Original Article

Evaluation of Roots and Canal Systems of Mandibular First Molars in a Vietnamese Subpopulation Using Cone-Beam Computed Tomography

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Abstract

Objectives: The aim of this study is to determine the prevalence of the first lower molars that have two roots or three roots and the number of the root canals of the mandibular first molars in the Vietnamese subpopulation using cone-beam computed tomography (CBCT).

Materials and Methods: The study was conducted on 166 patients who had CBCT as indicated by dentists in Nguyen Trai Dental CT Center, Ho Chi Minh City using the Picasso Trio (Ewoo Vatech, Korea). The number of root canals of the first lower molars was examined by moving cross-sectional slices from the pulpal floor to the apex. The orifices, middle thirds, and apical thirds of the canals of the first lower molar were observed, and the root canals of each root of the mandibular first molars were observed in three planes.

Results: The prevalence of two, three, and four root canals of the mandibular first molars was 4.5%, 66.8%, and 28.9%, respectively. For the distal roots of these molars, a classification of Vertucci type I was the most common at a rate of 80.8%–97.6%. Whenever these teeth had three roots, a Vertucci type I was the classification of 100% of distolingual roots.

Conclusion: Majority of the mandibular first molars has two roots and three canals. CBCT is appropriate equipment useful in investigating the complex root canal morphology of human teeth.

Keywords: *Cone-beam computed tomography, distolingual root, mandibular first molar, Vertucci*

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Introduction

The mandibular first molar is one of the first permanent teeth to erupt in the oral cavity; this eruption marks the beginning of the mixed dentition. The mandibular first molar plays an important role in the chewing of food and in keeping the lower facial vertical dimension. As mandibular first molars are the first permanent teeth to erupt, they spend a long time in function and are therefore subjected to much more damage that can lead to the need for dental treatments such as operative dentistry, endodontics, or extractions. The tooth that received the most endodontic treatment was the mandibular first molar.[1] The tooth with the most complex anatomy and requiring the most conservative treatment was the mandibular first molar.[2] Successful endodontic therapy includes thorough biomechanical preparation and chemical cleaning followed by hermetic obturation of the root canal system. To achieve these goals, an understanding of fundamental root canal anatomy is indispensable for endodontists to perform endodontic therapy. Therefore, a good knowledge of root anatomy, numbers and positions of the root canals in this kind of tooth are very important for endodontic treatment. The difficult position of the tooth in the jaw and the complex anatomy of the mandibular first molar made root canal treatment a challenge and reduced the treatment outcome. Incorrect identification of the

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number of roots and canals can lead to endodontic failures. In addition, variations in the root canal systems and the characteristic features in different races should be recognized before or during endodontic treatment.[3]

To evaluate the root and root canal morphology of the mandibular first molars, there are numerous techniques that have been developed such as root canal staining, tooth clearing, modified root canal staining technique, radiographic technique or micro-computed tomographic (μCT) technique.[4-8] μCT imaging is a new method for investigating the anatomy of a tooth. This method can provide valuable information on complex root canal systems without destroying the sample. The μCT technique also allows data about the root canal system to be recorded both before and after any intervention with high resolution. However, this method can only be used on extracted teeth, it takes considerable time to obtain data and works on relatively small sample size.[8] Due to the limitations of the μCT technique, other computed tomographic techniques such as medical computed tomography (CT) or cone-beam CT (CBCT) have been used in dental anatomic investigations.

CBCT uses a cone-shaped X-ray beam instead of a fan-shaped beam; this has been designed specifically for use in dentistry. The radiation doses needed for CBCT are significantly lower than those for conventional CT because CT uses only a single sweep of scanning to obtain data for constructing the tomographic image.[4] CBCT produces three-dimensional (3D) images faster than conventional radiography does as the latter must compress the 3D data into two-dimension data. CBCT does not need chemicals, a dark-room and film-like in conventional radiographs. The digital technology of CBCT allows for easier to acquire tomographic images and more convenient manipulation of the image.[9] A cone-shaped beam of X-rays, after passing through the target area, is detected by an amorphous silicon panel. Subsequently, the data are gathered and processed using a personal computer. CBCT can be used for *in vivo* studies, in which the researchers can link the anatomic configuration with other factors such as race, sex, and age.

The mandibular first molars have complex root and canal anatomy normally with two root and three root canals.[10] There have been many studies investigating the root and root canal anatomy of mandibular first molars in many different races. In Mongoloid races, the prevalence of three-rooted mandibular first molars (one more root in lingual-distal) was rather high, about 20%. However, up to now, no detailed data of the roots and root canal systems of the mandibular first molar in Vietnamese individuals who have had CBCT used for evaluation.

The aim of this study was to investigate the number of roots of the mandibular first molars with two or three roots in the Vietnamese population using CBCT.

Materials and Methods

This study was approved by the Research Ethics Committee of the University of Medicine and Pharmacy at Ho Chi Minh City, Vietnam. The approval number of the present study was 2245/QĐ-ĐHYD-SĐH. The study was conducted at Nguyen Trai Dental CT Centre, district 5, Ho Chi Minh City, Vietnam, in the period from October 2010 to June 2016. This was a retrospective analysis of CBCT images obtained from the Vietnamese subpopulation. Informed consent was not acquired for this study based on the university decision. Individuals with both right and left mandibular first molars, full information of age, sex, and date of capture were included in the study. Selected criteria for the mandibular first molars were as follows: maturated, normal position, absence of resorption, absence of periodontitis, absence of apical periodontitis, and absence of endodontic treatment. CBCT images which had appropriate brightness and contrast were included in the study. Exclusion criteria were blurred or distorted CBCT images, previous endodontically treated teeth, posts or crowns, periapical lesions, internal or external root resorptions.

The CBCT images of the patients were randomly chosen using the random number table for the patient record number. CBCT images of patients were acquired for reasons not related to the present study such as diagnostic requirements or implant therapy. Sample size was calculated based on the prevalence of three-rooted mandibular first molars of the Thai people in the study by Gulabivala *et al*., with the formulation $n = (Z^2_{1-\alpha/2} p\ (1 - p)/d^2)$ ($\alpha = 0.02$, $Z_{1-\alpha/2} = 2.32$, $d = 0.06$) at 166 individuals.[11] The CBCT images were captured using a Picasso Trio (Ewoo Vatech, Korea) with a field of the volume of 8 cm × 5 cm, slice thickness of 0.1 mm, captured time of 15 s, and reconstruction time of 29 s.

All patients' information was recorded into the data collection form. Whenever the data analysis was performed, patient information on the computer screen and the form was covered. CBCT images that were included in the study were observed on a personal computer with 14-inch flat monitor, resolution of 1366 × 768 pixels using EzImplant CD Viewer software from the manufacturer (Ewoo Vatech, Korea). CBCT images were reset to the original situation, by performing the reset all action, at a ×1.5. If needed, the brightness, contrast, and magnification were adjusted for observation and analysis. The positions of the left and right mandibular first molars were recorded. The root

numbers and root canal configuration were analyzed in three planes: axial, coronal, and sagittal ones using the EzImplant CD Viewer software. In each plane, teeth were analyzed to find out the number of roots, number of root canals, and the canal configuration by using the cursor to move the slices downward from pulpal floor to the apex, from the canal orifices to middle and apical thirds. Root canal systems of each root were classified according to the criteria by Vertucci.[12]

Two independent endodontists evaluated the root canal system morphology using the same software from the manufacturer. To evaluate the inter-examiner reliability, 33 CBCT images of patients were randomly chosen to have been reassessed the root canal configuration by the observers. After 2 weeks from the first evaluation of two observers, these same CBCT images were reassessed to measure the intra-examiner reliability.

Data analysis

The Kappa coefficient and intraclass correlation coefficient (ICC) were calculated to detect the inter- and intra-examiner reliabilities based on the categories of the data.

Data were statistically analyzed with the appropriate tests using SPSS version 18.0 (Statistical Package for the Social Sciences, IBM, Armonk, New York, USA) and the statistical significance was set at a 95% confidence level.

Results

For inter-examiner and intra-examiner reliabilities, the Kappa coefficients were larger than 0.85 (excellent) for canal configuration and the ICCs were larger than 0.8 (good) for number of roots and canals.

Sample characteristics

The sample includes CBCT images of 166 individuals, of which 56.6% were male and 43.4% were female [Table 1]. There were 83 individuals in the age group of 30–50 years old; this was twice the number of individuals in the age group of <30 years old and >50 years old.

Each participant had two mandibular first molars studied, 36 and 46, a total of 332 teeth were studied.

Table 1: Sample characteristics

Age of group	Sample size (n=166)		
	Male, n (%)	Female, n (%)	Total (n)
18-<30	16 (17)	25 (34.7)	41
30-<50	42 (44.7)	41 (56.9)	83*
>50	36 (38.3)	6 (8.3)	42
Total	94	72	166

*Group of 30-50 age was half of sample

Distribution of the number of roots and the number of root canals

Of these 332 mandibular first molars, there were 291 molars with two roots and 41 molars with three roots. The prevalence of mandibular first molars with two, three, and four root canals was 4.5%, 66.6%, and 28.9%, respectively. There were no significant differences in the frequency of the number of root canals between position (P = 0.97) and sex (P = 0.56). Almost all three-rooted mandibular first molars had four root canals, there were only two teeth with three root canals [Table 2].

Number of root canals in each root

Of the 291 mesial roots of two-rooted mandibular first molars, there were 275 (94.5%) roots with two root canals and 16 (5.5%) remaining roots had one root canal. Of the 291 distal roots, there were 235 (80.8%) roots with one root canal and the 56 (19.2%) remaining roots had two root canals [Table 3].

Of the 41 mesial roots of the three-rooted mandibular first molars, there were 38 (92.7%) roots with two root canals and the 3 (7.3%) remaining roots had one canal. Of the 41 distobuccal roots of the three-rooted mandibular first molars, there were 40 (97.6%) roots with one root canal and only one (2.4%) root had two root canals. All distolingual roots had one root canal [Table 4].

Root canal configuration of the mandibular first molars

Classification by Vertucci was used for analyzing the canal configuration of the mandibular first molars.[12] Of the 291 two-rooted mandibular first molars, in the mesial roots, a Type IV canal was the most frequency pattern (60.8%), followed by Type II (30.6%), Type I (5.5%), Type III (2.1%), and Type VI (1%). Whereas, in the distal roots, a Type I canal was the most frequent with 80.8%, Type IV, III, II, V, and VI was 6.5%, 5.5%, 5.2%, 1.7%, and 0.3%, respectively [Table 5].

Of the 41 three-rooted mandibular first molars, in the mesial root, a Type IV canal was the most frequency pattern (68.3%), followed by Type II (24.4%) and Type I (7.3%). In the distobuccal root, Type I canal was the most frequency with 97.6%, followed by Type III with 2.4%. The most frequent pattern in the distolingual root was a Type I canal [Table 5], it was 100%.

The configuration of the root canal system in two- and three-rooted mandibular first molars by location and sex is presented in Tables 6 and 7. There were no statistically significant differences in root canal configuration between sexes (P > 0.05) for both kinds of molars.

Table 2: Number and frequency of the number of roots and number of root canals in mandibular first molars by position and sex

	Left		Subtotal, *n* (%)	Right		Subtotal, *n* (%)	Total, *n* (%)
	Male (*n*)	Female (*n*)		Male (*n*)	Female (*n*)		
Mandibular first molars							
Single root	-	-	-	-	-	-	-
Two separate roots	84	66	150 (90.4)	78	63	141 (84.9)	291 (87.7)
Three separate roots	10	6	16 (9.6)	16	9	25 (15.1)	41 (12.3)
Number of root canals							
2 canals	1	8	9 (5.4)	0	6	6 (3.6)	15 (4.5)
3 canals	69	44	113 (68.1)	66	42	108 (65.1)	221 (66.6)*
4 canals	24	20	44 (26.5)	28	24	52 (31.3)	96 (28.9)
Mandibular first molars with four root canals							
Two separate roots	15	14	29 (65.9)	12	16	28 (53.8)	57 (59.4)
Three separate roots	9	6	15 (34.1)	16	8	24 (46.2)	39 (40.6)

*Mandibular first molars with three canals were two-third of the sample

Table 3: Number and frequency of the number of root canals in each root of two-rooted mandibular first molars

	1 canal	2 canals	Total
Mesial root, *n* (%)	16 (5.5)	275 (94.5)	291 (100)
Distal root, *n* (%)	235 (80.8)	56 (19.2)	291 (100)

There was no third canal in the mesial root of two-rooted mandibular first molars

Table 4: Number and frequency of the number of root canals in each root of three-rooted mandibular first molars

	1 canal	2 canals	Total
Mesial root, *n* (%)	3 (7.3)	38 (92.7)	41 (100)
Distobuccal root, *n* (%)	40 (97.6)	1 (2.4)	41 (100)
Distolingual root, *n* (%)	41 (100.0)	0 (0.0)	41 (100)

There was no third canal in the mesial root of three-rooted mandibular first molars

Discussion

In this study, the CBCT images of 166 patients of the Vietnamese subpopulation were analyzed for evaluation of the root and root canal morphology. A half of the sample was in the group of age ranging from 30 to 50. A total of 332 teeth, left and right mandibular first molars were analyzed. The first mandibular molars with three canals were two-third of the sample, and there was no third canal in the mesial root of both two-rooted and three-rooted mandibular first molars. This supports the hypothesis that the prevalence of the third canal in the mesial root of Vietnamese mandibular first molars was very low. Type IV canal configuration was the majority in the mesial root of these molars, and Type I canal configuration was the majority in the distal root or the two-rooted molars and in the distolingual root of the three-rooted molars. This agrees with the hypothesis that the Type I canal configuration was the majority in the distolingual root of the three-rooted molars for many different populations.

This study was conducted on a Vietnamese sample with reasonable sample size. This study was also performed using the high-resolution CBCT images with the small voxel size of 0.1 mm that satisfied the minimum requirement for endodontic research with CBCT, especially in the anatomy dental investigation. However, the study was retrospective one and done at only one CBCT center, therefore, the study could not reflect panoramic picture of the root canal morphology of the Vietnamese population.

There was no C-shaped canal system in the mandibular first molars in this study. This result was not the same as the result of the previous study in the Saudi population.[13]

In the present study, the prevalence of distolingual roots was 12.3%. This result was high and in agreement with the result of the previous study in Malaysia (12%) and Thailand (12.7%);[11,14] however, this was still lower than that in Korea (23.26%) and China (25%).[15,16] The fact that Asian people have more mandibular first molars with three roots than other racial groups was confirmed by this study. However, the prevalence of distolingual roots was 0% in the previous study in the Tanzanian population.[17]

Of the 166 individuals, there were 27 individuals who had at least one three-rooted mandibular first molar. The prevalence of individuals who had three-rooted molars on both sides was 8.5% (14/166), whereas individuals who had three-rooted molars on one side, it was 7.8% (13/166). In this study, there was no significant different between the number of three-rooted molars and sex. This agrees with the result of the previous study.[18]

The results of this study showed that the three-rooted mandibular first molars existed more in the right side than they did in the left side. This is similar to the result

Table 5: Configuration of the root canal system in mandibular first molars (*n*=332)

Type	Sex	Two-rooted mandibular first molars		Three-rooted mandibular first molars		
		Mesial root (%)	Distal root (%)	Mesial root (%)	Distobuccal root (%)	Distolingual root (%)
I	Male	2	136	2	25	26
	Female	14	99	1	15	15
	Subtotal	16 (5.5)	235 (80.8)	3 (7.3)	40 (97.6)	41 (100)
II	Male	55	4	6	0	0
	Female	34	11	4	0	0
	Subtotal	89 (30.6)	15 (5.2)	10 (24.4)	0 (0)	0 (0)
III	Male	4	8	0	1	0
	Female	2	8	0	0	0
	Subtotal	6 (2.1)	16 (5.5)	0 (0)	1 (2.4)	0 (0)
IV	Male	101	9	18	0	0
	Female	76	10	10	0	0
	Subtotal	177 (60.8)*	19 (6,5)	28 (68.3)*	0 (0)	0 (0)
V	Male	0	5	0	0	0
	Female	0	0	0	0	0
	Subtotal	0 (0)	5 (1.7)	0 (0)	0 (0)	0 (0)
VI	Male	0	0	0	0	0
	Female	3	1	0	0	0
	Subtotal	3 (1)	1 (0.3)	0 (0)	0 (0)	0 (0)
VII		0	0	0	0	0
VIII		0	0	0	0	0
Others		0	0	0	0	0
Subtotal	Male	162	162	26	26	26
	Female	129	129	15	15	15
	Subtotal	291	291	41	41	41

*Type IV canal was majority in the mesial root of mandibular first molars

Table 6: Configuration of root canal system in two-rooted mandibular first molars by location and sex (*n*=291)

	Mesial root			Distal root		
	Male (*n*)	Female (*n*)	Subtotal, *n* (%)	Male (*n*)	Female (*n*)	Subtotal, *n* (%)
Type I	2	14	16 (5.5)	136	99	235 (80.8)*
Type II	55	34	89 (30.6)	4	11	15 (5.2)
Type III	4	2	6 (2.1)	8	8	16 (5.5)
Type IV	101	76	177 (60.8)	9	10	19 (6.5)
Type V	0	0	0 (0.0)	5	0	5 (1.7)
Type VI	0	3	3 (1.0)	0	1	1 (0.3)
Type VII	0	0	0 (0.0)	0	0	0 (0.0)
Type VIII	0	0	0 (0.0)	0	0	0 (0.0)
Subtotal	162	129	291	162	129	291

*Type I canal was the majority of the distal root of the two-rooted mandibular first molars

of the previous study.[19] Some other authors concluded that these molars existed in the left side more than they did in the right side.[11,18] These different results may be due to sample selections and research methods depending on each author.

The prevalence of mandibular first molars with two root canals, three root canals, and four root canals were 4.5%, 66.8%, and 28.9%, respectively. These findings agree with those of the Taiwanese population in one study, the rates were 3.4%, 56.1%, and 40.5%, respectively.[20] In another study, the rates were 6%, 62.5%, and 31.5%, respectively.[21]

Of the two-rooted mandibular first molars, the prevalence of molars with two root canals, three root canals, and four root canals was 4.5%, 66%, and 17.2%, respectively. Of the three-rooted mandibular first molars, the prevalence of molars with three root canals and four root canals was 0.6% and 11.7%, respectively. Almost all three-rooted mandibular first molars had four root canals, only the two remaining molars had three root canals. These findings agree with the results of the previous study in the Taiwanese population. In the mandibular first molars with four root canals, the prevalence of three-rooted molars was more than a half (62.5%–68.3%).[21]

Table 7: Configuration of the root canal system in three-rooted mandibular first molars by location and sex (*n*=41)

Type	Mesial root			Distobuccal root			Distolingual root		
	Male (*n*)	Female (*n*)	Subtotal, *n* (%)	Male (*n*)	Female (*n*)	Subtotal, *n* (%)	Male (*n*)	Female (*n*)	Subtotal, *n* (%)
I	2	1	3 (7.3)	25	15	40 (97.6)	26	15	41 (100)*
II	6	4	10 (24.4)	0	0	0 (0.0)	0	0	0 (0.0)
III	0	0	0 (0.0)	1	0	1 (2.4)	0	0	0 (0.0)
IV	18	10	28 (68.3)	0	0	0 (0.0)	0	0	0 (0.0)
Others	0	0	0 (0.0)	0	0	0 (0.0)	0	0	0 (0.0)
Subtotal	26	15	41	26	15	41	26	15	41

*Type I canal was the majority of the distolingual root of the three-rooted mandibular first molars

There was not any third canal in the mesial roots of the mandibular first molars in this study. This result was not similar to that of the previous studies in other Asian nations.[22-24]

The result of this study showed that Type I, II, and IV canals were the main anatomic variations; others were rare or absence. The prevalence of anatomic variations of mandibular first molars may change depending on the populations and methods. There are many factors that can affect the distribution of root canal anatomic variations. These factors included different methods, techniques (*in vitro*, *in vivo*, CBCT, and clearing techniques) or a racial factor.[25] Of the two- or three-rooted mandibular first molars in this study, Type IV canals showed the most variation in the mesial roots.

The most common root canal configuration in the mesial root of mandibular first molars was the Type IV canal with a prevalence of 52.3%, followed by the Type II canal with a prevalence of 35%.[10] In the distal roots of these molars, the prevalence of Type I, II, and IV canals were 62.7%, 14.5%, and 12.4%, respectively.[10] These findings are not like those of the present study.

In the two-rooted mandibular first molars, the prevalence of Type IV canals in the mesial root was 43% in the US, 58.3% in Thailand, and 76.86% in Turkey.[4,11,25] In the three-rooted mandibular first molars, the prevalence of Type IV canals in the mesial root was 66.7% in Thailand and 46.2% in Turkey.[11,25] One study especially showed the very high prevalence of Type IV canals in the mesial roots of two- and three-rooted mandibular first molars at 94%.[18]

In the present study, the most common type of canals was Type I canals with a prevalence of 80.8% in the distal roots of two-rooted molars. In three-rooted molars, it was 97.6% in distal roots and 100% in distolingual roots. Type I canals were also the most common root canal configuration in the previous study.[4]

In this study, in the three-rooted mandibular first molars, the prevalence of Type I canals in the distolingual root was 100%. This finding agrees with the results of other previous studies in Thailand, China, and Turkey.[11,18,25]

The C-shaped canal configuration and the middle mesial canal in the mesial root of the mandibular first molars were not detected in the present study. These two characteristics of the root canal system existed in the nearby Asian nations, and therefore, these features might present in the Vietnamese population with the larger sample size of the research.

The prospective, larger sample size, multi-center, and broader range future research would be conducted to collect more valuable data about the Vietnamese root canal configuration of mandibular first molars and provide useful knowledge for clinicians in root canal treatment of these teeth.

Conclusion

The prevalence of two, three, and four root canals of the mandibular first molars was 4.5%, 66.8%, and 28.9%, respectively. There were no significant differences in the frequency of number of root canals between position and sex. For the mesial roots of the mandibular first molars, a classification of Vertucci type IV was the most common at a rate of 60.8%–68.3%. The next most common classification was Vertucci type II at a rate of 24.4%–30.6%. For the distal roots of these teeth, a classification of Vertucci type I was the most common at a rate of 80.8%–97.6%. Whenever these teeth had three roots, a Vertucci type I was the classification of 100% of these cases.

Majority of the mandibular first molars has two roots and three canals. CBCT is appropriate equipment useful in investigating the complex root canal morphology of human teeth.

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Conflicts of interest

There are no conflicts of interest.

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