Original Article

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Prevalence and morphology of middle mesial canals in a group of Thai permanent mandibular molars from cone-beam computed tomography images

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Objective: To determine prevalence and morphology of middle mesial (MM) canals in a group of Thai permanent mandibular first and second molars by using cone-beam computed tomography (CBCT).

Materials and Methods: CBCT images with a voxel size of 0.125 mm and field of view of 60 x 60 mm of 903 mandibular first and second molars from 595 Thai patients were examined. MM canals were classified as either confluent or independent type; fin (isthmus) type was not included. MM canal must have its own orifice within range of 1 mm from orifice level, with continuous canal at least half of root length. Presence and morphology of MM canals were recorded. Distances from MM canal to MB and ML canals were measured as well as the thinnest dentin thickness on furcal and mesial sides of MM canals.

Results: In overall, MM canals were found in 0.22% (2/903). Both MM canals were found in mandibular first molars (0.4%; 2/518). One was independent type, and the other was confluent type that joined with MB canal.

Conclusion: According to the classification, MM canals in this Thai population were very rare and detected only in mandibular first molars as either confluent or independent type.

Keywords: cone-beam computed tomography, mandibular molars, middle mesial canals, prevalence, root canal morphology, Thai

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Introduction

The goals of root canal treatment are to disinfect the root canal system and to prevent future reinfection by obturation of the cleaned and shaped root canal. One of the causes of failure in endodontic treatment is that clinician is unable to remove all the pulp tissue and clean the root canal system completely (1). Therefore, a better understanding of the root canal system and its variations is very important for successful endodontic therapy.

Mandibular molars are the most tooth type to be endodontically treated (2). There are several variations in the anatomy of mandibular molars. One of them is the additional canal in the mesial root known as the middle mesial (MM) canal. Pomeranz et al. (3) classified MM canals into three canal configurations, namely, fin, confluent, and independent. The prevalence of MM canals following this classification varies among the studies ranging from 0-46.2 % (3-21).

The difference in the prevalence of MM canals between the studies might be due to the investigation methods, the studied population, and the definition to justify MM canal. The laboratory methods used to analyze root canal morphology include tooth sectioning, clearing techniques, and microcomputed tomography (Micro CT). Clinically, radiographic interpretation and visual inspection (with magnification) are used during endodontic treatment. However, two-dimensional image of conventional periapical radiograph has a limitation to evaluate the root canal system due to the distortion and the superimposition of dental structures (22). Cone-beam computed tomography (CBCT) is a clinical radiographic technique that provides three-dimensional information. There are several useful applications of CBCT imaging in endodontics including identifying the root canal system (23).

The prevalence of MM varies among the studied populations and methods. For example, Wang et al. (18) reported finding three canals in the mesial root of mandibular first molars in 2.3% of a Chinese population using CBCT. The prevalence of MM canals in a Thai population was reported at a higher percentage of 5.61% by the laboratory clearing technique (13). However, the presence and morphology of MM canals in the studies were generally based on the Pomeranz's classification (3) that included the fin/isthmus type; this type is wherein the endodontic file can pass freely through the fin or isthmus between the MB and ML canals. The fin type is not a true separated canal and should not be counted as one type of MM canal. Thus, the reported prevalence of MM canals is likely to be over-estimated. Therefore, the aim of the study is to determine the prevalence and morphology of MM canals according to the strict classification (not including the fin/isthmus type) in Thai permanent mandibular first and second molars from CBCT images.

Materials and methods

The protocol was approved by the Institutional Review Board for Ethics Approval, Faculty of Dentistry/Faculty of Pharmacy, Mahidol University, Thailand. CBCT images of permanent mandibular first and second molars from the patients of the Oral and Maxillofacial Radiology Clinic at the Faculty of Dentistry, Mahidol University, Thailand, from 2013 to 2015 were collected. The CBCT images were taken using a 3D Accuitomo XYZ Slice View Tomograph (J. Morita, Kyoto, Japan) operating at 90 kV and 5.0 mA, with an

exposure time of 17.5 s. The voxel size was 0.125 mm, slice thickness was 1 mm, and field of view was 60 x 60 mm. All CBCT exposures were performed by an appropriately licensed radiologist.

The CBCT images and mandibular molars were selected according to the following criteria. Inclusion criteria were 1) Thai patients from 10 to 70 years old, 2) permanent mandibular first or second molars with complete root formation, and 3) CBCT at 60 x 60 mm field of view and 0.125 mm of voxel size. Exclusion criteria were 1) endodontic surgery/post placement, 2) crown restorations that hinders root canal inspection, 3) root canals with resorption and calcification, 4) root fracture, 5) C-shaped root canals, and 6) dental anomalies.

The selected CBCT images were analyzed with One Volume Viewer software on a 15-inch MacBook Pro LED screen with a resolution of 2880x1800. The contrast and brightness of the images were adjusted for the best visualization. The mesial root of mandibular molars was adjusted in vertical alignment and then carefully scrolled downward through the images from the canal orifice to the apex at the axial plane. The sagittal and coronal planes were also adjusted for the additional details of the root canal system. The collected data were recorded as follows and analyzed using descriptive statistics.

1) Gender and age of the patient.
2) Tooth type (permanent mandibular first or second molars).
3) Prevalence of MM canals. In this study, MM canal was defined as:
   - Located between mesiobuccal (MB) and mesiolingual (ML) canal.
   - Had orifice within range of 1 mm from the orifice level.
   - Continuous canal at least half of the root length.
4) Morphology of MM canal based on the modified Pomeranz's classification:
   - *Independent* MM: The canal originates as a separate orifice and terminates as a separate apical foramen.
   - *Confluent* MM: The canal originates as a separate orifice but apically joins the MB or ML canal.
5) The distances from the MM canal to the MB and ML canals.
6) Thinnest dentin thickness on furcal and mesial sides of the MM canal.

Results

Of the 595 Thai patients, 375 were women and 220 were men, with age range 11-68 years old. In total, 903 teeth (518 mandibular first molars and 385 mandibular second molars) were analyzed.

Two MM canals were identified in the 21 year-old female and the 38 year-old male. The MM canals were identified in 0.22% of all mandibular molars (2/903). Both MM canals were found in mandibular first molars (0.4%; 2/518). One canal was confluent type, wherein MM canal was joined with MB canal (Fig. 1), and the other was independent type (Fig. 2). No MM canal was detected in mandibular second molar in this study.

For the confluent type, the distances from the MM canal to the MB and ML canals as well as the thinnest dentin thickness on furcal and mesial sides of the MM canal were shown in Table 1. On the contrary, the independent type was not measured because the canal was already in the process of endodontic treatment before referred for CBCT to find the additional canal.

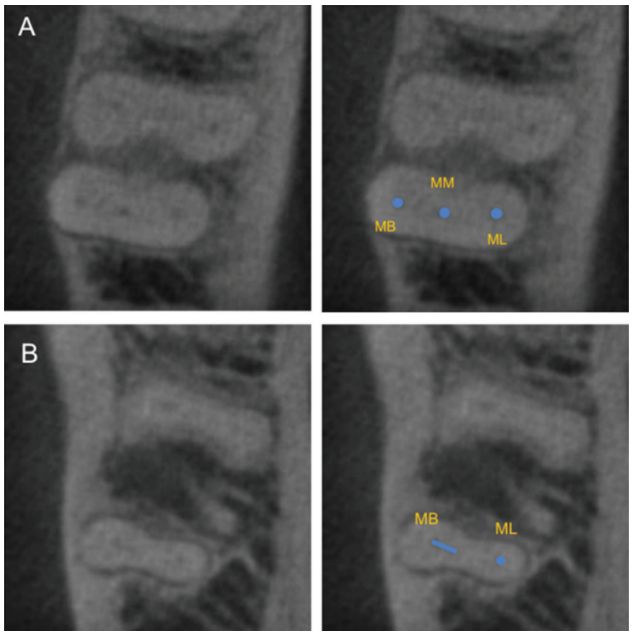

Figure 1 CBCT images of middle mesial canal that was confluent type: (A) Middle mesial canal at 1 mm below the orifice level. (B) Middle mesial canal joined with mesiobuccal canal at the 7 mm below orifice level. MB, mesiobuccal; MM, middle mesial: ML, mesiolingual.

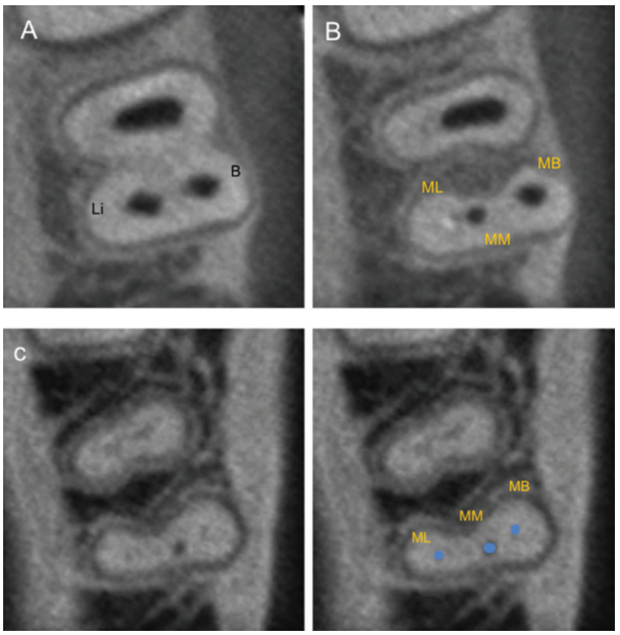

Figure 2 CBCT images of middle mesial canal that was the independent type: (A) At the orifice level, 2 canals were observed. (B) At 1 mm below the orifice level, there was an additional canal, which was the mesiolingual canal. The canal that was previously located next to the mesiobuccal canal was middle mesial canal. (C) At the apex of root, all three canals terminated as their own separate apical foramens. MB, mesiobuccal; MM, middle mesial: ML, mesiolingual.

Table 1 Characteristics of two middle mesial canals- one confluent type and one independent type.

Type of MM canal	Distance from (mm)		Minimal dentin thickness (mm)		
	MB canal	ML canal	Furcation side	Mesial surface	At root level
Confluent (to MB canal)	1.93	2.65	0.69	1.08	Middle
Independent			N/A*		

MB, mesiobuccal; ML, mesiolingual; N/A*- the independent type was not measured because the canal was changed from the process of initial endodontic treatment prior to referred for CBCT to find the additional canal.

Discussion

This study determined the prevalence and morphology of MM canals in Thai permanent mandibular first and second molars based on a retrospective analysis of CBCT images. Currently, CBCT has been used in endodontics for better understanding of the root canal system with the results conforming to the laboratory techniques (24, 25). In this study, scan settings of the studied CBCT images were at 60 x 60 mm field of view, 0.125 mm of voxel size for a clear image to investigate the root canal anatomy (26). Mirmohammadi et al. (27) reported that CBCT was a reliable method to detect a small canal, such as second mesiobuccal canal in maxillary molars.

However, CBCT has some limitations in detecting the root canal. It may be unable to show the details of root canal system in cases wherein the canal is very small. MM canal is located in sub-pulpal groove, and the canal is an additional canal that is usually smaller than the main canal. The canal may be smaller than the setting of the voxel size and, therefore, may not be detected in the image. This may affect the presence of MM canal in this study using CBCT images. Furthermore, CBCT is not used routinely in all cases of endodontic treatment and considered only when further radiographic details are required for diagnosis and treatment planning.

In the present study, we found 2 MM canals in 518 mandibular first molars (0.4%), lower than the previous studies which were 2.6-46.2% (3-21). This difference may be related to ethnicity of the samples, study design (*in vivo* vs. *in vitro*), technique of canal identification, and the definition of MM canal. In general, MM canals were classified based on the Pomerenz's classification as fin, confluent, and independent (3). For this study, we emphasized to apply the results for a clinical situation and decided not to include the fin type as MM canal. The definition of the fin type is wherein the instrument could pass freely through the fin or isthmus between the two main MB and ML canals. Thus, the root canal treatment of the fin type is not different from treating the root canal with a presence of isthmus.

Moreover, we add more details of the MM canal definition. The orifice must be within the range of 1 mm from the orifice level and had the continuous canal at least half of the root length. This strict definition of MM canal cause the lower chance to find MM canals that matched to the definition. In fact, we found the canals similar to MM canal in 11 other mandibular molars, but these canals did not match the strict definition because the canals were only 1 to 3 mm length or were found only at the apical part of the roots.

In addition, there were some studies reported that the age was one of the factors related to the prevalence of MM canals with decreased prevalence as age increased (21). There was a higher prevalence in the young population especially under 20 years old (7, 20). This may be due to the ongoing calcification process with aging (28). In this study, the majority of patients who required the CBCT examination were due to the pre-implant evaluation. There is a difference in distribution of age as the pre-implant cases were usually in the older patient population. In the younger population, the CBCT images were usually taken for impacted teeth, and the number of selected images was lower in this study.

The prevalence of MM canal in Asian populations was 1-13.3% (8, 9, 12, 13, 16, 18). In Thais, the prevalence of MM canal was 5.6% (13). Most of the root canal investigations were in laboratory using the clearing technique. Only Wang et al. (18) used CBCT and detected MM canal in 2.3% of the population studied. Nevertheless, these studies investigated root canal morphology and did not aim for MM canal only, so the prevalence of MM canals were analyzed from the Vertucci's classification (29) with additional modifications (13). These may cause the difference in details identifying MM canals and the prevalence compared to our study.

Most prevalence anatomies of MM canal were fin or confluent based on studies, but independent type was very rare (3, 7, 20). For this study, the morphology of two MM canals was with confluent and independent types. For the confluent type, MM canal joined the MB canal which was consistent with Campos (7), but different from Kazandag et al. (19) that reported that the majority (43%) of MM canals merged with the ML canals.

In conclusion, MM canals according to the strict classification were very rare in a Thai population. However, we should be aware of the complexity of mesial root of mandibular molar with the isthmus or fin between the main MB and ML canals.

Competing interests

None declared.

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