Detection of Permanent Three-rooted Mandibular First Molars by Cone-Beam Computed Tomography Imaging in Taiwanese Individuals

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Abstract

This study determined the prevalence of permanent three-rooted mandibular first molars and their morphology among a Taiwanese population by using cone-beam computed tomography (CBCT). Images from 744 patients were screened to obtain 123 samples for this study. All permanent mandibular first molars were evaluated in axial sections from the pulpal floor to the apices of the roots to determine the number of roots. The interorifice distances from the distolingual (DL) canal to the mesiobuccal (MB) and distobuccal (DB) canals were also estimated. The prevalence of permanent three-rooted mandibular first molars was 33.33%, with a bilateral incidence of a symmetrical distribution of 53.65%. There was a significantly greater incidence of three-rooted teeth on the right side of the mandible than on the left, but gender did not show a significant relationship with this variant prevalence.The mean interorifice distances from the DL canal to the DB, MB, and ML canals of the permanent three-rooted mandibular molars were 2.7, 4.4, and 3.5 mm, respectively. The high prevalence of the DL root in permanent mandibular first molars among the Taiwanese (Chinese) population and estimations of the interorifice distance of such teeth might be useful for successful endodontic treatments. *(J Endod 2009;35:503–507)*

Key Words

CBCT images, cone-beam CT, distolingual root, interorifice distance, periapical radiograph, permanent three-rooted mandibular first molars, radix entomolaris (RE), three-dimensional (3D) image, two-dimensional (2D) image

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Knowledge of tooth and root canal anatomy is important for dental practice and for identifying features of anthropologic significance. Permanent mandibular first molars usually have 2 roots placed mesially and distally and 3 root canals, but variations in the number of roots and in canal morphology are not uncommon (1). The additional third root (ie, the supernumerary root) in those permanent mandibular first molar variants that have 3 roots is typically distributed lingually. This was first described by Carabelli (2) and was termed *radix entomolaris* (RE) (3). This extra root is typically smaller than the distobuccal (DB) root and is usually curved, requiring special attention when root canal treatment is being considered (4). Pindborg (5) reported that 20% of individuals classified as being of Mongolian descent have an extra distal root on the permanent mandibular first molar. According to Table 1 in Tu et al (6), the extra distal root in permanent mandibular first molars differs significantly with race. The prevalence of permanent mandibular first molars with 3 roots, as detected in periapical radiographs, is reportedly high among Chinese populations (21.1%–26.9%) (6–8). Although Tu et al had stated that the extra distolingual (DL) root for the permanent mandibular first molar among Taiwanese individuals occurred more frequently on the right side than on the left side, no difference by gender had occurred. This study used 2-dimensional (2D) images (ie, periapical radiographs) as a study tool, which might be of some limitation when 2 detecting roots overlapped buccolingually by using the periapical radiographic (2D) technique (6, 9).

There have been several morphometric analyses of extracted permanent mandibular first molars that were based on micro–computed tomography (micro-CT) (10–12), but it is impossible to compare the results of these studies related to gender and the bilateral occurrence of such permanent three-rooted mandibular first molars. The recent introduction of cone-beam computed tomography (CBCT) potentially provides dentistry with a practical tool for noninvasive and 3-dimensional (3D) reconstruction imaging for use in endodontic applications and morphologic analyses (9, 13–15). CBCT images can be used to make the race, gender, and the morphology study and can determine the exact position of the DL root of the permanent mandibular first molars.

The purpose of this study was to determine the frequency of the occurrence of permanent three-rooted mandibular first molars and evaluate their morphology in a sample of CBCT images obtained from a Chinese population in Taiwan.

Materials and Methods

CBCT images from 744 subjects that had previously been obtained in a medical imaging center in Taichung City, Taiwan, from March 2005–July 2008 were screened and examined. The CBCT machine used for tooth identification (i-CAT; Xoran Technologies, Ann Arbor, MI; and Imaging Sciences International, Hatfield, PA) produced isotropic voxels with a size of 0.2–0.4 mm producing submillimeter resolution (mean, 0.25 mm). The 3D images were reconstructed in axial cross sections having a 640 × 640-pixel (floating point) format by using Implant Max software (version 3.0; Saturn, Taipei, Taiwan) for each subject.

The criteria for subject selection were the following: (1) each subject had to have fully erupted permanent mandibular first molars bilaterally; (2) the permanent

TABLE 1. Characteristics of the Studied Samples of 123 Taiwanese Individuals (246 examined teeth), Including Numbers and Percentages with Permanent Three-rooted Mandibular Molars

Gender	No.	Average age (y)	No. of incidences/ total no.	Proportion (%)
Male	59	35.43	18/123	14.63
Female	64	36.08	23/123	18.70
Total	123	36.10	41/123	33.33

mandibular first molars had to have fully formed apexes, no root canal fillings, posts, or crown restorations. Screening identified 123 subjects (59 male and 64 female) with bilateral permanent mandibular first molars (246 mandibular first molars) for inclusion in this investigation.

Prevalence Study

Three-dimensional images displayed on a 19-inch LCD monitor were inspected by 2 endodontists. The presence of an extra root was investigated by moving the toolbar from the crown down to the apex in an axial direction (Figs. 1 and 2) (16). Disagreement in the interpretation of images was discussed between the 2 endodontists until a consensus was reached (6, 17).

The total incidence, gender ratio, bilateral and unilateral appearance, and the correlation between right-side and left-side occurrences of these permanent three-rooted mandibular first molars were estimated and assessed by the χ^2 test.

Morphologic Study

Sixty-three permanent three-rooted mandibular molars were morphologically analyzed in detail by using Implant Max software. By using the toolbar to carefully roll downward from the crown down to the apex, the position orifices of DL, DB, mesiobuccal (MB), and mesiolingual (ML) canals larger than 0.25 mm in diameter could be viewed in 4 directions by rotating toolbar by using a supplemental long axial columnar created by the Implant Max software. The 4 canal orifices were marked as spots; then the distance values between 2 orifices are measured automatically in millimeter by the software. The magnification tool was used during the detecting of three-rooted, locating 4 orifices, and constructing the supplemental columnar axis of each canal. When all 4 orifices are determined, just press the tool in the software and select distances of DL–DB, DL–MB, and DL–ML. The measuring value is the same whether the images in the LCD monitor are magnified or not.

The distances from the DL canal orifice to the DB, MB, and ML canal orifices of the 63 permanent three-rooted mandibular molars were measured and collected, with the obtained values compared by using the *t* test.

Results

The 123 patients were aged between 9.4 and 81.3 years, with a mean age of 36.1 years. The incidence of permanent three-rooted mandibular first molars did not differ between men (n = 18, 14.63%) and women (n = 23, 18.70%; χ^2 test: $P = .4355$) (Table 1). The incidence of an extra DL root of the permanent mandibular first molar was 30.51% (18/59 patients) for men and 35.94% (23/64) for women. Collectively, the

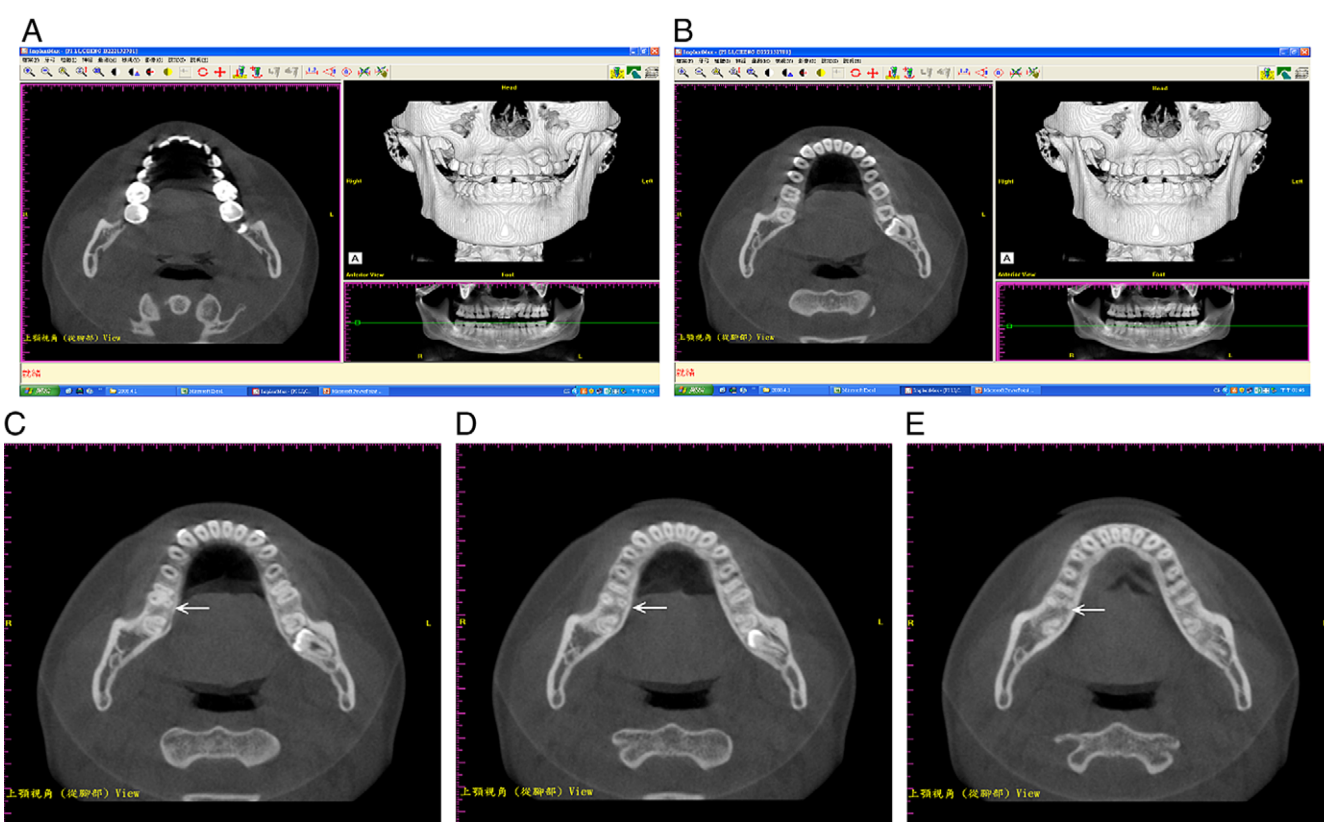

Figure 1. A case of a unilateral permanent three-rooted left mandibular first molar as viewed in the downward axial direction by using Implant Max software. (*A*) Coronal section, (*B*) pulp-chamber section, (*C*) coronal–third root section, (*D*) mid-root section, and (*E*) apical–third root section. Arrows indicate the extra DL roots.

Figure 2. Axial CT scans of bilateral permanent three-rooted mandibular first molars. (*A*) Coronal section, (*B*) pulp-chamber section, and (*C*) mid-root section. Arrows indicate bilateral extra DL roots.

overall incidence of patients with such teeth was 33.33% (41/123), and the prevalence of teeth with such extra DL roots was 25.61% (63/246). The incidence of an extra DL root in the left permanent mandibular first molar was lowest in male patients (1.70%), and the bilateral occurrence of permanent three-rooted mandibular first molar was highest in male patients (20.34%) (Table 2). The occurrence of such permanent three-rooted mandibular first molars differed significantly between the right side (13.01%) and the left side (2.44%; $P < .0001$) (Table 2). In 53.65% (22/41) of cases the permanent three-rooted mandibular first molars occurred bilaterally (Fig. 2, Table 3). Of the 19 unilaterally occurring teeth, 3 occurred on the left side, and 16 occurred on the right side.

The DL root canal orifice was separated from DB canal orifice by 2.72 ± 0.71 mm (mean ± standard deviation), from the MB canal orifice by 4.38 ± 0.72 mm, and from the ML canal orifice by 3.47 ± 0.60 mm (Table 4). These distances did not differ significantly between the permanent right and left mandibular first molars.

Discussion

The present study used a 3D imaging method to determine the occurrence of permanent three-rooted mandibular first molars in a Taiwanese (Chinese) population and found that 33.33% (41/123 subjects) of the examined patients had an extra DL root that could potentially affect endodontic procedures. This percentage is higher than those found by previous studies of Taiwanese subjects by using 2D imaging method (6–8). Compared with the prevalence of the permanent three-rooted mandibular molars in Taiwanese individuals, the resultant 33.33% data of the prevalence in the present study are higher than those 2D images studies by Tu et al (6) (21.1%) and Huang et al (8) (26.9%); the reason could be attributed to the use of 3D image analysis, which provides more accurate determination (9). In our study, the prevalence of such a dental anomaly for the total number of mandibular first molar teeth examined was 25.61% (63/246 teeth); this latter figure was higher than the results of a number of studies on Asian subjects and by using extracted teeth or radiographs of Asian subjects (6, 18–26). Some previous studies have used extracted teeth (18–27) to identify permanent three-rooted mandibular first molars, which might have led to an underestimation of their frequency because teeth with slender roots can easily be fractured on extracted teeth. Thus, the use of CBCT images in the present study facilitated a detailed and accurate assessment of these molars without teeth destruction that was likely to have been more reliable than the other methods used to determine the prevalence of tooth anomalies in different races.

According to the results of our study, the extra DL root for the permanent mandibular first molar occurred more frequently on the right side than on the left side ($P < .0001$). This result was similar to the results of Jayasinghe and Li (16), who stated that most permanent three-rooted mandibular first molars occurred on the right side by using spiral CT images (3D) analysis, and results in Hispanic children and Asian Chinese subjects (6, 22, 26, 28), which used periapical radiographs (2D) or extracted teeth analysis. However, such dental variants have been found more frequently on the left side in Singaporean Chinese and British white subjects (24, 27). We found that the incidence of bilateral permanent three-rooted mandibular molars was 53.65% (22/41 individuals), which is lower than the percentages found (56.6%–68.57%) in several research studies involving Asian subjects (those of Japanese and Chinese descent) (6, 22, 29). This interstudy

TABLE 2. Numbers and Percentages of Study Subjects with Permanent Three-rooted Mandibular First Molars by Gender, Unilateral and Bilateral Status, and Total Occurrence

		Unilateral							
		Left		Right		Bilateral		Total	
		n	%	n	%	n	%	n	%
No. of patients									
Male	59	1	1.70	5	8.47	12	20.34	18	30.51
Female	64	2	3.13	11	17.19	10	15.63	23	35.94
Total	123	3	2.44	16	13.01*	22	17.89	41	33.33
No. of total teeth examined	246	3	1.22	16	6.50	44	17.89	63	25.61

Chi-square test, $P < .0001$.

TABLE 3. Analysis of Distribution of Unilateral and Bilateral Occurrence among 41 Patients with Permanent Three-rooted Mandibular First Molars

		No. of patients	%
Permanent mandibular first molar with 3 roots			
Unilateral	Left	3	7.32
	Right	16	39.02
Bilateral		22	53.65
Total cases featuring extra		41	100

DL, distolingual.

TABLE 4. Distances from DL Orifice to Other 2 Orifices in 63 Permanent Three-rooted Right and Left Mandibular First Molars

	Distance (mm)		
Teeth	DLO-DBO	DLO-MBO	DLO-MLO
#36 (n = 25)	2.66 ± 0.71	4.35 ± 0.73	3.52 ± 0.74
#46 (n = 38)	2.78 ± 0.71	4.41 ± 0.71	3.41 ± 0.44
Total (n = 63)	2.72 ± 0.71	4.38 ± 0.72	3.47 ± 0.60

DLO, distolingual orifice; DBO, distobuccal orifice; MBO, mesiobuccal orifice; MLO, mesiolingual orifice.

variation might be attributable to differences in sample sizes and methods, making further investigations necessary.

Our finding that the incidence of such dental aberrations did not differ with gender is in concordance with the previous study by Tu et al (6) that was based on periapical radiographs of Taiwanese subjects.

Conventional CT images (3D) have been used to study tooth morphology *in vivo*, but the major concern is the radiation dosage (16, 30). CBCT is characterized by the rapid acquisition of volume images from a single low radiation dose scan of the patient, in contrast to spiral CT (13, 16). According to the present study, there are some limitations in the morphologic study in the root canal system of teeth when using CBCT *in vivo*. If the diameter of the root canals is smaller than 0.25 mm, they are impossible to view clearly in the LCD monitor. The exact root canal numbers of the tooth could be accurately determined by micro-CT *in vitro* because of high resolution (0.01 × 0.01 mm). Therefore, if we could collect certain amounts of extracted permanent three-rooted mandibular first molars, the further morphology study of such teeth could consider using micro-CT as a tool, and their accuracy is well-documented (10–12). But micro-CT technique is not suitable and practical for clinical use, even though it can become a powerful tool for research.

Extra DL roots of permanent mandibular first molars are typically smaller than the DB root and are curved buccolingually. Calberson et al (31) described 4 types of RE, and De Moor et al (32) classified REs evaluated from extracted teeth into types I–III. Accurate clinical knowledge of the general morphology of the specific pulp cavity of a tooth being considered for endodontic work is essential before contemplating any endodontic procedure. Dentists could use CBCT to obtain the 3D images of a tooth before commencing access preparations for teeth with an extra DL root. Undertaking appropriate straight-line access preparation and locating the orifice of the extra DL root canal (located a mean of 2.7 mm from the DB canal orifice, 4.4 mm from the MB canal orifice, and 3.5 mm from the ML canal orifice in the present study) typically warrant modifying the classic triangular opening technique for such a tooth to a trapezoidal form of opening to improve the localization of and access to the root canals.

CBCT might be an accurate, noninvasive, and practical method to reliably compare the results of studies relating to gender and bilateral occurrence of permanent three-rooted mandibular first molars among different ethnic groups. CBCT images can also reveal the true nature of the tooth structures in 3 dimensions and allow for reliable angulations and distance estimates (9, 13–15). Therefore, it is a useful endodontic tool for endodontists treating or retreating teeth with extra roots.

The data presented here indicate that approximately one third of Taiwanese (Chinese) people have a permanent three-rooted mandibular first molar, and that more than half of them also have a bilateral incidence of a symmetrical distribution of supplementary roots on their permanent mandibular first molars. The mean interorifice distances from the DL canal to the DB, MB, and ML canals of the permanent three-rooted mandibular molars were 2.7, 4.4, and 3.5 mm, respectively. These values might help dentists to locate orifices and to achieve successful endodontic treatments of permanent three-rooted mandibular first molars.

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