

Evaluation of the Root Canal Morphology of Molars by Using Cone-beam Computed Tomography in a Brazilian Population: Part I

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Abstract

Introduction: One of the factors influencing the success of endodontic treatment is anatomic knowledge of the root canal system. Because of the difficulties of using conventional radiographic methods to evaluate root canals, cone-beam computed tomography (CBCT) has been very useful for evaluating the morphology of root canals. The purpose of this study was to use CBCT to evaluate differences in the anatomy of the mandibular first molars with respect to the patient's sex and the location of the tooth in a Brazilian population. **Methods:** The study included CBCT images from 198 patients (106 women and 92 men), representing a total of 342 teeth. **Results:** Of the 342 mandibular first molars included in the study, 0.3% had 2 canals, 75.1% had 3 canals, 23.7% had 4 canals, and 0.9% had 5 canals. The ages of the patients ranged from 19 to 81 years old, with an average age of 48.9 years. Women were more likely to have 2 canals on the distal root of the right side than men were ($P < .05$). **Conclusions:** Because the Brazilian population has differences in root canal morphology compared with other populations around the world, further studies are needed to aid endodontic diagnosis and treatment. (*J Endod* 2016; ■:1–4)

Key Words

Cone beam computed tomography, dental anatomic gender differences, molars, morphology, root canals

Three-dimensional evaluation of structures is very important in endodontics, especially with respect to the anatomy of the root canal system. The correct diagnosis and treatment of dental elements that have pulp or periapical pathologic changes depend on radiographic exams; however, conventional radiographs can be problematic in some cases because of their limitations in presenting only 2-dimensional images.

Success in endodontic treatment depends on the proper cleaning, shaping, and obturation of the root canal system. Extensive knowledge about the morphology of root canals is essential for providing the appropriate treatment (1). Therefore, radiographic examination is essential for the diagnosis of and development of treatment plans for root canals (2, 3).

Conventional radiographs often fail to identify the correct number of canals in teeth that require endodontic treatment (4, 5). This inaccuracy with respect to the root canal system can negatively influence the outcome of endodontic treatments (6).

However, cone-beam computed tomography (CBCT) could help overcome the limitations of conventional x-ray examination and could facilitate endodontic treatment (7). In comparison with conventional periapical radiographs, CBCT eliminates the overlap of adjacent structures on the images, which provides clinically relevant information (8).

Morphology and root configuration can be classified according to the original classification system created by Vertucci (9) and its modification, which was published by Gulabivala et al (10). These ratings are widely used when studying the morphology of root canals and are based on the number of canals that are present in each root and on their configuration.

The anatomy of the root canal may pose a clinical challenge that is directly related to treatment outcome. Ethnicity is a predisposing factor in anatomic variations, including the number of roots (11). In the Brazilian population, it has been difficult to correlate the internal configuration and number of canals in the roots because of this population's diversity and heterogeneity; previous studies have used conventional imaging such as periapical imaging or *in vitro* evaluation to attempt to accomplish this task (12–15).

Significance

This is a relevant subject for clinicians treating ethnically highly diverse Brazilian population where there are a limited number of anatomic studies that used CBCT. By using the classification proposed by Vertucci, we found a gender difference in molar root canal anatomy.

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Clinical Research

The current Brazilian population is very diverse and considered one of the most heterogeneous populations in the world, which makes it difficult to determine classifications on the basis of ethnicity. There are important genetic contributions to the population from the following groups: Europeans, Africans, Asians, and Native Americans. Therefore, it is important to analyze and characterize the morphology of the mandibular molar root canals in the modern Brazilian population by using CBCT (16).

The purpose of this study was to use CBCT to evaluate differences in the anatomy of mandibular first molars with respect to the patient's sex and the location of the tooth in a Brazilian population. We also purposed to relate the number of roots and canals to both the patient's gender and the position of the tooth (left or right).

Materials and Methods

We evaluated a total of 260 CBCT images and included 198 patient images (92 men and 106 women) in the study, and we evaluated a total of 342 teeth from the Analysis Laboratory and Processing Image of Radiology's Discipline database. Patients underwent CBCT examinations with the goal of planning for future procedures, for example, planning for the installation of implants, for the evaluation of dental fractures, and for endodontic and surgical treatments. The Ethics Committee of the Faculty of Dentistry, University of São Paulo, approved the study.

CBCT images were selected on the basis of the following criteria: the analyzed image presented a first mandibular molar tooth with no previous root canal treatments, and the permanent teeth had fully developed roots.

The exclusion criteria were as follows. Images showing artifacts that interfered with the observation of the tooth of interest, making the evaluation of those teeth difficult, were excluded. The following artifacts were observed during evaluation of the images: obturation material from the root canal, intraradicular post, and metal crown restorations and dental implants in neighboring teeth. Teeth with open apices, root resorption, or calcification were also excluded from the study.

The CBCT images were collected by using the Gendex CB500 system (Gendex Dental Systems, Des Plaines, IL) with voxel size of 0.2 mm and field of view of 8 × 14 cm for all images.

CBCT images were first analyzed by using i-CAT Xoran software (Technologies Inc 3.1.62; Ann Arbor, MI). The data were stored in DICOM (digital imaging communication in medicine) and imported to an iMac computer (Mac OS X 10.6; Apple, Inc, Cupertino, CA) with an Intel Core i5 2.5 GHz processor, 4 GB of memory, and 500 GB of storage with 21.5-inch screen and at a resolution of 1920 by 1080 pixels. The software used for viewing the images was OsiriX (version 4.0 OsiriX; Pixmeo, Geneva, Switzerland). Two trained researchers made observations of the images independently from one another.

We evaluated the frequency distributions of the number of roots in accordance with the tooth position (right or left). The distribution was analyzed in relation to the patient's gender and age.

An axial view (thickness of 0.3 mm) was used to analyze the numbers of roots, canals, and the apical foramen. The following 3 portions of these components were observed: cervical third, middle, and apical.

Sagittal, coronal, and transaxial views (2-mm slice thickness) and 3-dimensional reconstructions were used to help determine the number of roots and the canal configurations on the basis of the classification system by Vertucci (9) and Gulabivala et al (10).

Results

Of the 342 mandibular first molars included in this study, 0.3% had 2 canals, 75.1% had 3 canals, 23.7% had 4 canals, and 0.9% had 5 canals. The ages of the patients ranged from 19 to 81 years, with an average age of 48.9 years.

For the concordance analysis between the sides (left/right), we calculated the kappa statistics between the teeth and the respective percentage of agreement.

Table 1 shows a high concordance between the sides of the teeth, thus confirming the importance of not treating the teeth that are from the same patient as independent observations.

Table 2 lists the number of canals in each root and each side by the gender of the patient. Patients who did not have teeth in at least one side (there were 0 canals for all of the roots of one side), as shown in the table, were not included in the percentage calculation or the hypothesis test. The results suggest that women are more likely to have 2 root canals in the distal root than men are.

The right side showed a significant difference at the stipulated level of significance ($P = .002$). In contrast, although the percentage was higher among women versus men on the left side, the difference was not sufficient to reach significance ($P = .113$).

Table 3 shows the distribution of the configuration categorized by the evaluated root type. A Fisher exact test was used to evaluate the relationship between root configuration and gender; however, women only had a lower frequency for setting type I for the root canals going to the distal root on the right side ($P = .033$).

Discussion

The use of CBCT to evaluate root canal morphology is very important (17, 18); it is considered to be a reliable tool to accurately assess the degree of curvature associated with the roots of the teeth, wherein only certain anatomic shapes are considered normal (19).

CBCT is superior to other available methods for assessing the root canal (8, 20, 21). The quality of the images and the possibility of obtaining various types of cuts, which helps in the evaluation of the images, are advantages that have been described in previous studies and emphasize the importance of this tool. The possibility of using open-access software that is easy to operate, such as OsiriX, enables the straightforward analysis of quality images and increases the advantages of using CBCT.

Because one limitation of CBCT (8, 19, 22) is that there are artifacts present on the images, we excluded any images that had artifacts that would interfere with the observation of the tooth of interest.

Ethnicity is a factor that predisposes individuals for anatomic variations such as the number of roots (11). However, it is difficult to categorize the current Brazilian population because of its diversity (16). In addition, this difficulty is exacerbated because the number of studies that have used CBCT to evaluate the morphology of roots and canals in a Brazilian population is small compared with the number of studies that have been conducted in populations from other countries such as China (18, 23), Korea (24, 25), India (26), Thailand (27), and Turkey (28). In our study because we used a database of CBCT images, we categorized the population on the basis of previous studies (16, 29) to characterize the modern Brazilian population.

TABLE 1. Kappa Statistic and Concordance to Number of Root Canals and Side (right/left)

Tooth	Kappa statistic			Concordance		
	Estimate	95% CI		Estimate	95% CI	
		Inf	Sup		Inf	Sup
Mandibular molar	0.795	0.638	0.952	92.4%	86.4	95.9

CI, confidence interval; Inf, inferior; Sup, superior.

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