

Evaluation of Root Canal Configuration of Maxillary Molars in a Brazilian Population Using Cone-beam Computed Tomographic Imaging: An *In Vivo* Study

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Abstract

Introduction: The aim of this study was to analyze and characterize root canal morphology of maxillary molars of the Brazilian population using cone-beam computed tomographic (CBCT) imaging. **Methods:** Patients referred for a CBCT radiographic examination for accurate diagnosis and treatment planning were enrolled in the study. A total of 620 healthy, untreated, fully developed maxillary first and second molars were included (314 first molars and 306 second molars). The following observations were recorded: (1) number of roots and their morphology, (2) number of canals per root, (3) fused roots, and (4) primary variations in the morphology of the root canal systems. **Results:** First and second molars showed a higher prevalence of 3 separate roots, mesiobuccal, distobuccal, and palatal, with 1 canal in each root (52.87% and 45.09%, respectively). Two canals in the mesiobuccal roots represented 42.63% of teeth, whereas mesiobuccal roots of second molars presented 2 canals in 34.32%. The most common anatomic variation in the maxillary first molar was related to the root canal configuration of the mesiobuccal root, whereas the root canal system of the maxillary second molar teeth showed more anatomic variables. **Conclusions:** Mesiobuccal roots of maxillary molar teeth had more variation in their canal system than the distobuccal or palatal roots. The root canal configuration of the maxillary second molars was more variable than the first molars in a Brazilian population. CBCT imaging is a clinically useful tool for endodontic diagnosis and treatment planning. (*J Endod* 2014;40:173–176)

Key Words

Anatomy, cone-beam computed tomographic imaging, maxillary molars, morphology, root canal

Complete debridement, disinfection, and obturation of the root canal system are essential to increase the favorable outcome of root canal treatments. Therefore, clinicians should be aware of common root canal configurations and possible anatomic variations (1). Maxillary first molars have been frequently investigated because of their complex root anatomy and canal morphology (1–7). Based on the published results, it is generally accepted that most maxillary first molars have 3 roots and 4 canals (1–7). Most studies reported incidences of a second canal (MB2) in the mesiobuccal (MB) root in over 50% of the cases (4–9). Additional anatomic variations include distobuccal and palatal roots with more than 1 canal (8, 9) as well as C-shaped canals (10).

Some commonly used methodologies to analyze canal morphology include root canal staining and tooth clearing (2, 11, 12), conventional and digital radiographs (13–15), and radiographic assessment enhanced with contrast media (16). Recently, cone-beam computed tomographic (CBCT) images have been found to be useful in providing accurate anatomic details in 3 dimensions for diagnosis and treatment planning before endodontic therapy (17, 18). CBCT acquires high-resolution imaging of the hard tissues of the maxillofacial region with faster and easier image acquisition (5). By providing a 3-dimensional representation of the maxillofacial tissues in a cost- and dose-efficient manner, a better preoperative assessment can be obtained for diagnosis and treatment, thus increasing the outcome of the therapy and avoiding further complications.

Internal complexities of the root canal are genetically determined and have definitive importance in anthropology (19). From a genetic and ethnic perspective, the current Brazilian population is very diverse and considered to be one of the most heterogeneous populations in the world, with an important genetic contribution from 4 main continental groups: Europeans, Africans, Asians, and Native Americans. A recent study characterized the anatomy of mandibular molars in a Brazilian population (20). However, there are no reports on the root and canal morphology of Brazilian maxillary molars. The aim of this *in vivo* study was to analyze and characterize the root canal morphology of maxillary molars in the Brazilian population using CBCT imaging.

Materials and Methods

CBCT images of 314 maxillary first molars and 306 second mandibular molars from 294 Brazilian people (108 men and 186 women) were identified in the database of the oral radiology department. They were referred to this department between

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TABLE 1. The Distribution and Percentage of Variants of Root Canal System Morphology of the Maxillary First Molar

	Variant											
	1	2	3	4	5	6	7	8	9	10	11	Total
Number	0	0	0	0	8	0	0	166	132	2	4	314
Percentage	0	0	0	0	2.55	0	0	52.87	42.63	0.65	1.3	100

2010 and 2012 and required tomographic examination using CBCT imaging as part of their dental examination, diagnosis, and treatment planning. Written and verbal consent from each patient was obtained and approved by the university institutional review board. Teeth were selected according to the following criteria: (1) a first and second maxillary permanent molar 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 (20).

The CBCT images were taken 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 . The radiation dosimetry of the i-CAT has been independently analyzed by Ludlow and Ivanovic (21) and determined to be 29 microsieverts. All scans were taken following the manufacturer’s recommended protocols. 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 ALARA (as low as reasonably achievable) protocol was strictly followed, exposing patients to the least amount of radiation while still gaining the most useful information for proper diagnosis.

The CBCT images were analyzed with i-CAT software (i-CAT 3.1.62; Xoran Technologies, Ann Arbor, MI) on a Dell Precision T5400 workstation (Dell, Round Rock, TX), with a 32-inch Dell LCD screen with a

resolution of 1,280 \times 1,024 pixels in a darkroom. The contrast and brightness of the images were adjusted using the image-processing tool in the software to ensure optimal visualization. An oral radiologist and an endodontist were calibrated based on the criteria and variants established before their evaluation. All images were analyzed simultaneously to reach a consensus for the interpretation of the radiographic findings. All teeth were analyzed 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; and (3) primary variations in the morphology of the root canal systems similar to Zhang et al (3) including variant 1: 1 root with 1 canal; variant 2: 1 root with 2 canals; variant 3: 1 root with 3 canals; variant 4: 2 separate roots, a buccal and a palatal, with 1 canal in each root; variant 5: 2 separate roots, a mesial and a distal, with 1 canal in the mesial root and 2 canals in the distal root; variant 6: 2 separate roots, a mesial and a distal, with 2 canals in the mesial root and 1 canal in the distal root; variant 7: 2 separate roots, a mesial and a distal, with 2 canals in each root; variant 8: 3 separate roots, MB, distobuccal, and palatal, with 1 canal in each root; variant 9: 3 separate roots with 1 canal in each of the distobuccal and palatal roots and 2 canals in the MB root; variant 10: 3 separate roots with 1 canal in each of the distobuccal and MB roots and 2 canals in the palatal root; and variant 11: 2 separate roots, a mesial and a distal, with 1 canal in the distal root and 2 canals in the mesial root.

Results

Of the 314 maxillary first molars included in the study, only variants 5, 8, 9, 10, and 11 were observed. The presence of 3 separate roots, MB, distobuccal, and palatal, with 1 canal in each root (variant 8) represented the most common morphology (52.87%). The second most common morphology was the presence of 3 separate roots with 1 canal in each of the distobuccal and palatal roots and 2 canals in the MB root (variant 9) (42.63%). The presence of teeth with 2 separate roots, a

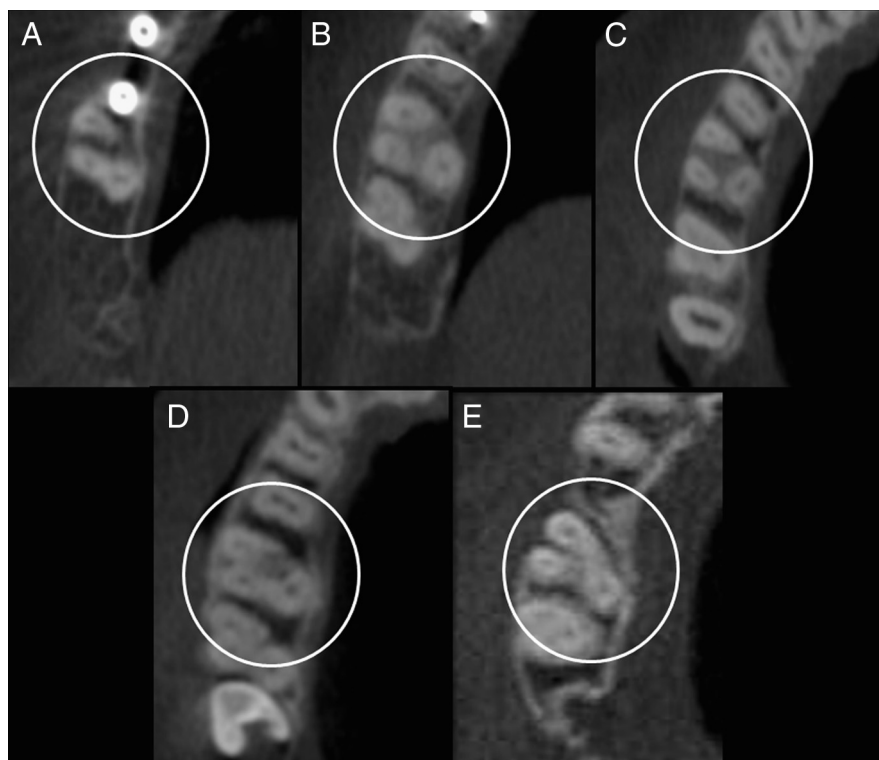


Figure 1. Examples of variants (A) 5, (B) 8, (C) 9, (D) 10, and (E) 11 found in maxillary first molars.

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