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Original

A stereomicroscopy study of root apices of human maxillary central incisors and mandibular second premolars in an Iranian population

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Abstract: Mandibular second premolars and maxillary central incisors usually have one root, one canal, and one apical foramen. However, some studies have revealed anatomic variations in these teeth. The aim of the present study was to investigate such variations in canal configuration, foramina, lateral and accessory canals and apical deltas in the root apex of human maxillary central incisors and mandibular second premolars, using a clearing technique and stereomicroscopy. One hundred maxillary central incisors and 137 mandibular second premolars were collected, and India ink was injected into their canals. The teeth were then demineralized with 0.5 N nitric acid, cleared with methyl salicylate, and studied at × 5 and × 16 magnification. The incidence of one canal and one apical foramen was 100% for maxillary central incisors and 94.16% for mandibular second premolars. The main apical foramen was located in the center of the root apex in 21.89% and 17% of mandibular second premolars and maxillary central incisors, respectively. Lateral and accessory canals were found in 84.50% and 77.15% of maxillary central incisors and mandibular second premolars, respectively. Several foramina were found in 11% of maxillary central incisors and 24.08% of mandibular second premolars. Apical deltas were seen in 4.38% and 2% of mandibular second premolars and maxillary central incisors, respectively. The rate of anatomic variations in the apical part of the tooth, especially in posterior teeth, is thus considered to be high. (J Oral Sci 51, 411-415, 2009)

Keywords: root apex; lateral and accessory canals; foramina; clearing; mandibular second premolar; maxillary central incisor.

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Introduction

The main objectives of root canal therapy are thorough cleaning and shaping of all pulp spaces and complete obturation of these spaces with an inert filling material. The presence of an untreated canal may be a reason for failure. A canal may go untreated because the clinician fails to detect it. It is extremely important that clinicians use all modalities at their disposal to locate and treat the entire root canal system. The complexity of the spaces that must be accessed, shaped, cleaned, and filled is remarkable.

The root apex is of interest to endodontists because of the various stages of root development and the types of tissue present within the roots of teeth. The morphology of the apical root varies tremendously, including numerous accessory canals, areas of resorption and its repair, attached, embedded, and free pulp stones, and varying amounts of irregular secondary dentin (1,2).

The root apex contains a variety of anatomic structures and tissue remnants. Intercanal connections can become exposed, and a single foramen may become multiple. Treatment results are poor if these anatomical anomalies are not recognized, prepared, and obturated. One study evaluating the root apex of teeth with refractory apical periodontitis that did not respond to root canal therapy found that 70% had significant apical ramifications (3). This incidence strongly suggests a close relationship between the anatomic complexity of the root canal system and the persistence of periradicular pathosis.

According to Green (4,5) the incidence of accessory foramina ranged from a minimum of 10% in maxillary central incisors and mandibular cuspids to a maximum of 47% in mandibular second premolars, other teeth having incidences between these two values. The aim of the present study was to evaluate the variations in canal configuration, foramina, lateral and accessory canals and apical deltas in the root apices of human maxillary central incisors and mandibular second premolars, using a clearing technique and stereomicroscopy.

Materials and Methods

A total of 100 extracted maxillary central incisors and 137 mandibular second premolars were collected from a dental faculty, clinics, and private offices in Tabriz, a city in northwestern Iran. The identification of these teeth as mandibular second premolars and maxillary central incisors was confirmed by two independent observers using the accepted criteria of Woelfel (1990) (6). Only teeth on which both investigators agreed were used. The teeth were gathered during one year and stored in 10% formalin. Since a large number of these teeth had been extracted because of periodontal problems, they were intact or had only small carious or filled areas in the coronal portions. The selected teeth were cleaned of any adherent soft tissues, bone fragments and calculus by scaling and polishing. An endodontic access cavity was then prepared in each tooth with diamond fissure burs (D&Z, Diamant, Germany). The floors of the pulp chambers were examined with a DG16 endodontic explorer (Hu Freiday, Chicago, IL, USA) to identify the root canal orifices. After locating the orifices, the teeth were placed in 5.25% sodium hypochlorite solution (Golrang, Tehran, Iran) for 48 h to dissolve debris and pulp remnants. All the specimens were then thoroughly rinsed in running water for 4 h to clean the root canals of any debris. Once washed, India ink was injected into the root canals and the teeth were demineralized for 3 days in 5% nitric acid at room temperature (20°C). The nitric acid solution was changed every day. After demineralization, the teeth were rinsed in running water for 4 h. The dehydration process consisted of a series of ethyl alcohol (Ararat, Tehran, Iran) rinses starting with 80% overnight, followed by 90% for 1 h and then 100% ethyl alcohol rinses for 1 h. The dehydrated teeth were placed in methyl salicylate (Merck, Darmstadt, Germany) for 2 h to make them clear and transparent. The cleared teeth were then examined under a magnifying glass (Lumagny, No.7540, Hong Kong) at × 5 (7) and also using a stereomicroscope (Zeiss, Munich, Germany) at × 16 magnification. The root canal systems were classified according to the classification of Vertucci (8) and the additional classification of Sert et al. (9) (Fig. 1).

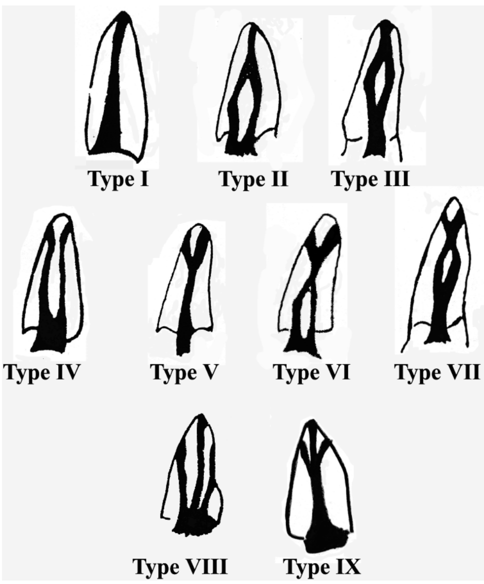

Fig.1 Classification of Vertucci (type I-type VIII) and additional classification of Sert et al. (type IX)

Results

All maxillary central incisors and mandibular second premolars were one-rooted. The root canal configurations of the central incisors were type I (96%) and type III (4%) (Table 1 and Fig 2).

The configurations of the canals in mandibular second premolars were: type I (89.79%), type V (3.64%), type III (2.92%), type II (1.46%), type IV (1.46%) and type IX, or three apical foramina were found in one (0.73%) of the mandibular second premolars (additional clacification of Sert et al.) (9) (Table 1 and Fig. 3).

The locations of the main apical foramina were centric in 17% and eccentric in 83% of central incisors and centric in 21.89% and eccentric in 78.11% of mandibular second premolars (Table 2).

The highest frequency of lateral canals was found in the apical third of root canals in both maxillary central incisors (85.49%) and mandibular second premolars (83.80%) (Figs. 4, 5). The numbers of foramina in central incisors and mandibular second premolars were 9 (9%) and 18 (13.13%) respectively (Table 2). The apical delta was seen in 2% of maxillary central incisors and 4.38% of mandibular second premolars (Table 2 and Fig. 6).

Table 1 Canal configurations of the root according to the classification of Vertucci (8) and additional classification of Sert et al. (9)

Teeth	Canal configurations of the roots									total
	I	II	III	IV	V	VI	VII	VIII	IX	
Maxillary central incisor										
Number	96	0	4	0	0	0	0	0	0	100
Percent	96%	0	4%	0	0	0	0	0	0	100
Mandibular second premolar										
Number	123	2	4	2	5	0	0	0	1	137
Percent	89.79	1.46	2.92	3.64	0	0	0	0	0.73	100

Table 2 Anatomic variations of the root canals in human maxillary central incisors and mandibular second premolars

Teeth	Canal variation of the roots					
	Apical foramen		lateral canals	apical delta	foramina	anastomoses
	centric	eccentric				
Maxillary central incisor						
Number	17	83	36	2	9	0
Percent	17%	83%	36%	2%	9%	0
Mandibular second premolar						
Number	30	107	53	6	18	12
Percent	21.89%	78.11%	38.7%	4.38%	13.13%	8.70%

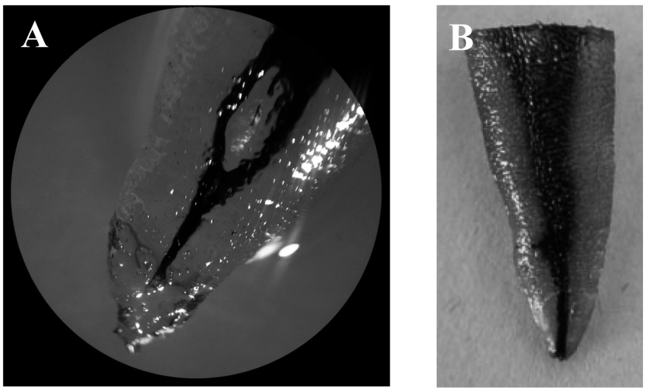

Fig.2 The type III configuration (A) (stereomicroscopic view, original magnification ×16) and type I configuration (B) in maxillary central incisors.

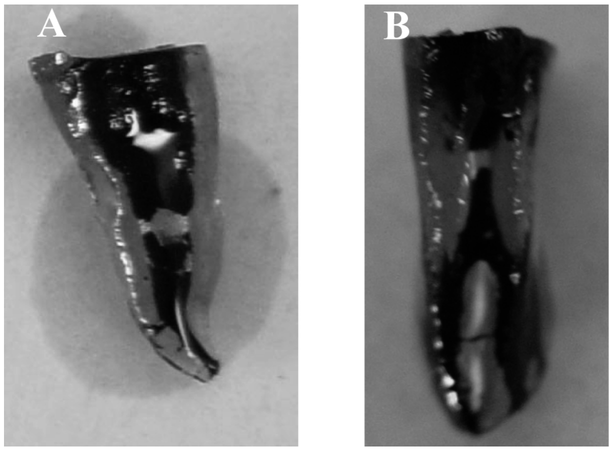

Fig. 3 The type I configuration (A) and type IX configuration (B) in mandibular second premolars.

Anastomosis between canals was only seen in mandibular second premolars with a frequency of 8.70% (Table 2). These anastomoses were in the middle third in 58.34% and apical third in 41.66% (Fig. 7).

Discussion

The configuration of the root canal, and specially the root apices, are important because of their significant impact on the practice of endodontics. The maxillary central incisors have the least, and mandibular second premolars have the highest number of foramina among the human permanent teeth (4,5). Therefore, the present study was designed to evaluate the anatomic complexity of the root apices in maxillary central incisors and mandibular second premolars.

There are different methods for studying the morphology

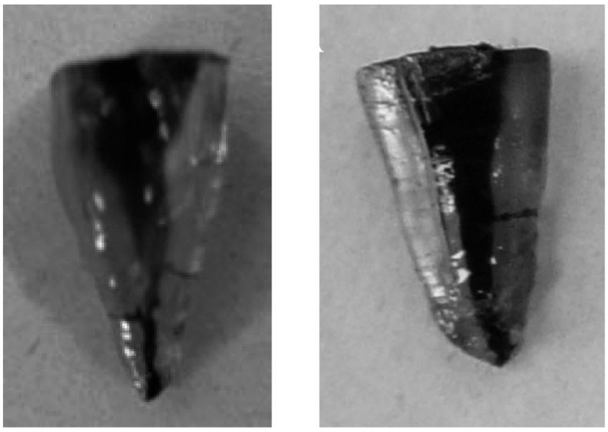

Fig. 4 Lateral canals in central incisors.

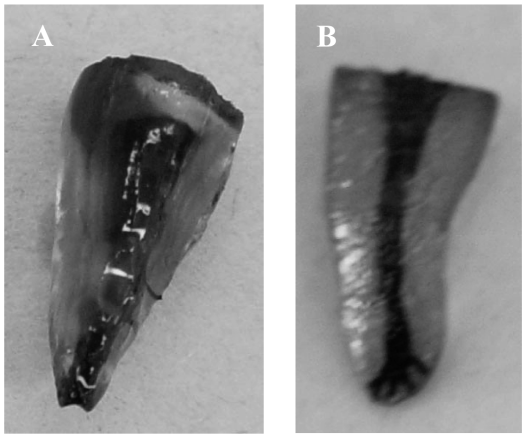

Fig.6 The apical delta in a maxillary central incisor (A) and in a mandibular second premolar (B).

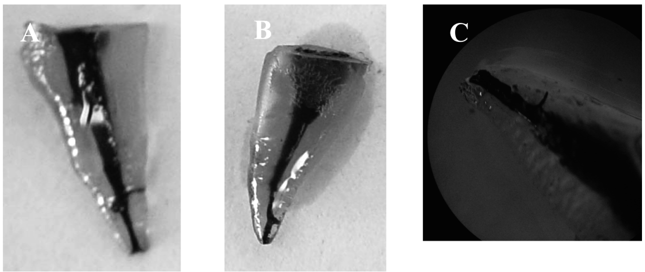

Fig. 5 Lateral canals in mandibular second premolars (A, B) and stereomicroscopic view of lateral canals in mandibular second premolars (original magnification ×16) (C).

Fig. 7 Anastomosis between canals in a mandibular second premolar.

of human permanent teeth. These include the use of radiography (10), placing files in the canals to determine the canal configuration, cutting the teeth at different levels (11), making polyester resin cast replicas of the pulp space (12), and clearing and injection of dye (13). The clearing technique is valuable for studying root canal anatomy because it produces a 3D view of the pulp cavity (14), and instruments are not needed to enter the pulp system (8). Therefore, this technique helps to maintain the original form of the pulp system (15). Because of the accuracy of the clearing technique, this method was employed in this study. In addition, the Vertucci classification (8) and additional classification of Sert et al. (9) were used for classification of the teeth.

The prevalence of lateral and accessory canals of maxillary central incisors in this study was 36%, which was higher than that reported by Vertucci (12%) (8) and less than that reported by Kasahara (60%) (16). The main foramen in 17% of central incisors in this study was centric, in accordance with Vertucci (12%) (8) but less than the prevalence reported by Kasahara (45%) (16). These differences may be related to racial differences and the study methods employed. The prevalence of foramina in the apex of maxillary central incisors in this study, 11%, was in accordance with Green's figure of 10% (4). The prevalence of lateral and accessory canals of mandibular second premolars was 38.70%, which was similar to the results of Vertucci (8) and DeDeus (17). The prevalence of foramina in the mandibular second premolars was 24.08%, and the main foramen was eccentric (laterally) in 78.11% and centric in 21.89%, similar to the results of several other studies (8,9,17,18).

Anasatomoses between canals were present in 8.70%, which was less than the prevalence reported by Vertucci (30%) (8), but within the range reported by Sert et al. (12%) (9). The prevalence of the apical delta in mandibular second premolars was 4.38%, within the range reported by Vertucci (3.40%) (8) but less than the figure reported by Sert et al. (25.50%) (9).

All these differences could be related to racial differences and the study methods employed, and will need to be considered in endodontic practice because of the importance of knowledge about anatomic variations to the outcome of endodontic treatment.

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