

# Root Canal Morphology of the Mandibular First Premolars in an Iranian Population Using Cross-sections and Radiography

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## Abstract

**Introduction:** Successful endodontic treatment is dependent on a perfect knowledge of normal root canal anatomy and variations from the norm. This study was aimed to investigate the root canal anatomy of mandibular first premolars by both radiography and cross-sectional methods in an Iranian population. **Methods:** Two hundred seventeen extracted human mandibular first premolars were used. Radiographs were taken in both mesiodistal and buccolingual directions for each premolar. Then, all the teeth were decoronated at the cemento-enamel junction and resected perpendicular to their long axes into three equal sections and stained with fuscine. Digital photographs of the cross-sectional root surfaces were taken and surveyed at 40× magnification. The root canal configuration types were determined separately by radiographs and cross-sectional images for each premolar. **Results:** Out of 217 teeth examined, 192 (88.47%) had a single root canal. The remaining 25 teeth (11.53%) showed two canals in at least one cross-section of their roots with five root canal configurations. In the mesiodistal (MD) radiographs, only 5.99% of premolars showed two canals with three root canal configurations. **Conclusions:** One-hundred ninety two out of 217 premolars showed one canal in both cross-section and MD radiography. Only 7 premolars were diagnosed as having more than one canal with the same canal configuration in both cross-sections and MD radiography methods. (*J Endod* 2010;36:214–217)

## Key Words

Cross-sectional, mandibular first premolar, radiography, root canal anatomy

The success of root canal treatment is dependent on a thorough understanding of normal root canal anatomy as well as variations from the norm. Proper cleaning, shaping, and obturation of the root canal system in the three dimensions is based on a working knowledge of such information (1, 2). According to Hoen and Pink (3), the incidence of missed roots or canals in the teeth that needed retreatment was 42%. Mandibular premolar teeth tend to vary greatly from the normal anatomy (4). The wide variation in root canal anatomy of these teeth makes them the most challenging of all in performing successful endodontic treatments (5). A high percentage of mandibular first premolars had more than one canal in different studies (6–9). The incidence, location, and morphology of the root canal systems of teeth may vary in different ethnic or regional populations (6–11).

The incidence of mandibular first premolars with two or more canals varied from 13.7% in American white individuals (6) to 46% in a Chinese population (7). Zillich and Dowson (8) and Walker (9) reported the occurrence of three canals in mandibular first premolars to be 0.4% and 2%, respectively. C-shaped root canals have also been found in these teeth (7, 12, 13). In a study by Fan et al (13) the prevalence of C-shaped root canals in mandibular first premolars was reported to be 24%.

The purpose of this study was to investigate the root canal anatomy of mandibular first premolars in an Iranian population because racial and/or regional predispositions contribute in the wide internal anatomic variation of this tooth and also such information was lacking in Iran.

## Materials and Methods

Two hundred seventeen extracted human mandibular first premolars were used in this study. The teeth were collected from Iranian citizens who were referred to various oral surgery clinics in four cities of Golestan province for extraction. The reasons for extraction, age, and sex were not recorded, but most of the population in these cities is white. The teeth were cleaned from any soft-tissue attachments, disinfected by 5.25% sodium hypochlorite, and stored in 10% neutral-buffered formalin before analysis. All the teeth had mature and intact root structure and were devoid of any fractures or apical resorptions. The buccal, lingual, and proximal surfaces of each tooth were examined carefully. Any root surface concavities or grooves as well as bifurcations or apical curvatures were recorded.

Root canal configuration was determined in two ways: first, by evaluating the buccolingual and mesiodistal radiographs and, second, by evaluating the images gained from coronal, middle, and apical cross-sections. The anatomical apices were also photographed to verify the number of exiting apical foramina. Then, the root canal configurations were assigned according to Vertucci et al's classification (14). Fan et al's categorization (15) in the mandibular second molars was used as a reference in the C-shaped canal configurations.

Radiographs were taken in both mesiodistal and buccolingual directions for each premolar at a focal spot to an object distance of 2 cm (Orix, Italy, 65 KVP). When the distal aspect of the tooth was placed on the film (Agfa Dentus E speed, Agfa, Germany), the radiograph showed the buccolingual view of the root canal system; therefore, it was called an MD radiograph. Accordingly, BL radiographs were made by placing the lingual aspect of the teeth. The number of each tooth was recorded on its radiograph. All the teeth were decoronated at cemento-enamel junctions. Then, each root was fixed and resected perpendicular to its long axis into three equal sections using a metal disc and a hand piece under running water. Each section was dried and stained with fuscine.

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**TABLE 1.** A Cross Tab between Mesiodistal (MD) Radiography and Cross-sectioning Methods in Determining Root Canal Configuration Types

Cross-sectioning	Mesiodistal radiography						Total
	Type I (1 canal)	Type II (2-1 Canal)	Type III (1-2-1Canal)	Type IV (2 Canals)	Type V (1-2 Canals)	C-shaped Canals	
Type I (1 canal)	192	0	0	0	0	0	192
Type II (2-1 canal)	3	1	0	0	0	0	4
Type III (1-2-1 canal)	5	0	2	0	0	0	7
Type IV (2 canal)	0	2	0	0	0	0	2
Type V (1-2 canal)	4	0	1	0	4	0	9
c-shaped canals	0	0	3	0	0	0	3
Total	204	3	6	0	4	0	217

Digital photographs of root surfaces at the coronal, middle, and apical one thirds were taken by a digital camera (DSC-T30; Sony, Tokyo, Japan). All the images were surveyed from the coronal third to the apical third at 40× magnification on a computer screen.

The evaluation was made by two endodontists. Disagreement in the interpretation was discussed between two examiners until a consensus was reached. The agreement between two methods was assessed. Because some agreement could have occurred by chance, the actual agreement was also revealed by kappa.

**Results**

The results were shown in Table 1 and Figures 1 through 3. All of the 217 first premolar teeth used in this study had only one root. Among all the mandibular first premolars examined, 157 (72.35%) had straight roots, 38 (17.5%) exhibited distal curvatures, and none of them (0%) showed mesial curvatures in their apical one thirds. In the buccolingual aspect, four teeth (1.84%) possessed a buccal curvature and three teeth (1.38%) a lingual curvature. Bayonet curvature was seen in three samples (1.38%). Three teeth (1.38%) with distobuccal and nine (4.14%) with distolingual curves in their apical third were also noted.

The examined teeth exhibited five root canal configurations as type I through V according to Vertucci's classification. Additionally, C-shaped configuration was also found, which was categorized according to Fan's classification (15).

**Cross-sectional Canal Configuration**

Out of 217 teeth examined, 192 (88.47%) had a single root canal. The other 25 teeth (11.53%) showed two canals in at least one cross-section of their roots. There were 9 teeth (4.14%) with type V, 7 (3.22%) with type III, 4 (1.84%) with type II, and two teeth (0.9%) with type IV morphology. Three teeth (1.38%) showed C-shaped configuration. These teeth had a groove or a deep concavity

on the mesiolingual area of their external root surfaces that was deeper in the middle third section than in the coronal and apical thirds.

**Radiographic Canal Configurations**

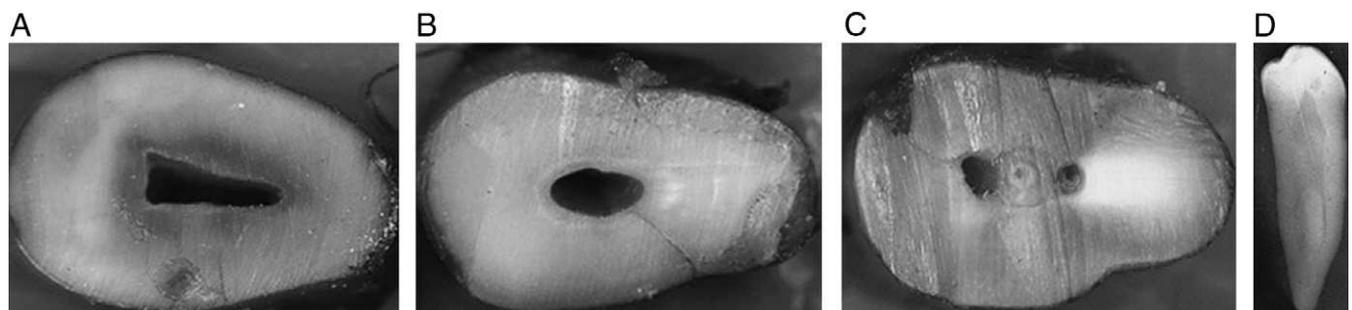
In BL radiographs, only 11 teeth (5.06%) out of 217 first premolars showed a sudden change in radiographic density of the root canal spaces that suggested a second canal. The morphologic types of the root canals were not clear in these radiographs.

In the MD radiographs, 13 (5.99%) premolars showed two canals out of which there existed six teeth (2.76%) with type III, four (1.84%) with type V, and three (1.38%) with type II morphology.

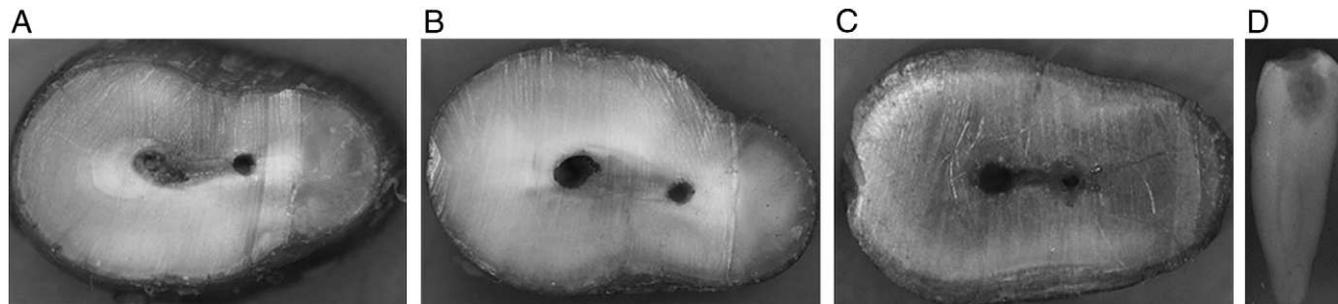
As shown in Table1, 192 premolars showed one canal in both cross-section and MD radiographic images. Only one out of four teeth detected as type II in cross-sections was also considered as type II in MD radiography, and the other three were detected as type I. Two out of seven premolars designated as type III in cross-sections were also detected as type III in radiographs. The other five were considered as type I. Finally, the four teeth out of nine considered as type V in cross-sections were also determined as having the same configuration type in radiography. Out of the remaining five teeth, four samples were classified as type I and one as type III canal configuration. In other words, among all samples, seven teeth were diagnosed as having more than one canal in both methods, of which one had type II, two type III, and four type V configurations. The agreement between two methods was calculated by the sum of the teeth with the same canal configuration type assessed by both methods divided by the total number of teeth examined (ie,  $192 + 1 + 2 + 4/217 = 0.917$ ). The actual agreement beyond chance was 84.3% ( $kappa = 0.843$ ).

**Discussion**

A thorough knowledge of the root canal anatomy of teeth is essential for root canal treatment and post room preparation. Slight deviations from the original straight root path can cause procedure



**Figure 1.** One of the type V canal configurations in a mandibular first premolar, (A and B) one canal in the coronal and middle thirds and (C) two canals in the apical third. (D) A mesiodistal radiograph of the same premolar showing a type III canal configuration.



**Figure 2.** (A-C) One of the type I V canal configurations in a mandibular first premolar and two separate canals in the coronal, middle, and apical thirds. (D) A mesiodistal radiograph of the same premolar showing a type II canal configuration.

accidents (ie, ledging, perforation, or root fracture) during endodontic treatment, post room preparation, and post insertion (16).

We used both BL and MD radiographs to provide three-dimensional images of the root canal systems. Clinically, 15° to 20° angled radiographs either mesial or distal to the horizontal long axis of the root has been suggested as a clue for diagnosing obscured roots or canals in mandibular premolar teeth (17). Besides, the cross-sectioning method combined with the magnification revealed the morphology of the root canal systems clearly. In this study, the prevalence of mandibular first premolars with more than one canal (ie, two canals) was lower than previously stated (7–14). Variations in sample size and ethnic and/or regional background of tooth sources as well as the differences in methods used have been stated as the reasons why these diversities may occur (6, 7, 10, 11, 13). The prevalence of bicanaled mandibular premolars (11.53%) in the present investigation based on cross-sectioning closely approximated that of Trope et al (6) who reported it to be 13.7% through radiographic assessment in white Americans. Interestingly, most of the Iranian population involved in the current study was white.

The morphology of the majority of the canals in this study was oval at the coronal third, round or oval at the middle third, and round in the apical third sections. These results are comparable to those reported by Ingle and Bakland (18).

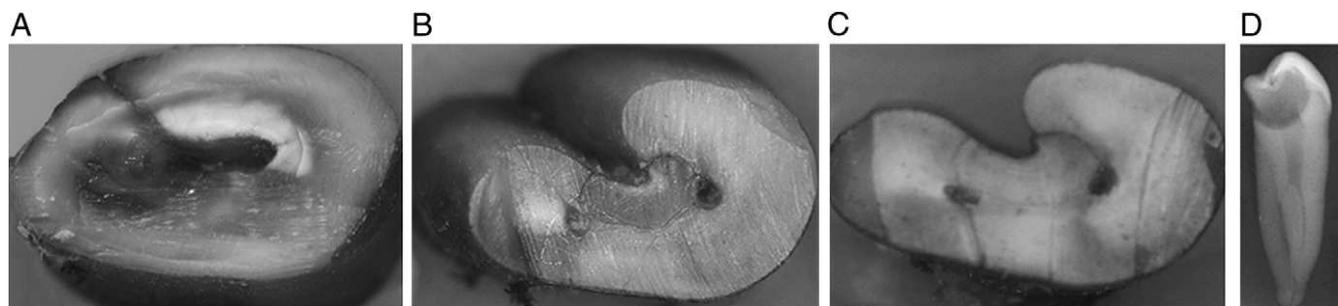
In present study, C-shaped canals were classified as C3, were located at the middle and apical thirds of the canals, and had an oval shape in their coronal thirds. This finding is in agreement with Lu et al (7) who found C-shaped canals at 3-mm and /or 6-mm level from the apex cross-sections. They noted that the location of C-shaped morphology in mandibular first premolars is quite different from that of second molars and is difficult to detect from coronal approach.

Three C-shaped canals in cross sections were classified as type III in MD radiographs because the canals were bifurcated within the root and then merged to exit as one canal. Their corresponding grooves on

the external root surfaces were observed in these radiographs (Fig. 3). Therefore, C-shaped canals in mandibular first premolars were associated with type III canals in radiography. A deep concavity or groove associated with a type III canal in an MD radiograph could help predict the presence of C-shaped canals.

Two type IV canals in cross sections were classified as type II in MD radiographs (Fig. 2). Besides, one type V configuration detected by cross-sectioning method was diagnosed as having type III in an MD radiograph (Fig. 1). This might have been because of the canals tapering toward the apex so that the radiographs were not able to determine the exact root canal anatomy.

Only 7 of 25 teeth (28%) with two canals in the cross-sectioning exhibited two canals in MD radiographs so the sensitivity of MD radiography was 28% in detecting premolars with more than one canal compared with cross-sectioning. In addition, the morphologic type of the root canals was not clear enough in BL radiographs. Therefore, the complex root canal anatomy of the mandibular first premolars may hide on the routine straight-on or even angled radiography in clinical situations. A spiral computed tomography (SCT) scan was suggested for the confirmatory diagnosis in these cases in a three-dimensional manner. The involved tooth is focused, and its morphology is revealed in transverse, axial, and sagittal sections of 0.5-mm thickness, along with three-dimensional reconstructed images by using dental software. Therefore, SCT would be able to present the variable morphologic structure of root canals and their interrelations (2). The higher incidence of teeth with type V configuration in the cross-sectioning among teeth with two canals in the current study corresponded with that of previous investigations (7, 12, 14). Complete cleaning of the root canal system can be very difficult in the presence of type V canal configuration and C-shaped canals because the canal divides into two or more parts in the apical one half of the root. In these complex anatomic configurations, extending the access cavity in a more buccolingual direction will establish a straight-line access to the root canal system and hence



**Figure 3.** (A) A mandibular first premolar with C-shaped root canal, a single oval canal in the coronal third and (B and C) two separate canals in the middle and apical thirds. (D) A mesiodistal radiograph of the same premolar showing a type III canal configuration.

results in a more successful endodontic treatment (5, 13). Also, additional flaring of the coronal and middle thirds have been advocated (12), but the small size of this tooth may limit a buccolingually wider coronal access or increased coronal flaring. The use of a SCT scan (2) and/or an operative microscope (19) in determining or confirming the presence and location of the canal bifurcation(s) instrumentation by sonic and ultrasonic devices and obturation by thermoplasticized techniques (20) may be good modalities to obtain positive outcomes in endodontic treatment of such complex teeth.

## Conclusions

According to the results of this study, 88.5% of mandibular first premolars had a single canal. The remaining 11.5% showed two canals in at least one cross-section of their roots. The examined teeth with two canals in cross-sections exhibited five root canal configurations as type II, type III, type IV, type V, and C-shaped configuration. In the MD radiographs, only 5.99% of premolars showed two canals with three canal configurations as type II, type III, and type V.

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