OPEN ACCESS

Saudi Journal of Biomedical Research

Abbreviated Key Title: Saudi J Biomed Res
ISSN 2518-3214 (Print) |ISSN 2518-3222 (Online)
Scholars Middle East Publishers, Dubai, United Arab Emirates
Journal homepage: https://saudijournals.com

Review Article

Use of Artificial Intelligence in Diagnosing Root Fractures: A Systematic Review

Dr. Yashashwi Bhandari, BDS[1]*, Dr. Yash Bhandari, BDS[1], Dr. Sowmya Akkanapally, BDS[2], Dr. Rutuja Patil, BDS, MSRA[3], Dr. Umaarah Asif, BDS[4], Dr. Helly Thaker, BDS, MHA[5], Dr. Nishtha Sharma, BDS[6], Dr. Helly Shiroya, BDS[7]

[1]Post Graduate, Oral Medicine and Radiology, IND
[2]Panineeya Institute of Dental Sciences & Research Centre, Hyderabad, IND
[3]Clinical Research Assistant, MGB, Boston, USA
[4]Dental Assistant, Pennsylvania, USA
[5]Townline Dentistry, Cambridge, Ontario, Canada
[6]University of Massachusetts, Lowell, USA
[7]Pacific Academy of Higher Education and Research University, Udaipur, IND

DOI: https://doi.org/10.36348/sjbr.2026.v11i04.002 | **Received:** 30.01.2026 | **Accepted:** 26.03.2026 | **Published:** 04.04.2026

***Corresponding author:** Dr. Yashashwi Bhandari, BDS
Post Graduate, Oral Medicine and Radiology, IND

Abstract

Background: Root fractures represent a relatively rare form of dental trauma and are often challenging to identify using routine clinical examination and conventional radiographic techniques. Accurate and timely diagnosis is crucial for appropriate treatment planning and to achieve favourable clinical outcomes. In recent years, artificial intelligence (AI) has gained attention in dentistry due to its ability to analyze imaging data with high precision and assist clinicians in diagnostic decision-making. ***Purpose:*** The aim of this systematic review is to assess the role and diagnostic effectiveness of artificial intelligence in identifying root fractures. ***Study selection:*** A systematic literature search was performed using PUBMED, MEDLINE, EMBASE, and COCHRANE Library with language restriction to English. The search was carried out incorporating the published literature till 2025 using the MeSH (medical subject heading) terms. A literature search was done out of 205 publications, related to search strategy, 57 full articles, which were related to the study, were acquired for further inspection. Out of the 57 articles, 9 articles met the inclusion criteria. Information related to study characteristics, types of AI models used, imaging techniques, and reported diagnostic performance was collected and reviewed. ***Results:*** The findings from the 9 selected studies indicate that AI systems, especially deep learning models such as convolutional neural networks, demonstrate considerable potential in detecting root fractures in dental images. Many investigations reported strong diagnostic performance with notable levels of accuracy, sensitivity, and specificity. These findings highlight the significant potential of AI-assisted analysis helped improve diagnostic consistency and supported clinicians in recognizing fractures that may be difficult to detect through visual assessment alone. ***Conclusion and Relevance:*** Artificial intelligence shows significant promise as a supportive diagnostic tool for the detection of root fractures. Despite the encouraging results, further well-designed studies with larger datasets and clinical validation are required before AI technologies can be widely integrated into routine dental practice. Artificial intelligence enhances the accuracy and consistency of root fracture detection, aiding clinicians in early and reliable diagnosis. Its integration into dental imaging can reduce diagnostic errors and support timely treatment decisions.

Keywords: Artificial intelligence, Root fracture, detection, therapeutic management.

INTRODUCTION

Root fractures are less widespread compared to other injuries in classification dental-trauma. Root fractures represent 0.5-7% of injuries in permanent teeth and 2-4% of injuries in primary teeth. [1,2] Root fractures are an important clinical complication encountered in dental trauma and endodontic practice. They may occur as a result of traumatic injuries, excessive occlusal forces, or as a consequence of endodontic procedures. Root fracture is most important in permanent teeth. Root fracture healing is effect of location of fracture, type, root developing and distance of between fracture fragments [3]. Root fractures are commonly classified as horizontal or vertical fractures depending on the orientation of the fracture line. Among

these, vertical root fractures are particularly challenging to diagnose because they often present with vague clinical signs and symptoms that may mimic other periodontal or endodontic conditions. Early and accurate detection of root fractures is essential for appropriate treatment planning and for preventing unnecessary procedures or tooth loss.

Conventional diagnostic methods for detecting root fractures include clinical examination and radiographic imaging, particularly periapical radiographs. However, the diagnostic capability of two-dimensional radiographs is limited due to anatomical superimposition, image distortion, and the orientation of the fracture line relative to the X-ray beam. These limitations often lead to delayed or missed diagnoses. The introduction of advanced imaging techniques such as cone-beam computed tomography (CBCT) has improved the visualization of root fractures by providing three-dimensional images with greater spatial resolution. Evolving technology has changed the whole interface of diagnostic methodology as well as the degree of precision of restorative and endodontic treatment modalities [4]. Artificial intelligence (AI) technology has been intensely introduced into almost every branch of dentistry and is involved in diagnostic aspects and decision making [5]. In the context of dentistry, the integration of AI into information systems (IS) has shown promising potential [6]. The literature provides evidence where AI algorithms support in the interpretation of dental imagery, diagnosis of oral conditions, and prediction of potential issues based on input data from X-rays, patient records, or other dental imaging modalities [7,8].

Artificial intelligence (AI) models have emerged as a potential diagnostic aid. [10] This systematic review seeks to critically analyze the existing evidence regarding the application of artificial intelligence in the detection of root fractures using different dental imaging modalities, including periapical radiographs, panoramic radiography, and cone-beam computed tomography (CBCT). The review aims to compare the various diagnostic methods employed, evaluate the methodological strengths and limitations of the included studies, and explore the potential clinical implications of AI-assisted technologies in the diagnosis of root fractures. In addition, it highlights areas where further research is required to enhance the reliability and clinical integration of AI in dental diagnostics.

MATERIALS AND METHODS

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure comprehensive and transparent reporting.[9]

The protocol for this systematic review was registered in advance with the International Prospective Register of Systematic Reviews (PROSPERO) to ensure transparency and methodological rigor. Prospective registration helps minimize the risk of bias and promotes accountability in the review process. The study was recorded in the PROSPERO database under the registration number: CRD420261335233

Eligibility Criteria

Inclusion criteria

Studies were considered eligible for inclusion in this systematic review if they investigated the application of artificial intelligence in the detection or diagnosis of root fractures. Eligible studies included those that utilized dental radiographic imaging modalities such as cone-beam computed tomography (CBCT), periapical radiographs, or panoramic radiography for the identification of root fractures. In addition, studies were required to report diagnostic performance outcomes of the AI systems, including measures such as accuracy, sensitivity, specificity, or other relevant diagnostic indicators. Only original research articles that provided primary data and detailed methodological descriptions were included in the review. To ensure accessibility and consistency in data interpretation, only studies published in the English language were considered

Exclusion criteria

Studies were excluded if they did not focus on the use of artificial intelligence for diagnosing root fractures.

Literature Search

A comprehensive search was conducted across four electronic databases: PubMed, Embase, Web of Science, and Scopus, to identify studies investigating the application of AI in the detection. The strategy combined Medical Subject Headings (MeSH), such as Artificial Intelligence, Root Fractures, detection, diagnosis.

RESULT

A comprehensive literature search was performed across multiple databases, including Scopus, Embase, PubMed, and Web of Science, yielding a total of 205 records (Table 1). After removing 88 duplicate entries, 117 unique studies remained for title and abstract screening. During this stage, 81 records were excluded because they did not meet the eligibility criteria; these included 31 irrelevant studies, 47 review articles, and 3 editorials.

Table 1: Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Population	Studies involving human teeth with suspected or confirmed root fractures. Studies using dental radiographic imaging modalities (CBCT, periapical, or panoramic radiographs) for evaluating root fractures.	Studies using non-human samples, animal models, or simulation datasets.
Intervention	Studies using Artificial Intelligence techniques (machine learning or deep learning) for detecting or diagnosing root fractures. Studies applying AI models to dental radiographic images such as CBCT, periapical, or panoramic radiographs.	Studies not using Artificial Intelligence techniques for root fracture detection.
Comparator	Studies comparing Artificial Intelligence models with conventional diagnostic methods, such as evaluation by dental professionals. Studies comparing AI performance with standard radiographic interpretation or existing diagnostic techniques for detecting root fractures.	Studies not comparing AI results with conventional diagnostic methods or expert interpretation.
Outcome measures	Studies reporting diagnostic performance metrics such as accuracy, sensitivity, specificity, precision, or AUC. Studies evaluating the effectiveness of Artificial Intelligence in detecting root fractures using radiographic images.	Studies with insufficient or unclear data on diagnostic accuracy or related metrics.
Study design	Original research studies evaluating Artificial Intelligence for detection of root fractures. Diagnostic accuracy, retrospective, or prospective studies using radiographic datasets.	Studies not designed to evaluate AI-based diagnosis of root fractures.
Language	English	Non-English studies without available translations

Subsequently, 57 full-text articles were assessed for eligibility. Of these, 39 studies were excluded due to the lack of relevant outcomes related to the research objective. Among the remaining articles, 9 studies were further excluded as they were not based on artificial intelligence models. Ultimately, 9 studies met all inclusion criteria and were incorporated into the final systematic review. This structured screening process ensured a comprehensive and methodical selection of studies aligned with the aims of the research.

Figure 1: Coronal view depicts root fracture in cbct

Figure 2: Sagittal view depicts root fracture in cbct

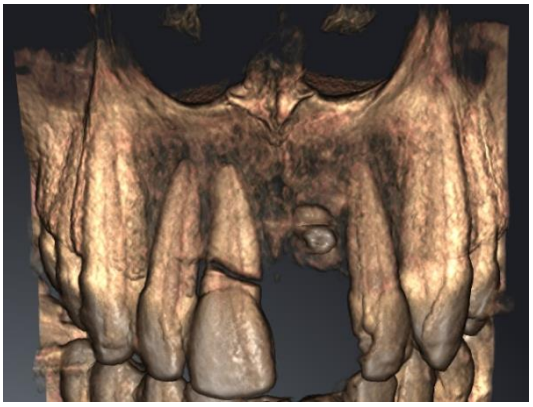

Figure 3: 3D view depicts root fracture in cbct

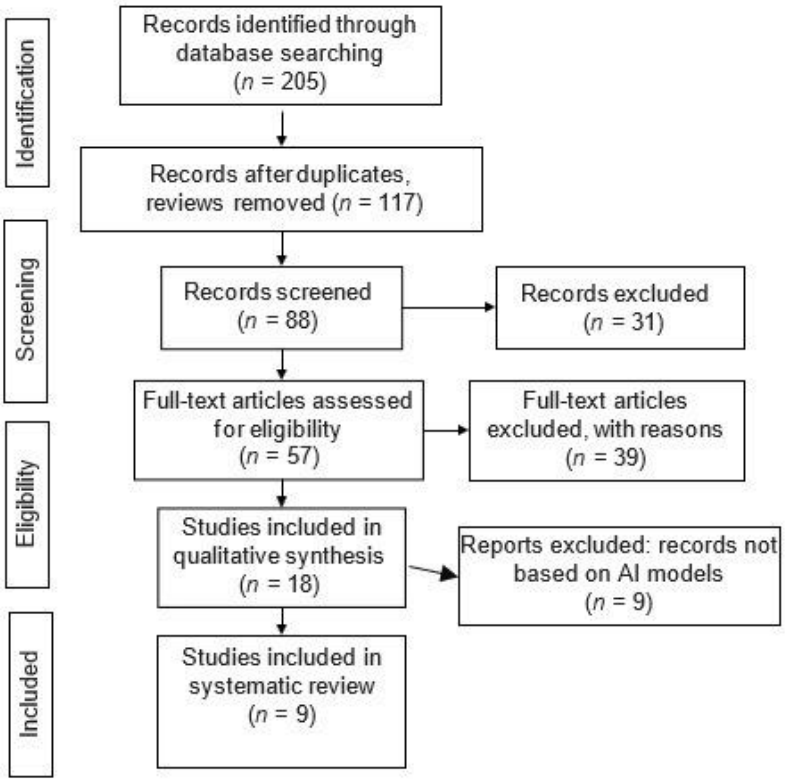

Figure 4: PRISMA Flow Diagram of the Study

Table 2: Detection of root fractures by AI.

Author	Publishing year	Study design	Dataset Type and Size	AI model	Performance Outcome (%) Accuracy	Sensitivity	Specificity
Shankargouda Patil *et al.,* [10]	2026	Systematic review including diagnostic accuracy studies	2D radiographs and CBCT images	CNNs, ResNet-50 deep learning & PNN	75%-97.8%	75%-98%	60%-99%
Marwaha J [11]	2023	Narrative review article	No dataset used	ANN, CNN, Machine Learning model	Not reported	Not reported	Not reported
Karobari MI *et al.,* [12]	2023	Comprehensive Literature Review	No primary dataset used	ANN, CNN and Machine Learning algorithms	Not reported	Not reported	Not reported
Chang *et al.,* [13]	2024	Retrospective AI-based predictive study using 5-fold cross-validation	Mixed-type tabular clinical dataset; 145 teeth (97 fractured, 48 non-fractured) with 17 features	Deep Neural Network	86.7%	80.7%	93.7%
Saeed Asgary [14]	2024	Retrospective AI-based predictive study	Mixed-type tabular clinical dataset; 145 teeth (97 fractured, 48 non-fractured)	Deep Neural Network (DNN) (compared with SVM)	86.7%	80.7%	93.7%
Parinitha *et al.,* [15]	2024	Retrospective deep-learning predictive study	Mixed-type tabular clinical dataset; 145 teeth (97 fractured, 48 non-fractured)	Deep Neural Network (DNN) (compared with SVM)	86.7%	80.7%	93.7%
S. Sahoo *et al.,* [16]	2025	AI-based diagnostic study evaluating a deep learning model for automated root fracture detection	50 CBCT images	VGG19-based Convolutional Neural Network (CNN)	92%	90%	93%
Riem Abdelazim *et al.,* [17]	2024	In-vitro experimental AI diagnostic study evaluating deep learning	400 radiographic images	VGG16, VGG19, ResNet50, DenseNet121, and DenseNet169 (CNN models)	98%	89.4%	93.6%
Hu Z *et al.,* [18]	2022	Retrospective diagnostic study using Artificial Intelligence / Deep Learning	276 periapical radiographs	Three deep learning networks (ResNet50, VGG19 and DenseNet169)	97.8%	97.0%	98.5%

DISCUSSION

Early and accurate detection of root fractures is critical, given its implications for treatment modalities and prognosis.[17] This systematic review compiled the existing evidence regarding the diagnostic accuracy of AI models in identifying VRFs using various imaging techniques, such as CBCT, periapical radiography, and panoramic radiography.[19]

This systematic review evaluated the effectiveness of artificial intelligence (AI) in diagnosing root fractures using radiographic imaging. CBCT, due to its 3-dimensional and high-resolution imaging, could provide much more detailed image information of tooth than panoramic radiography.[18] The findings indicate that AI-based models demonstrate promising diagnostic performance, with several studies reporting high accuracy, sensitivity, and specificity. These results suggest that AI can serve as a useful adjunct to clinicians in improving the detection of root fractures.

Diagnosing root fractures, particularly vertical root fractures, remains challenging due to subtle clinical signs and limitations of conventional radiography. Imaging modalities such as periapical radiographs and cone beam computed tomography (CBCT) are commonly used; however, their interpretation depends largely on clinician experience and may lead to variability in diagnosis. Due to the different applications and tasks involved, various algorithms have been developed. Common examples include convolutional neural networks (CNNs) for image classification.[13] AI models, especially deep learning algorithms such as convolutional neural networks, have shown the ability to identify fracture patterns in radiographic images with considerable precision. The combination of CNNs and ANNs has led to significant progress in endodontics, especially in tasks related to image recognition.[14] ANNs, CNNs, and other advanced techniques play pivotal roles in diagnosing various aspects.[15]

Most included studies used CBCT or periapical radiographs to train AI algorithms. In several cases, AI systems demonstrated diagnostic performance comparable to experienced clinicians, highlighting their potential to enhance diagnostic consistency and support clinical decision-making. Early and accurate detection of root fractures is crucial for appropriate treatment planning and prevention of complications such as persistent pain or tooth loss.

Despite these encouraging results, several limitations were observed. Many studies were based on relatively small datasets and lacked external validation, which may affect the generalizability of the findings. Differences in imaging modalities and AI methodologies also make comparisons across studies difficult. Therefore, further research using larger datasets and standardized evaluation methods is necessary to validate the clinical applicability of AI in root fracture diagnosis.

Future Directions

Artificial intelligence has grown in importance as a central concept as we see significant advances in technology and science.[12] Incorporating multi-modal data, such as clinical information and patient history, could also enhance the model's diagnostic capabilities and make it more applicable in real-world settings. Future studies should validate the model using larger, multi-institutional datasets to ensure robustness.[16]

CONCLUSIONS

This systematic review evaluated the current evidence on the application of artificial intelligence (AI) for detecting root fractures using CBCT, periapical, and panoramic imaging. AI has been viewed as a helpful tool by a variety of professionals and dentists.[11] The included studies consistently indicated that AI models trained on CBCT images demonstrate the highest diagnostic accuracy and specificity, with moderate certainty of evidence under controlled research conditions.

The integration of AI with advanced imaging modalities, particularly CBCT, shows strong potential to enhance the detection of root fractures, improve diagnostic consistency, and assist clinicians in clinical decision-making. Nevertheless, further research using larger and multicenter datasets is required to validate these findings and support the routine clinical implementation of AI-assisted diagnostic systems in dentistry.

Financial Support and Sponsorship: Nil.

Conflicts of Interest: There are no conflicts of interest.

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