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EXISTING AND EMERGING APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN ENDODONTICS

Dentistry

Dr. Sathish Sankar* Reader Department Of Conservative Dentistry And Endodontics Adhiparasakthi Dental College And Hospital Affiliated To Tamilnadu Dr Mgr Medical University Chennai *Corresponding Author

Dr. Snekha Ganesan Under Graduate Student Department Of Conservative Dentistry And Endodontics Adhiparasakthi Dental College And Hospital Affiliated To Tamilnadu Dr Mgr Medical University Chennai.

Dr. Ravisankar. B Senior Lecturer Department Of Public Health Dentistry Adhiparasakthi Dental College And Hospital Affiliated To Tamilnadu Dr Mgr Medical University Chennai

Dr. Hariharan Sivakumar BDS Department Of Conservative Dentistry And Endodontics Adhiparasakthi Dental College And Hospital Affiliated To Tamilnadu Dr Mgr Medical University Chennai.

ABSTRACT

Introduction: Artificial intelligence (AI) can imitate human intelligence for complex decision-making in healthcare, leading to enormous growth. It has a wide range of applications in dentistry, particularly in endodontics. This paper explores existing AI applications in endodontics and anticipates future developments. **Methods:** We reviewed articles on AI uses in endodontics to get relevant information. **Results:** AI simulations, including convolutional and artificial neural networks, have been beneficial in endodontics for investigating root canal morphology, identifying apical conditions and fractures, as well as estimating working length. Evaluations are used to determine the vitality of stem cells from dental pulp and the effectiveness of retreatment procedures. Scheduling, patient care, drug interactions, prognostic diagnosis, and robotic-assisted endodontic surgery are examples of possible applications for this technology. **Conclusions:** Artificial intelligence can accurately identify, determine, and anticipate diseases in endodontics. AI can enhance diagnosis and therapy, leading to better outcomes. The success of endodontic treatment results. Before implementing AI models in clinical practice, it's important to ensure their trustworthiness, applicability, and cost-effectiveness.

KEYWORDS

Artificial intelligence; artificial neural networks; convolutional neural networks; endodontics

INTRODUCTION

Artificial intelligence (AI) is a division of modern software first described by John McCarthy in 1956. Artificial intelligence (AI) is transforming several industries, including healthcare, by replicating human intelligence with advanced computational systems. AI includes a variety of technologies, including machine learning (ML), deep learning, natural language processing, and computer vision, that allow systems to analyze data, discover patterns, and make predictions or choices. The virtual type comprises mathematical algorithms for diagnosis, prognosis, imaging, osteoporosis, appointment scheduling, drug dosing, interactions, and electronic health records. These skills are revolutionizing several medical sectors, including dentistry.

Endodontics, a specialist field of dentistry that focuses on diagnosing, preventing, and treating dental pulp and root canal diseases, is witnessing the application of artificial intelligence to improve clinical outcomes. The use of AI in endodontics can potentially increase diagnosis accuracy, streamline treatment planning, and optimize clinical workflow. From evaluating radiographic images to predicting treatment outcomes, AI techniques have proven beneficial in dealing with the complexity of endodontic care.

Endodontists may use AI technologies to make better decisions, increase patient happiness, and push the boundaries of dental innovation. Therefore, they need to be up-to-date on AI applications. This study aimed to review the literature discussing AI applications in endodontics, including diagnostic, clinical decision-making, and treatment planning, and identify voids in the field.

MATERIALS AND METHODS:

This review study analyzed published studies on AI in Endodontics: Current Applications and Future Directions. Several databases, such as Pub Med, Science web, google scholar used in adding up most relating article. This included terms like AI, Endodontics, Dentistry. All studies on AI in Endodontics: Current Applications and Future Directions were acquired using this strategy. We included every article on AI in Endodontics: Current Applications and Future Directions. We excluded articles with less procedure and dated. This evaluation contains just the most relevant publications based on our inclusion criteria.

Existing Applications Of Artificial Intelligence In Endodontics:

Diagnosing And Identifying Dental Pathologies:

Radiographic Analysis: AI-powered technology uses dental radiographs to detect periapical diseases, fractures, and root canal defects with high accuracy.

Early Detection: Machine learning methods can identify minor pulp health and inflammation changes.

CBCT Interpretation: Artificial intelligence (AI) helps interpret cone-beam computed tomography (CBCT) data, making complicated anatomical structure recognition faster and more reliable.

Periapical Lesion Detection:

It is a major area in endodontics where AI has the potential to significantly improve diagnostic accuracy and efficiency. AI-powered methods analyze 2D radiographs and 3D CBCT images to detect periapical diseases with excellent sensitivity and specificity. Conventional examinations could miss small or early-stage abnormalities, but these technologies can identify them. AI also enables automatic segmentation of periapical regions, which separates diseased areas from healthy tissues and provides doctors with a clearer picture of lesion size, shape, and extent. Detecting a periapical lesion on a radiograph can vary greatly across examiners, and discriminatory skill depends mainly on expertise. AI systems can decrease variance and bias among examiners. Furthermore, predictive AI algorithms evaluate lesion development and prognosis, which aids in suited treatment planning. Despite its advantages, challenges like variability in imaging quality, the requirement for broad and thorough training datasets, and potential over-reliance on AI must be addressed to maximize its clinical value. Additionally, semiautomated documentation may help dentists save time during assessments, perhaps reducing diagnostic efforts. More investigations required in improving sensitivity of neural network for healthcare applications. The study's main drawback was its potential lack of certain information in the algorithm. As research progresses, AI is poised to become an indispensable tool for the early detection and effective management of periapical pathology.

Identifying Root Fractures:

Identifying fractures in the root is a key difficulty in endodontics due to the limits of traditional diagnostic methods, like periapical radiographs, which frequently fail to show fractures that are concealed by other anatomical features. Vertical root fractures (VRFs), which make up 2%-5% of crown/root fractures, are a severe consequence that may need root resection or tooth extraction. Radiographs and CBCT imaging can detect difficult-to-diagnose VRFs. Uncertainty in diagnosis might lead to unneeded surgeries or tooth extractions. AI has shown the potential to increase diagnostic accuracy by using machine learning algorithms to examine radiographic pictures more precisely. Deep learning models, particularly convolutional neural networks (CNNs), can detect minute fracture lines and patterns that the human eye may miss. These innovations improve early detection, minimize misdiagnosis, and enable more effective treatment planning, eventually leading to better patient outcomes. In another study, a probabilistic neural network was developed to identify VRFs in intact and root-filled teeth using periapical radiographs and CBCT images. The study found that CBCT scans have higher accuracy, sensitivity, and specificity for detecting root fractures than 2D radiography. However, this result was based on an examination of a single-rooted premolar. Subsequent investigations ought to concentrate on the neural network's capacity to detect vertical fractures in the roots of several rooted teeth.

Predicting Postoperative Pain:
Artificial neural networks (ANNs) are widely used in medical diagnosis, prognosis, and decision-making. Future RCTs may benefit patients and dentists due to the ANN's exceptional prediction accuracy depending on the BP algorithm. Continuous refining of measuring methods is projected to improve ANN models' accuracy, leads in better accuracy in forecasting root canal treatment results.

Determination of Working Length:
Endodontic therapy requires accurate working length estimation to provide full cleaning and shaping of root canal system while avoiding over- or under-instrumentation. AI-powered solutions are transforming this procedure by more accurately interpreting radiographic images and electronic apex locator data. Machine learning methods and intense learning models improve the accuracy of recognizing the apical constriction and root canal termination, even in situations with complicated canal anatomy. AI enhances the accuracy and consistency of working length estimation, increasing the success rate of endodontic treatments and lowering the risk of treatment failure.

Saghiri et al. investigated the accuracy of ANN-based working length assessment in a human cadaver model, simulating clinical scenarios. The study observed no significant variation in root length measures between an ANN and real measurements after extraction. They also reported that the ANN (96%) performed superiorly in minor anatomic constriction determination compared with an endodontist (76%) using periapical radiographs. Hence, ANNs can be an accurate way of determining working lengths.

Morphology of Root and Root Canal System:
Understanding the complex morphology of roots and root canal systems is crucial for successful endodontic therapy. Variations in canal shape, curvature, and branching patterns often challenge clinicians during cleaning, shaping, and obturation. AI has emerged as an effective technique for analyzing and diagnosing root canal morphology. Using advanced image processing techniques and machine learning models, AI can analyze cone-beam computed tomography (CBCT) images and other imaging modalities to provide comprehensive, three-dimensional insights into root canal anatomy. These advancements enable clinicians to plan treatments more effectively and reduce the possibility of missing canals or procedural errors.

Predictions:
Predicting The Retreatment: Campo et al. introduced a case-based reasoning paradigm. To predict the results of root canal retreatment without surgery, including the risks and benefits**.** The system indicated if retreatment was necessary or not. The system includes statistics on performance, recall, and statistical probability. The system's ability to accurately predict retreatment outcomes is its main strength. The system's effectiveness was limited by the quality of the data**.** Case-based thinking involves solving issues based on similar past experiences. Retrieving comparable examples allows for the integration of valuable information. Variability and different approaches may lead to system heterogeneity. Future articles should reflect the variability of human approaches and increase sample size to improve sensitivity, specificity, and accuracy.

Estimating the Stem Cells' Viability: Artificial intelligence (AI) is revolutionizing the assessment of stem cell viability, particularly in regenerative medicine and endodontics. By analyzing complex datasets, including cell morphology, genetic markers, and environmental conditions, AI models can predict stem cell health, proliferation potential, and differentiation capacity with remarkable accuracy. Techniques such as machine learning and deep learning facilitate the early identification of non-viable or suboptimal cells, ensuring the selection of high-quality stem cells for clinical applications.

Bindal et al. used the neuro-fuzzy inference method to assess the effectiveness of dental stem cells extracted from the pulp in various regenerative treatments. In a clinical simulation, our approach predicted the result by assessing stem cell survival after being exposed to bacterial lipopolysaccharides. The system of neuro-fuzzy inference predicts cell survival following regeneration treatments with microbial infection. The authors assessed the vitality of dental pulp stem cells following lipopolysaccharide treatment to generate an inflammatory response. The authors evaluated the accuracy of adaptive neuro-fuzzy interferences in predicting stem cell survival following microbial invasion.

For Patient Management: Virtual dental assistants, powered by artificial intelligence, outperform human assistants in terms of accuracy and error margin. Using virtual assistants reduces the need for human assistance, increasing operational efficiency. Their skills cover diagnosis, treatment plan, appointment and management. Robotic assistance provide dentists with useful information regarding patients history, habits. For emergency when dentist is absent, patient can use tele assistance.

Challenges And Limitations Of Current Ai Applications In Endodontics:
Despite its potential, integrating AI into endodontics faces several challenges and limitations. A significant obstacle is the lack of consistent, high-quality datasets for training. AI. Models can lead to performance unpredictability and poor generalizability. Furthermore, the complex structure of root canal systems complicates proper image processing and diagnosis. Ethical considerations about patient data privacy and the interpretability of AI algorithms prevent adoption.

Inform doctors about potential pharmaceutical interactions and therapeutic adjustments based on available information. As people live longer and take more medicines, electronic health records become increasingly important. With access to healthcare data, AI may be able to anticipate patient-specific drug-drug interactions.

Endodontists can provide accurate physical and robotic microsurgical therapy; with implant-related technology, robots that perform oral surgery can aid the operator in properly navigating the implant site. Endodontists may benefit from using the same method for navigation during surgery. Future research should examine the accuracy and safety of robotically guided placements.

Furthermore, the high cost of implementation and the need for physician training in AI technology may act as barriers. Although the provided AI models exhibit promising results, it's important to highlight limitations in experiment. Above all, such models are created using the small amount of datasets for training. To successfully overcome these constraints, In order to train and test AI models, future research should focus on merging a wider range of datasets.

CONCLUSION:
In endodontics, AI might help with clinical applications such as detecting periapical pathosis and root fractures, determining working length, and disease prediction. Before AI is widely adopted into ordinary clinical practice, high-quality evidence is required to evaluate its performance in terms of dependability, applicability, legal and ethical issues, and cost-effectiveness.

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