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Cone beam computed tomography in detecting the second mesiobuccal canal in the upper molars: A pilot study

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ABSTRACT

Background: *Root canal treatment aims to heal and/or prevent apical periodontitis. It is accomplished by removing inflamed or necrotic pulp, followed by sealing with the appropriate materials. Studies show that the endodontic treatment of the maxillary molars has the highest failure rate because of anatomical variations in the mesiobuccal (MB) roots.* ***Purpose:*** *This study aims to evaluate cone beam computed tomography (CBCT) to accurately identify the second mesiobuccal (MBII) canal in human maxillary first molars.* ***Methods:*** *The investigation was approved by the Research Ethics Committee of the Research Management Institute, Universiti Teknologi MARA (UiTM). Images were sourced from the Radiology Unit of the Centre for Oral Radiology Studies, Faculty of Dentistry, UiTM. CBCT images of permanent maxillary molars (n = 24) were selected. The images were of intact permanent maxillary first molars with complete root formation, with or without the presence of obturation material. The presence or absence of the MBII canals was analyzed by three examiners, and the data were recorded.* ***Results:*** *The MBII canals were present in 86% (n = 19) of the investigated upper first molars. All of the previously endodontically treated teeth (n = 10) revealed the presence of MBII canals, which were not obturated. Seventy-five percent (n = 3) of the patients exhibited four canals in both the right and left upper first molars.* ***Conclusion:*** *The MB roots of maxillary molar teeth have more variations in their canal system than the other two roots. CBCT is a good diagnostic tool for detecting and mapping the MB root-canal system and can potentially improve the quality of endodontic treatment.*

Keywords: *cone-beam computed tomography; mesiobuccal canal; pulp canal anatomy; root canal treatment; medicine*
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INTRODUCTION

Root canal therapy is deemed successful when it can prevent apical periodontitis, pain, and tooth loss.[1] This is achieved by the elimination of the inflamed and/or necrotic pulp tissue by means of a thorough chemomechanical debridement of the root canal system, followed by restoration of the canal space with an appropriate obturation material. Many in-vitro studies suggest the combination of photodynamic therapy and sodium hypochlorite to improve intracanal disinfection.[2–4] It is well established that the success of root canal treatment is multifactorial. It includes the root canal system's complexity, the diffusion ability of the intracanal medicament and irrigation within the dentinal tubules, their effect on biofilm formation, the degradation and resistance toward the intracanal pathogens, the quality of the obturation, and the final restoration.[5]

Root canal treatment of the maxillary molar teeth has the lowest success rate, possibly because of its intricate root and canal configuration with significant aberrations in the mesiobuccal (MB) roots.[6] Considerable dissimilarities in the occurrence of a second mesiobuccal canal (MBII) have been noted between the initial (primary) nonsurgical endodontic treatments and the retreatments.[7] This proves that the failure to locate, disinfect, and/or obturate an MBII canal is possibly the culprit for the technical shortcomings in the maxillary molars, directly causing inferior long-term prognoses.[7] Untreated canals or underfilled root canals result in the multiplication of bacteria, with a long-standing periapical inflammatory response expected to occur.

A dentist may leave a canal untreated if they fail to locate its presence or location. Therefore, all possible means should be utilized to locate the complete root canal system. In laboratory studies, many methods have been

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implemented to reveal canal anatomy. However, the use of an operating microscope[8] and conventional radiography are the most common methods to assess tooth anatomy.[8,9]

The permanent first and second maxillary molars show the most complexity and variation in the root canal system.[10–12] Commonly, these teeth present with three roots and four canals. The palatal root, which is ribbon-like and broad in mesiodistal width, usually presents with only one canal. The distobuccal root is conical in shape and contains a single canal. By contrast, the mesiobuccal root is broad in the buccolingual direction and usually contains two canals.[10]

The finding rate of MBII canals in the upper molars is higher in reports conducted *ex vivo* than *in vivo*. At least 70% of upper first permanent molars have MBII canals. Understandably, more MBII canals are being located as dentists become more skilled, and more specific instruments are used for endodontic treatments.[11,12] Having said that, not even 40% of upper first molars have MBII canals when treated clinically.

Radiographic examination is a vital adjunct to endodontic treatments. Radiography offers effective, nondestructive examination. Most importantly, it helps visualize periapical bone lesions. A number of techniques may produce somewhat precise observations, depending on the size and location of the disease process. Intraoral periapical radiographs have been the main technique for years.[13] However, observation by periapical radiograph does not always match with what is witnessed by the naked eye or some other anatomical appearances, as the two MB roots are overlapped in the direction of the x-ray. Notably, a periapical radiograph displays a two-dimensional image of a three-dimensional object; thus, the buccolingual dimension of a root cannot be fully understood.[13,14] The inability to detect an MBII canal prevents the comprehensive application of biomechanical instrumentation, irrigation, and obturation, leading to treatment failure.

Recently, digital radiography has increased in popularity in dentistry. Initially introduced in the 1990s, cone-beam computed tomography (CBCT) has the potential to show periapical bone loss that is not readily visualized by conventional periapical radiographs.[13,15–18] The innovation of CBCT has overcome numerous downsides of conventional radiography. It has many applications in dentistry, owing to its three-dimensional images that allow the visualization of a tooth in the axial, coronal, and sagittal planes. Studies show that the number of root canals and their locations relative to one another can be determined from the axial plane.[13,14,19,20] Furthermore, CBCT images can accurately show anatomical structures in their true state with no obvious magnification or distortion.[14,18–20] CBCT has been prescribed and used in endodontics to assess internal anatomy, diagnose the presence or absence of apical lesions, detect the presence and size of root resorption, identify root fractures,[9] and estimate the length of root canals.[13,14,16,17] This new technology provides a three-dimensional representation with minimal distortion and clarifies the detection of what used to be unknown in two-dimensional radiographs. CBCT has higher sensitivity and specificity than intraoral periapical radiographs, as demonstrated by *in vitro* studies on skeletal material, as well as clinical studies.[21] Among the many advantages of CBCT is that it is user-friendly. It also provides a three-dimensional picture of the exposed area, which can be of great benefit when dealing with multi-rooted teeth. From an endodontic standpoint, one of the most significant potential applications of this technology is root canal morphology.[14,21]

CBCT is a noninvasive, high-precision three-dimensional imaging technique that can increase the percentage of therapeutic success.[21] Research using an *in vitro* human model demonstrates the advantage of CBCT over conventional radiographs in detecting the presence of accessory canals.[19] An *in vitro* pilot investigation has revealed that CBCT is a trusted method for the identification of MBII canals, compared with the gold standard, the physical sectioning of specimens.[11] Therefore, this study aims to evaluate the accuracy of CBCT in identifying the MBII canal in human maxillary first molars.

MATERIALS AND METHODS

An interest in the intricate morphology and anatomy of the MB root led to this research. To appreciate the MB root, the use of the current technology, namely CBCT, was thought to be appropriate. The research proposal was prepared and presented at the Faculty of Dentistry's Research Proposal Meeting. Ethics approval was sought from and approved [reference number: 600-IRMI 95/1/6)] by the Research Ethics Committee of Research Management Institute, Universiti Teknologi MARA (UiTM), prior to the commencement of this investigation.

CBCT images were sourced from the Radiology Unit of the Centre for Oral Radiology Studies, Faculty of Dentistry, UiTM, Sungai Buloh Campus. All of the images were taken for diagnosis and treatment planning using a CS 9300 CBCT machine (Rochester, New York, USA) with isotropic resolutions of 0.09–0.5 mm and fields of view ranging from 5 × 5–17 × 13.5 cm. The 24 (n = 24) images selected as test subjects for this investigation were only of intact permanent maxillary first molars with complete root formation and with or without the presence of obturation material.

The 24 CBCT images of permanent maxillary first molars were processed using the CS 3D Imaging software (Atlanta, Georgia, USA) and projected onto a screen with a resolution of 1,280 × 1,024 pixels. This enabled observations in the coronal, sagittal, and axial views, as well as multiplanar reconstructed sections. Image magnification, display contrast, and image brightness were adjusted using the software's image processing tools to ensure optimal visualization.

The images were concurrently analyzed by three examiners: an endodontist and two final-year UiTM dental

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students. All the observers attended a short course in manipulating and reading images using the software, and interobserver reliability analysis was carried out. Analyses were performed twice by all the examiners after a one-week interval to reach a consensus in the interpretation of the MB root/canals. Following the evaluation and assessment of all the images, the number of MB roots and the presence or absence of MBII canals were evaluated. The data obtained from the investigation were recorded. The canal orifices were the radiolucent spots at which the canal evaluations began, the main canal was the long line that initiated from the orifice and ended in the apical foramen, and the final radiopaque appearance of the root structure was the root tip.

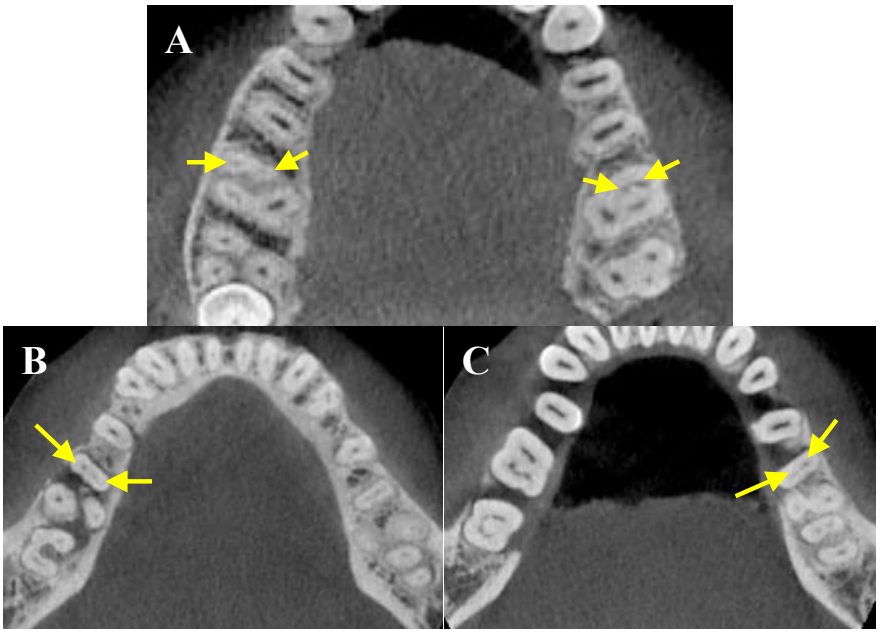

Figure 1. (A) Bilateral first molar teeth with four canals as seen from the axial view. (B and C) Bilateral first molar teeth with four canals of another patient (axial view). The yellow arrows point to both MB canals.

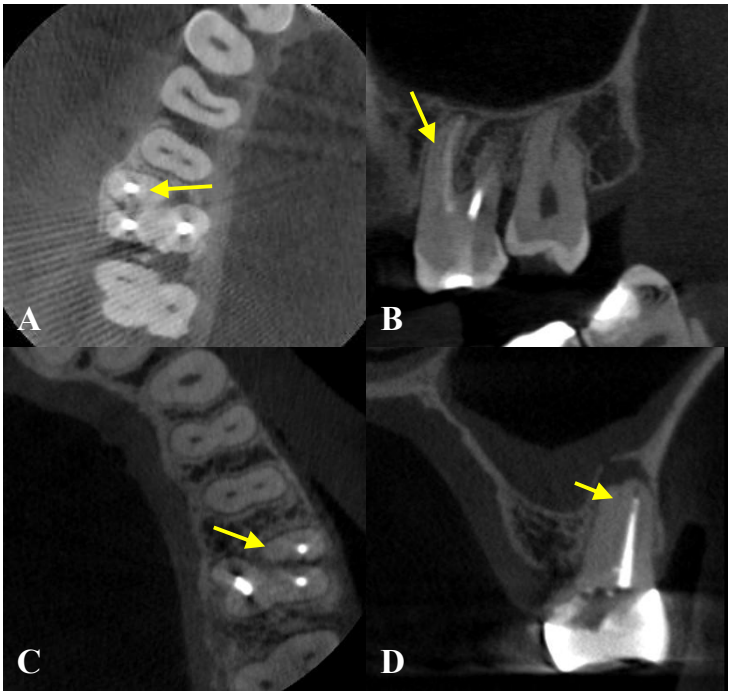

Figure 2. (A and B) CBCT images of two maxillary first molar teeth with four canals as seen from the axial and sagittal views. The yellow arrows show the missed MB canals. (C and D) Endodontically treated maxillary first molar tooth with four canals as seen from the sagittal and axial views. The yellow arrows show a missed MB canal. Also noted from the sagittal view is the periapical lesion associated with the MB root.

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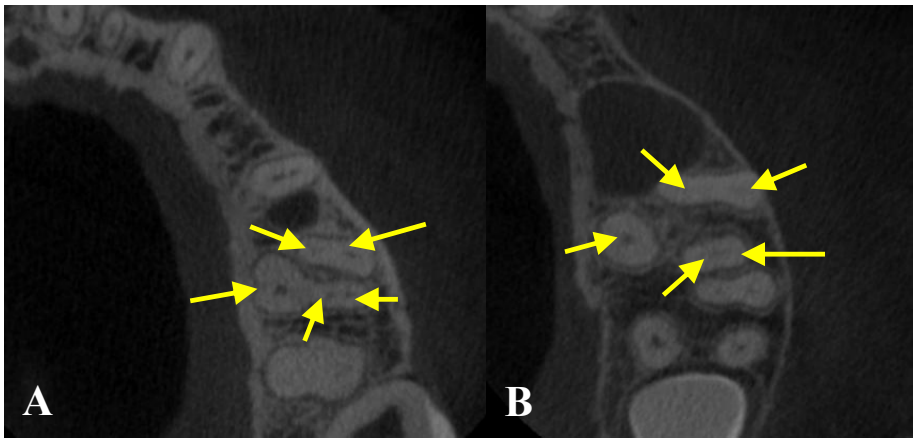

Figure 3. (A and B) CBCT images of two maxillary first molar teeth with five canals appreciated from the axial view. The yellow arrows show all of the canals.

Figure 4. Maxillary first molar with three canals appreciated from the axial view.

RESULTS

Twenty-four permanent maxillary first molars were included in this investigation. Out of 24, 10 were endodontically treated. The endodontic treatments of all the teeth were performed by previous final-year students of the Faculty of Dentistry, UiTM, between 10 and 20 months earlier.

The presence of MBII canals was noted in 86% of the teeth (n = 19) (Figures 1–4). All 10 (100%) of the previously endodontically treated teeth showed the presence of MBII canals within the MB roots. All of these MBII canals were not located by the previous operator; thus, no signs of obturation materials were detected within the canals. Periapical lesions associated with these missed MBII canals were also noted (Figures 2C and 2D).

Table 1. Data from the evaluation and analysis of the CBCT images

CBCT image (n = 24)	Number of canals			Number of missed canals from previous endodontic treatment	
	P	DB	MB	MB	Other
Tooth 1	1	1	2	1	
Tooth 2	1	1	2	1	
Tooth 3	1	1	2	1	
Tooth 4	1	1	2	1	
Tooth 5	1	1	2	1	
Tooth 6	1	1	2	1	
Tooth 7	1	1	2	1	
Tooth 8	1	1	2	1	
Tooth 9	1	1	2	1	
Tooth 10	1	1	2	1	
Tooth 11	1	1	2		
Tooth 12	1	1	2		
Tooth 13	1	1	1		
Tooth 14	1	1	1		
Tooth 15	1	2	2		
Tooth 16	1	1	2		
Tooth 17	1	1	2		
Tooth 18	1	1	2		
Tooth 19	1	1	2		
Tooth 20	1	1	1		
Tooth 21	1	1	1		
Tooth 22	1	2	2		
Tooth 23	1	1	1		
Tooth 24	1	1	2		

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This investigation also examined the CBCT images of four patients presenting with both permanent maxillary molars (n = 8). Interestingly, three out of four patients (75%) presented with four canals in both maxillary first molars. The analyzed CBCT images also showed that 9% (n = 2) had five canals: one P canal, two MB canals, and two DB canals (Figures 3A and 3B). Table 1 presents the data collected during the investigation.

DISCUSSION

Based on the findings of this investigation, 86% of the studied CBCT images of permanent maxillary first molars showed the presence of MBII canals. It is safe to assume that the majority of patients that come to the Faculty of Dentistry, UiTM, Sungai Buloh, have four canals. This information should be considered by all operators and/or clinicians at the center, especially when performing root canal treatments. This finding is consistent with a study of subpopulations in Brazil and Mexico.[12] Interestingly, a study of the Thai population found a lower incidence of MBII canals at 63.6%.[16]

All the previously endodontically treated upper first molars showed the presence of MBII canals. All these canals were not obturated and were witnessed with the presence of periapical lesions. This significant finding was also noted by do Carmo et al.[22] In their research, 134 out of 186 (72.4%) endodontically treated first upper molars showed missed MBII canals with periapical lesions. In this current study, the patients were called for review appointments, and upon clinical examination, all the endodontically treated teeth showed signs and symptoms. The pain was described as either a persistent pain (especially during mastication), a dull uneasy feeling, or an uncomfortable feeling of the tooth. Clinically, 9 out of 10 teeth were tender to percussion, half of the teeth presented with deep gingival pockets, two teeth had been restored with a crown, and no mobility was noted.

Within the Faculty of Dentistry, UiTM, a student will be assigned to one endodontist or restorative specialist as their supervisor for their clinical endodontic molar projects. Routinely, students will not have ample time to review root canal treatments performed on molar teeth, which, according to the American Association of Endodontics, should be between 6 and 12 months. The outcomes of the treatments delivered by the students were never assessed, or only if the patients were referred for further treatment by other students and/or specialists. This investigation revealed that all the patients who received endodontic treatments from previous students suffered from pain and uneasiness. The author felt that it is vital to review the old protocol for molar endodontic exercises for undergraduate students in the faculty. It may be helpful to have at least two supervisors for a clinical endodontic project when the teeth of concern are the first maxillary molars. This is because these teeth show variations in canal anatomy and number. If there are disagreements between the supervisors regarding the presence or absence of MBII canals, CBCT radiographs should be carried out so that a final consensus can be reached.

Conventional periapical radiographs are essential for (1) endodontic preoperative diagnosis and during (2) endodontic treatments and (3) postoperative evaluations. Its uses are routine around the world, including in the Faculty of Dentistry, UiTM. However, periapical radiographs only provide two-dimensional information of three-dimensional objects, limiting their diagnostic effectiveness. Furthermore, the interpretation of the images may pose some difficulties with regard to factors such as the superposition of anatomical structures and the high density of the bony zygomatic arch or impacted teeth.[23] Abuabara et al.[10] detected MBII canals in maxillary molars in 39.2% and 8% of these, respectively, through conventional periapical radiographs, demonstrating the low effectiveness of the method. Studies have concluded that conventional x-ray images are not reliable for identifying multiple canals.[20,24] Therefore, it is crucial to know and use any available and supplementary tools to aid in detecting MBII canals in the diagnostic phase.

In this study, 75% (n = 3) of the patients had four canals in both the right and left upper first molars. Evidently, MBII canals have a high tendency to appear bilaterally, which is similar to reports from a previous study.[11,16] Among the difficulties faced during this investigation was the need for well-trained personnel to fix the CBCT machine and software when they were not working properly. During our data collection, the CBCT machine and its software broke down and could only be fixed by the manufacturer. This took time and delayed the investigation. As this study's timeline was not long, the continuation of this research, including the calculation of the results and the discussion, was affected. Moreover, the author acknowledges the small number of images. Since this is a retrospective study, the images collected from the Radiology Unit, Faculty of Dentistry, UiTM, that could be used were limited. This study would have been more impactful if the number of samples had been bigger. The statistical analysis of the anatomy of the MBII occurrence would have mirrored the population and patient pool at the faculty better. The author also acknowledges that the images used for this study were of various resolution settings and fields of view. However, the author understands that higher resolution with the smallest field of view is recommended for root canal evaluation. Images with a larger field of view have poorer clarity and specificity. The last challenge was the stigma among clinicians regarding the CBCT imaging system itself. A few clinicians are worried about exposure in CBCT-system projects and assert that its usage in endodontics is not important. Nevertheless, the use of CBCT as a diagnostic tool for suitable endodontic cases is internationally growing and accepted.[21,24]

The failure of endodontic treatments of maxillary first permanent molar teeth is largely due to the failure to identify

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and disinfect the MBII canals.[8,10,12] The use of CBCT adjunct to conventional radiography can save time, help in treatment planning and diagnosis, and hopefully ensure a favorable prognosis of the treatment. With that being said, the author suggests that additional CBCT imaging is necessary only when the number of canals and/or the morphology of the pulp cannot be accurately investigated and studied via conventional radiographs.

According to the As Low as Reasonably Achievable (ALARA) principles, examination protocols must provide both adequate diagnostic ability and reduced radiation exposure.[21] Although CBCT is a reasonable method for investigating the presence of MBII canals, the radiation dose should be considered according to and following the basic principles of justification of means and aims.

The author feels that a continuation of this pilot study is vital. Another study should continue with a higher number of samples. This may be achieved by obtaining or including data from all CBCT units in Selangor or even Malaysia. With enough data, the occurrence of MBII canals among citizens of Malaysia can be appreciated and later divided into races and genders. Another way to improve future investigations is to recruit an oral radiologist to help interpret the CBCT images. The study of CBCT imaging is not taught in detail to undergraduate students, leading to limitations in interpretation and maneuvering information received from the CBCT machine and software. In this study, the endodontist involved helped overcome this issue, but the investigation would have been much better if another specialist had been involved. The author also notes that the usage of CBCT in all states of Malaysia is impossible due to its high cost and low availability. The author feel that with better marketing, other clinics and/or hospitals without CBCT imaging systems can refer their patients to the Faculty of Dentistry, UiTM. This can help solve many dental problems, as well as facilitate networking between medical centers.

Based on this study's results, it can be concluded that the MB roots of maxillary molar teeth have more anatomical variations in their canal system than the other two roots. CBCT is a good diagnostic tool for detecting and mapping the MB root-canal system and can potentially improve the quality of endodontic treatment.

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