Assessment of the middle mesial canals of mandibular first molars using cone-beam computed tomography: an *in vivo* study

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Abstract. – OBJECTIVE: For a successful root canal therapy, it is necessary to locate all the canals debride and seal them with an inert filling material. The clinician must be aware of the internal morphology and variations in a permanent tooth. Mandibular first molars are widely studied to identify variations in the anatomy of the pulp space. In this study, the primary objective was to measure the distance between the mesiobuccal (MB) and mesiolingual (ML) canals in patients with and without a middle mesial canal (MMC) using cone-beam computed tomography (CBCT). The secondary objectives were to assess the tapering degree of the mesial root and to measure the dentinal thickness in relation to the danger-zone area in patients with and without an MMC.

MATERIALS AND METHODS: A total of 200 CBCT scans were evaluated for the presence of an MMC. Two observers performed the observations, and the results obtained were subject to statistical analyses.

RESULTS: The results revealed the prevalence of MMC was 5%. The average distance between the MB and ML canals was higher when there was an MMC [M(SD) = 3.61 (0.6) *vs.* 2.69 (0.66)]. However, there were no differences between the groups in the distance to the danger-zone area and the tapering degree of the mesial root. On CBCT images, the MMC was clearly visible 3 mm apical to the level of the cementoenamel junction; beyond 3 mm, the MMC could not be traced.

CONCLUSIONS: Based upon the results of this study, the average distance between the MB and ML canals was higher when there was an MMC. A lesser degree of taper would be preferred to prepare the MMC than to prepare the other canals. It is recommended that careful examination of the canal 3 mm apical to the cementoenamel junction should be carried out when attempting to detect an MMC.

Key Words:
Cone-beam computed tomography, Mandibular first molar, Middle mesial canal root canal.

Introduction

A successful root canal treatment requires thorough mechanical and chemical cleaning of the canals, followed by a seal with an inert filling material. Generally, improper cleaning and shaping of the canals occur either due to a lack of proper understanding of root canal morphology or due to improper identification of the canals[1]. This occurs due to the anatomical variations in the number of roots, number of root canals, or even the shape of the root canals, which are often encountered. So, many clinicians today are equipped with newer diagnostic aids like (CBCT, micro-CT, and microscopes) which enable the identification of these cases with aberrant anatomy[1]. Mandibular first molars have one mesial root with two canals and one distal root with one or two canals[1].

In 1974, Vertucci and Williams[2] reported the presence of a middle mesial canal (MMC), and since then, there have been many reported cases of mandibular molars with aberrant root canal morphology. MMCs are situated mainly between the two main root canals: the buccal and lingual canals[3]. In their study, Pomeranz et al[4] found that 12 out of 100 molars had an MMC, which were classified into 3 types: fin, confluent, and independent.

The most common diagnostic methods used for locating root canals include the use of multiple preoperative radiographs, sharp explorers,

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ultrasonic tips, 1% methylene blue dye (for staining the chamber floor), sodium hypochlorite (for performing the "champagne bubble test"), as well as visualization of canal bleeding points[5]. In recent years, operating microscopes have revolutionized the practice of endodontics by allowing clinicians to visualize the canal more efficiently[6].

In recent times, computed tomography (CT) has been used widely in endodontics as an aid to diagnose additional canals. There have been many recent advances in CT, such as cone-beam computed tomography (CBCT), which was a major breakthrough in dental imaging when it was introduced in the late 1990s[7]. CBCT is a three-dimensional imaging system with a reduced radiation dose that easily facilitates the simultaneous viewing of images in 3 orthogonal planes: axial, sagittal, and coronal. It allows selected reconstruction of slices in all three planes and dynamic transversion of the area of interest in "real-time", rather than being restricted to the limited two-dimensional mesiodistal (proximal) plane of conventional radiography[8].

The mandibular first molar is the most common endodontically treated tooth and the most commonly extracted tooth after root canal treatment[9,10]. One of the reasons for the failure of endodontic treatment is the complexity of the root canal system and anatomical variations[4]. These variations include a separate distolingual root, C-shaped canals, the presence of an isthmus between the mesiobuccal (MB) and mesiolingual (ML) canals, and the MMC[11,12]. Therefore, it is imperative for clinicians to be aware of these variations in order to disinfect the root canal system[13,14].

Successful reduction of the microbial load leads to successful root canal treatment[15]. According to a systematic review[16], the prevalence of MMC ranges from 0.26% to 53.8%. This variation may be due to race, age, or the type of methodology used in the research. CBCT is more sensitive for the exploration of the root canal system than two-dimensional radiography[17]. Therefore, CBCT was used to compare patients with and without an MMC. The primary objective was to assess the association between the incidence of MMC and the distance between the MB and ML canals at the level of the cementoenamel junction (CEJ). The secondary objectives were to assess the relationship between the incidence of MMC and the degree of mesial root tapering, and the third objective was to assess the relationship between the incidence of MMC and the distance of the danger-zone area from it.

Materials and Methods

Sample Selection

This study was approved by the Institutional Review Board between January 2019 and January 2020. According to Karapinar-Kazandag et al[18], the M(SD) of MB-ML canal distance in the presence of MMC was 3.21 (0.76). Therefore, the power analysis indicated at least 16 cases (8 with MMC and 8 without MMC) in order to detect this mean. 200 CBCTs were selected using simple random sampling without replacement after excluding endodontically treated teeth, C-shaped roots, and roots with anomalies. Two 2nd year postgraduate students in the Endodontic Department at College of Dentistry examined the CBCT images for the presence of an MMC in mandibular first molars. Faculty and staff with 10 years of clinical experience mediated disagreements and excluded questionable cases. The CBCT scan demographics were blinded for privacy protection; therefore, we were not able to perform an analysis based on age and sex.

Technique

A 50 x 50 mm preoperative CBCT scan with a voxel size of 0.16 (Orthophos SL 3D; Dentsply Sirona Extraoral Imaging Systems, Bensheim, Germany) was used for the study purpose.

Image Evaluation

200 CBCT scans were evaluated for the presence of MMC, out of which 10 CBCT scans of cases with MMC were identified and compared to 10 CBCT scans of cases without MMC, and the following parameters were assessed:

1. The distance between the MB and ML canals (Figure 1A);
2. The mesial root thickness was examined by assessing the degree of taper of the root. In order to evaluate this, we measured the buccolingual distance at two levels: the CEJ level (Figure 1B) and 3 mm from the apex (Figure IC);
3. The distance to the danger-zone area (Figure 1D).

Statistical Analysis

The Shapiro-Wilk test was used to evaluate the distribution of the parameters, and a two-tailed *t*-test was used to compare the mean distance of each parameter in both groups. A paired *t*-test and Pearson's correlation were employed to assess the observer's reliability. All the statistical analyses were performed using IBM SPSS software (Version 25; IBM Corporation, Armonk, NY, USA) and considered a *p*-value of <.05 as statistically significant.

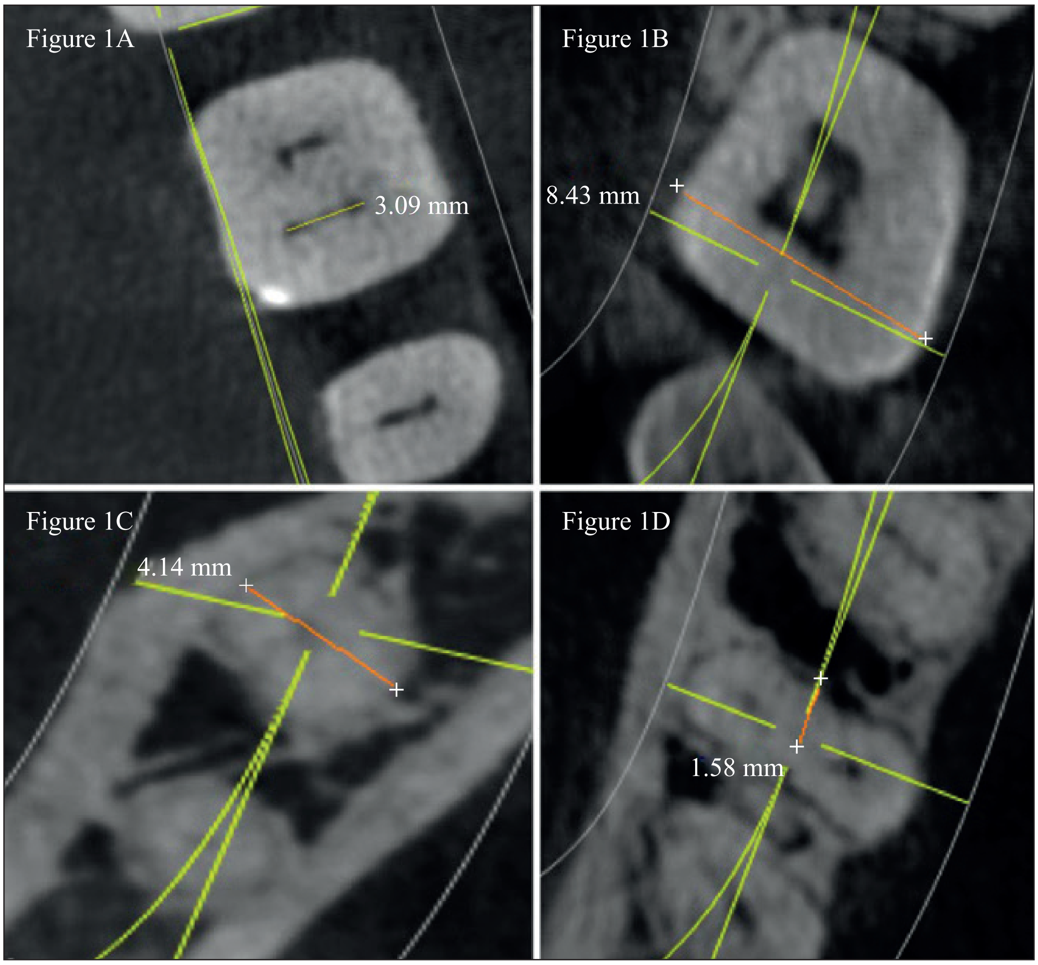

Figure 1. A, Axial view of the measurement of the distance between the MB and ML canals. **B,** Axial view of the measurement of the buccolingual distance at the CEJ level. **C,** Axial view of the measurement of the buccolingual distance at 3 mm from the apex level. **D,** Axial view of the measurement of the distance to the danger-zone area.
MB, mesiobuccal; ML, mesiolingual; CEJ, cementoenamel junction.

Results

200 CBCT images of the first molar were selected for this study. The postgraduate students identified 13 (6.5%) CBCTs images that had MMC, of which 3 CBCTs were excluded due to disagreement after the endodontic faculty's evaluation, which was related to whether the structure seen on the image was true MMC or an isthmus. Hence a total of 10 CBCTs were agreed. There was no significant difference between the two observers' measurements by paired *t*-test (*p*-value > 0.05). Moreover, there was strong correlation between the observers' measurements (r = 0.88) (*p*-value = .016).

10 CBCTs with MMC's were compared to 10 CBCTs without MMC's. It was found that the average distance between the MB and ML canals was higher when there was an MMC [M(SD) = 3.61 (0.6) *vs*. 2.69 (0.66)], and this difference was statistically significant (*p*-value = .005). It was also observed that there was no difference between the groups regarding the degree of taper of the root and the relationship between the dentinal thickness and the danger-zone area (*p*-value > .05) (Table I). The MMC was clearly visible 3 mm apical to the CEJ level, and beyond 3 mm, the MMC could not be traced on the CBCT images.

Discussion

Successful root canal therapy requires good knowledge of root canal anatomy and proper identification of the root canal systems. For the clinician, it is always technically challenging to

Table I. Comparison of parameters in the with-MMC and without-MMC groups by the independent *t*-test.

Parameters	With-MMC *(n)* = 10		Without-MMC *(n)* = 10		*p*-value
	Mean	SD	Mean	SD	
MB-ML distance	3.61	0.6	2.69	0.66	0.005*
Dentinal thickness to the danger-zone area	1.28	0.21	1.08	0.3	0.103
BL distance at the CEJ level	9.13	0.37	8.97	0.33	0.322
BL distance at 3 mm from the apex level	5.44	1.4	5.56	0.72	0.813

MB, mesiobuccal; ML, mesiolingual; CEJ, cementoenamel junction; BL distance, buccal-to-lingual distance; MMC, middle mesial canal; SD, standard deviation* (*p*-value < .05).

identify the aberrant canal anatomy of the molars. Most often, the mandibular first molars require root canal treatment because they show a high degree of anatomic variability and are more prone to caries[19]. Over the past, conventional Intraoral radiographs were used in the evaluation of the root canal systems. However, it has its inherent limitations to identify the root canal systems[20].

In the 1990s, conventional multidetector computed tomography (CT) was first introduced in the field of endodontics[20]. The CBCT has been shown to provide comparable images with reduced dose and cost to be an alternative to CT imaging in endodontics[20]. La et al[20], in their study, were the first to emphasize the use of CBCT technology to accurately diagnose the presence of MMC in their first case report. Hence, in this study, CBCT technology was used to evaluate the incidence of MMC and its relationship to the MB-ML inter-orifice distance and its location in relation to the danger zone.

Petridis et al[21], in their review on the clinical case, reported 0-15% of the middle mesial canal in mandibular first molars. Likewise, our study showed the prevalence of middle mesial canals to be 5% which is in accordance with this study. Patel et al[22] in their study, suggested the emphasis of different CBCT machines and their parameters. They differ in terms of image reconstruction, image detection sensitivity, and voxel parameters that influence the accuracy of the measurements. This study also emphasized that CBCT machines with small voxel sizes provide a higher detection level due to their higher sensitivity; based on these observations, in our study, CBCT machine with a small voxel size is used[22].

Akbarzadeh et al[23] in their study on 210 CBCT scans operating with 0.30 mm voxel size with an 8 x 8-inch field of view, were employed. The MB-ML inter orifice distance was inversely associated with the presence of MM canal[23]. In contrast, in our study, 10 CBCTs with MMC's were compared to 10 CBCTs without MMC's. It was found that the average distance between the MB and ML canals was higher when there was an MMC [$M(SD)$ = 3.61 (0.6) *vs.* 2.69 (0.66)], and this difference was statistically significant (*p*-value = .005). In our study CBCT scans operating at a 0.16 mm voxel size, which is half the size used when compared to the 0.30 mm voxel size used in the previous study[23]. This is due to the fact that CBCT machines with small voxel sizes provide a higher detection level due to their higher sensitivity[23].

A previous study[24] investigated the effect of troughing on the incidence of MMC, and they found that MMC of incidence increased after 2-mm troughing. However, troughing should not be performed to more than 2 mm because there is a chance of perforation due to the closeness to the danger-zone area. Keles et al[25] showed a significant decrease in all levels after preparing MMCs using micro-CT. In this study, the relationship between dentinal thickness and the danger-zone area was not significantly different between the two groups. Therefore, a high-tapered preparation should be avoided. Clinicians must be wise enough to use lesser-tapered files while preparing such canals.

Versiani et al[26] measured the size of the MB, ML, and MM orifices using micro-CT, and they found that the MMC was 2-3 times smaller than the MB and ML canals. This may explain the finding was noticed when the MMC was evaluated, i.e., the canal disappeared apically. This may be because the voxel size used could not detect the canal owing to its apical narrowing. Therefore, clinicians should carefully evaluate the presence of an MMC within 3 mm of the CEJ.

The limitation of this study was that we could not evaluate the age and sex of the participants to investigate if there was a difference in demographics. Furthermore, more accurate results would appear if the control group was evaluated on all the CBCT images and not only 10 matched cases. A higher number of *in vivo* assessments combined with clinical assessments are required for establishing an accurate relationship between age, sex, and MMC occurrence. In future studies, different parameters should be searched to validate our results.

Conclusions

CBCT machines with small voxel sizes provide a higher detection level due to their higher sensitivity and excellent diagnostic aid for diagnosing the internal anatomic variations of the pulp space. We concluded that an MMC is most likely to be found when the average of the MB-ML canal distance is [$M(SD)$ = 3.61(0.6)]. Additionally, when there is an MMC, the thickness of the dentin in relation to the danger-zone area is almost the same as that of patients without an MMC. In addition, the clinician must carefully examine the canal 3 mm apical to the CEJ when he/she searches for an MMC using CBCT. More *in vivo* assessments with different parameters are required in the future to validate our results.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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