The Association between the Anatomic Landmarks of the Pulp Chamber Floor and the Prevalence of Middle Mesial Canals in Mandibular First Molars: An *In Vivo* Analysis

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Abstract

Introduction: The present study aimed to determine the incidence and anatomic variation of the middle mesial (MM) canal in mandibular permanent first molars using cone-beam computed tomographic imaging and to evaluate the association between the presence of MM canals and anatomic landmarks of the pulp chamber floor in the mesial root. **Methods:** In this *in vivo* cross-sectional study, 210 CBCT scans of mandibular fist molars from 210 patients were included. CBCT scans were evaluated in 3 sections, and the following data were collected for further analysis: identification of the MM canal, the distance between the mesiobuccal (MB) and mesiolingual (ML) orifices, the presence of any isthmus between the MB and ML orifices, and the MB and ML root canal system (RCS) configurations. Binary logistic regression was performed to assess the effect of pulp floor anatomic characteristics as an independent variable on the outcome variable (the presence of an MM canal). **Results:** The overall prevalence of the identification of an MM canal regardless of age was 14.7%. Mandibular first molars with an isthmus between the MB and ML RCS configurations were almost 5 times more likely to show an MM canal ($P < .05$, odds ratio [OR] = 4.9). The MB-ML intraorifice distance was inversely associated with the presence of an MM canal ($P < .05$, OR = 0.73). Patients less than 42 years old were 4 times more likely to have an MM canal in their CBCT scans compared with patients older than 42 years old ($P < .05$, OR = 3.9). **Conclusions:** The suggested anatomic landmarks of the pulp chamber floor could act as a reliable predictive factor for the presence of an MM canal. This knowledge of anatomic clues may serve to better direct endodontists in locating an MM canal, which could prevent excessive removal of tooth structures. *(J Endod 2017;■:1–5)*

Key Words

Cone-beam computed tomography, mandibular molar, mesial canal, middle mesial canal, morphology

Significance

The MB-ML intraorifice distance and the age of the patient had an influence on the presence/absence of an MM canal.

The success of nonsurgical root canal treatment (NS RCT) depends on the effective reduction of the microbial load from the root canal system (RCS) configuration (1, 2). Missed RCS configurations are 1 of the factors that have been associated with a significantly higher prevalence of endodontic lesions and lower healing outcomes (3, 4). Therefore, understanding the internal anatomy of the tooth is crucial in the overall success of NS RCT.

The mesial root of mandibular first molars exhibits a high degree of anatomic variability (5, 6). The middle mesial (MM) canal is 1 of the anatomic complexities of the mesial root, with an incidence ranging from 3%–46% (7–9). Considering the adverse impact of missed RCS configurations on the outcome of NS RCT (3), various studies have attempted to explore the anatomy of the mesial root of mandibular molars with a focus on MM canals (7–9). However, none of these studies have been able to propose clinical guidelines to help clinicians better predict the presence of an MM canal using reliable diagnostic tools such as cone-beam computed tomographic (CBCT) imaging.

CBCT imaging can be used as a reliable aid in the identification of RCS configurations with superior sensitivity relative to 2-dimensional radiographic modalities (10). Recently, several *in vitro* studies have attempted to investigate the incidence of MM canals using a dental operating microscope or spiral computed tomographic imaging (7–9). However, none of these studies have assessed the various anatomic configurations of MM canals and their association with anatomic landmarks of the pulp chamber floor using CBCT imaging.

The complex anatomy of the mesial roots of mandibular molars, if not addressed, may harbor reservoirs of microorganisms (11). Effective management of an MM canal requires a thorough understanding of its complex anatomy and relationship with other RCS configurations. Hence, the purpose of this study was to determine the incidence and

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anatomic variations of MM canals in mandibular permanent first molars using CBCT imaging and to evaluate the association between the presence of an MM canal and anatomic landmarks of the pulp chamber floor in the mesial root.

Materials and Methods

Sample Selection

CBCT scans of patients who visited Case Western Reserve University School of Dental Medicine, Cleveland, OH, between January 2012 and January 2016 were reviewed. The study design was approved by the Case Western Reserve University Institutional Review Board. All CBCT images were taken for diagnostic purposes such as oral surgery, orthodontic treatment, implant treatment planning, and maxillofacial diagnosis. Four hundred fifty-one CBCT records containing mandibular first molars were collected and reviewed.

Radiographic Techniques

All CBCT scans were obtained by a Carestream 9300 unit (Carestream Health, Atlanta, GA) operating at a 0.30-mm voxel size, 8 × 8 inch field of view, 90 kVp, a 5-mA tube current, and a 20-second exposure time. Images were taken according to the manufacturer's recommended protocol by an appropriately licensed radiology technician strictly following the "as low as reasonably achievable" principle.

Image Evaluation and Data Extraction

Images were analyzed using Invivo 5 (Anatomage, San Jose, CA) on a Dell Precision T5400 workstation (Dell, Round Rock, TX) in a darkroom. All CBCT scans that allowed for a clear reading of the mandibular molar anatomy were reviewed. Teeth with previous endodontic treatment, root resorption, immature apices, and restorative material below the roof of the pulp chamber were excluded. Exclusion criteria included low-quality CBCT images in which RCS configurations were not discernible as well as those with scatter or beam-hardening obstruction of the mesial root because of an adjacent implant, orthodontic appliance, or jaw pins/screws. After application of the primary inclusion criteria, 210 CBCT scans of mandibular first molars from 210 patients were included in the present study.

Two endodontic residents (N.A. and N.K.) independently evaluated the CBCT records twice with a 1-month interval between the assessments. To confirm the reliability of the data, intraexaminer calibration was performed before the experiment. In cases of disagreement, CBCT images were reviewed with a board-certified radiologist until a final consensus was reached among the 3 evaluators. Images were obliquely aligned to the long axis of the tooth to be examined. The contrast, brightness, and sharpening tools of the image processing software were adjusted to ensure optimal visualization. All CBCT scans under evaluation were analyzed in 3 planes (coronal, sagittal, and axial) by carefully scrolling the toolbar from the pulp chamber floor to the apex. The following data were collected for further analysis:

1. Patients' age and sex
2. Identification of any MM canal (present/absent); distinct orifices within the range of 0–2 mm below the pulpal floor were considered as MM canals
3. The distance between the orifices of the mesiobuccal (MB) and mesiolingual (ML) canals
4. The presence of any isthmus between the MB and ML orifices (present/absent)
5. MB and ML canals
6. The configuration based on Weine et al's classification (12)

In cases in which an MM canal was identified, the following additional data were collected using Invivo 5 software's built-in measuring tool with the MM canal orifice as the reference point as shown in Figure 1*A* and *B*: the MM orifice distance to the MB and ML orifices, the MM orifice distance to the periodontal ligament on the distal side of the root (danger zone), and the morphology of the MM canal as it travels apically (whether the MM canal joins with the MB/ML canals or exits independently).

Statistical Analysis

Statistical analysis was performed using SPSS Version 24 (SPSS, Inc, Chicago, IL). Binary logistic regression was used to determine the possible association between predictor (independent) variables such as age; sex; the MB-ML orifice distance; the MB-ML canal configuration according to Weine et al's configuration; the presence of an isthmus between the MB and ML canals; and the occurrence of the outcome variable, which was the presence of an MM canal.

Results

A total sample of 210 mandibular first molars were included in this study. This sample was collected from the CBCT scans of 210 patients (134 men and 76 women) with a mean age of 56 years old.

The intraobserver and interobserver reliability were calculated with a Cohen kappa coefficient during the calibration period in the study. Both intra- and interobserver reliability yielded high kappa coefficients (0.93 and 0.87, respectively).

Of the 210 CBCT scans of mandibular first molars, an MM canal was identified in 31 of the scans. Figure 2*A–L* depicts the identified MM canal at 3 different levels (ie, coronal, middle, and apical) in the axial view. The overall prevalence of an MM canal regardless of age was 14.7%. Table 1 details the anatomic characteristics of an MM canal with regard to the pulp chamber landmarks. According to Table 1, the mean distance between the MB and ML orifices was 3.1 mm in samples in which an MM canal was identified. This distance was 3.7 mm in cases in which an MM canal could not be identified ($P < .05$). An MB-ML isthmus was present in 87% of mandibular first molars with an identifiable MM canal. Furthermore, in 77% of samples in which an MM canal was identified, the MB and ML RCS configurations showed a Weine type III configuration. The MM canal joined to either the MB or ML RCS configuration 76% of the time (Weine type II). However, 24% of the time the MM canal exited as a separate foramen (Weine type III). The average MM orifice distance to the periodontal ligament on the distal side of the root (danger zone) was 1.7 mm.

Binary logistic regression was performed to predict the presence of an MM canal based on anatomic characteristics of the mesial root and the pulpal floor. In this model, age, the MB-ML orifice distance, an MB-ML isthmus (present or absent), and the MB-ML configuration (Weine type II/III) were considered as predictor variables. Because the median age of the patients was 42 years old, age was categorized into 2 groups of ≤42 and >42 years old. The results of the regression analysis have been detailed in Table 2.

In the present model, age, the presence of an MB-ML isthmus, the MB-ML orifice distance, and the MB-ML Weine configuration remained significantly associated with the presence of an MM canal. Mandibular first molars with an isthmus between the MB and ML canals were almost 5 times more likely to have an MM canal ($P < .05$, OR = 4.9). The MB-ML intraorifice distance was inversely associated with the presence of an MM canal ($P < .05$, odds ratio [OR] = 0.73). In other words, the presence of an MM canal was 2 times less likely to be identifiable in mandibular molars with every 1-mm increase in the distance of MB-ML orifices. There was a significant association between the MB-ML Weine type