Complicated Root Canal Morphology of Mandibular Lateral Incisors Is Associated with the Presence of Distolingual Root in Mandibular First Molars: A Cone-beam Computed Tomographic Study in a Taiwanese Population

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Abstract

Introduction: The aim of this study was to assess the root canal configurations in permanent mandibular lateral incisors (PMLIs) and the correlation between the root canal configurations of PMLIs with the appearance of a distolingual root (DLR) in permanent mandibular first molars (PMFMs) using cone-beam computed tomographic (CBCT) imaging. **Methods:** A total of 1200 CBCT images (300 patients) of PMFMs and PMLIs were investigated. The frequency and distribution of DLRs in PMFMs along with root canal configurations of PMLIs were assessed ipsilaterally and contralaterally. Multivariable logistic regression analysis was used to evaluate the correlation between the root canal configurations of PMLIs with the appearance of a DLR in PMFMs. **Results:** The prevalence of PMFMs with a DLR was 24.3%, and the incidence of complicated root canal configurations in PMLIs was 25.0%. The most prevalent root canal systems of PMLIs were Vertucci types I (75%) and III (23.0%). The incidence of complicated root canal configurations in PMLIs was 19.5% in the non-DLR group (ie, no DLR was found on either side of the PMFMs), 33.3% in the unilateral DLR (Uni-DLR) group (ie, a DLR was found in 1 of the PMFMs [the left or right side] and a DLR was not found on the other PMFM), and 39.8% in the bilateral DLR (Bil-DLR) group (ie, a DLR was found in both the right and left PMFMs). After adjusting for categoric variables including sex, age, and side, the odds ratios for the frequency of complicated root canal configurations of PMLIs in the Uni-DLR and Bil-DLR groups compared with the non-DLR group were 2.12 ($P = .003$) and 2.707 ($P < .001$), respectively. **Conclusions:** The simultaneous appearance of DLRs in PMFMs and complicated root canal configurations in PMLIs is prominent in Taiwanese individuals. Clinicians should be aware of the correlation between the anatomic variants of PMFMs and PMLIs, which are important before endodontic treatment. *(J Endod 2017;■:1–7)*

Key Words

Cone-beam computed tomography, distolingual root, mandibular incisors, mandibular molar, root canal configuration

Significance

An increasing and corresponding trend between the presence of DLRs in PMFMs and complicated root canal configurations in PMLIs was noted in Taiwanese individuals. Clinicians should evaluate the anatomic variants of PMFMs and PMLIs with caution before endodontic treatment.

A thorough knowledge of both root and root canal morphology is a fundamental prerequisite for successful root canal treatment (1). This awareness, including pre- and intraoperative assessment of any aberrant anatomy in the root and root canal system, benefits clinicians in locating, negotiating, and cleaning canals thoroughly (1).

The permanent mandibular first molar (PMFM) is the first permanent molar to erupt into the oral cavity and is the tooth that most often requires root canal treatment (2). A growing body of evidence suggests that potential pulpal and periapical complications stem from variations in the anatomic and morphologic characteristics of roots and the canal morphology of PMFMs, such as taurodontism (3), C-shaped canals (4), middle mesial canals, fused roots, and distolingual roots (DLRs) (5–7). The DLR, also named the radix entomolaris, is 1 of the major variants in PMFMs (5–10). Clinicians should be aware of the high racial prevalence of DLRs in PMFMs among the Taiwanese (Chinese) population, which may lead to difficulties during endodontic

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treatment (5, 6, 8, 11), periodontal therapy (7, 11), restoration (9), and even extraction (10). Our previous study was the first to correlate the complicated root canal of permanent mandibular first premolars (PMFPs) and PMFMs with DLRs (12). These results provided additional evidence for clinicians to be more aware of the occurrence of complicated canal configurations in PMFPs during endodontic treatment (12).

Previous studies have shown that the presence of complicated root canal systems in permanent mandibular lateral incisors (PMLIs) increases the complexity in shaping and filling procedures during endodontic treatment (2, 13–15). The wide range of variation reported regarding the prevalence of complicated canal configurations (ie, second canal) in PMLIs has been related mostly to racial and analytic differences (1, 13, 16–24). Notably, Chinese populations exhibited a relatively higher prevalence of PMLIs with complicated canal configurations than European, North American, and Brazilian populations (1, 17, 20–23). However, for detecting the intricate canal system of PMLIs, traditional radiography only provides 2-dimensional images in which the roots may overlap with the surrounding structures. In recent years, cone-beam computed tomographic (CBCT) scanning has gained increasing significance in the study of hard tissues in endodontics (25, 26). This CBCT technology offers a reproducible technique that can be applied quantitatively as well as qualitatively for a 3-dimensional assessment of the root canal system.

To date, only a limited number of studies have reported detailed descriptions of the anatomic variation in mandibular incisors using CBCT imaging and its association with a specific anatomy of another tooth. Recently, an increasing and corresponding trend between the presence of DLRs in PMFMs and complicated root canal configurations in PMFPs was noted in Taiwanese individuals (12). Similar to PMFPs, a high prevalence of PMLIs with complicated canal configurations was noted in an Asian population; however, the association between the root canal configuration of PMLIs and PMFMs with DLRs has not been investigated. Knowledge regarding these aberrant anatomy characters in permanent mandibular teeth, such as lateral incisors, first premolars, and first molars, may be beneficial for clinicians to achieve a favorable outcome of root canal treatment. Thus, the purpose of this study was to assess the root canal configurations in PMLIs and bilateral consistency and to determine the correlation between the root canal configurations of PMLIs with the appearance of DLRs in PMFMs using CBCT imaging.

Materials and Methods

Database Confidentiality, Retrieving, and Image Acquisition

All images investigated in this study were retrieved from an encrypted CBCT database that is confidentially protected. This database stored the examined images in the Digital Imaging and Communications in Medicine format, which was taken from the patients in the Department of Dentistry, Tri-Service General Hospital, Taipei, Taiwan, from January 2012 to December 2016. Therefore, all images were not taken with specific intent to be used in this study. This project and protocol have been approved by the Institutional Review Board of Tri-Service General Hospital, National Defense Medical Center (Tri-Service General Hospital Institutional Review Board no. 2-105-05-07).

Without sacrificing image quality while following the "as low as reasonably achievable" principle, the images were acquired by 2 board-certified radiologists operating a CBCT machine (NewTom 5G; QR, Verona, Italy) with the x-ray tube at an accelerated potential of a 110-kV peak, a beam current of 11.94 mA, and an automatic adjustment to exposure time according to the area of the scan (about 7 seconds for a full arch) (12).

The CBCT images of 1100 patients were initially examined, and only 300 patient images qualified for further analysis based on the following inclusion criteria as previously described (11, 12):

1. Permanent mandibular central incisors, PMLIs, and PMFMs 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
7. Presence of high-quality CBCT images in which canal orifice(s) and root canal configuration could be recognized

Morphologic Analysis and Classification

All qualified images of PMLIs and PMFMs were morphologically studied in detail using ImplantMax software (HiAim Biomedical Technology, Taipei, Taiwan). The images were reoriented so that the mandible was bilaterally symmetric and the occlusal plane, either in the frontal or sagittal view, was parallel to the ground. A series of images were assessed from the crown down to the apex, and the root and canal configurations were examined in PMLIs and PMFMs (Fig. 1*A*).

The presence or absence of DLRs in PMFMs was defined according to the previous study (11, 12). The participants were further categorized based on the presence or absence of a DLR (Fig. 1*B*) as follows:

1. Non-DLR: absence of DLR was found on both sides of the PMFMs
2. Unilateral DLR (Uni-DLR): a DLR was found in 1 of the PMFMs (the left or right side), and a DLR was not found on the other PMFM
3. Bilateral DLR (Bil-DLR): a DLR was found in both the right and left PMFMs

The canal configuration and the number of roots and canals of PMLIs were defined and classified according to the criteria of Vertucci (27) (Fig. 1*C*). The configuration of root canals of PMLIs, single or complicated, was investigated with a series of cross-sectional images from the cementoenamel junction to the apex (Fig. 1*C*) and further categorized by a previous study as noted (28).

Image Validation

All images were displayed on a 19-inch LCD monitor (ChiMei; Innolux Corporation, Tainan, Taiwan) with a 1920 × 1080 pixel resolution. To assess data reliability, all images were repositioned and examined in a dimly lit environment by 2 calibrated endodontists (Y.-C.W. and C.-C.S). Intraexaminer and interexaminer calibrations were performed for nominal variables to assess data reliability based on the anatomic diagnosis of CBCT images by the evaluation of 50 randomly selected images. Kappa analysis was performed before disagreements among examiners were discussed and resolved (29). The kappa statistic values for nominal variables were 0.973 and 0.966 for intra- and interobserver agreement, respectively (data not shown). After calibration, the 2 examiners separately evaluated the images, and any disagreement in the interpretation of images was discussed until a consensus was reached.

Statistical Analysis

Descriptive statistics were expressed as mean values and standard deviations, frequencies, or percentages as appropriate for each measurement calculated at person and tooth levels. The chi-square test was used for examining differences with categoric variables such