JOURNAL OF DENTAL INNOVATION AND MEDICAL SCIENCES
ideaspringjournals.com

Vol :1 Issue:2 Year:2026

REVIEW ARTICLE

Applications of Artificial Intelligence in Detection of Vertical Root Fractures on CBCT: A Review of Recent Advances

Dr. Koppula Reshma Reddy [1*]

[1] ***MDS 1st year, Conservative Dentistry and Endodontics, Meghana Institute of Dental Sciences, Nizambad***

[*]***Author of Correspondence: Dr. Koppula Reshma Reddy, MDS 1st year, Conservative Dentistry and Endodontics, Meghana Institute of Dental Sciences, Nizambad***

Email: reshmareddy1723@gmail.com

KEYWORDS:
Artificial Intelligence, Cone-Beam Computed Tomography, Tooth Fractures, Deep Learning

Received date-26-06-2026
Accepted date-29-06-2026
Published date -30-06-2026

Citation format- Reddy KR. Applications of artificial intelligence in detection of vertical root fractures on CBCT: A review of recent advances. J Dent Innov Med Sci. 2026;1(2):69–73.

ABSTRACT

Vertical root fractures pose diagnostic challenges in endodontic practice, often mimicking other dental pathologies. Cone-beam computed tomography (CBCT) has enhanced the visualization of dental structures, aiding in diagnosis, although interpretation can be affected by artefacts and observer experience. Recently, artificial intelligence (AI) has shown promise in dental diagnostics, utilizing machine learning and deep learning algorithms to detect subtle features of vertical root fractures on CBCT scans. This technology could improve diagnostic accuracy and reduce variability among observers. The review discusses AI applications in detecting these fractures, evaluates the performance of various deep learning models, and notes the advantages and limitations of AI in endodontics. It also highlights the need for standardized datasets and multicentric validation for successful clinical implementation.

Introduction

Vertical root fracture (VRF) refers to a fracture that runs longitudinally from the root canal toward the surrounding periodontium. It is regarded as one of the most challenging diagnostic dilemmas in endodontics due to the overlap of its clinical signs and symptoms with those of periodontal disease, unsuccessful endodontic treatment, or periapical

lesions [1]. VRFs frequently occur in teeth that have undergone endodontic treatment and can result from factors such as excessive mechanical preparation, forces from obturation, placement of posts, or occlusal stress [2].
Timely and precise identification of VRF is crucial, as delays in diagnosis can result in significant bone loss, ongoing infection, and ultimately, tooth loss [3]. Traditional periapical radiography has been widely utilized for diagnosis; however, its two-dimensional format restricts the ability to visualize fracture lines, especially when they are oriented buccolingually. Cone-beam computed tomography (CBCT) has greatly improved the diagnostic abilities of endodontists by offering three-dimensional imaging with enhanced anatomical detail [4].
Although CBCT offers several benefits, accurately interpreting the images can be difficult due to issues such as beam hardening artefacts, noise, and the often subtle appearance of fracture lines. The diagnostic accuracy can differ based on the experience of the observer and the quality of the images. The swift progress in artificial intelligence (AI), particularly in deep learning technologies, has added a new aspect to the interpretation of radiographic images.AI algorithms can effectively identify complex patterns in images, aiding clinicians in detecting pathological conditions. In endodontics, their use is expanding to tasks such as determining working length and recognizing fractures. Notably, the application of AI in detecting vertical root fractures on CBCT images may enhance diagnostic accuracy and reduce human error. However, interpreting CBCT images can be challenging due to factors like beam hardening artifacts and image quality, affecting diagnostic precision. This review assesses recent advancements in AI-supported detection of vertical root fractures through CBCT imaging [5-7].

Vertical root fractures and diagnostic challenges

Vertical root fractures often occur in teeth that have received endodontic treatment. Clinical signs may include pain during chewing, formation of sinus tracts, localized periodontal pockets, swelling, and tenderness when pressure is applied. However, these symptoms are not specific and could resemble several other dental issues [2].
Radiographic identification of vertical root fractures is frequently challenging. Traditional radiographs may reveal indirect indicators such as halo-shaped radiolucencies, an increase in the width of the periodontal ligament space, or angular defects in the bone. Direct visualization of fracture lines is rare because visibility is contingent upon how the fracture is oriented in relation to the X-ray beam [3].
Cone Beam Computed Tomography (CBCT) has become a more effective imaging technique due to its capability to provide multiplanar reconstruction and three-dimensional views. Hassan et al. showed that CBCT has greater sensitivity in identifying vertical root fractures than conventional radiographs [4]. Nevertheless, CBCT imaging comes with its own limitations. Materials used for root fillings, intracanal posts, and metallic restorations can create artifacts that obscure fracture lines and hinder image analysis [5].
Variability related to the observer adds further challenges to diagnosis. Research has indicated significant differences in diagnostic accuracy among clinicians based on their experience levels. As a result, there is increasing interest in computer-assisted diagnostic tools that could enhance consistency and reliability.

Fundamentals of Artificial Intelligence in Dental Imaging

Artificial intelligence encompasses computer systems that can carry out tasks generally requiring human intellect. A branch of AI known as machine learning allows these systems to learn from data patterns and enhance their performance without needing specific programming. Deep learning, which leverages artificial neural networks with several hidden layers, has gained significant importance in the field of image analysis [6].
Convolutional neural networks (CNNs) are some of the most commonly used deep learning architectures in medical and dental imaging. CNNs are capable of automatically identifying image features and recognizing pathological changes with minimal human input. Their design facilitates the gradual learning of increasingly intricate visual patterns [7].
In the realm of dental radiology, AI systems are developed using extensive datasets of annotated images. Throughout the training process, the algorithm becomes adept at differentiating between normal

anatomical structures and pathological issues such as fractures, lesions, or resorptive defects. After training, the system can assess new images and deliver predictive insights regarding the presence or absence of disease.
The use of AI in the interpretation of CBCT images is particularly beneficial because CBCT produces a significant amount of image data that can be labor-intensive for clinicians to review manually. AI systems can quickly process these datasets and recognize subtle patterns that might be overlooked by human observers.

Artificial Intelligence in Detection of Vertical Root Fractures

In recent years, there have been notable advancements in the AI-assisted identification of vertical root fractures (VRFs) in cone beam computed tomography (CBCT) images. Deep learning techniques have demonstrated promising results in detecting fracture lines across different imaging conditions.
Fukuda et al. explored the application of deep convolutional neural networks for detecting tooth fractures in radiographic images, reporting favourable diagnostic accuracy. Initially, research primarily concentrated on two-dimensional imaging; however, later studies transitioned to fracture detection using CBCT [8]. Johari et al. assessed the diagnostic performance of deep learning systems in recognizing vertical root fractures on CBCT scans and discovered that AI-assisted models exhibited sensitivity similar to that of skilled radiologists [9].
The research underscored the potential of AI in reducing variability that depends on the observer's judgment. A key advantage of AI systems is their capability to detect subtle grayscale differences and structural irregularities that might not be easily noticeable to human observers.
Deep learning algorithms can examine voxel patterns, cortical disruptions, and radiolucencies associated with fractures with impressive accuracy. Setzer et al. pointed out that interpreting CBCT in endodontics requires significant expertise and may still lead to false positives or false negatives due to artefacts. AI systems have the potential to mitigate these mistakes by employing standardized analytical criteria for all images [10].
Multiple studies have also shown the effectiveness of transfer learning methods, where pre-trained neural networks are modified for dental diagnostic uses. Transfer learning decreases the need for very large datasets and enhances computational efficiency. This technique has enabled the creation of AI models specifically tailored for endodontic imaging.

Advantages of AI-Assisted Detection

AI-assisted CBCT analysis presents numerous benefits for diagnosing VRFs. One of the key advantages is enhanced diagnostic precision. Machine learning algorithms can consistently assess intricate image patterns better than human observers and may detect minor fractures that might otherwise go unnoticed.
Another significant benefit is the decrease in observer variability. Human interpretation is affected by fatigue, clinical experience, and personal judgment. AI systems utilize consistent analytical criteria, which improves reproducibility and standardization.
In addition, efficiency is a notable advantage. CBCT datasets contain many slices that need careful review. AI systems can swiftly scan images and pinpoint areas of concern, thereby decreasing interpretation time and optimizing clinical workflow [7].
AI also has educational benefits. Automated detection systems can act as supportive resources for undergraduate students and less seasoned clinicians by directing focus toward potential fracture sites. These tools may enhance diagnostic confidence and support the learning process.
Moreover, integrating AI into radiographic software could provide real-time diagnostic assistance at the chairside. This integration might improve treatment planning and enable clinicians to make prompt decisions regarding tooth preservation or extraction.

Limitations and Challenges

Despite its promising potential, AI-assisted detection of VRFs faces several limitations. One of the major challenges is the availability of large, high-quality annotated datasets. Deep learning algorithms require extensive training data for optimal performance, and acquisition of standardized CBCT datasets can be difficult.
Variability in CBCT machines, voxel sizes, imaging protocols, and artefact levels may affect algorithm performance. AI models trained on one dataset may

not generalize effectively to different clinical settings.

Another concern relates to interpretability. Deep learning systems often function as “black boxes,” providing diagnostic outputs without clear explanation of the underlying decision-making process. This lack of transparency may reduce clinician trust and complicate medico-legal accountability.

Artefacts caused by metallic restorations and root canal filling materials continue to present diagnostic difficulties even for AI systems. While algorithms may reduce interpretive error, they cannot completely eliminate imaging limitations inherent to CBCT technology.

Ethical considerations must also be addressed. Integration of AI into clinical practice requires adherence to patient privacy regulations and secure handling of radiographic data. Furthermore, AI systems should complement rather than replace clinical judgement.

Cost and infrastructure requirements may limit widespread adoption in smaller dental practices. Advanced computational systems and software integration may involve substantial financial investment.

Future Perspectives

The outlook for AI in endodontic imaging looks very promising. Ongoing progress in deep learning models is anticipated to enhance both diagnostic accuracy and computational effectiveness. Collaborative databases from multiple centers may aid in creating more resilient and broadly applicable algorithms.

Integrating clinical data with radiographic assessments in hybrid models could boost diagnostic capabilities. The unification of patient symptoms, periodontal evaluations, and CBCT analysis into comprehensive AI systems may lead to improved diagnostic precision for vertical root fractures (VRFs).

Cloud-based AI solutions could allow for remote analysis of images and tele-endodontic consultations, thereby increasing access to specialized diagnostic services in areas with limited resources.

Explainable AI represents a growing field of interest. Developers are creating systems that can visually pinpoint fracture areas and clarify the reasoning behind diagnostic conclusions. This innovation may enhance the confidence of clinicians and encourage acceptance in clinical settings.

Future investigations should focus on conducting prospective clinical trials, establishing standardized validation processes, and comparing AI systems with expert human evaluators. Additionally, long-term studies assessing real-world clinical impacts are essential.

As AI technologies progress, their integration into standard endodontic practices has the potential to revolutionize diagnostic processes and enhance patient care.

Conclusion

Vertical root fractures present a complicated diagnostic issue in endodontics, even with advancements in imaging technologies. Although CBCT has significantly enhanced the visualization of fractures, its interpretation can still be affected by artifacts and variability among observers. Artificial intelligence, especially through deep learning algorithms, has proven to be a useful complement in the CBCT-based diagnosis of vertical root fractures.

Recent research indicates that AI systems show promising diagnostic accuracy and may help clinicians identify subtle fracture lines more consistently and effectively. The incorporation of AI in endodontic imaging has the potential to improve diagnostic reliability, enhance treatment planning, and minimize unnecessary procedures.

However, there are still several hurdles to overcome, including the standardization of datasets, the generalizability of algorithms, interpretability issues, and ethical considerations. Ongoing research and technological advancements are crucial for achieving broader clinical application.

Artificial intelligence should be seen as a supportive resource that enhances professional skills instead of substituting the clinician's judgment. With continuous progress, AI-assisted CBCT analysis could become a vital part of future endodontic diagnostic practices.

References

1. American Association of Endodontists. Cracking the cracked tooth code: detection and treatment of various longitudinal tooth fractures. Chicago: American Association of Endodontists; 2008.

2. Walton RE, Torabinejad M. Principles and Practice of Endodontics. 5th ed. St Louis: Elsevier; 2015.
3. TAMSE, A. (2006), Vertical root fractures in endodontically treated teeth: diagnostic signs and clinical management. Endodontic Topics, 13: 84-94.
4. Hassan B, Metska ME, Ozok AR, van der Stelt P, Wesselink PR. Detection of vertical root fractures in endodontically treated teeth by a cone beam computed tomography scan. J Endod. 2009 May;35(5):719-22.
5. Metska ME, Aartman IH, Wesselink PR, Özok AR. Detection of vertical root fractures in vivo in endodontically treated teeth by cone-beam computed tomography scans. J Endod. 2012 Oct;38(10):1344-7.
6. LeCun Y, Bengio Y, Hinton G. Deep learning. Nature. 2015 May 28;521(7553):436-44.
7. Schwendicke F, Golla T, Dreher M, Krois J. Convolutional neural networks for dental image diagnostics: A scoping review. J Dent. 2019 Dec;91:103226.
8. Fukuda M, Inamoto K, Shibata N, Ariji Y, Yanashita Y, Kutsuna S, Nakata K, Katsumata A, Fujita H, Ariji E. Evaluation of an artificial intelligence system for detecting vertical root fracture on panoramic radiography. Oral Radiol. 2020 Oct;36(4):337-343.
9. Johari M, Esmaeili F, Andalib A, Garjani S, Saberkari H. Detection of vertical root fractures in intact and endodontically treated premolar teeth by designing a probabilistic neural network: an ex vivo study. Dentomaxillofac Radiol. 2017 Feb;46(2):20160107.
10. Setzer FC, Hinckley N, Kohli MR, Karabucak B. A Survey of Cone-beam Computed Tomographic Use among Endodontic Practitioners in the United States. J Endod. 2017 May;43(5):699-704.