
Artificial Intelligence as a Clinical Decision-Support System in Endodontic Retreatment: Challenges and Clinical Implications

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Abstract

Artificial Intelligence (AI) is increasingly transforming dental practice, particularly in endodontics, by serving as a clinical decision-support system (CDSS). In endodontic retreatment, treatment planning and prognosis are often complex due to anatomical variations, prior interventions, and the risk of treatment failure. AI technologies, including machine learning and deep learning algorithms, have shown promise in assisting clinicians with accurate diagnosis, risk assessment, and evidence-based treatment planning. However, the integration of AI in clinical practice faces several challenges, including limited high-quality data, ethical and legal concerns, workflow compatibility, and clinician acceptance. Despite these hurdles, the potential clinical implications are substantial, with AI offering enhanced diagnostic accuracy, improved treatment outcomes, and more efficient clinical decision-making. This review explores the current applications, challenges, and future directions of AI as a CDSS in endodontic retreatment, emphasizing the need for validated models and standardized protocols to ensure safe and effective clinical adoption.

Keywords: Artificial Intelligence, Clinical Decision-Support System, Endodontic Retreatment, Machine Learning, Deep Learning, Diagnostic Accuracy, Treatment Planning, Clinical Implications

I. Introduction

Endodontic retreatment is a complex dental procedure often required when initial root canal therapy fails due to persistent infection, anatomical variations, or procedural errors. The success of retreatment heavily depends on accurate diagnosis, treatment planning, and clinician decision-making, which can be challenging due to the variability in tooth morphology and the presence of previous restorations or obturation materials (Kaur, 2021).

Artificial Intelligence (AI) has emerged as a transformative tool in dentistry, offering capabilities to assist clinicians in complex decision-making processes. AI technologies, including machine learning and deep learning algorithms, can analyze large volumes of clinical and radiographic data, detect patterns, and provide predictive insights to support treatment planning (Singh, 2022).

Specifically, AI-based clinical decision-support systems (CDSS) have shown promise in improving diagnostic accuracy, reducing human error, and optimizing treatment outcomes in endodontic retreatment (Kaur, 2021; Chen, Stanley, & Att, 2020).

Despite its potential, the integration of AI into routine clinical practice faces several challenges, including data quality limitations, ethical considerations, and the need for seamless workflow integration (Singh, 2022). Nevertheless, leveraging AI as a CDSS offers significant clinical implications, including enhanced decision-making, improved patient outcomes, and increased efficiency in endodontic retreatment procedures. This underscores the growing importance of AI in modern endodontics and highlights the need for continued research and validation of AI-driven models.

II. AI in Endodontic Retreatment

Artificial Intelligence (AI) has emerged as a transformative tool in endodontic retreatment, addressing the complexities of diagnosis, treatment planning, and prognosis. Machine learning and deep learning algorithms can analyze large datasets of radiographs, patient histories, and clinical outcomes to support clinicians in making evidence-based decisions (Singh, 2022). AI-driven systems assist in detecting periapical lesions, identifying root canal anatomy variations, and predicting the success rate of retreatment procedures, which are often challenging due to prior interventions or anatomical complexities (Chen, Stanley, & Att, 2020).

Clinical decision-support systems (CDSS) specifically designed for endodontic retreatment have demonstrated their potential in optimizing treatment choices. By comparing options such as retreatment versus extraction, these AI tools provide recommendations that enhance diagnostic accuracy and reduce subjective bias in clinical decision-making (Kaur, 2021). Furthermore, AI models can integrate historical data to predict procedural outcomes, estimate risk factors, and improve individualized treatment planning.

The application of AI in endodontic retreatment also extends to workflow efficiency. Automated image analysis and predictive modeling allow clinicians to focus on complex procedural aspects, while AI handles routine diagnostic interpretation. Despite these advancements, successful integration requires careful consideration of data quality, model validation, and clinician engagement to ensure reliable and safe use in everyday practice (Singh, 2022; Chen, Stanley, & Att, 2020).

III. Challenges in Implementation

The integration of Artificial Intelligence (AI) as a clinical decision-support system (CDSS) in endodontic retreatment faces several significant challenges that must be addressed for effective clinical adoption.

1. Data Limitations and Quality Issues

A primary barrier is the availability of high-quality, standardized datasets for training AI models. Endodontic cases often vary widely due to anatomical differences, previous treatments, and radiographic inconsistencies, which can limit the accuracy and generalizability of AI predictions (Singh, 2022). Additionally, many existing datasets are small or institution-specific, making it difficult to develop robust models capable of performing reliably across diverse clinical scenarios (Chen, Stanley, & Att, 2020).

2. Ethical and Legal Considerations

AI applications in clinical decision-making raise ethical and legal concerns. Questions regarding accountability in case of misdiagnosis, patient consent for AI-assisted interventions, and data privacy remain unresolved (Kaur, 2021). Regulatory frameworks for AI in dentistry are still evolving, which may delay widespread implementation and clinician trust in these systems (Singh, 2022).

3. Integration with Clinical Workflow

Effective use of AI requires seamless integration into existing dental workflows. Many AI tools demand specialized software, hardware, or additional time for data input, which can disrupt standard clinical practice and reduce efficiency (Chen, Stanley, & Att, 2020). Resistance from clinicians due to unfamiliarity with AI interfaces and lack of training can further limit adoption (Kaur, 2021).

4. Reliability and Clinician Acceptance

Even with accurate predictive models, AI adoption depends on clinician confidence. The “black box” nature of many AI algorithms makes it difficult for practitioners to understand the rationale behind recommendations, which can reduce trust and willingness to rely on AI in critical treatment decisions (Singh, 2022). Continuous validation, transparency, and clinician education are essential to improve acceptance.

In summary, while AI holds considerable promise as a CDSS for endodontic retreatment, overcoming challenges related to data quality, ethics, workflow integration, and clinician trust is crucial for safe and effective implementation.

Conclusion

Artificial Intelligence (AI) has demonstrated substantial potential as a clinical decision-support system (CDSS) in endodontic retreatment, offering enhanced diagnostic accuracy, improved treatment planning, and the ability to predict treatment outcomes more effectively (Singh, 2022). The integration of AI into clinical workflows can support clinicians in navigating complex cases, minimizing the risk of treatment failure, and optimizing patient care (Kaur, 2021). However, several challenges remain, including the need for high-quality, standardized data, ethical and legal considerations, and ensuring clinician trust and acceptance of AI-assisted recommendations (Chen, Stanley, & Att, 2020). Despite these obstacles, the clinical implications of AI are significant, with the potential to streamline decision-making, reduce errors, and improve overall treatment efficiency. Future research should focus on rigorous clinical validation, development of standardized protocols, and strategies for seamless integration into routine endodontic practice. In conclusion, while AI is not a replacement for clinical expertise, its role as an adjunctive tool in endodontic retreatment holds promise for advancing precision dentistry and enhancing patient outcomes (Singh, 2022; Kaur, 2021).

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