chair time, and patient experiences (13). CAD plays a pivotal role in the field of endodontics, contributing advanced capabilities to treatment planning and navigation (14). In root canal treatment, CAD technology is instrumental for navigating complex canal systems, especially in cases where canals may be obliterated. Utilizing 3D digital mapping, CAD ensures precise navigation during root canal procedures, enhancing treatment outcomes. Moreover, CAD/CAM technology has significantly impacted restorative dentistry by revolutionizing traditional processes (15). This technology enables the creation of custom, patient-specific restorations, and prosthetics without relying on manual techniques (16). The fine milling process of ceramic blocks in CAD/CAM applications ensures the production of dental restorations with exceptional precision. Beyond precision, CAD/CAM dentistry is also notable for its time-saving benefits, digitizing and streamlining traditional manual processes in dentistry (17). While old technologies have contributed significantly to improving the efficiency of dentistry for both patients and healthcare providers, the emergence of advanced AI models has brought about significant changes in the diagnosis and treatment of oral diseases, particularly in tooth root development. Hence, we have chosen to reassess the existing narrative to

examine the role of AI and learning models in the management and diagnosis of dental root diseases.

AI and machine learning in diagnosis

The integration of AI into dentistry has shown significant success in enhancing diagnostic precision. The consistently high accuracy levels reported in these studies highlight the potential of AI to revolutionize dental diagnosis, promising improved patient outcomes and streamlined dental care processes. As this collaboration between AI and dentistry evolves, further innovations and advancements are anticipated in dental diagnostics and treatments.

AI has become an important tool that can either work alone or assist dentists in increasing the accuracy of diagnosing dental root diseases (18).

Xu et al. (2022) have developed and validated an AI-assisted method that can identify the history of root canal treatment by using periapical films. The method involves a pre-processing technique that extracts the regions of interest (ROI) containing root canals. The dataset was expanded using data augmentation to improve the generalization ability. Three machine learning methods, including SIFT-SVM, CNN, and transfer learning, were used to develop models based on the operating characteristic curve (ROC) analysis. These models showed accuracy levels higher than 95%, and the area under the curve (AUC), sensitivity, and specificity of all three machine learning methods were confirmed to be high (19).

In 2019, Hiraiwa et al. conducted a study to evaluate the diagnostic performance of a deep learning system for classifying the root morphology of mandibular first molars on panoramic radiographs. The results of the study showed that the deep learning system had a high accuracy in distinguishing between a single or extra root in the distal roots of mandibular first molars. This new technology has the potential to greatly improve the accuracy and speed of dental diagnosis and could lead to more efficient and effective treatment options for patients (20).

Dentistry has made significant advancements in recent times, including the development of new diagnostic methods to enhance dental care and improve the work of dentists. De Angelis et al. (2022) conducted a study to evaluate the validity and usefulness of a new diagnostic method that utilizes Orthopantomograms and Apox software. The Apox software analyses the panoramic image and automatically detects various dental features such as dental formula, dental implants, prosthetic crowns, fillings, and root remnants. The sensitivity and specificity of this tool were found to be 0.89 and 0.98, respectively, indicating its accuracy and reliability in dental diagnosis (21).

Başaran et al (2022). presented a deep learning model for diagnostic investigations in dentistry. This AI model showed promising results in detecting dental conditions in panoramic radiographs. The sensitivity values for crown, implant, and embedded tooth were found to be particularly high. However, the sensitivity values for pontic, caries, and dental caries were comparatively lower. The accuracy values for pontic veneer, implant, and implant-supported crown were found to be high. However, the accuracy values for residual root, caries, and dental mass were found to be relatively low (22).

It has been reported that the AI tool presented by Gardiyanoğlu et al. (2023) has a high and appropriate diagnostic accuracy (0.99 and 0.99) for detecting the need to fill the root canal and remaining roots (23). Fukuda et al. (2020) have presented a convolutional neural network (CNN) system for detecting vertical root fracture (VRF) in panoramic radiographs, which has been successful in diagnosing dental root diseases. This AI-based tool involves a CNN-based deep learning model that was built to detect VRFs using DetectNet with DIGITS version 5.0. The detection accuracy of this model was reported to be 0.93 (24).

AI in root canal treatment

The impact of AI models on the area of dentistry is quite captivating. Although they are unable to directly conduct therapeutic procedures, they are demonstrating their usefulness in anticipating postoperative discomfort and enhancing many

areas of dental care. The remarkable performance of neural network models in predicting pain and their extensive utilization in dentistry, spanning from diagnosis to treatment planning, serve as exemplary instances of how AI may augment accuracy, effectiveness, and overall patient welfare. The continuous advancement of AI models customized for specific applications in health sciences, namely in the field of endodontics, represents a potential path toward improved dental care standards and the well-being of patients.

In the field of treatment, until today, AI models are not able to directly perform therapeutic operations. Robots have been designed in this field; however, they have not yet reached the operational stage and are still used as an idea. Evidence shows that AI and learning models play an indirect role in the treatment of dental root problems (Figure 1). AI tools have been successfully employed to predict pain after a root canal procedure. Gao et al. (2021) developed a neural network model using the back-propagation (BP) technique to predict postoperative pain after endodontic treatment. The BP neural network model was built using the MATLAB 7.0 neural network toolbox. The accuracy of this model in predicting pain after RCT surgery was found to be 95.60% (25).

AI in dentistry serves to augment the dental treatment procedure. AI can help dentists in several areas including patient management, diagnostic dentistry, prosthetic dentistry, periodontics, orthodontics, and pathology. It can facilitate precise diagnosis, formulation of treatment strategies, and execution of surgical interventions (26). Furthermore, AI may assist in patient care by offering comprehensive data on patients' lifestyles, medical backgrounds, and tele-guided diagnostic support. Moreover, AI may be employed in the production of surgical guides and dental implants, enhancing the accuracy and efficacy of surgical procedures. AI functions as a tool to enhance the precision and effectiveness of dental operations (27).

AI is undergoing remarkable advancements that are reshaping the landscape of endodontic treatments. Convolutional neural networks and other AI models are playing a pivotal role across the entire spectrum of endodontics, from diagnosis and treatment planning to execution and outcome prediction. This integration of AI technologies is significantly enhancing the precision and efficacy of endodontic procedures, ultimately leading to improved success rates. By leveraging AI, practitioners in endodontics can benefit from more accurate diagnoses and enhanced treatment planning, fostering a positive impact on patient outcomes (28). The influence of AI in endodontics also extends to clinical decision-making, presenting practitioners with novel opportunities to refine their approaches and deliver better overall patient care. The ongoing development and performance of AI models tailored for applications in health sciences, particularly within the specialized field of endodontics, underscore the continuous progress and potential transformative impact of AI in advancing the standards of care in dental health (29).

Conclusion

The influence of AI models on dentistry is very interesting demonstrating their usefulness in several areas despite their incapacity to actively perform therapeutic operations. The remarkable achievement of neural network models in accurately predicting postoperative pain and their extensive use in dentistry, spanning from diagnosis to treatment planning, show the ability of AI to enhance precision, efficacy, and overall patient well-being. The continuous advancement of AI models specifically designed for health sciences, notably in the field of endodontics, shows potential for improving dental care standards and augmenting patient well-being. Moreover, the incorporation of AI into the field of dentistry has proven to be highly effective in improving the accuracy of diagnoses, as evidenced by consistently high levels of precision recorded in various research. The partnership between AI and dentistry is positioned for more

breakthroughs and progress, offering a significant and revolutionary influence on dental diagnoses and treatments in the changing healthcare environment.

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SM, AD conceptualized the study objectives and design. SM, AD are infectious disease specialists who contributed to data collection from patients along with SM, AD drafted the study design protocols to be submitted to research centers. Data were was analyzed by SM, AD. Manuscript was drafted by SM, AD. All authors contributed in revisions.

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None

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Tables/ Fig

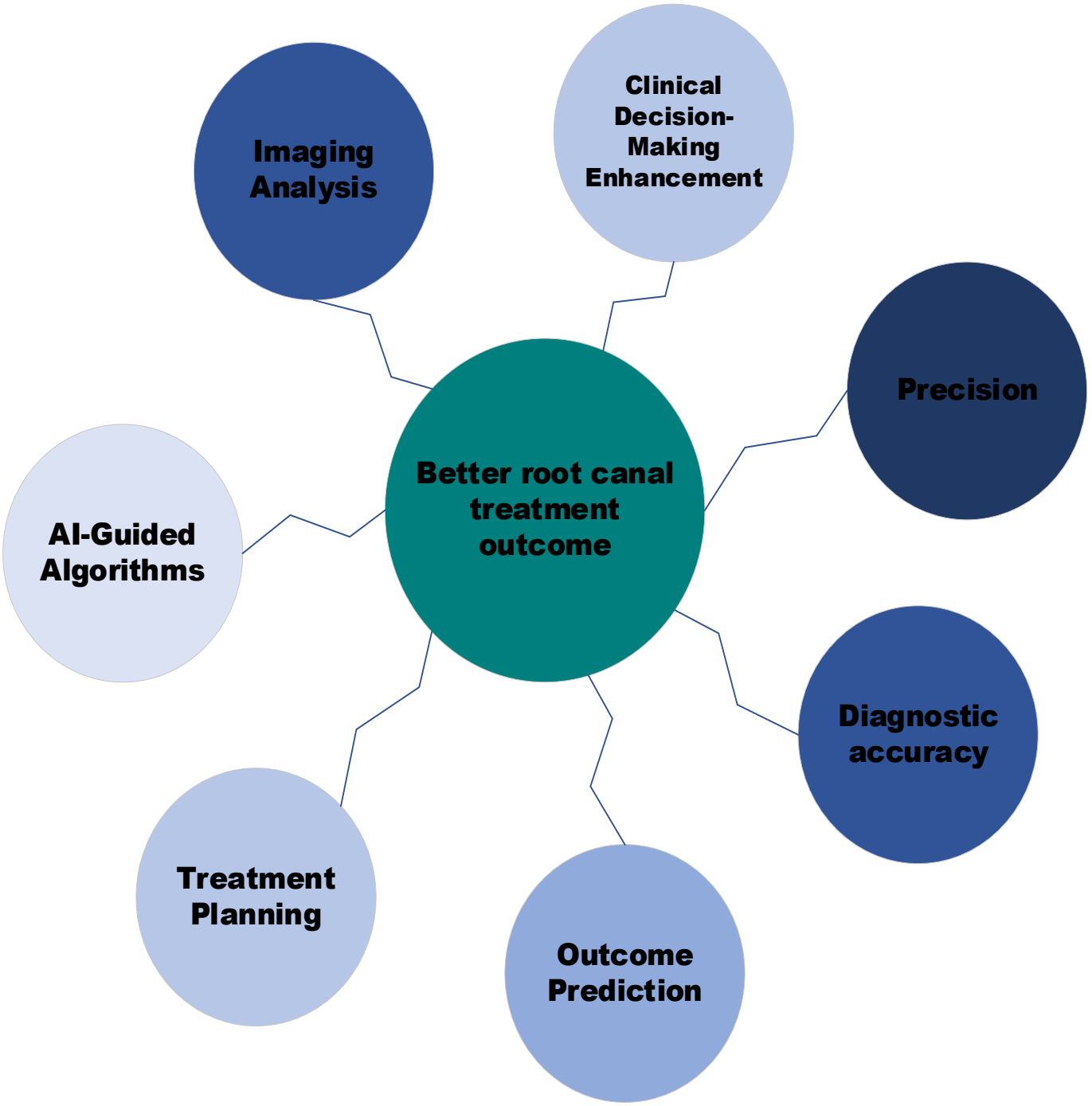

Figure 1. Indirect effect of AI in increasing treatment success