Relationship of the Incidence of C-shaped Root Canal Configurations of Mandibular First Premolars with Distolingual Roots in Mandibular First Molars in a Taiwanese Population: A Cone-beam Computed Tomographic Study

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Abstract

Introduction: The aim of this study was to determine the prevalence of C-shaped canal configurations (CSs) and radicular grooves (RGs) in permanent mandibular first premolars (MPs) and to investigate the relevance of such complexities with the presence of distolingual roots (DLRs) in permanent mandibular first molars (MMs). **Methods:** A total of 800 pairs of MPs and MMs were investigated using a cone-beam computed tomographic system (NewTom 5G; QR srl, Verona, Italy). The frequency and symmetry of DLRs in MMs along with the occurrence of RGs and CSs in examined MPs were evaluated. Multivariable logistic regression analysis was applied to examine the correlation between the CSs of MPs with the appearance of DLRs in MMs. **Results:** In the examined teeth, 23.0% of MMs had a DLR, whereas 16.6% of MPs had RGs and 12.5% of MPs had C-shaped canals. Although the most common canal configuration in MPs is the single canal (74.1%), the other 25.9% still possess complicated root canals. Of these MPs that have different canal configurations, 54.6% had 2 canals, whereas 44.4% had CSs. Specifically, the CS showed a high prevalence of C3 morphologies at 98.9% followed by C1 at 1.1%. A corresponding and increasing frequency was noted in CSs and RGs of MPs and MMs with DLRs ($P < .001$). After adjusting for related categoric variables, the adjusted odds ratios for CSs of MPs in the bilateral DLR group compared with the non-DLR group was 3.294 ($P < .001$). **Conclusions:** This study showed an increased appearance of CSs in MPs when DLRs were present in MMs in the Taiwanese population. *(J Endod 2018;■:1–8)*

Key Words

Cone-beam computed tomography, C-shaped root canal configuration, distolingual root, mandibular first molar, mandibular first premolars

Significance

This study showed increased C-shaped canal configurations and radicular grooves in MPs when DLRs were present in MMs in the Taiwanese population. These findings may provide clinicians with a thorough understanding of the anatomic variants of MMs and MPs.

Having abundant knowledge regarding root and canal morphology of permanent teeth would benefit clinicians in locating, negotiating, and cleaning canals in their daily practice (1, 2). On the contrary, inadequate knowledge regarding anatomic features of the root and canal systems of treated teeth may result in endodontic treatment failure (2).

Several morphologic variants of the permanent mandibular first molar (MM) have been reported in the past (3). Recently, there has been an increase in publications addressing potential clinical challenges regarding aberrations in root and canal morphology of MMs, such as the distolingual root (DLRs) (also named radix entomolaris), which is 1 of the major variants in MMs (3–11). The presence of this additional root is associated with many morphologic traits such as crown dimension (7), interorifice distance of canals (5), furcation level (4), periodontal-supporting tissue (6), and distance to the buccal cortical bone (11). However, there are limited studies addressing the possible correlation between the occurrence of a DLR in MMs with morphologic characteristics of neighboring teeth.

Previous studies have shown that the canal morphology of permanent mandibular first premolars (MPs) is associated with ethnicity, age, and sex (1, 12). Notably, 1 of the most common established complexities includes the high occurrence of C-shaped canals (12, 13). Such complex canal systems are especially common in the Chinese population, where up to 18% of MPs possess C-shaped canal configurations (14, 15). Moreover, the existence of a radicular groove (RG) is also closely related to the

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root morphology and canal configuration of MPs (16–18). Therefore, a thorough understanding of the anatomic features of RGs and root canal morphology is essential for clinicians to execute successful dental treatments (18). Our previous studies showed that the prevalence of a DLR in MMs is correlated to a higher incidence of complex canal morphology in permanent mandibular lateral incisors (19), central incisors (20), and MPs (21). However, to our knowledge, little is known about whether the presence of a DLR in MMs would be related to the incidence of C-shaped canals and RGs in MPs. Therefore, the purpose of this study was to determine the prevalence of C-shaped canal configurations and/or RGs in MPs through cone-beam computed tomographic (CBCT) technology and to evaluate the relevance of such complexities with the presence of a DLR in MMs.

Materials and Methods

Database Confidentiality and Retrieving

All experimental protocols in this study were approved by the Ethics Committee and Institutional Review Board of the Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan (TSGHIRB no. 2-105-05-078). All images investigated in this study were retrieved from an encrypted CBCT database confidentially protected as previously described (19, 21). Therefore, all images were not taken with the specific intent of being used in this study. Images were obtained from a total of 1432 patients requiring CBCT imaging as part of their dental examination between January 2012 to July 2017 at the Department of Dentistry, Tri-Service General Hospital, National Defense Medical Center and saved in an encrypted Digital Imaging and Communications in Medicine format.

Image Acquisition and Qualification

Without sacrificing image quality while following the as low as reasonably achievable principle, all CBCT scans were acquired by board-certified radiologists using a CBCT machine (NewTom 5G; QR srl, Verona, Italy) at an accelerated potential of 110 kV peak with a beam current of 11.94 mA and an exposure time of about 7 seconds for a full arch. The slice thickness was 0.15 mm, and the field of view was fixed at 30.5×20.3 cm^2 (21).

The CBCT images of 1652 patients were initially examined, and only 400 patients' images qualified for further analysis based on the following inclusion criteria as previously described (19, 21):

1. High-quality CBCT images of MPs, permanent mandibular second premolars, MMs, and permanent mandibular second molars were present bilaterally with complete root formation
2. Absence of root canal treatment and obturation material
3. Absence of coronal or post and core restorations
4. Absence of large metallic restorations, which may obscure image analysis
5. Absence of root resorption or periapical lesions
6. No previous root amputation or hemisection or periapical surgery

Morphologic Analysis and Classification

The qualified images of MPs and MMs were displayed on a 19-inch LCD monitor (ChiMei Innolux Corporation, Tainan, Taiwan) with a 1920×1080 pixel resolution in a semidark room for assessment using ImplantMax software (HiAim Biomedical Technology, Taipei, Taiwan). To ensure data reliability and reproducibility, all images were repositioned so that the morphology of the root and canal analysis in the axial, coronal, and sagittal planes from the cementoenamel junction to the apex could be documented as previously described (21).

During the assessment of the images, the presence of DLRs in MMs was recorded according to a previous study by Huang et al (4), and participants were further categorized depending on symmetry as follows (Fig. 1*A*):

- Non-DLR: the patient has no MMs with a DLR
- Unilateral DLR (Uni-DLR): the patient has only 1 MM with a DLR either on the right or left side
- Bilateral DLR (Bil-DLR): the patient has DLRs in both the right and left MMs bilaterally

For the purpose of our study, an RG or a developmental invagination along the root (a groove or concavity present on the root) of MPs was defined according to a previous study (23) and can either be categorized as present or absent from the examined teeth (Fig. 1*B*).

The root and canal configurations of MPs were categorized by investigating a series of cross-sectioned images from the cementoenamel junction to the apex and were further classified according to previous studies (14) and the criteria of Vertucci (24) as follows:

- Single: the presence of 1 canal in 1 root in MPs
- Complicated: the occurrence of more than 1 canal or more than 1 root

C-shaped root canal anatomy was classified according to a previous study by Fan et al (22) as follows (Fig. 1*C*):

- Category I (C1): the canal shape was an uninterrupted "C" with no other separations or divisions
- Category II (C2): the canal shape resembled a semicolon resulting from a discontinuation in the "C" outline
- Category III (C3): 2 separate round, oval, or flat canals
- Category IV (C4): only 1 round, oval, or flat canal

Data Acquisition and Validation

Two calibrated examiners (Y.-C.W. and C.-C.S.) assessed all images after the adjustment of contrast and brightness to ensure optimal visualization. During the inspection of images, any disagreement was discussed until a consensus was reached by the examiners. Intraexaminer and interexaminer calibrations were performed for nominal variables to confirm data reliability of the CBCT images. The kappa statistic values were 0.966 and 0.957 for intra- and interobserver agreement by evaluating 50 randomly selected images (data not shown).

Statistical Analysis

Descriptive statistics were expressed as frequencies or percentages as appropriate of each measurement calculated at the subject and tooth levels. The chi-square test was used for examining differences with categoric variables such as age (age <50 vs age ≥ 50 years), sex (male vs female), side (left vs right), and DLR groups (Non-DLR, Uni-DLR, and Bil-DLR) (21). To evaluate the independent effect on the C-shaped canal configurations of MPs, a multivariable logistic regression analysis was used and was simultaneously adjusted for other confounding variables, such as sex, age, and side. Statistical analysis was performed using SPSS for Windows (Version 22.0; IBM Corp, Armonk, NY). The level of statistical significance was set at $P < .05$.

Results

Of the 1652 consecutive patients initially examined, 400 patients (800 mandibular first premolars and 800 mandibular first molars) were qualified for further analysis. Among these examined subjects, 236 (59.0%) were male and 164 (41.0%) were female, with a mean