JFCR
Journal of Fundamental and Clinical Research
https://jfcr.journals.ekb.eg/
ISSN 2735-023X
Vol. 4, No. 2, 107-118, December 2024

Accuracy of Dental Operating Microscope versus CBCT in Detecting the Number of Root Canals for Maxillary Second Molars Indicated for Retreatment

Ayman A. Hegab[1], Nihal Sabet[2], Ahmed Khalaf[3]

ABSTRACT

Introduction: A key failure of root canal treatment is the practitioner's inability to detect all the canals during treatment. Root canal detection aids like Cone Beam Computer Tomography (CBCT) scans and Dental Operating Microscopes (DOM) are valuable for an endodontist. Although CBCT scans are considered the most reliable method for canal detection, they cannot be employed in all cases due to the potential risk of subjecting patients to excessive levels of radiation. Nevertheless, the usage of DOM can be a valuable tool to avoid undetected canals. ***Aim:*** To assess the diagnostic precision of dental operating microscopes in identifying the number of canals in maxillary Second Molars requiring retreatment, in contrast to CBCT scans. ***Materials and Methods:*** Thirty-five individuals with upper second molars who required retreatment were included. A pre-operative Cone Beam Computed Tomography (CBCT) scan was acquired for all patients. However, it was not presented to the practitioner who performed the access cavity. **CBCT stage:** Scans were randomly assigned to endodontic specialists for segmentation, and the number of canals was documented. **Clinical stage:** Six endodontic postgraduate researchers created access cavities, removed the old root canal filling, and documented the number of canals. The data acquired in both stages was compared. ***Results:*** There was no statistically significant difference between the detected number of canals by the two methods. ***Conclusion:*** There was no significant difference between the detected number of canals by CBCT and the dental operating microscope. ***Recommendations:*** It is recommended that a dental operating microscope be employed for retreatment cases.

Keywords: Number of Canals, Dental Operating Microscope, DOM, CBCT.

INTRODUCTION

Treatment of root canals is a complex procedure that requires the achievement of multiple goals to prevent treatment failure. The objectives encompass a comprehensive cleansing and shaping of the root canal system, along with a precise and complete filling of the cleaned root canal system in three dimensions. However, a crucial goal of

1-Postgraduate Researcher, Endodontics Department, Faculty of Oral and Dental Medicine, Misr International University, Cairo, Egypt.
2-Professor of Endodontics, Endodontics Department, Faculty of Dentistry, Cairo University, Egypt.
3-Lecturer of Endodontics, Endodontics Department, Faculty of Oral and Dental Medicine, Misr International University (MIU), Cairo, Egypt.

root canal therapy is to identify all the canals within the root canal system, as the failure to locate a canal is a major factor contributing to treatment ineffectiveness.[1, 2]

Based on the literature, the primary factors contributing to practitioners' inability to find and treat canals are insufficient understanding of root canal morphology and limited availability of canal detection tools, such as dental operating microscopes (DOM) or cone beam computed tomography (CBCT). These tools are particularly useful in complex cases involving blocked canals caused by calcifications, posts, or broken instrument fragments.[3, 4]

In addition, numerous practitioners who are unable to identify all the canals within a root canal system continue to rely exclusively on two-dimensional imaging techniques. However, compared to three-dimensional imaging techniques like CBCT scans, two-dimensional imaging methods demonstrated significantly lower accuracy. Therefore, caution should be exercised when using two-dimensional imaging techniques to detect apical periodontitis or assess canal morphology due to the high likelihood of obtaining false-negative results.[5]

The maxillary second molar is a permanent molar that exhibits variances and complications in its root canal system. The complications referred to are primarily observed as extra canals or morphological differences within the existing canals. The occurrence of a second mesio-buccal canal in maxillary first molars is particularly noteworthy, with a prevalence ranging from 35% to 95%. This variation is believed to be influenced by racial differences.[6]

Additionally, as stated by Walcott et al., cases that require retreatment have a greater likelihood of having missed MB2 canals compared to cases that undergo initial treatment. This, in turn, can result in a higher probability of bacterial growth and the reoccurrence of infection. Clinically, this is evident through persistent pain, while radiographically, it is seen as the presence of a persistent periapical lesion.[7]

Cone beam computed tomography (CBCT) can offer a non-invasive approach to prevent the occurrence and minimize the impact of missed canals in root canal treatment. CBCT scans can provide practitioners with a precise and detailed 3-D visualization of the internal root canal anatomy. The utilization of 3-dimensional scans prevents issues arising from overlapping neighboring anatomical structures, which is commonly observed in 2-dimensional scans. Furthermore, unlike micro-CT, which offers a more detailed visualization of the internal canal structure, CBCT scans have a modifiable field of view (FOV) and a radiation dose that allows for their practical application in clinical settings.[8]

Nevertheless, it was found that the accuracy of CBCT scans in detecting canals during retreatment procedures may be compromised when the canals have been previously filled or when a high voxel size was utilized. Consequently, it was advised to remove the filling material in the root canal and use a limited field of view (FOV) to ensure the lowest voxel size is employed, thereby guaranteeing the maximum achievable resolution.[9]

Another tool that, if utilized, could greatly enhance a practitioner's ability to locate canals is the DOM (Dental Operating Microscope). The high magnification and coaxial illumination capabilities of a dental operating microscope (DOM) greatly enhance the clinical capabilities of clinicians. It was found that practitioners using magnification provided by a DOM are three times more likely to successfully locate MB2 canals compared to practitioners who do not use magnification.[10]

Moreover, in cases when retreatment is necessary due to blocked canals caused by broken instruments, it was found that operators who utilized a dental operating microscope (DOM) in conjunction with ultrasonic tips had a 76% probability of achieving success, with the likelihood varying depending on the specific location of the broken instrument.[3]

The aim of the study is to assess the diagnostic precision of dental operating microscopes in identifying the number of canals found in maxillary Second Molars requiring retreatment, in contrast to CBCT scans.

MATERIALS AND METHODS

After the MIU-IRB had reviewed the subject protocol by the Convened Board and ethical approval was obtained, A total of 35 patients were referred to the dental clinics complex at MIU for retreatment of their permanent upper second molars. After obtaining the patients' informed agreement, a Cone Beam Computed Tomography (CBCT) scan was performed utilizing the Endo mode prior to starting the treatment. However, it was not presented to the practitioner who performed the access cavity.

A pre-treatment periapical radiograph was obtained to assist the practitioner in preparing the access cavity.

CBCT stage: CBCT scans were randomly assigned to endodontic specialists for segmentation, and the number of canals was documented. The CBCT scans were encoded using patients' file numbers rather than their names. Subsequently, they were randomized using randomization software (Microsoft Office Excel, USA) for interpretation.

Clinical stage: Patients were randomly assigned to six endodontic postgraduate students who were engaged in the endodontic master's program at MIU. Subsequently, the students continued to create access cavities, remove the old root canal filling, and document the number of canals discovered. The data acquired in both stages was subsequently compared.

CBCT Stage:

A pre-operative CBCT scan was performed utilizing the Soredex Cranex 3D Dental Imaging System, Finland. The scan was conducted with the following parameters: XS FOV dimensions of 61 x 41 mm (HxD), XS FOV high resolution with 90 kV, 4 - 12.5 mA, and 6.1 s exposure time.

The scan field of view (FOV) was set to a narrow range (Endo mode) to get the highest possible picture resolution by utilizing the smallest voxel size that was available. The samples were assigned in a random manner to 2 co-supervisors for the purpose of segmenting and determining the number of canals. By utilizing the OnDemand program (USA), the CBCT images were analyzed and divided into segments.[11-14]

CBCT Analysis:

The pictures were enlarged by 150%, and the axial view of each upper second molar was adjusted to the sagittal plane.

To identify the existence of a missed canal, the axial plane of each maxillary second molar was examined along the whole length of the roots, beginning from the cemento-enamel junction, and extending to the root apex.

In addition, in cases when the two co-supervisors had differing opinions on the number of canals, a radiologist was involved to facilitate a resolution until an agreement between the two was established.[14]

Clinical Stage:

In this stage, 35 patients were allocated randomly among 6 postgraduate students using randomization software. The practitioners then performed access preparation utilizing a dental operating microscope (Leica M320D with 16x magnification and a fully integrated 4K camera). **(Figure 1)**

After receiving confirmation from clinic supervisors, it has been verified that all prior root canal filling has been removed and that thorough cleaning and shaping of the canals have been performed to the entire working

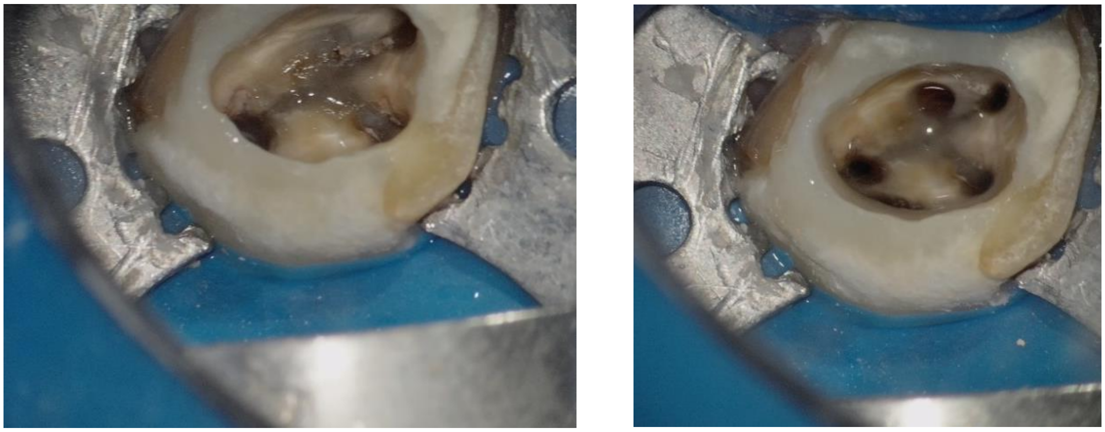

Figure (1): Showing Leica M320D 16x magnification when performing the access cavities.
A): Showing Access Cavity before removal of old root canal filling.
B): Showing Access Cavity after removal of old root canal filling and locating the second mesio-buccal canal.

length. Following the completion of the study procedures documentation, all cases were subsequently obturated by the same researcher.[15]

Grouping of samples:

The collected data was subsequently divided into two groups according to the canal detecting approach.

Group I, CBCT: The number of canals detected via the segmentation of CBCT scans performed by two endodontic professionals, which is considered the benchmark.

Group II, Clinical: The number of root canals identified through clinical examination utilizing dental operating microscope (DOM) after a postgraduate student performed access cavity preparation.

Statistical Analysis:

Qualitative data were presented as frequencies and percentages. Wilcoxon signed-rank test was used to compare between the number of canals detected by the two methods. *Kappa* statistic was used to assess agreement between different methods. *K*appa values ranging from 0.6 to 0.8 indicate good agreement, while values ranging from 0.8 to 0.99 indicate very good agreement. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. ROC (Receiver Operating Characteristic) curve was constructed to determine the diagnostic accuracy measures of AI in relation to CBCT and clinical examination. ROC curve analysis was performed with MedCalc® Statistical Software version 19.5.1 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2020).

RESULTS

I. Comparison between the two methods

There was no statistically significant difference between the detected number of canals by the two methods (*P*-value = 1). CBCT and clinical examination findings were the same. **(Table 1 & Figure 2)**

Table (1): Descriptive statistics and results of Wilcoxon signed-rank test for comparisons between detected number of canals by the two methods.

Number of canals	CBCT (n = 35)		Clinical examination (n = 35)		*P*-value
	n	%	n	%	
Two canals	2	5.7	2	5.7	1
Two canals	21	60	21	60	
Four canals	12	34.3	12	34.3	

Significance level at P ≤ 0.05

II. Agreement between different methods

The number of canals detected by CBCT and clinical examination (*Kappa* = 1) were perfectly in agreement.

III. Diagnostic accuracy of CBCT in relation to clinical examination

ROC curve analysis of CBCT for detection of a number of canals utilizing clinical examination as the Gold Standard is presented in Table (2) and Figure (3). ROC curve analysis showed that CBCT has excellent sensitivity (100%), excellent specificity (100%) and excellent diagnostic accuracy (100%). **(Table 2 & Figure 3)**

The comparison between Cone Beam Computed Tomography (CBCT) and clinical examination methods for detecting the

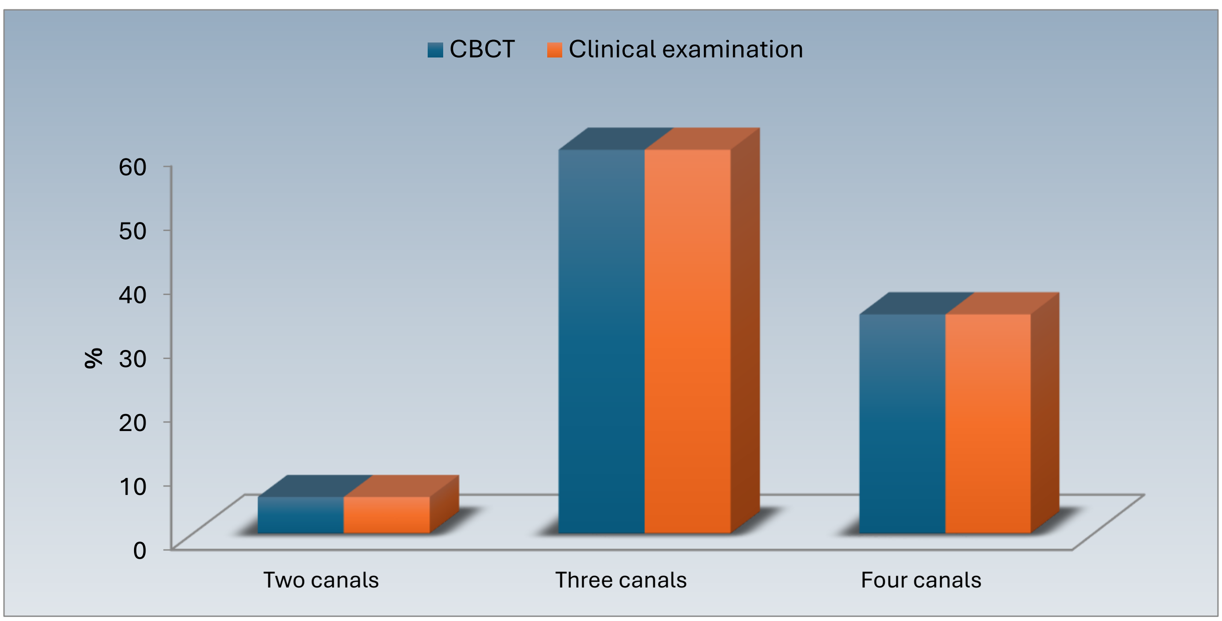

Figure (2): Bar chart representing number of canals detected by the two methods.

number of canals in dentistry revealed no statistically significant difference (P-value = 1). Both methods yielded consistent findings, with no variation in the detected number of canals between CBCT and clinical examination. This suggests that both CBCT and clinical examination are equally effective in detecting canal numbers, providing clinicians with reliable diagnostic options.

The agreement between Cone Beam Computed Tomography (CBCT) and clinical examination methods for detecting the number of canals in dentistry was perfect, with a Kappa value 1. This indicates complete agreement between the two methods in identifying the number of canals. The high Kappa value suggests strong concordance between CBCT and clinical examination findings, reinforcing the reliability of both approaches for diagnosing canal numbers in dental assessments.

Table (2): Sensitivity, specificity, predictive values, diagnostic accuracy, Area Under the ROC curve (AUC) and 95% confidence interval (95% CI) of the (AUC) for CBCT using clinical examination as the Gold Standard.

Sensitivity %	Specificity %	+PV %	-PV %	Diagnostic accuracy %	AUC	95% CI
100	100	100	100	100	1	0.897-1

+PV: Positive Predictive Value.
-PV: Negative Predictive Value.

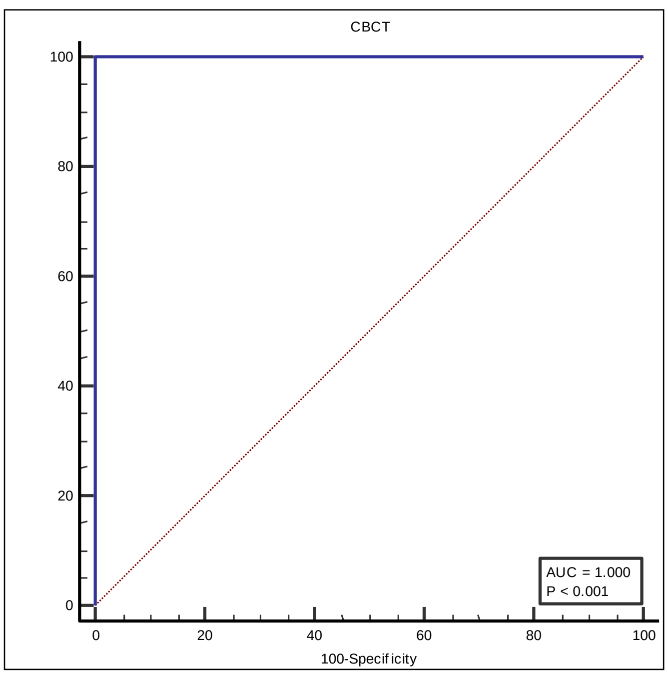

Figure (3): ROC curve of CBCT accuracy of detecting number of canals using clinical examination as the Gold Standard.

The Cone Beam Computed Tomography (CBCT) showed diagnostic accuracy in detecting the number of canals in relation to clinical examination, with clinical examination serving as the Gold Standard. The analysis reveals that CBCT exhibits outstanding performance, with 100% sensitivity, specificity, positive predictive value, negative predictive value, and diagnostic accuracy. Additionally, the Area Under the ROC Curve (AUC) is 1, indicating flawless discrimination between individuals with and without the condition. These results underscore the reliability and effectiveness of CBCT as a diagnostic tool in dentistry, particularly in identifying the number of canals.

DISCUSSION

First, we need to understand why retreatment is done; in a study regarding the correlation between untreated canals and the occurrence of periapical diseases in teeth that have had root canal treatment, it was revealed that 82.6% of teeth with untreated canals were associated with periapical diseases. In addition, molars that had an undiagnosed canal had a 3.1-fold higher probability of having periapical illness than molars that had received treatment for all canals. The researchers discovered a robust and significant correlation between the existence of untreated canals and the prevalence of apical periodontitis in teeth that have received endodontic therapy.[16]

When it comes to 2D radiographs and whether it is accurate in detecting correct canal numbers, it is widely acknowledged that periapical radiography has inherent limitations, particularly in the detection of root canals. The reason for this is that periapical radiographs are a two-dimensional image of a three-dimensional structure, and there are also anatomical landmarks that can obscure the view of the root canal. A study aimed to examine the accuracy of canal detection in the MB roots of maxillary molars using three different imaging techniques: Micro CT (considered the gold standard), CBCT, and digital periapical radiograph. The results indicated a comparable outcome between CBCT and micro-CT, with periapical radiography demonstrating lower efficacy in detecting canals. This justifies why 2D radiographs were not chosen as a technique in this study in detecting root canals.[17]

In the current study, CBCT was chosen because of its beneficial and valuable aid in detecting root canals. The precise identification of secondary canal anatomy by CBCT is crucial for general practitioners and endodontists to make informed treatment decisions. The combined assessments of the precision of CBCT yielded a sensitivity of 94% and a specificity of 93.1% for identifying the second mesio-buccal canal in permanent teeth. Cone beam computed tomography (CBCT) is an invaluable imaging modality for detecting the presence of an additional canal. Clinicians must acknowledge that the accuracy of their findings can differ depending on the specific characteristics of the teeth and the presence of extra canals in various populations.[18]

Furthermore, CBCT is commonly utilized by endodontists and general practitioners to ensure a well-informed decision-making process. A study sought to assess the influence of CBCT on the clinical decision making of endodontists and general practitioners following unsuccessful root canal treatment. The findings revealed that practitioners were inclined to modify their treatment approach in 49.8% of the cases after examining CBCT scans, as opposed to initially reviewing periapical radiographs.[19]

In this study, DOM was chosen as a technique in detecting root canals as it is a valuable tool in detecting root canals by magnifying the very small anatomical field that practitioners work in. Usually, in endodontics, there are several limitations due to its focus on extremely small anatomical structures, which restricts the working space available. A significant occurrence of apical periodontitis was seen in root canal-treated teeth with undiscovered or untreated canals, reaching nearly 90%. Most of these unnoticed canals were identified in the first and second molars of both the maxillary and mandibular dental arches. Therefore, professionals who handle complex situations seem to require a higher level of eye sharpness and intense concentration in order to perform well and detect all canals, thereby avoiding any possible failures in root canal therapy. The human eye has a limited capacity to perceive objects beyond the aperture of the canal. Furthermore, the sharpness of natural eyesight tends to decrease after an individual reaches the age of 40.[20]

The access cavities in this study were performed exclusively with the aid of a dental operating microscope. The application of magnification techniques in the field of endodontics is attributed to their ability to improve treatment results. Presbyopia is a gradual decrease in visual sharpness that typically begins to affect individuals around the age of 40. The Dental operating microscope (DOM) has demonstrated its effectiveness in reducing age-related vision deterioration by virtue of its magnification and coaxial lighting capabilities. Dental Operating Microscopes (DOM) are currently regarded as the optimal choice for endodontic therapy because of their exceptional ergonomics, magnification, and documentation capabilities. The Dental Operating Microscope (DOM) is primarily utilized for various objectives, such as the precise identification of all canals.[15]

In a retrospective study conducted on the effect of using the dental operating microscope on the outcome of non-surgical retreatment, it was found that maxillary second molars referred for retreatment had a higher likelihood of having a periapical lesion in the MB root if the original treatment was performed without the use of an aid, such as DOM, to determine canal morphology. Specifically, the MB root was found to be three times more likely to have a periapical lesion under these circumstances. This concept demonstrates the significance of identifying all canals during both initial root canal treatment operations and retreatment procedures.[21]

To further emphasize the results of the current study, another paper compared the utilization of a dental operating microscope and CBCT in cases involving retreatment. The findings suggested no difference between the two techniques in identifying canals. This indicates the necessity of employing high levels of magnification in endodontics in order to prevent the occurrence of missed canals. Although both methods of canal detection are generally comparable in importance, there was a distinct instance when the canal was not seen in the CBCT scan but was identified during the clinical examination. The difference in results can be explained by the presence of gutta percha, which causes an artifact, as well as the voxel size of the CBCT, which affects the X-ray quality.[9]

CONCLUSION

Based on the current study, it was concluded that the use of a dental operating microscope is crucial in the field of endodontics.

1. There is no differentiation between Cone Beam Computed Tomography (CBCT) and Dental Operating Microscope (DOM) when it comes to precisely detecting the number of root canals.

2. The analysis of the X-ray image can be affected by the voxel dimensions and the existence of artifacts in the CBCT scan.

RECOMMENDATIONS

It is recommended to employ a dental operating microscope for retreatment cases, regardless of what the CBCT scan indicates about the presence of additional canals. Through a comprehensive inspection and examination using a dental operating microscope, the presence of additional canals can be identified in all instances.

FUNDING

There was no external funding.

CONFLICT OF INTEREST

The authors confirm the absence of any conflicts of interest.

REFERENCES

1. Abarca J, Gómez B, Zaror C, Monardes H, Bustos L, Cantin M. Assessment of mesial root morphology and frequency of MB2 canals in maxillary molars using cone beam computed tomography. Int J Morphol. 2015 Jun;33(4):1333-7.
2. Tabassum S, Khan FR. Failure of endodontic treatment: The usual suspects. Eur J Dent. 2016 Jan;10(1):144-7.
3. Ling JQ, Wei X, Gao Y. Evaluation of the use of dental operating microscope and ultrasonic instruments in the management of blocked canals. Zhonghua kou qiang yi xue za zhi= Zhonghua kouqiang yixue zazhi= (Chinese journal of stomatology). 2003 Sep 1;38(5):324-6.
4. Patel S. New dimensions in endodontic imaging: Part 2. Cone beam computed tomography. Int Endod J. 2009;42(6): 463–75.
5. Estrela C, Bueno MR, Sousa-Neto MD, Pécora JD. Method for determination of root curvature radius using cone-beam computed tomography images. Braz Dent J. 2008;19:114-8.
6. Martins JN, Marques D, Silva EJ, Caramês J, Versiani MA. Prevalence studies on root canal anatomy using cone-beam computed tomographic imaging: a systematic review. J Endod. 2019 Apr 1;45(4):372-86.
7. Wolcott J, Ishley D, Kennedy W, Johnson S, Minnich S. Clinical investigation of second mesiobuccal canals in endodontically treated and retreated maxillary molars. J Endod. 2002 Jun 1;28(6):477-9.
8. Guo J, Vahidnia A, Sedghizadeh P, Enciso R. Evaluation of root and canal morphology of maxillary permanent first molars in a North American population by cone-beam computed tomography. J Endod. 2014 May 1;40(5):635-9.
9. Vizzotto MB, Silveira PF, Arús NA, Montagner F, Gomes BP, Silveira HD. CBCT for the assessment of second mesiobuccal (MB2) canals in maxillary molar teeth: effect of voxel size and presence of root filling. Int Endod J. 2013 Sep;46(9):870-6.
10. Buhrley LJ, Barrows MJ, BeGole EA, Wenckus CS. Effect of magnification on locating the MB2 canal in maxillary molars. J Endod. 2002 Apr 1;28(4):324-7.
11. Fayad M. The Impact of Cone Beam Computed Tomography in Endodontics: A New Era in Diagnosis and Treatment Planning. Colleagues for excellence, AAE, 2018,1-8.
12. Patel S, Brown J, Pimentel T, Kelly RD, Abella F, Durack C. Cone beam

computed tomography in Endodontics - a review of the literature. Int Endod J. 2019;52(8):1138–52.

13. Venskutonis T, Plotino G, Juodzbalys G, Mickevičienė L. The importance of cone-beam computed tomography in the management of endodontic problems: a review of the literature. J Endod. 2014; 40(12):1895–901.
14. Estrela C, Bueno MR, Sousa-Neto MD, Pécora JD. Method for determination of root curvature radius using cone-beam computed tomography images. Braz Dent J. 2008;19(2):114–8.
15. Low JF, Dom TNM, Baharin SA. Magnification in endodontics: A review of its application and acceptance among dental practitioners. Eur J Dent. 2018;12 (4):610–6.
16. Baruwa AO, Martins JN, Meirinhos J, Pereira B, Gouveia J, Quaresma SA et al. The influence of missed canals on the prevalence of periapical lesions in endodontically treated teeth: a cross-sectional study. J Endod. 2020 Jan 1;46 (1):34-9.
17. Domark JD, Hatton JF, Benison RP, Hildebolt CF. An ex vivo comparison of digital radiography and cone-beam and micro computed tomography in the detection of the number of canals in the mesiobuccal roots of maxillary molars. J Endod. 2013 Jul 1;39(7):901-5.
18. Aung NM, Myint KK. Diagnostic accuracy of CBCT for detection of second canal of permanent teeth: a systematic review and meta-analysis. Int J Dent. 2021 Jul 20;2021:1-8.
19. Rodríguez G, Patel S, Durán-Sindreu F, Roig M, Abella F. Influence of cone-beam computed tomography on endodontic retreatment strategies among general dental practitioners and endodontists. J Endod. 2017 Sep 1;43(9): 1433-7.
20. Mashyakhy M, Hadi FA, Alhazmi HA, Alfaifi RA, Alabsi FS, Bajawi H et al. Prevalence of missed canals and their association with apical periodontitis in posterior endodontically treated teeth: a CBCT study. Int J Dent. 2021 Jun 28; 2021:1-6.
21. Khalighinejad N, Aminoshariae A, Kulild JC, Williams KA, Wang J, Mickel A. The effect of the dental operating microscope on the outcome of nonsurgical root canal treatment: a retrospective case-control study. J Endod. 2017 May 1;43(5):728-32.