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Importance of computed tomography for identifying the second mesiobuccal canal in endodontic procedures: a systematic review of clinical studies

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Abstract

Introduction: Endodontists must have detailed knowledge of the typical anatomy of the dental structure and the atypical forms of external and internal root canals. The first permanent maxillary molar and the second permanent maxillary molar are the teeth with the greatest complexity of root canals, presenting higher rates of endodontic failure. Cone beam computed tomography (CBCT) has made it possible to visualize anatomical structures that are difficult to access in three dimensions, and has become a valuable aid as a complementary examination for endodontic diagnosis and treatment. **Objective:** This study aimed to address the main considerations and outcomes of clinical studies on the use of cone beam computed tomography in the identification and treatment of second mesiobuccal canals. **Methods:** The PRISMA Platform systematic review rules were followed. The search was carried out from October to November 2024 in the Scopus, PubMed, Science Direct, Scielo, and Google Scholar databases. The quality of the studies was based on the GRADE instrument and the risk of bias was analyzed according to the Cochrane instrument. **Results and Conclusion:** A total of 112 articles were found, 14 articles were evaluated in full and 12 were included and developed in the present systematic review study. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 46 studies with a high risk of bias and 22 studies that did not meet GRADE and AMSTAR-2. Most studies did not show homogeneity in their results, with X^2=91.5%<50%. Results and Conclusion: It was concluded that endodontic treatment success can be increased and clinicians' time can be saved by using the newly developed AI-based models to identify variations in root canal anatomy before treatment. Patient gender, tooth type, and treatment modality play essential roles in identifying the MB2 canal. Furthermore, the availability of preoperative CBCT images was associated with a greater ability to localize the MB2 canal. Understanding the incidence of MB2 canals and the distribution pattern of canal orifices in the pulp floor can help clinicians quickly identify and locate MB2 canals.

Keywords: Endodontic treatment. Second mesiobuccal canal. Cone beam computed tomography.

Introduction

The endodontist must have detailed knowledge of the typical anatomy of the dental structure and the atypical forms of external and internal root canals. For example, maxillary molars have second mesiobuccal canals (MB2), with a prevalence of up to 40.2 to 64% [1,2]. A retrospective cone beam computed tomography (CBCT) study found that in cases of endodontic failure, 72.7% of MB2 canals were unfilled. The occurrence of endodontic failure is mainly due to the lack of MB2 canals, which leads to a worse prognosis [3].

In this context, the first permanent maxillary molar and the second permanent maxillary molar are the teeth with the most complex root canals, presenting higher rates of endodontic failure. In this sense, a high percentage of treatment failures is due to the

impossibility of detecting the presence and location of MB2, located in the mesiobuccal root of the first permanent maxillary molar and the second maxillary molar, which prevents the correct implementation of biomechanical instrumentation, irrigation, and obturation [1-3].

As a corollary of this, the percentage of visualization of the MB2 canal varies according to the technique used in each study, including histological sections, diaphanization, magnifying loupes, endodontic surgical microscope, scanning electron microscope, microcomputed tomographic analysis and CBCT [3,4].

In recent years, CBCT has made it possible to visualize anatomical structures that are difficult to access in three dimensions. It has become a valuable aid as a complementary examination for diagnosis and endodontic treatment with a lower radiation dose than conventional computed tomography. Several articles have used CBCT to study the morphology of maxillary molars and verify its ability to visualize the MB2 canal [1-5].

Given this, the present study aimed to address the main considerations and outcomes of clinical studies on the use of cone beam computed tomography in the identification and treatment of second mesiobuccal canals.

Methods

Study Design

The present study followed the international systematic review model, following the rules of PRISMA (preferred reporting items for systematic reviews and meta-analysis). Available at: http://www.prisma-statement.org/?AspxAutoDetectCookieSupport=1. Accessed on: 10/18/2024. The methodological quality standards of AMSTAR-2 (Assessing the methodological quality of systematic reviews) were also followed. Available at: https://amstar.ca/. Accessed on: 10/18/2024.

Data Sources and Research Strategy

The literary search process was carried out from October to November 2024 and was developed based on Scopus, PubMed, Lilacs, Ebsco, Scielo, and Google Scholar, covering scientific articles from various eras to the present. The descriptors (DeCS /MeSH Terms) were used: "Endodontic treatment. Second mesiobuccal canal. Cone beam computed tomography", and using the Boolean "and" between the MeSH terms and "or" between historical discoveries.

Study Quality and Risk of Bias

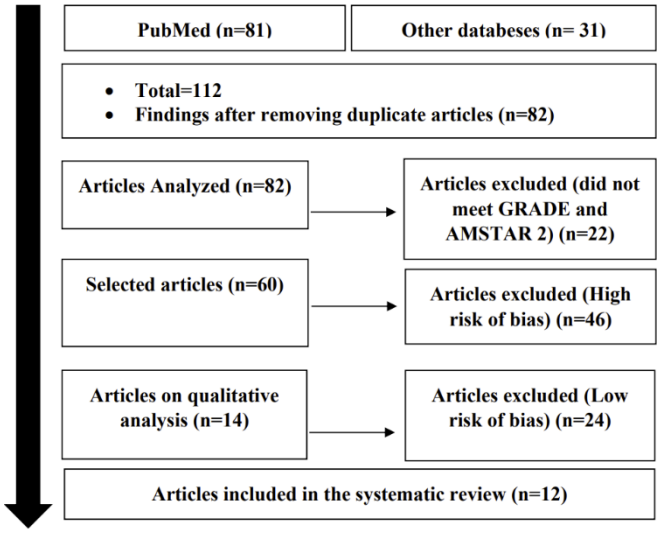
Quality was classified as high, moderate, low, or very low in terms of risk of bias, clarity of comparisons, precision, and consistency of analyses. The most evident emphasis was on systematic review articles or meta-analyses of randomized clinical trials, followed by randomized clinical trials. The low quality of evidence was attributed to case reports, editorials, and brief communications, according to the GRADE instrument. The risk of bias was analyzed according to the Cochrane instrument by analyzing the Funnel Plot graph (Sample size versus Effect size), using the Cohen test (d).

Results and Discussion

Summary of Findings

A total of 112 articles were found that were subjected to eligibility analysis, with 12 final studies being selected to compose the results of this systematic review. The studies listed were of medium to high quality (Figure 1), considering the level of scientific evidence of studies such as meta-analysis, consensus, randomized clinical, prospective, and observational. The biases did not compromise the scientific basis of the studies. According to the GRADE instrument, most studies showed homogeneity in their results, with X^2=91.5%<50%. Considering the Cochrane tool for risk of bias, the overall assessment resulted in 46 studies with a high risk of bias and 22 studies that did not meet GRADE and AMSTAR-2.

Figure 1. Articles eligibility process.

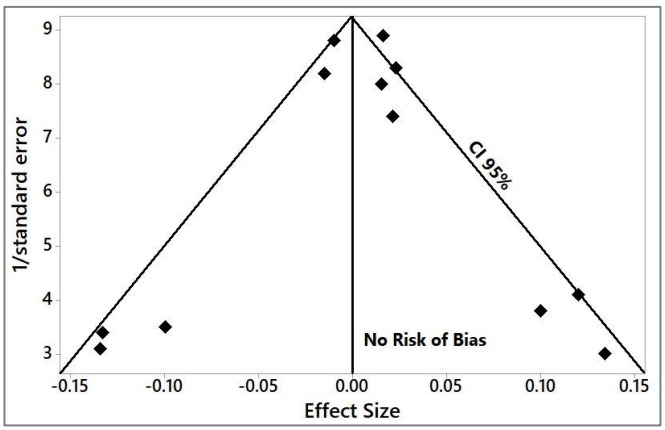


Source: Own authorship.

Figure 2 presents the results of the risk of bias of the studies using the Funnel Plot, showing the calculation of the Effect Size (Magnitude of the difference) using the Cohen Test (d). Precision (sample size) was determined indirectly by the inverse of the standard error (1/Standard Error). This graph had a symmetrical behavior, not suggesting a significant risk of bias, both between studies with a small sample size (lower precision) that are shown at the bottom of the

graph and in studies with a large sample size that are presented at the top.

Figure 2. The symmetric funnel plot suggests no risk of bias among the small sample size studies that are shown at the bottom of the graph. High confidence and high recommendation studies are shown above the graph (n= 12 studies).



Source: Own authorship.

Major Clinical Findings

Due to the formation of tertiary dentin, as well as calcification above the canal orifice caused by aging and specific pathological factors, it becomes difficult to identify MB2. In this regard, CBCT imaging has been shown to confirm the existence of MB2 canal in endodontic diagnosis [1,2,5]. Govil et al. [6] and Likhyani et al. [7] confirmed the root canal morphology accurately in the mesiobuccal root of maxillary molars where they found Vertucci type VIII (3-3) and Vertucci type XXI (4-1), respectively.

A clinical study used a machine learning model to detect second mesiobuccal canals (MB2). A total of 922 axial sections of cone beam computed tomography (CBCT) images from 153 patients were used. The segmentation method was employed to identify MB2 canals in maxillary molars that had not undergone endodontic treatment previously. The labeled images were divided into training (80%), validation (10%), and testing (10%) groups. The artificial intelligence (AI) model was trained using the You Only Look Once v5 (YOLOv5x) architecture with 500 epochs and a learning rate of 0.01. The sensitivity of the MB2 canal segmentation model was 0.92, the accuracy was 0.83, and the F1 score value was 0.87. The area under the curve (AUC) in the ROC plot of the model was 0.84. The mAP value at 0.5 inter-over unions (IoU) was found to be 0.88. The deep learning algorithm used showed high success in detecting the MB2 canal [8].

Furthermore, a clinical study investigated the influence of various factors on the location of the MB2 in maxillary molars, a canal commonly missed during endodontic treatment. Factors such as patient gender, age, tooth type, pulp status, preoperative CBCT scan, and treatment modality were examined. Among 333 treated maxillary molars, the MB2 canal was identified in 60.1%. The prevalence of MB2 canals was significantly higher in the first molars (72.3%) compared to the second molars (40.2%). Multiple logistic regression models showed that gender, tooth type and treatment modality emerged as significant determinants of MB2 canal location: males [odds ratio 3.01 (95% CI: 1.71-5.32), p<0.001], first molar tooth [odds ratio 4.26 (95% CI: 2.53-7.18), p<0.001] and secondary endodontic treatment [odds ratio 0.06 (95% CI: 0.004-0.890), p<0.04] [9].

The authors Sakthivel et al. (2024) [10] analyzed the prevalence as well as configuration of MB2 in maxillary 2nd molars and predicted its existence based on mesiobuccal-palatal (MB-P) distance, MB-P/distobuccal-palatal (DB-P) distance ratio and mesiobuccal, distobuccal and palatal (MDP) orifice angle with the help of cone beam computed tomography. The prevalence of MB2 increases as the values increase in MB-P distance (>5.25 mm), MB-P and DB-P ratio (>1.25), and MDP angle (>95°). Out of 150 MB2 teeth, Vertucci type 2, 4, and 8 configurations are seen in 103 (68.6%), 46 (30.6%) and 1 (0.67%), respectively.

Another clinical study evaluated the efficacy of clinical methods in identifying the presence of a second mesiobuccal canal in maxillary first molars. A total of 66 teeth were selected and the mesiobuccal canal was confirmed in all samples by CBCT. After accessing the endodontic cavity, the teeth were evaluated by direct vision; dental loupe, and surgical microscope. None of the methods were successful in finding the mesiobuccal canal in all samples. For professionals <40, magnification did not influence the location. For professionals >40, magnification significantly influenced the location. In direct vision, professionals >40 years of age located fewer canals than those <40 years of experience [11].

A study investigated the incidence and location of the MB2 of the maxillary first molar and the relationship between the presence of an MB2 canal and the distribution of the canal orifices in the pulp floor with the aid of CBCT. A total of 1008 maxillary first molars (548 patients) were randomly selected and analyzed using CBCT images. Most of the maxillary first molars with 3 roots had 2 root canals (85.4%) in the mesiobuccal root. The incidence of MB2 canals did not show a statistically significant difference between the left and right sides ($p > 0.05$), but it was significantly associated with the sex and age of the patients ($p<0.05$). ROC curve analysis showed high diagnostic accuracy (area under the ROC

curve = 0.92) when using the ratio of the distance between the mesiobuccal and palatal main root canal orifices and the distance between the distobuccal and palatal root canal orifices to predict the presence of an MB2 canal [12].

In addition, a clinical study evaluated direct vision, dental operating microscope (DOM), selective dentin removal under DOM, and CBCT in the clinical detection of MB2 in maxillary molars. A total of 122 maxillary first and second molars indicated for root canal treatment were included. The clinical detection of the MB2 canal in our study was 90%, with 93% in the maxillary first molar and 86% in the maxillary second molar. 64% of MB2 canals were located in Stage I (direct vision), which improved to 84% in Stage II (under DOM) and 90% in Stage III (selective dentin removal under DOM). CBCT investigation (Stage IV) further improved the identification of the MB2 canal, leading to an overall prevalence of 93%. The results demonstrated that the MB2 canal can be clinically detected in up to 90% of maxillary molars by using DOM and selective dentin removal. Investigation by CBCT is indicated when MB2 canals are not clinically detected [13].

Finally, a study described in vivo the prevalence and location of MB2 in the mesiobuccal root of the first maxillary molar (1MM) and the second maxillary molar (2MM) using CBCT images. A total of 550 CBCT images of the 1MM and 550 of the 2MM were analyzed. To detect the MB2 canal, observation and measurements were made 1 mm apical to the pulp floor to standardize the methodology. The geometric location of the central point of the MB2 canal (PMB2) was measured to the central point of the mesiobuccal canal (PMB1) and the projected line between the PMB1 and the central point of the palatal canals (PP). In 1MM, the prevalence of the MB2 canal was 69.82%, being more frequent in women ($p = 0.005$). The distance between PMB1 and PP was 7.64 ± 1.04 mm. The mean distance between PMB1 and PMB2 was 2.68 ± 0.49 mm, and for PMB2 and the projected line between the PMB1 and PP canals, it was 1.25 ± 0.34 mm. In 2MM, the MB2 canal was identified in 46.91%, being more frequent in men ($p = 0.000$). The distance between PMB1 and PP was 7.02 ± 1.30. The mean distance between PMB1 and PMB2 was 2.41 ± 0.64 mm, and for PMB2 and the projected line between the PMB1 and PP canals, it was 0.98 ± 0.33 mm. Therefore, CBCT is an effective and highly accurate diagnostic tool for not only detecting but also localizing in vivo the MB2 canal in the mesiobuccal root of maxillary molars [14].

Conclusion

It was concluded that endodontic treatment success can be increased and clinicians' time can be saved by using the newly developed AI-based models to identify variations in root canal anatomy prior to treatment. Patient gender, tooth type, and treatment modality play essential roles in identifying the MB2 canal. Furthermore, the availability of preoperative CBCT images was associated with a greater ability to localize the MB2 canal. Understanding the incidence of MB2 canals and the distribution pattern of canal orifices in the pulp floor can help clinicians quickly identify and localize MB2 canals.

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No additional data are available.

Conflict of Interest

The authors declare no conflict of interest.

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It was performed.

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