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ORIGINAL ARTICLE

Root and canal morphology of maxillary first premolars in a Turkish population

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Abstract *Background/purpose:* The purpose of this study was to evaluate root and canal morphology in maxillary first premolars in a Turkish population.
Materials and methods: We collected 653 maxillary premolars from patients who came for extractions needed for several reasons, such as caries or prosthodontic or orthodontic treatment. The extracted teeth were thoroughly washed and cleaned to remove blood, saliva, or debris. The cleaned samples were then stored in normal saline till further experiment was carried out. A sample of maxillary first premolars was subjected to visual examination and digital radiography to determine the number of roots and root canals and their types.
Results: Of the 653 teeth, 295 (45.2%) had one, 351 (53.7%) had two, and three molars (1.1%) had three roots. Of these, 7.8% (51 teeth) had single canal (Type I canal), 90.7% (592 teeth) had two canals (Types II and III), and 1.5% (10 teeth) had three canals (Type IV).
Conclusion: Turkish maxillary first premolars are mainly two rooted and predominantly have Type III canal morphology.

Introduction

Root-canal treatment (RCT) is an essential part of comprehensive, quality dental care.[1] Successful endodontic treatments depend on complete root-canal cleansing and shaping, three-dimensional hermetic root-canal system obturation, and good fittings with no leakage of coronal restorations.[2] The lack of thorough knowledge about the anatomy of root canals is one of the main reasons for treatment failure in endodontics.[3] Therefore, the first step in achieving a successful endodontic outcome is an exact diagnosis of the root-canal system and its anatomical variations. The relative simplicity and uniformity of the external surfaces of roots often masks internal complexity.[4]

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Maxillary first premolars show a considerable variation in root-canal morphology. The internal anatomy of the maxillary first premolars is particularly complex due to their variation in the number of roots and canal configuration.

Many studies have been carried out to determine the root and canal morphology of maxillary first premolar teeth and significant variations related to ancestry or geographic origins have been noted.[3,5–7] In studies performed by Kartal et al,[5] Carns and Skidmore,[8] Loh,[9] Bellizzi and Hartwell,[10] and Vertucci and Gegayff,[11] the prevalence of one root ranges from 22.0% to 49.4%, two roots from 50.6% to 72%, and three roots from 0 to 6%. Studies reported by Carns and Skidmore,[8] Green,[12] and Pineda and Kuttler,[13] dealing with the canal morphology of the first maxillary premolars, have shown that in most cases they have two canals (from 73.3% to 92%), although teeth with one or three root canals do exist (prevalence from 8% to 26.2% and from 0% to 6%, respectively).

The aim of this study is to determine the external root morphology and internal root-canal variations of the maxillary first premolar in the Turkish population, and to compare the findings with published reports of people from different regions.

Materials and methods

We collected 653 maxillary premolars from patients who came for extractions because of caries or prosthodontic, periodontic, or orthodontic needs. The extracted maxillary first premolars came from various special and public dental clinics in seven different cities of Turkey without consideration of patient's age, sex, and religion. Identification of maxillary first premolar was achieved by the coronal morphological features described earlier. Care was exercised to distinguish it from the second premolar, which does not possess the identifying features of the first premolar. Teeth that were ambiguous or hard to classify were not included in this study. Moreover, teeth included in this study had intact clinical crowns and fully developed apices. The extracted teeth were thoroughly washed and cleaned to remove blood, saliva, or debris. They were then placed in 5% sodium hypochlorite solution for 30 minutes to remove organic debris from the surface. If there was calculus, it was removed using an ultrasonic scaler. The cleaned samples were then saved in normal saline until further investigation was carried out.

We determined the external root morphology visually and recorded the findings. The teeth were separated into four groups according to their external root forms, based on the number of roots[9,14–16]:

1. Group I: single root
2. Group II: two separate roots
3. Group III: two fused roots
4. Group IV: three roots

After visual examination, all the teeth were radiographed in two planes (mesiodistal and mesiodistal + horizontal angle of 40°) to evaluate the root-canal morphology. Subsequently, teeth were embedded up to the cementoenamel junction in cold-polymerizing transparent acrylic resin, with their long axis oriented vertically to evaluate the internal root-canal anatomy. After that, the teeth were cross-sectioned with the aid of an IsoMet diamond blade (125 mm × 0.35 mm × 12.7 mm at 330 °C), mounted on an IsoMet low-speed saw (Buehler Ltd, Lake Bluff, IL, USA). During sectioning, the specimens were subjected to continuous water cooling to prevent buildup of frictional heat. After sectioning, internal root-canal anatomy was evaluated according to Weine's[17] classification (Table 1).

Results

Of the 653 maxillary first premolars studied, 295 teeth (45.2%) had one root and 351 (53.7%) had two. Of the two-rooted premolars, 283 (43.3%) had separate roots, while 68 (10.4%) had fused roots. Seven (1.1%) premolars had three roots. The number of roots in the maxillary first premolar reported in several studies is summarized in Table 1, alongside the results of this study.

When the internal root anatomy was examined, 51 maxillary first premolars (7.8%) were classified as Type I, with a single root canal extending from the pulp chamber to the apex. Another 145 teeth (22.2%) had two separate root canals that were joined short of the apex to form a single apical foramen (Type II), and 447 (68.5%) had two separate root canals that remained separate with two apical foramina (Type III); the incidence of Type IV canals

Table 1 *In vitro* studies on root morphology of the first maxillary premolar.

Author (year)	Origin	No. of teeth	One root (%)	Two roots (%)	Three roots (%)
Ingle (1965)	Not available	Not available	43.0	55.0	2.0
Pineda and Kuttler (1972)	USA	259	43.0	54.6	2.4
Carms and Skidmore (1973)	USA	100	22.0	72.0	6.0
Vertucci and Gegayuff (1979)	Not available	400	26.0	70.0	4.0
Pecora et al. (1991)	Brazilian	240	55.8	41.7	2.5
Loh (1998)	Singaporeans	957	49.4	50.6	0.0
Kartal et al (1998)	Turkish	600	37.3	61.3	1.3
Chaparro et al (1999)	Andalusian	150	40.0	56.7	3.3
Lipski et al (2003)	Polish	142	15.5	75.4	9.2
Atieh (2008)	Saudi	246	17.9	80.9	1.2
Awawdeh (2008)	Jordanian	600	30.8	68.4	0.8
The present study	Turkish	653	45.2	55.7	1.1

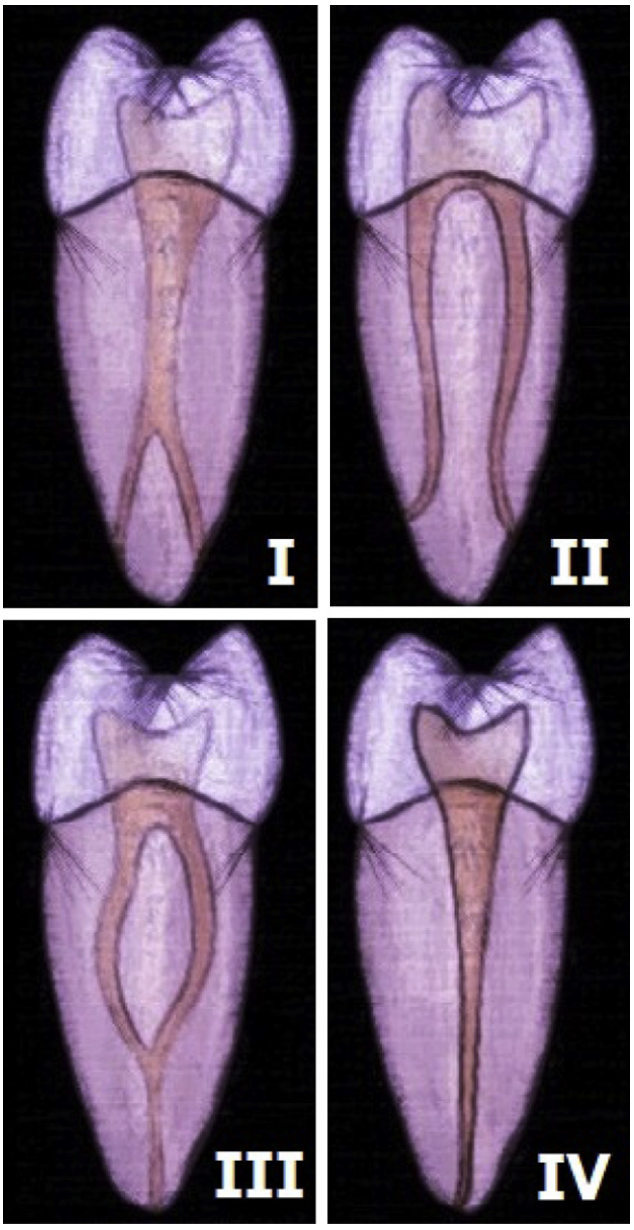

Figure 1 Classification of root morphology of the first maxillary premolar: Type I—a single root canal extend from the pulp chamber to the apex; Type II—separate root canals leave the pulp chamber and join short of the apex to form one canal; Type III—two separate root canals leave the pulp chamber and remain separate to the site of exiting; Type IV—three separate and distinct root canals extend from the pulp chamber to the apex.

was 1.5%, with only 10 teeth having three root canals (Fig. 1).

Discussion

An accurate knowledge of the root-canal morphology and its anatomical variations is mandatory for successful RCT. Sufficient sample size is very important in studies evaluating root-canal anatomy, so that the results are descriptive of the general population.[16] Hence, this study ensured that molars were collected from practitioners across the country, from patients of unknown ethnicity. More than 77 million people live in Turkey, a Eurasian country that stretches across the Anatolian peninsula in western Asia and Thrace in the Balkan region of south-eastern Europe. Approximately 80% of the population is Turkish. The remaining 20% are mainly Kurds, Circassians, Bosniaks, Albanians, Arabs, Armenians, and Jews, who have integrated into the Turkish culture.

The number of roots in maxillary first premolars shows wide variation.[5,7–9,15] In the dental literature, the incidence of a single-rooted maxillary first premolar was reported to range from 22.0% in one study to 55.8% in another by Pecora et al (Brasil),[7] while Loh (Singaporeans)[9] reported the lowest incidence of two-rooted teeth at 50.6% and Carns and Skidmore (USA)[8] reported the highest incidence. In the present study, 45.8% of maxillary first premolars were found to have a single root. All other reports recorded a small number of teeth with three-rooted morphology (0–6%).[6,8,14,15,18]

In our study, 45.2% of maxillary first premolars had a single root, which is a higher figure than that reported in some earlier studies by Carns and Skidmore,[8] Vertucci and Gegayff,[11] and Atieh,[15] and lower than in studies conducted by Loh[9] and Pecora et al.[7] Another study in a Turkish population performed by Kartal et al[5] found an incidence of 37.3% for single-rooted maxillary first premolars, which is lower than the present study. Interestingly, the percentage of two-rooted maxillary first premolars observed in our study was 53.7%, which was higher than that found in studies conducted by various authors (Pecora et al[7] and Loh[9]) but lower than in studies by Carns and Skidmore,[8] Chaparro et al,[19] Kartal et al,[5] Vertucci and Gegayff,[11] Atieh.[15] The number of roots in the maxillary first premolar as reported in several studies is summarized in Table 1 alongside the results of this study.

In our study, three-rooted maxillary first premolars were observed in seven out of 653 subjects, with a frequency of 1.1%. The prevalence of three-rooted maxillary first premolars in this study was lower than that reported in several studies[3,7,8,13,19] and consistent with other studies performed in Turkish, Jordanian, and Arab populations.

An accurate knowledge of the root-canal morphology and its anatomical variations is essential for a successful RCT. Different investigations have reported variations in root-canal morphology of maxillary first premolars.[5,7,14–16] Only 7.8% of the teeth examined in our study had one canal. This figure is similar to those of some previously published studies[5,8,12,15] and considerably lower than the findings of some earlier studies.[7,13] The percentage of two canals (Types II and III) in maxillary first premolars ranged from 73.3%, as reported by Pineda and Kuttler,[13] to 92%, as reported in another study. In our study, 90.1% of maxillary first premolars had two canals, which was almost consistent with the findings of the studies conducted by Kartal et al (Turkey),[5] Lipski et al (Poland),[20] and Atieh (Saudi Arabia),[15] and slightly lower than that in one previous study (USA).[12] Table 2 summarizes the percentage of root canals in maxillary first premolars reported by several studies, including this one.

Table 2 *In vitro* studies on root-canal morphology of the first maxillary premolar.

Author (year)	One canal (%)	Two canals (%)	Three canals (%)
Pineda and Kuttler (1972)	26.2	73.3	0.5
Green (1973)	8.0	92.0	0.0
Carms and Skidmore (1973)	9.0	85.0	6.0
Vertucci and Gegayuff (1979)	8.0	97.0	5.0
Pecora et al (1991)	17.1	80.4	1.7
Kartal et al (1998)	8.7	89.6	1.7
Lipski et al (2003)	2.1	88.6	9.2
Atieh (2008)	8.9	89.8	1.2
The present study	7.8	90.7	1.5

The incidence of three-canaled maxillary premolars has been observed as between 0% and 6% of first premolars.[5,7,8,11–13,15,20] In their study, Vertucci and Gegauff[11] found 5% of 400 maxillary first premolars to have three canals: 0.5% of these were three canals in a single root, 0.5% were configured as two canals in one root and one canal in a second root, and 4% consisted of one canal in each of three separate roots. Carns and Skidmore[8] found that six of 100 maxillary first premolars had three canals, all of which existed as one canal in each of three roots. The prevalence of supernumerary teeth in our study was found to be 1.5%.

Relative simplicity and uniformity of the external surfaces of roots often mask their internal complexity.[4] Maxillary first premolars show a considerable variation in root-canal morphology. The internal anatomy of the maxillary first premolars is particularly complex, due to differences in the number of roots and canal configuration. In the literature, there is a great deal of variation with respect to the number of roots and internal canal morphology of teeth.[4–7,9–11] The differences discussed above, with respect to the number of roots, are often explained as racial differences[3,5,7,14,21] and by use of different procedures to identify or classify teeth. The wide range of findings highlights the importance of identifying the internal morphology as precisely as possible as the primary step in RCT.

Although many studies have been carried out to explore the prevalence of different root-canal morphologies, they have used differed methodologies, including various types of clearing studies using decalcification[22] and injection with India ink,[7,14,23,24] Chinese ink,[25] hematoxylin dye,[3] plastic casting,[26] *in vitro* endodontic access with radiography and instruments[26,27] or instruments only,[28] *in vitro* radiopaque gel infusion and radiography,[29] *in vitro* RCT,[30] *in vitro* radiography,[13,30,31] *in vitro* macroscopic examination,[32] scanning electron microscope examination of the pulp floor,[33] and grinding or sectioning.[16,34,35] In this study, the teeth were radiographed to visualize the root-canal morphology. Although the radiograph is a two-dimensional image of a three-dimensional object, we managed to achieve relatively good reproduction of the root-canal system. Radiographing teeth in two planes enables such a reproduction of the root-canal system. Moreover, we suggest that clinical evaluation of the root-canal system is possible only by taking such radiography into consideration.

Traditionally, most endodontic canal detection procedures have relied on the doctor's tactile dexterity and mental image of the canal system, because the ability to visualize the canal orifices was severely limited.[36] Recent advances in endodontic equipment and instruments have improved tremendously. The use of magnification and fiber-optic illumination in endodontic therapy offers a major advantage in locating and negotiating extra canals.[37] Moreover, it enhances clinicians' ability to selectively remove dentine with great precision, thereby reducing procedural errors.

In everyday clinical practice, knowledge of root and root-canal morphology can aid in the location and negotiation of canals, as well as in their subsequent management, and it may be useful for tracing the origins of world populations. Because of the relatively small size of our sample, findings of root and canal morphology of maxillary first premolars in the present study should be considered with caution, as they may not be representative of the overall population of Turkey. Nonetheless, further studies are needed to explore the tooth morphology in the Turkish population using a larger sample size and more advanced techniques, such as the use of dissecting light microscope and computed tomography, to study the root-canal morphology.

Clinically, it is important to identify the root-canal anatomy prevalent in a population to reduce errors during endodontic treatment. Turkish maxillary first premolars are mainly two rooted and predominantly present Type III canal morphology.

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