Evaluation of Root Canal Configuration of Mandibular Molars in a Brazilian Population by Using Cone-beam Computed Tomography: An *In Vivo* Study

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Abstract

Introduction: The aim of this study was to analyze and characterize root canal morphology of mandibular molars of the Brazilian population by using cone-beam computed tomography (CBCT). **Methods:** Patients who required CBCT radiographic examinations as part of their routine examination, diagnosis, and treatment planning were enrolled in the study. A total of 460 healthy, untreated, fully developed mandibular first and second molars were included (234 first molars and 226 second molars). The following observations were recorded: (1) number of roots and their morphology, (2) number of canals per root, (3) C-shaped canals, and (4) primary variations in the morphology of the root canal systems. **Results:** First molars showed a higher prevalence of 2 canals in the mesial root and 1 in the distal root with 2 separate roots (74%). In the mandibular second molars, the presence of 2 separate roots with 2 canals in the mesial root and 1 canal in the distal root represented 54% of the total. In 32% of the cases, 2 separate roots with 1 canal each in the mesial and distal roots were presented. The incidence of C-shaped canals was 1.7% of first molars and 3.5% of second molars. **Conclusions:** A higher prevalence of 2 separate roots with 2 canals in the mesial root and 1 canal in the distal root was observed in mandibular first and second molars (74% and 54%, respectively). Also, a lower incidence of C-shaped canals and 3-rooted teeth was observed in a Brazilian population. CBCT is a clinically useful tool for endodontic diagnosis and treatment. *(J Endod 2013;39:849–852)*

Key Words

Anatomy, CBCT, mandibular molars, morphology, root canal

The complexity of the root canal system and internal morphology is directly correlated with endodontic treatment planning, therapy, and outcome. Mandibular first molars are the first permanent teeth to erupt, often requiring endodontic treatment because of early caries (1). Typically, mandibular molars present with 2 well-defined roots. The mesial root is characterized by a flattened mesiodistal surface and widened buccolingual surface. The distal root is typically straight with a wide oval canal or 2 round canals (2). A critical evaluation of individual cases is necessary to identify the variations that exist with regard to the root morphology and root canal anatomy of mandibular molars (3–7).

There are numerous reports on root canal morphology of mandibular molars (3–7). Commonly used methods to analyze canal morphology include root canal staining and tooth clearing (8–10), conventional and digital radiography (11–13), and radiographic assessment enhanced with contrast medium (14). Recently, cone-beam computed tomography (CBCT) images have been found to be useful in providing accurate anatomic details in 3 dimensions for diagnosis and treatment planning during the course of endodontic therapy (15, 16).

Internal complexities of the root canal are genetically determined and have definitive importance in anthropology (2). Studies have reported that root canal systems vary according to ethnicity (3–7, 9–12). Most of the published literature is based largely on studies conducted on populations of Caucasoid origin and are therefore not applicable to a heterogeneous population such as the Brazilian population. Literature also reveals that no study has previously been performed on root canal morphology of mandibular molars in a modern heterogeneous Brazilian population.

From a genetic and ethnicity perspective, the current Brazilian population is very diverse and considered to be one of the most heterogeneous populations in the world. The Brazilian population derives important genetic contributions from 4 main continental groups: Europeans, Africans, Asians, and Native Americans. Currently, no study has been conducted to characterize the anatomy of this diverse ethnic community. The aim of this *in vivo* study was to analyze and characterize root canal morphology of mandibular molars in a Brazilian population by using CBCT.

Materials and Methods

CBCT images of 234 mandibular first molars and 226 second mandibular molars from 154 Brazilian individuals (70 men and 84 women) were identified in the database of the Oral Radiology Department. These individuals were referred to this department between 2010 and 2011 and required tomography examination by CBCT as part of their

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dental examination, diagnosis, and treatment planning. Written and verbal consent of each patient was obtained and approved by the University Institutional Review Board. Teeth were selected according to the following criteria: (1) first and second mandibular permanent molars with no previous root canal treatment and (2) mature teeth with fully developed roots. Teeth with open apices, root resorption, or calcification were excluded from the study.

The CBCT images were taken by using the i-CAT system (Imaging Sciences International, Hatfield, PA) operated at 120 kVp and 7 mA, with an exposure time of 40 seconds and a voxel size of 200 μm. All scans were taken following the manufacturer's recommendation protocol. According to the examination requirements, a field of view of 80 $\times$ 80 mm was used. All CBCT exposures were performed with the minimum exposure necessary for adequate image quality by an experienced licensed radiologist. The as low as reasonably achievable protocol was strictly followed, exposing patients to the least amount of radiation while still obtaining the most useful information for proper diagnosis.

The CBCT images were analyzed with the i-CAT software (i-CAT Xoran Technologies Inc 3.1.62, Ann Arbor, MI) on a Dell Precision T5400 workstation (Dell, Round Rock, TX), with a 32-inch Dell LCD screen with a resolution of 1280 by 1024 pixels in a darkroom. The contrast and brightness of the images were adjusted by using the image-processing tool in the software to ensure optimal visualization. An oral radiologist and an endodontist evaluated all images simultaneously to reach a consensus for the interpretation of the radiographic findings. The reviewers were calibrated on the basis of the criteria and variants established before their evaluation. All teeth were analyzed by using 3 planes (sagittal, axial, and coronal), and the following anatomic features were recorded:

1. Number of roots and their morphology
2. Number of canals per root
3. C-shaped canals
4. Primary variations in the morphology of the root canal systems, according to Zhang et al (17):

Variant 1: 2 separate roots, a mesial and a distal root, with 1 canal in each root
Variant 2: 2 separate roots, 1 canal in the mesial root and 2 canals in the distal root
Variant 3: 2 separate roots, 2 canals in the mesial root and 1 canal in the distal root
Variant 4: 2 separate roots, 2 canals in the mesial root and 2 canals in the distal root
Variant 5: 3 separate roots, mesial, distobuccal, and distolingual roots, with 1 canal in each root
Variant 6: 3 separate roots, 2 canals in the mesial root and 1 canal in the distobuccal and distolingual roots
Variant 7: 4 separate roots, mesiobuccal, mesiolingual, distobuccal, and distolingual roots, with 1 canal in each root
Variant 8: 1 root with 1 canal
Variant 9: 1 root with 2 canals
Variant 10: 1 root with 3 canals

Examples of anatomic variations are illustrated in Figures 1–3.

Results

Of the 234 mandibular first molars included in the study, only variants 1, 3, 4, and 9 were observed. The presence of 2 canals in the mesial root and 1 canal in the distal root of teeth with 2 separate roots (variant 3) represented the most common morphology (74%). The next most common morphology was the presence of 2 separate roots with 2 canals in the mesial root and 2 canals in the distal root (variant 4) (12%). The presence of teeth with 2 separate roots with 1 canal in the mesial root and 1 canal in the distal root (variant 1) was recorded in 11% of the cases, whereas only 3% of the sample had 1 root with 2 canals (variant 9) (Table 1).

Of the 226 mandibular second molars included in the study, the presence of 2 separate roots with 2 canals in the mesial root and 1 canal in the distal root (variant 3) was recorded in 54% of cases. In 32% of the cases, 2 separate roots with 1 canal each in the mesial and distal roots (variant 1) were present. In 4% of the cases, 1 canal in 1 root (variant 8) was observed. In 3.5% of the cases we observed 1 root with 2 canals (variant 9). In 3.5% of the cases there were 3 separate roots (mesial, distobuccal, and distolingual), each with 1 root canal (variant 6). One root with 3 canals (variant 10) was observed in 2% of cases, and 2 separate roots with 2 canals in the mesial root and 2 canals in the distal root (variant 4) were observed in only 1% of the sample (Table 2).

C-shaped canals were observed in only 12 of the 460 total first and second molars (2.6%). The incidence of C-shaped canals was 4 cases of 234 first molars (1.7%) and 8 cases of 226 second molars (3.5%).

Discussion

The study of root canal anatomy is important for clinical dental practice and has immense anthropological significance. Different *in vitro* techniques have been described to evaluate root canal morphology, the most popular of which are demineralization and staining of extracted teeth (8). Clinically, however, CBCT provides an

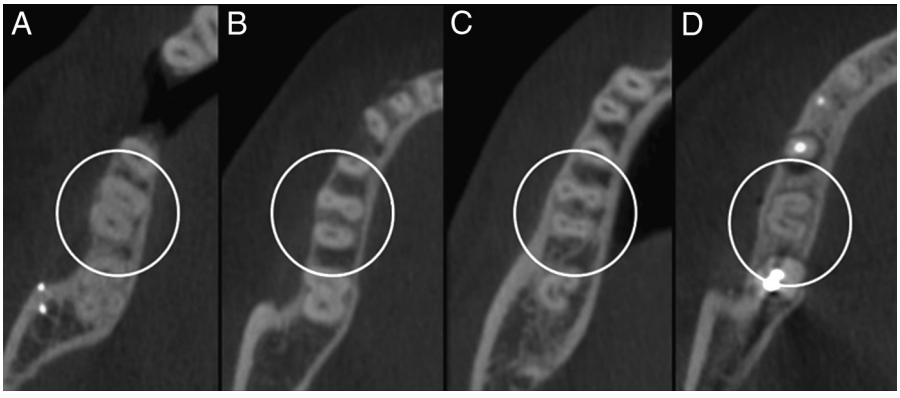

Figure 1. Examples of variants 1 (*A*), 3 (*B*), 4 (*C*), and 9 (*D*) found in mandibular first molars.