# The Presence of Distolingual Root in Mandibular First Molars Is Correlated with Complicated Root Canal Morphology of Mandibular Central Incisors: 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 prevalence of complicated root canals in permanent mandibular central incisors (PMCIs) and its correlation with the presence of a distolingual root (DLR) in permanent mandibular first molars (PMFMs) using cone-beam computed tomographic imaging in a Taiwanese population. **Methods:** A total of 400 patients (800 pairs of PMCIs and PMFMs) were qualified for further analysis. The prevalence of DLRs in PMFMs along with root canal configurations of PMCIs were assessed at subject and tooth levels. Multivariable logistic regression analysis was used to evaluate the correlation between the root canal configurations of PMCIs with the existence of DLRs in PMFMs. **Results:** The prevalence of PMFMs with DLRs and complicated root canal configurations in PMCIs was 23.0% and 15.6%, respectively. A significant difference in age (<50 years vs ≥50 years) was found for complicated root canal configurations in PMCIs. The most prevalent root canal system in PMCIs was Vertucci type I (84.4%) followed by type III (13.5%). A positive correlation between the presence of DLRs in PMFMs and complicated root canal configurations in PMCIs was noted. After adjusting for categoric variables including sex, age, and side, the odds ratios for the occurrence of complicated root canal configurations of PMCIs in the unilateral DLR group and the bilateral DLR group compared with the non-DLR group were 2.13 and 2.53, respectively. **Conclusions:** The concurrent appearance of DLRs in PMFMs and complicated root canal morphology in PMCIs is prominent in Taiwanese individuals. *(J Endod 2018;■:1–6)*

## 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 morphology in PMCIs was noted in Taiwanese individuals. Clinicians should evaluate the anatomic variants of PMFMs and PMCIs with caution before endodontic treatments.

Variations of the root canal morphology present challenges for successful endodontic treatment because of increased difficulties in cleaning, shaping, and filling of the root canal system 3-dimensionally (1, 2). A comprehensive understanding of the possible anatomic complexities in root and root canal morphology is fundamental for successful root canal treatment and favorable long-term prognosis (1).

One of the most prominent variations in permanent mandibular first molars (PMFMs) is having a distolingual root (DLR), which features the presence of an additional root distributed distolingually (3–6). An additional root located distolingually in mandibular molars is also known as radix entomolaris (7). This extra root has been recognized as a genetically determined racial trait in PMFMs among the Taiwanese (Chinese) population (7) and requires special attention during endodontic treatments (3, 4, 6, 8), periodontal therapy (5), restoration (9), and even extraction (10). In a previous study, we showed the correlation between complicated root canal configurations of permanent mandibular first premolars (PMFPs) and PMFMs with DLRs (11). Therefore, the presence of DLRs in PMFMs may be indicative of complicated root canal morphologies in many other teeth.

The permanent mandibular central incisor (PMCI) typically presents with a single root with a single canal (1, 12–15). However, PMCIs may have additional canals and various canal configurations (1, 12, 14, 16, 17), which may vary significantly within

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sex categories and ethnicities and have a critical impact on endodontic treatments (1, 12, 14, 16–19).

For detecting the variability of the root canal anatomy of PMCIs, cone-beam computed tomographic (CBCT) imaging is now becoming a well-established supplemental technique and, in many aspects, is superior to the 2-dimensional conventional radiographic technique (1, 14, 16, 19). It can be applied both quantitatively and qualitatively for a 3-dimensional assessment of the intricate root canal system and surrounding overlapped structures. Several studies have evaluated the root canal variations of PMCIs using CBCT images (1, 14, 16, 19); however, reports providing a detailed description of the anatomic variation of PMCIs and their relationships with a specific anatomy among other permanent teeth are still limited.

Thus, the purpose of the present study was to assess the prevalence and bilateral consistency of various root canal configurations in PMCIs and to determine the correlation between the root canal configurations of PMCIs and the appearance of DLRs in PMFMs using CBCT images.

## Materials and Methods

### Database Confidentiality and Retrieving

The project has been reviewed and approved by the Institutional Review Board of Tri-Service General Hospital, National Defense Medical Center (TSGHIRB No. 2-105-05-078), Taipei, Taiwan. All investigated images in the Digital Imaging and Communications in Medicine format were retrieved from a confidentially protected CBCT database, which was taken from the patients in the Department of Dentistry, Tri-Service General Hospital, National Defense Medical Center from January 2012 to May 2017. Therefore, all images were not intended to be taken for the use of this study.

### Image Acquisition, Validation, and Calibration on Examiner Reliability

The CBCT images were obtained with a CBCT machine (NewTom 5G; QR, Verona, Italy), which was operated 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) (11).

The examined images (1920 × 1080 pixel resolution) 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.

### Calibration on Examiner Reliability

Two calibrated examiners (Y.-C.W. and W.-C.C.) separately evaluated the CBCT images, and any disagreement in the interpretation of images was discussed until a consensus was reached. The intra- 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. The kappa analysis was performed before disagreements among examiners were discussed and resolved (20). The kappa statistic values for nominal variables were 0.956 and 0.942 for intra- and interexaminer agreement, respectively (data not shown).

### Specific Criteria for Image Selection

The CBCT images of 1432 consecutive patients were initially examined from the encrypted CBCT database, and only 400 patients' images (800 pairs of PMCIs and PMFMs) were qualified for further analysis based on the following inclusion criteria as previously described (4, 11):

1. PMCIs, permanent mandibular lateral incisors (PMLIs), PMFPs, permanent mandibular second premolars, and PMFMs were present bilaterally with complete root formation
2. Absence of root canal treatment and obturation material(s)
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 surgical treatment
7. Presence of high-quality CBCT images in which canal orifice(s) and root canal configuration could be easily recognized

### Morphologic Analysis and Classification

All qualified images of PMCIs and PMFMs were morphologically studied in detail using ImplantMax software (HiAim Biomedical Technology, Taipei, Taiwan). A series of images were assessed from the crown down to the apex, and the root and canal configurations were examined in PMCIs and PMFMs.

The presence or absence of DLRs in PMFMs was defined according to previous studies (4, 11). The participants were further categorized based on the presence or absence of a DLR as follows (Fig. 1*A*):

- Non-DLR: no DLR was found in PMFMs in both sides
- Unilateral DLR (Uni-DLR): a DLR was found in 1 PMFM, either the left or right side, and no DLR was found in the other PMFM on the other side
- Bilateral DLR (Bil-DLR): DLRs were found in both right and left PMFMs

To determine the configuration of root canals of PMCIs, a series of cross-sectioned images was examined from the cementoenamel junction to the root apex, and the canal configuration was categorized by previous studies as follows (11, 21):

- Single: the presence of 1 root and 1 canal in PMCIs was categorized as a "single canal" (Fig. 1*B*)
- Complicated: the occurrence of more than 1 root and canal in PMCIs was categorized as a "complicated canal" (Fig. 1*B*)

The symmetric distribution pattern of the complicated canal in PMCIs was further categorized as follows:

- Bilateral: the presence of a "single" or "complicated canal" in PMCIs bilaterally (Fig. 1*B*)
- Unilateral: the occurrence of a "complicated canal (Uni-Comp)" in either the left or right PMCI (Fig. 1*B*)

The canal configuration and the number of roots and canals of PMCIs were classified according to the criteria and scheme devised by Vertucci (22). Representative images of the root canal(s) from the coronal to the apical third of PMCIs were also illustrated (Fig. 1*C*).

1. Type I: a single canal appears from the pulp chamber to the apex
2. Type II: 2 separate canals leave the pulp chamber but merge into 1 to the exit
3. Type III: 1 canal leaves the pulp chamber, divides into 2 within the root, and then merges to the exit
4. Type IV: 2 distinctly separate canals are present from the pulp chamber to the apex
5. Type V: a single canal leaves the pulp chamber but divides into 2
6. Type VI: 2 separate canals leave the pulp chamber, join at the midpoint, and then divide again into 2 with 2 separate apical foramina