

## Assessment of Root Morphology and Apices of First and Second Maxillary Molars in Tehran Population

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### Abstract

**Introduction:** Objective: This study aimed to assess the possible variations in root canal anatomy and topography of the apices of first and second maxillary molars. **Materials and methods:** A total of 67 first and second maxillary permanent molars were collected. Access cavity was prepared and 2% methylene blue was injected. The teeth were demineralized by 5% nitric acid and cleared with methyl salicylate. Specimens were evaluated under stereomicroscopy and analyzed using the sample t-test. **Results:** Based on Vertucci's classification, the mesiobuccal root of maxillary first molars was type I in 87.5% and type IV in 12.5% of the cases. The mesiobuccal root of second maxillary molars was type I in 60%, type II in 8.6%, type IV in 25.7% and type V in 5.7% of cases. In maxillary first and second molars, the distobuccal and palatal roots were type I in 100% of the cases. The distance of the apical constriction from the apical foramen was  $0.21 \pm 0.09$  mm, the distance from the apical constriction to the anatomic apex was  $0.44 \pm 0.19$  mm and the distance of the apical foramen from the anatomic apex was  $0.15 \pm 0.15$  mm. The mean percentage of delta prevalence was 3.2% in both teeth. **Conclusion:** The mean distance of the apical foramen and apical constriction from the anatomic apex was less than 0.6 and 1.2 mm, respectively. In maxillary first and second molars, the mean distance of the apical constriction from the apical foramen and anatomic apex was 0.21 and 0.44, respectively and the mean distance of the apical foramen from the anatomic apex was 0.15 mm.

**Key words:** Apical constriction, Clearing, Apical foramen, Maxillary first molar, Maxillary second molar

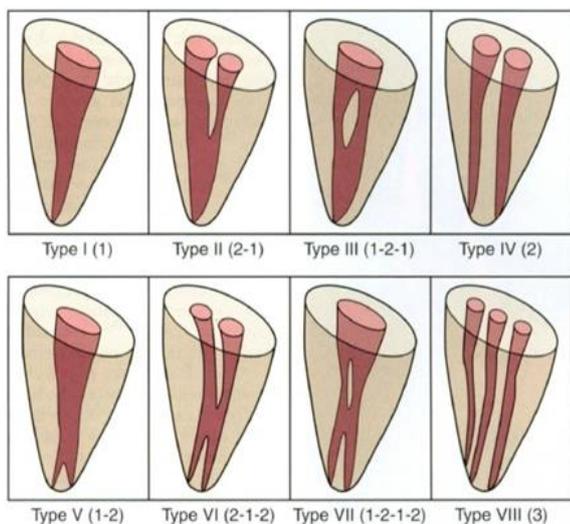
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### Introduction

The main goal of root canal therapy (RCT) is to biomechanically clean the pulp chamber and root canals and prepare the root canal system for obturation; RCT must achieve a three-dimensional seal at the apical and coronal regions and prevent any connection between the internal root canal system and the surrounding periodontal tissues (1). Inadequate cleaning and shaping of the apical region often results in remaining contaminated tissue residues and necrotic debris in the canal. Presence of these stimulants at the apical region can cause persistent periapical inflammation and subsequent root canal treatment failure (1). Radiography is a diagnostic tool in endodontic treatment. However, due to its two-dimensional nature, it has many limitations. Thus, knowledge as to the number and morphological variations of the root canals and the odds of extra canals being present can help achieve higher treatment success .

The roots of some teeth, especially the mesiobuccal (MB) root of maxillary molars, distal root of mandibular molars and to a lesser extent, the maxillary first premolar and mandibular anterior teeth have two canals

(2-7). Vertucci classified root canals in 8 groups (Figure 1) (1, 8)



**Figure 1.** Vertucci's classification of root canal systems (1, 8)

To date, several studies have evaluated tooth apices. Multiple foramina, apical delta, apical isthmus and accessory canals have been frequently reported in the apical one-third of teeth. Such variations can complicate the process of cleaning and shaping of root canal systems (1). Apical delta is defined as the division of the main canal and presence of multiple apical foramina at the apical region (9).

In normal root canals, the most apical part of the canal narrows and forms the apical constriction (1). The canal then widens from this point on and is referred to as the main apical foramen (10). The main apical foramen does not usually correspond to the anatomic apex and is laterally deviated in such way that it is often located 0.5 to 2 mm coronal to the anatomic apex (1).

In a study by Green et al, almost 50% of main foramina directly opened to the apex and the amount of deviation from the apex was reported to be up to 2mm (11). Kuttler et al, in their study on two age groups of 18-25 yrs. and 55 yrs. reported that in 32% and 20% of cases, apical foramina did not deviate from the anatomic apex, respectively. The mean distance of apical foramina from the anatomic apices was 495 microns in the first and 607 microns in the second age group (12, 13). This study aimed to assess the possible variations in root canal anatomy and topography of the apices of first and second maxillary molars.

## Materials and Methods

This in-vitro study was conducted on 35 permanent maxillary first and 35 permanent maxillary second

molars collected from several dental clinics in Tehran. The teeth were stored in glass jars containing 10% formalin. The majority of teeth had been extracted due to periodontal problems and the remaining had small carious lesions or simple coronal restorations. The teeth that met the inclusion criteria underwent scaling and polishing and the soft tissue and bone residues and the calculi were removed. The access cavity was prepared using a diamond fissure bur (D & Z, Diamant, Germany) and high-speed handpiece (Kavo, West, Germany). Canal orifices were detected using the tip of DG16 endodontic explorer (Hu-Friedy, Chicago, IL, USA). The teeth were marked at the mesiobuccal line angle using a hand piece in an area close to the root without manipulating the root end using 0-1 system. Next, the teeth were fixed and #8 K file (Kerr, SybronEndo, Germany) was inserted into the canals. The distance of the apical foramen from the anatomic apex and the amount and direction of deviation of the apical foramen from the anatomic apex mesiodistally and buccolingually were determined using a stereomicroscope (SZX ILLB200 Olympus Optical and LTD, Japan) under  $\times 12$  magnification and 0.01 mm readability. Specimens were immersed in 5.25% sodium hypochlorite solution (Golrang, Paakshou, Tehran, Iran) for 48h at room temperature (20°C) and then rinsed under running water for 4h .

In the next step, 2% methylene blue was injected via the access cavity into the canals using a 27 gauge insulin syringe (Supa, Tehran, Iran). Injection was done in two steps: while applying negative pressure at the apex using central suctioning system with an approximate pressure of 25 mmHg and then through the access cavity and without suctioning. Access cavity was then temporarily restored (Coltosol, Ariadent 37gr). The margins of the temporary restoration and tooth were coated with acrylic resin lacquer and the specimens were prepared for the process of decalcification and clearing.

For decalcification, the specimens were immersed in 5% nitric acid solution at room temperature for 3 days. The solution was stirred 3-4 times a day and refreshed daily. After 3 days, specimens were washed under running water for 4-6h. Dehydration was done using ethyl alcohol (Ararat, Tehran). Specimens were immersed in 80% ethyl alcohol for one day, 90% ethyl alcohol for an hour and 100% ethyl alcohol for another hour. Dehydrated teeth were cleared by immersion in methyl salicylate (Merck, Darmstadt, Germany) for 2h and evaluated and measured under stereomicroscopy at  $\times 12$  magnification and 0.01 mm readability. The morphology of the apical foramen was evaluated and the distance of the apical constriction from the center of the apical foramen and distance of the apical constriction from the anatomic apex were measured.

Other morphological variations of the root canal system namely apical delta and type of canal according to Vertucci's classification were also determined. The results were analyzed using sample t-test ( $P < 0.05$  was considered statistically significant).

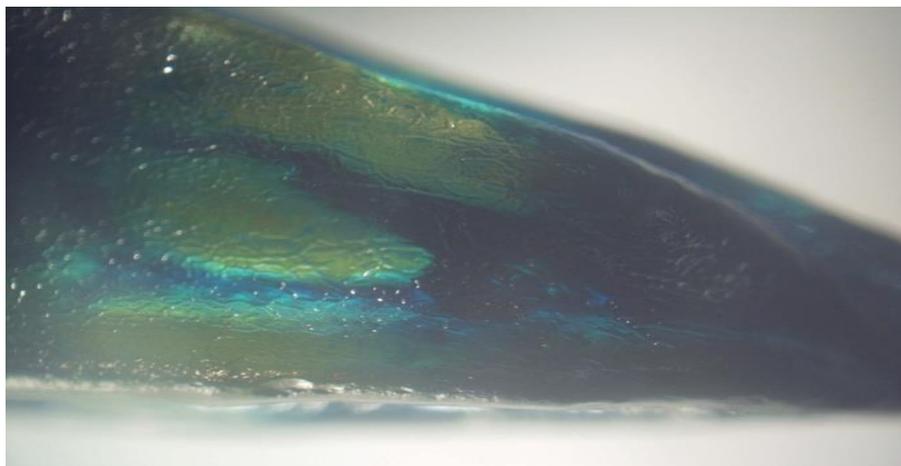
### Results

All maxillary first and second molars evaluated in our study had three roots and no separate extra root was found. MB, DB and palatal canals were present in all first and second molars but the MB2 canal was only observed in 12.5% and 40% of first and second molars, respectively. In this study, according to Vertucci's classification, MB root canals in the maxillary first molar were type I and type IV in 87.5% and 12.5% of cases, respectively; and DB and P roots were type I in 100% of the cases. MB root in the maxillary second molar was type I in 60%, type II in 8.6%, type IV in 25.7% and type V in 5.7% of the cases (Figure 2). DB and P roots were type I in 100% of the cases (Table 1).

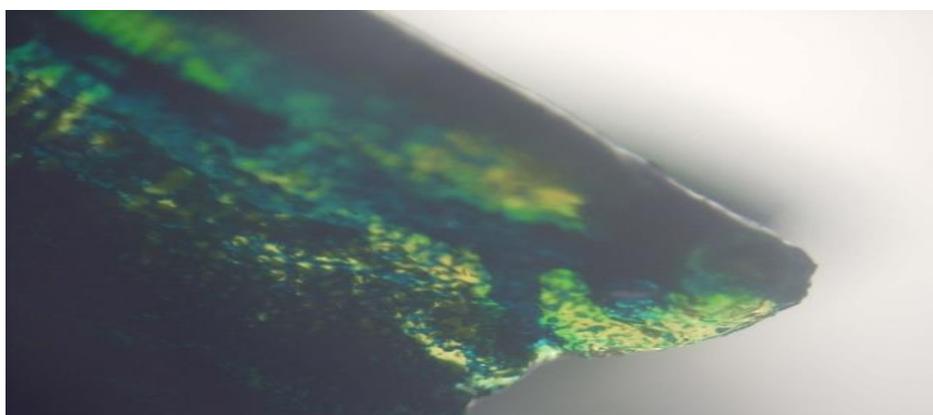
The mean prevalence of apical delta (Figure 3) was 3.2% in the first and second maxillary molars.

Distance between apical foramen, apical constriction and anatomic apex in the canals of maxillary first and second molars is summarized in Table 2. In maxillary first molars, the distance from apical constriction to apical foramen was  $0.21 \pm 0.09$  mm, the distance from apical constriction to anatomic apex was  $0.44 \pm 0.19$  mm and the distance from apical foramen to anatomic apex was  $0.15 \pm 0.15$  mm.

Table 3 shows the prevalence (%) of deviation of apical foramina from the anatomic apex in the MB, DB and P canals of maxillary first and second molars (from the buccolingual and mesiodistal dimensions). The prevalence of non-deviated apical foramina from the mesiodistal and buccolingual dimensions in the MB1, MB2, DB and P canals of maxillary first molars was 15.6, 0, 3.1 and 25%, respectively. These values were 8.5, 14.2, 8.5 and 8.5 for the maxillary second molars, respectively.



**Figure 2.** Type II MB root of maxillary second molar based on Vertucci's classification at 12× magnification



**Figure 3.** Apical delta in the MB root of maxillary first molar at 12× magnification

**Table 1.** Prevalence of canal types based on Vertucci's classification and prevalence of apical delta in the maxillary first and second molars in MB, DB and P roots

Root/ Type	MB		DB		P	
	First molar	Second molar	First molar	Second molar	First molar	Second molar
Type I	87.5%	60%	100%	100%	100%	100%
Type II	0%	8.6%	0%	0%	0%	0%
Type IV	12.5%	25.7%	0%	0%	0%	0%
Type V	0%	5.7%	0%	0%	0%	0%
Delta	MB1:3.1% MB2:0%	MB1:5.7% MB2:14.3%	3.1%	0%	6.2%	0%
Total	32	35	32	35	32	35

**Table 2.** Distance between apical foramen (AF), apical constriction (AC) and anatomic apex (AA) in MB, DB and P roots of the maxillary first and second molars(mm)

Tooth/Canal	Distance from AC to AF		Distance from AC to AA		Distance from AF to AA	
	First molar	Second molar	First molar	Second molar	First molar	Second molar
MB1	0.25±0.13	0.18±0.07	0.45±0.16	0.36±0.13	0.15±0.12	0.19±0.17
MB2	0.21±0.13	0.20±0.10	0.76±0.38	0.69±0.33	0.13±0.05	0.30±0.29
DB	0.21±0.08	0.19±0.06	0.44±0.20	0.36±0.12	0.12±0.11	0.10±0.10
P	0.23±0.08	0.20±0.07	0.24±0.12	0.44±0.16	0.13±0.07	0.16±0.11

**Table 3.** Prevalence of apical foramen deviation from the anatomic apex in the maxillary first and second molars from the buccolingual (BL) and mesiodistal (MD) dimensions.

Dimension	Deviation side	MB1		MB2		DB		P	
		First molar	Second molar						
BL dimension	D	31.2%(10)	37.1%(13)	25%(1)	28.6%(4)	31.2%(10)	25.7%(9)	34.4%(11)	25.7%(9)
	M	25%(8)	34.3%(12)	25%(1)	42.9%(6)	21.9%(7)	40%(14)	6.2%(2)	45.7%(16)
	No deviation	43.8%(14)	28.6%(10)	50%(2)	28.6%(4)	46.9%(15)	34.3%(12)	59.4%(19)	28.6%(10)
MD dimension	L	46.9%(15)	34.3%(12)	0%	36.7%(5)	53.1%(17)	31.4%(11)	37.5%(12)	34.3%(12)
	B	15.6%(5)	25.7%(9)	25%(1)	21.4%(3)	21.9%(7)	20%(7)	28.1%(9)	22.9%(8)
	No deviation	37.5%(12)	40%(14)	75%(3)	42.9%(6)	25%(8)	48.6%(17)	34.4%(11)	42.9%(15)
Both BL and MD dimension	No deviation	15.6%	8.5%	0%	14.2%	3.1%	8.5%	25%	8.5%

## Discussion

Successful RCT requires knowledge of tooth anatomy and root canal morphology. Although the external morphology and internal anatomy of teeth seem to be the same in different individuals, the fact is, numerous variations have been reported in number and morphology of root canals in permanent teeth (1, 14).

Laboratory techniques designed for the study of root canals and apex include injection of methylene blue (15), injection of India ink (16-21), injection of China ink (14), hematoxylin staining (22), metal or plastic casting, in-vitro endodontic access along with the use of radiography and instruments (23, 24) or use of instruments alone (25, 26), injection of radiopaque gel and radiography (27), in-vitro root canal treatment (28), in-vitro radiography (29, 30), macroscopic evaluation by naked eye, evaluation of pulp chamber floor with electron microscopy (31) and preparation and sectioning (31, 32, 33). Clearing technique by decalcification is among the laboratory techniques also used for this purpose by Vertucci (22) and others (17, 18, 20, 21, 26). The clearing technique provides a 3D model of the root canal anatomy without destruction of tooth structure and is as accurate as CBCT and spiral computed tomography (34)

In our study, MB canals of maxillary first molars were type I in 87.5% and type IV in 12.5% of cases according to Vertucci's classification. But, DB and P roots had type I anatomy in 100% of cases. MB root canals of maxillary second molars were type I in 60%, type II in 8.6%, type IV in 25.7% and type V in 5.7% of cases. DB and P root canals had type I anatomy in 100% of the cases. Prevalence of two canals in MB root of maxillary first and second molars was 12.5% and 40%, respectively (Table 1)

In our study, in maxillary first and second molars the distance from apical foramen to the anatomic apex was always less than 0.6 mm and the distance from the apical constriction to anatomic apex was always less than 1.2 mm. The mean distance from the apical constriction to the anatomic apex was 0.44 mm, the mean distance from the apical foramen to the anatomic apex was 0.15 mm. The mean distance from the apical constriction to the apical foramen was 0.21mm. However, in studies by Kuttler and others (12, 13), this distance was reported to be in the range of 0.5-1 mm. This difference may be attributed to the different understudy teeth, age, sex and race of patients or study design and methodology.

In our study, the prevalence of apical foramen without deviation from the anatomic apex in MB1, MB2, DB and P canals of maxillary first molars was 15.62%, 0%, 3.1% and 25%, respectively. This value for the maxillary second molar was 14.2% for MB2 and 8.5% for other canals. Only the results reported for the

MB root of the maxillary second molar in Vertucci's study (22) were in agreement with our values (Table 3).

In our study, the mean prevalence of delta in the maxillary first and second molars was 3.2%. The results of Vertucci's study for the maxillary first molars were similar to ours. However, the results regarding maxillary second molars were largely different from ours.

## Conclusion

In the maxillary molars, the distance from the apical foramen to the anatomic apex, apical constriction to anatomic apex and apical constriction to apical foramen was found to be equal or less than 0.6, 1.2 and 0.4 mm, respectively. Anatomical variations observed in maxillary molar roots in our study emphasize the importance of cognizance of all the canals and their anatomic variations.

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Conflict of interest: The authors have no conflict of interest.

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