Attahadi Medical Journal
2026;3(3):322-326
https://doi.org/10.69667/amj.26308

Review article

AI vs. Human: The Accuracy of Deep Learning in Detecting MB2 Canals

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Keywords:
MB2 canal, Mesiobuccal canal, Maxillary molars, Artificial intelligence, Deep learning.

ABSTRACT

Complex root canal anatomy and limitations of diagnostic tools and clinicians' ability to accurately detect the MB2 canal in maxillary molars make successful root canal treatment challenging. Artificial intelligence (AI) has been used in various areas of dentistry and represents a potential tool to aid in detecting MB2 canals. This review aimed to evaluate the accuracy of AI in detecting the MB2 canal in maxillary molars and compare it with human performance. A literature review was conducted using PubMed and Google Scholar databases for studies published between 2010 and 2026, retrieving articles investigating AI-based detection of MB2 canals using CBCT imaging. AI models demonstrated variable sensitivity (53.8%–100%) with overall good diagnostic performance (AUC 0.80–0.90). AI models, image quality, and resolution had a significant impact on AI diagnostic accuracy. AI shows promising potential in enhancing MB2 canal detection; however, it should be used as an adjunct to support, not replace, clinical expertise.

Introduction

Endodontic treatment, also known as root canal treatment (RCT), is a treatment procedure performed on teeth affected by irreversible pulpitis, pulp necrosis, or periapical disease. The treatment consists of three main steps; firstly, eliminating infected pulp tissue, chemo-mechanical disinfection of the root canal and finally sealing the root canals to restore tooth function and prevent reinfection (1). If the root canal treatment is performed to a high standard, it has a high success rate and allows maintenance of tooth function and prevents tooth loss (2). Successful cleaning and shaping of the canals require identification and complete disinfection of the full root canal system, including all canals. Missed or untreated canals will act as a reservoir for microorganisms and tissue remnants causing persistent infection and compromised healing (3). Studies using Cone beam computed tomography (CBCT) have shown that missed and untreated canals are associated with increased post-treatment complications (4). Therefore, identification and accurate detection of all root canals is a prerequisite for long term success of endodontic treatment.

The root canal anatomy of human teeth has been shown to be more complex than expected posing a real challenge for adequate disinfection. Complexities of root canal system such as accessory canals, isthmuses, apical deltas and bifurcations are difficult to detect clinically and radiographically (2, 5). CBCT assessment of root canal morphologies have shown a far more complex anatomy than previously assessed using traditional imaging methods (6). These anatomical complexities are more evident in molar teeth, where canal anatomy has been shown to be highly variable between individuals. Maxillary molars in particular are known for their complex root canal anatomy with additional canals that are often missed or difficult to instrument (7).

The mesiobuccal canal of maxillary molars, commonly known as MB2, is considered as one of the most clinically important anatomical complexities in endodontics. The mesiobuccal root of upper molars often contains two canals usually referred to as MB1 and MB2. The prevalence of the MB2 canal usually depends on the population under study and the detection method. It was estimated that MB2 canal is present in approximately 60% - 70% of the teeth assessed using CBCT analysis (8). However, MB2 is often missed clinically and contributes to failure of endodontic treatment of maxillary molars. Failure to locate MB2 is attributed to several factors. In most cases, the MB2 canal is small, narrow, often partially calcified, concealed by dentine or located in visually inaccessible position during access cavity preparation. Furthermore, MB2 canal extends from pulp chamber at a sharp mesial angle and then bends again distally (9-11). As a result, the MB2 canal is the most frequently discussed anatomical challenge in modern endodontics.

The clinical importance of the MB2 canal is coming from the fact that it has a relatively high prevalence and accounts for high number of endodontic failure cases. Due to challenges encountered in detecting and locating MB2 canal, it is commonly missed during endodontic treatment. Incomplete instrumentation, disinfection, and obturation of the MB2 canal resulting in residual bacteria remaining within the root canal space. This in turn results in persistence of the infection and treatment failure even when the canals are adequately disinfected and obturated (3, 12). Therefore, in modern endodontic practice, careful exploration of the mesiobuccal root of maxillary molars is strongly emphasised. It is advised that clinicians assume that MB2 canal may be present until proven otherwise by exploration. Nowadays, the MB2 canal has become a typical example of how handling anatomical complexities can influence the success of endodontic therapy.

Received*: 11-05-2026 -* ***Accepted****: 09-07-2026 -* ***Published****: 17-07-2026*

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Traditionally, dentists serve as the primary diagnostic agent responsible for navigating the complex pulp chamber floor. A combination of anatomical knowledge, clinical experience, tactile sensation, visual inspection, and radiographic examination can aid dentists and endodontists in locating root canals. The pulp chamber is visually inspected and carefully examined utilising the laws of pulp chamber anatomy to aid in predicting canal locations based on colour change and geometry of the pulp floor. Tactile exploration using sharp endodontic explorers (like the DG16) is also used to catch the canal orifice within the developmental groove between the mesial and palatal canals (13). As MB2 canal orifice may be concealed by a layer of dentine, a troughing technique is usually useful. It involves the controlled removal of dentin layer or calcifications using burs or more commonly ultrasonic tips to expose the hidden orifice (14).

The use of an operating microscope has particular advantages by improving illumination and magnification and helping clinicians to identify canal orifices. It enhances the detection of MB2 canal leading to higher number of these canals being identified and treated, which may lead to higher-quality endodontic treatment (15). Likewise, controlled troughing can be performed under magnification, thereby reducing the significant risk of perforations. Conventional periapical radiographs are often taken preoperatively as a part of the routine diagnosis process. However, when it comes to the identification of MB2 canal, periapical radiographs may fail to reveal additional canals because of the two-dimensional nature of the radiograph and the superimposition of roots and surrounding structures (16). Unlike conventional radiographs, CBCT provides three-dimensional imaging has become particularly useful in complex cases aiding in revealing additional canals like MB2 canal.

Although the above factors have improved clinical detection, human performance remains with inherent limitations. The operator experience plays a significant role, for instance, undergraduate students and general practitioners often report lower detection rates compared to experienced endodontists who are generally more successful in identifying the MB2 canal (17). Even with all advances, the MB2 canal can still be missed in cases with calcified chambers or unusual canal locations. Another limitation is the adequacy of the available visual and radiographic information. Even when CBCT images are available, interpretation also requires clinician's experience in examining multiple slices and correctly identify the canal anatomy. Human variations exist when it comes to CBCT images interpretation, and misinterpretation can occur as a result of fatigue, lack of experience, or subjective judgment. Therefore, the detection of the MB2 canal may be inconsistent, even with the use of advanced tools like CBCT. As a result, there has been increasing interest in Artificial intelligence (AI) technologies that may support or enhance human detection by enhancing the reliability and standardisation of canal detection particularly in complex challenging cases.

Artificial intelligence refers to computer-based systems used to perform tasks such as interpreting patterns, learning from data and assisting in diagnosis (18). The use of AI in healthcare has increased significantly in recent years especially with deep learning. Deep learning refers to the use of layered networks to analyse large data sets and identify meaningful features or patterns (19). In dentistry, AI has already been introduced in caries detection, assessment of bone loss, jaw analysis for orthodontics, implant placement analysis and oral radiology (18, 20). It was suggested that AI may enhance diagnostic accuracy, decrease variability between observers, and aid in identifying findings that may be overlooked. In endodontics, the use of AI has been investigated in detecting periapical lesions, root fractures, working length determination, and analysing root canal anatomy on radiographic and CBCT images (20, 21).

MB2 canal detection can be a potential application for AI via image interpretation and identification of small anatomical details. Deep learning models can be trained on suitable datasets thereby these models can guide clinicians on the possible presence and location of MB2 canal on conventional radiographs or CBCT images. Nevertheless, the dentist's role remains fundamental and AI is not expected to replace the dentist. Instead, the most realistic role of AI in endodontics acts as an adjunctive tool that complements the human role and enhances confidence. Therefore, diagnosis, treatment planning, and decision-making will remain the responsibility of the dentist. However, with regards to human under-detection of MB2 canals, AI support could be especially valuable. Understanding how accurate AI is in detecting MB2 and whether it is comparable to that or more accurate than human detection may help estimate its clinical degree of usefulness and its future role in endodontics. Considering the high prevalence of the MB2 canal and the effect of its missing on endodontic treatment outcome, evaluating the accuracy of deep learning in this context would be highly advantageous. The aim of this review is to evaluate the accuracy of artificial intelligence in detecting the MB2 canal in maxillary molars and to compare its accuracy to that of human detection methods.

Methodology

Searching strategy

PubMed and Google Scholar databases were used to conduct an electronic search covering articles published between January 2010 and March 2026. Search results were imported into EndNote. Following the removal of duplicates, titles and abstracts of articles were screened to exclude non-relevant publications. Keywords used in the search include; MB2 canal; Mesiobuccal canal; Maxillary molars; Artificial intelligence; Deep learning; CBCT; Root canal anatomy; Endodontic treatment; Canal detection; Diagnostic accuracy.

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Inclusion and exclusion criteria
The inclusion criteria included studies evaluating the detection of MB2 canals in maxillary molars, studies using artificial intelligence, deep learning, or machine learning models, studies using CBCT or radiographic imaging, studies comparing AI with human/clinician performance, articles published between 2010 and 2026, and articles published in English
The exclusion criteria included animal studies, case reports and case series, review articles and systematic reviews, studies not related to MB2 canal detection, and studies not involving CBCT or radiographic imaging.

Results
The initial search retrieved a total of 11 articles. Following the application of the inclusion and exclusion criteria, a total of 8 articles have been selected for this review. The name of the study, the deep learning model and its main findings is presented in Table 1.

Table 1: Summary of studies investigating the use of AI in detecting MB2 canal of maxillary molars on CBCT scans.

Study	Deep learning model	Main findings
Albitar et al., 2022 (22)	3D U-Net (Three-Dimensional U-Net)	Sensitivity of 80% and specificity of 98%
Duman., 2024 (23)	YOLOv5x (You Only Look Once version 5)	Sensitivity of 92%
Ji., 2024 (24)	Basicvsr++	Identification of MB2 was 72% in the CBCT group and enhanced to 92% in the super-resolution computed tomography (SRCT) group, and it was 100% in the Micro-CT group
Mansour., 2025 (25)	Customized CNN and U-Net	Sensitivity was 100%, but the low area under the curve (AUC) (0.57) indicates weak discrimination ability of the model.
Shetty, 2025 (26)	Inception v3 (CNN) and multiple ML models: Logistic Regression (LR), Neural Network (NN), SVM, Random Forest, Naïve Bayes and kNN	Sensitivity ≈ 92.5% with best performing model (SVM). AUC values were around 0.89–0.90, indicating a good overall diagnostic performance.
Altunkum, 2026(27)	ChatGPT	Sensitivity of 96.6%, 99.4% specificity, and 97.8% overall accuracy
Güllü., 2026 (28)	nnU-Netv2	Sensitivity of 53.8% and AUC of 0.8
Lin., 2026 (29)	Modified VGG16 and ConvNeXt–Transformer architecture	Sensitivity of 84%, specificity 86% and AUC of 0.85.

The included eight studies used various deep learning models, ranging from traditional Convolutional Neural Networks (CNNs) like U-Net to advanced models such as YOLOv5x. The findings show high variability in the ability of the deep learning model to detect MB2 canals in maxillary molars. The sensitivity of the model (the ability of the model to detect MB2) ranged from a low of 53.8% (Güllü, 2026) to a peak of 100% (Mansour, 2025). It was noted that advanced models, namely YOLOv5x and Inception v3 showed a sensitivity level above 90%. The overall performance indicated by the AUC values (overall ability of AI model to distinguish between two classes "MB2 canal is present" versus "MB2 canal is absent" was between 0.80 and 0.90, indicating good discriminative ability. However, in some models such as (Mansour., 2025) the high sensitivity accompanied by poor AUC, reflecting weak overall reliability. Overall, the findings indicating that AI models can identify MB2 canal on CBCT scans with accuracy although performance varied depending on the model used.

Discussion
The extracted sensitivity of the included studies demonstrated a high variability ranging from as low as 53.8% to as high as 100%. Most studies demonstrated high AUC values (≥0.8) reflecting a good overall performance. As a result, AUC values may be considered a better indicator of general performance of AI model than sensitivity or specificity alone. As noted in some studies, there was inconsistency between sensitivity, specificity and AUC values. In other words, very high sensitivity was accompanied by relatively low AUC values, which is usually indicative of potential over-detection and probably increased false positives. Therefore, it is advisable that the interpretation should include a combination of different metrics and not relying on a single measure of as this can be misleading, resulting in unnecessary dentin removal or damage during MB2 exploration.
The high variability observed is likely resulting from lack of standardisation of AI models used in the different studies. This indicates that although AI exhibited a strong potential in detecting MB2, its accuracy and clinical performance is highly influenced by several factors mainly the AI model, quality of CBCT scans, and training methods (18). Different AI designs, in

***Received**: 11-05-2026 - **Accepted**: 09-07-2026 - **Published**: 17-07-2026*

particular convolutional neural networks CNNs, provide different results based on how they are structured and the learning strategies used (30). In addition, the data used to train AI models is crucial as a good training set is the key for model accuracy. Dataset parameters such as quality, size, and diversity are determinant of model accuracy. When high quality datasets are employed to train models along with well-annotated CBCT scans are more likely to outperform those trained on low quality or heterogeneous data (31). Another factor that impacts AI model's performance is the pre-processing of CBCT images. Image normalisation, segmentation and resolution enhancement also affect diagnostic consistency. AI models performance can also be influenced when different datasets is used for training and testing making an AI model less reliable in clinical scenarios (30). All these factors emphasize the urgent need for standardising AI model design, image processing and data quality in future studies.

Interestingly, it was demonstrated that AI accuracy was enhanced from standard CBCT (≈72% accuracy) to (up to 100%) in micro-CT indicating that AI performance is largely affected by the quality of the original scans in terms of resolution and imaging artifacts. The ability of AI to detect fine anatomical details increases when high quality and resolution scans are used. Those fine details may not be detected if low quality or noise containing images are used. Micro-CT is able to identify the small and fine canals such as MB2, unlike CBCT, which its effectiveness is limited by noise and moderate resolution. As a result, it is important to understand that while CBCT produces clinically acceptable images, noise and imaging artifacts can reduce the reliability of AI interpretation. AI can potentially misinterpret unclear or poor-quality images leading to false positive or false negative results. All the above factors clearly demonstrate that detecting MB2 canal does not depend solely on dentist experience or AI performance, instead it is largely dependent on image quality and resolution.

Since most studies are retrospective and single-center in addition to the use of variable AI models which greatly limits the comparability of studies and generalisation of the findings. It is unclear how well these models will perform if used in different populations with potential different anatomy, used with different imaging devices, or more diverse clinical settings (31). Another critical limitation is that variations in the training datasets can lead to bias. While AI may perform well on familiar dataset, its reliability may be limited when applied on unseen cases and real-world clinical settings (18). Furthermore, the retrospective nature of most studies limits the real time challenges may be faced by practitioners when locating MB2 canals. Ideally, future research should be multicentre and use standardised AI models, larger datasets and imaging protocols to improve the comparability, generalisation, external validity, and clinical applicability of AI in endodontics.

Overall, AI systems showed promising abilities in detecting fine anatomy such as MB2. However, the fundamental question remains is whether AI can reliably replace clinician's detection? To answer this question, both advantages and limitations of AI detection should be carefully analysed. AI provides valuable advantages as AI algorithms, particularly those dependent on deep learning, can effectively analyse large datasets rapidly. AI approach reduces the inter- and intra-observer variation leading to more standardised diagnosis. Moreover, AI can be trained on patterns from previous cases and can aid in identifying root canal morphology, missed canals and assessing working length. This is particularly useful for less experienced clinicians as it provides real-time guidance and educational support. Despite these advantages, AI should be viewed as an adjunct tool that aids the clinician's expertise rather than replacing clinical judgment. AI also lacks the interpretation of other fundamental diagnostic factors such as patient's history and clinical examination.

To sum up, AI can be utilised as valuable supportive tools rather than replacements for clinician's expertise. Clinician can link diagnostic information obtained from patients' history, clinical examination and AI interpretation to arrive at informative diagnosis. AI can play an adjunctive role by performing time-consuming, repetitive, or prone to human error tasks. In endodontics, AI can be particularly useful in the interpretation of CBCT images, where subtle anatomical variations may be overlooked due to clinician fatigue or limited experience.

Conclusion

Generally, AI showed high diagnostic performance across multiple studies and can be potentially used as an adjunctive tool in detecting MB2 canals in maxillary molars. However, it is important to emphasize that model performance is largely influenced by factors such as AI model design, image quality and resolution, and dataset features. AI should be used to enhance detection accuracy and reduce human variability rather than replacing the clinician's comprehensive diagnostic role. AI can be efficiently integrated with other diagnostic information obtained from patient history, examination, and professional expertise. Improving the reliability and integration of AI into routine endodontic practice requires further research focusing on standardization, training on larger datasets, and real-world validation.

Conflict of interest. Nil

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Received*: 11-05-2026 -* ***Accepted****: 09-07-2026 -* ***Published****: 17-07-2026*

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Received*: 11-05-2026 -* ***Accepted****: 09-07-2026 -* ***Published****: 17-07-2026*