Root Canal Morphology of Permanent Three-rooted Mandibular First Molars—Part I: Pulp Floor and Root Canal System

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Abstract

Introduction: Racial variations in root form and canal anatomy present endodontic challenges for clinicians. This study examined root canal morphology of three-rooted mandibular first molars by micro–computed tomography scans. **Methods:** A total of 122 extracted mandibular first molars were collected from a native Chinese population. After calculating the frequency of occurrence, 20 three-rooted (experimental group) and 25 two-rooted first molars (control group) were scanned and reconstructed three-dimensionally. **Results:** The frequency of three-rooted mandibular first molars was 31.97% (39/122). The mean interorifice distances from the distolingual (DL) canal to the distobuccal (DB) and mesiolingual canal were 2.93 mm and 2.86 mm, respectively. The mesial root predominately contained a type 2-2 root canal, with an incidence of 65% in the experimental group and 64% in the control group. Type 1-1 canals were seen more frequently in the DL and DB roots of the three-rooted first molars as well as in the distal roots of the two-rooted first molars. The incidences were 100% (20/20), 95% (19/20), and 72% (18/25), respectively. Accessory and lateral canals rarely occurred in the extra DL roots. The incidence was only 10% (2/20). A furcation canal extending from the floor to the furcation region was not observed. **Conclusion:** Three-rooted mandibular first molars commonly have 4 separate canals with high incidences of accessory canals in the mesial and DB root. The geometric data of pulp floors are useful for locating the extra DL canal. *(J Endod 2010;36:990–994)*

Key Words

Accessory canal, micro–computed tomography scan, permanent three-rooted mandibular first molar, root canal system

Permanent mandibular first molars usually have two roots: mesial and distal. However, in a number of individuals a third root develops (1, 2). Literature review showed the prevalence of three-rooted mandibular first molar falls between 0.9% and 3.4% in whites (3, 4). In African populations, a maximum of 3% was found (5, 6). In Mongoloid populations, it occurred with a greater frequency of 5% to more than 40% (1, 7–9). This trait has been widely used for population comparisons in the field of anthropology.

Moreover, mandibular first molars with three roots have great clinical significance. The routine diagnostic periapical film is usually exposed straight on. The image of the third root is easily superimposed by that of the distal root (DR) and is therefore unclear (10). The canal in the third root may be left untreated if the dentist fails to identify its presence, which may lead to failure of endodontic treatment.

In recent years, micro-computed tomography (micro-CT) has been used to evaluate the root canal anatomy because of its high resolution and nondestruction of the specimens (11–13). By using this method, Fan et al (14, 15) studied C-shaped root canal configuration in mandibular second molars and first premolars in Chinese populations, yet three-rooted mandibular first molars have not been examined by micro-CT despite its important role in endodontic treatment and anthropology. The purpose of this study was to investigate the anatomic features of the pulp floor and root canal system in three-rooted mandibular first molars by micro-CT.

Materials and Methods

A total of 122 permanent mandibular first molars were collected in the Dental Department of the First Hospital of Wujiang City during 2006 to 2009. All subjects were native Chinese and chosen at random. The teeth were extracted because of non-restorable caries, periodontal disease, trauma, or prosthodontic reasons. In order to eliminate bias, specimens with root canal fillings, crown restorations, open apices, cracks, or fracture were also collected. The molar type (mandibular first molar) of the specimen was accurately identified by the operator according to its external anatomy, position in the dental arch, tooth sockets in jaw bone, and dental history. If the tooth fractured in extraction, the fractured parts were collected and preserved together. Each specimen was labeled and individually stored in a bottle of 10% formalin. Details including age, sex, side, and root number of the specimen were accurately recorded by the practitioner immediately after tooth extraction. This information together with the label number were then input to the computer and later used to calculate the

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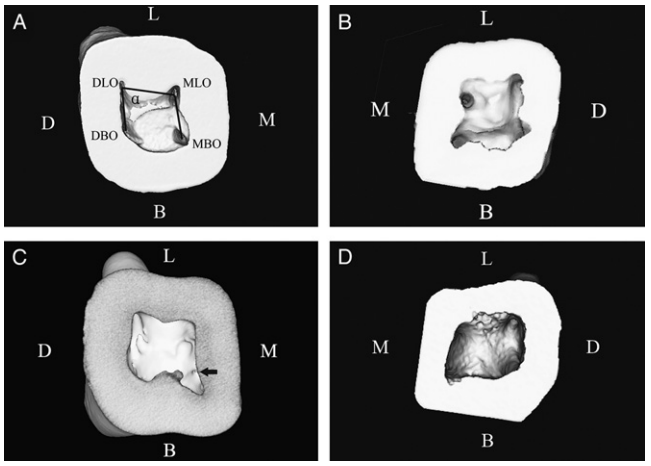

Figure 1. Three-dimensional reconstructed pulp chamber floors of three-rooted mandibular first molars: M, mesial side; D, distal side; B, buccal side; L, lingual side; O, orifice. (*A*) Measurement of the interorifice distances and angle α formed by lines MLO-DLO and DBO-DLO (specimen from a 40-year-old woman), (*B*) grooves present between MBO and DBO and DBO and DLO (specimen from a 55-year-old woman), (*C*) arrow indicates tiny orifice of middle mesial canal in the mesial root (MR) (specimen from a 35-year-old woman), and (D) pulp chamber floor with one mesial and two distal orifices (specimen from a 17-year-old male).

incidences. The age of the subjects ranged from 15 to 79 years old (mean age = 43.21 years). Before investigation, the specimens were immersed in 5% sodium hypochlorite solution for 2 hours to remove adherent soft tissue. Calculus and stains were removed by an ultrasonic scaler.

Excluding teeth with fractured roots or other major defects, 20 three-rooted (experimental group) and 25 two-rooted mandibular first molars (control group) with intact roots were selected for investigation using a micro-CT scanner (eXplore Locus SP; GE HealthCare, London, Ontario, Canada). Each specimen was scanned along the teeth axis with voxel sizes of 21 μm × 21 μm × 21 μm. The resulting data were then processed by software Microview 2.1.2 (GE HealthCare, London, Ontario, Canada). to prepare three-dimensional models. By adjusting the opacity of the model, viewing angle, and magnification, the pulp floor and root canal system can be displayed completely. The interorifice distances (length of a line between center points of two orifices) from the mesiobuccal (MB) canal to the mesiolingual (ML) canal and from the distolingual (DL) canal to the distobuccal (DB) and ML canals were measured by using the geometric measurement module of the software. The angle (angle a) formed by lines DBO-DLO (between the DB canal orifice and the DL canal orifice) and MLO-DLO (between the ML canal orifice and the DL canal orifice) was also measured as shown in Figure 1*A*.

The Student *t* test was performed to compare the mean ages of different groups and mean interorifice distances. The chi-square test was used to compare the frequencies. A p value of less than 0.05 was considered significant.

TABLE 2. Mean Age of the Subjects in Different Groups

Group	*n*	Mean (y)	SD
Single rooted	2	34.00	12.72
Two rooted	81	45.43	16.64
Three rooted	39	38.62	18.40
Male	48	42.19	17.24
Female	74	43.90	17.68
Sex combined	122	43.21	17.45

Results

Table 1 shows the root number variation of the sample teeth. Of the total 122 mandibular first molars (65 right and 57 left), 2 were single rooted, 81 were two rooted, and 39 were three rooted (24 right and 15 left). The frequency of three-rooted first molars was 31.97%; 31.25% (15/48) in males and 32.43% (24/74) in females. No significant difference was found between sexes ($\chi^2 = 0.019, p = 0.891$). The frequency of three-rooted specimens was 36.92% (24/65) on the right side and 26.32% (15/57) on the left side. Difference between sides was not significant ($\chi^2 = 1.571, p = 0.210$). The percentage of the specimens with fractured roots was 48.72% (19/39) in the three-rooted group, much higher than the 25.93% (21/81) seen in the two-rooted group ($\chi^2 = 6.154, P = 0.013$).

Table 2 presents the mean subject ages. The mean age was 38.62 years for the three-rooted group, significantly lower than 45.43 years of the two-rooted group ($t = 2.03, P = 0.045$).

Morphology of the Pulp Floor

The configuration of pulp floors is determined to a large extent by the number and position of the canal orifices. Differences between the three- and two-rooted first molars were marked (Figs. 1 and 2). For the three-rooted molars, pulp floors with two mesial and two distal orifices were relatively frequent (16 specimens, including a specimen with an additional middle mesial orifice between MBO and MLO, Fig. 1*C*). The third root usually curved severely in the proximal view (Fig. 3*A* and *B*). The lingual edge of the orifice might form a dentinal shelf, which blocks the view of the DL canal. For two-rooted molars, the presence of two mesial and one distal orifice on the pulp floor was more frequent (18 specimens). The presence of one mesial and one distal (four teeth) or two mesial and two distal orifices (3 teeth, Fig. 2*D*) were less common.

Mean interorifice distances are shown in Table 3. The mean distance of DBO-DLO is much greater than that of MBO-MLO ($p < 0.01$). The mean angle α (Fig. 1*A*) was $75.24° \pm 10.17°$ ($n = 16$).

In the specimens of the older subjects, secondary dentin was found deposited in a convex shape. In some specimens, the bulging roof and floor met at the apex (Fig. 4). Grooves could be observed between adjacent canal orifices (Fig. 1*A* and *B*). They may be buried into the bulging secondary dentin and formed canals or fissures.

TABLE 1. Root Number Variation of 122 Permanent Mandibular First Molars

		Three-rooted			Two-rooted			Single-rooted
Sex	Number of teeth	NF	F	NF+F	NF	F	NF+F	NF
Male	48	8	7	15	26	6	32	1
Female	74	11	13	24	34	15	49	1
Total	122	20	19	39	60	21	81	2

NF, nonfractured roots; F, teeth with fractured root (or roots).