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Evaluation of Root Canal Anatomy and Morphology of Lower First Premolar Teeth in a Turkish Subpopulation: Cone Beam Computed Tomography Study

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ABSTRACT

Objective: The aim of the present study is to evaluate the anatomy and morphology of mandibular first premolar teeth in a Turkish subpopulation, based on common classification using cone beam computed tomography.

Methods: Five hundred and five teeth that met in inclusion criteria included the study. Teeths classified according to the Vertucci Classification. All evaluations were made by two endodontists for each tooth. After recording demographic data, the root canal configuration of the teeth, number of roots, number of canals, direction and level of canal branching were recorded and evaluated. The results were statistically analysed using chi square.

Results: The most common morphology in both tooth group was Vertucci Type 1, while the second most common morphology was Vertucci Type 5.A significant difference was found between root number and gender (p<.05). Males were three times more likely to have two roots than females. No statistically significant difference was found between Vertucci classification and tooth location (right-left) and age group. Additionally, no statistically significant difference was found between tooth localization and canal number, root number, branching level and branching direction. (p>.05) According to the findings of the current study, a statistically significant difference was found between Vertucci classes and gender. (p<.05) However, no significant difference was shown between the number of roots and tooth location and age group. (p>.05)).

Conclusion: Having information about the morphology of premolar teeth with variable anatomical variations will prevent possible complications and increase success. CBCT is complementary to clinical applications in fully determining anatomical variations in three dimensions.

Keywords: anatomy, classification, Cone Beam Computed Tomography, morphology, premolar

1.INTRODUCTION

The success of root canal treatments depends on the thorough cleaning and three-dimensional obturation of the root canal system, which has a very complex structure. Being aware of the complex anatomy of the root canal system and possible anomalies is very useful during the preparation and filling of root canals (1). Ingle (2) reported that the most important cause of endodontic failures is incomplete canal instrumentation followed by incorrect canal filling. Anatomical variations that manifest themselves in different ways in each tooth group; It may appear as extra roots, extra canals, and canal branching that can be seen in different localizations. Endodontic treatment is challenging, especially in mandibular first premolars, due to the existence of many variations and limited access to the second canal (3,4). Slowey (5) stated that mandibular premolar teeth are the most difficult teeth to treat endodontically due to differences in canal anatomy. Variations in root canal morphology may lead to endodontic flare ups and failures. Clinically, visual methods and hand sensitivity are used to determine root canal anatomy. Although radiological evaluations are performed before and after treatment, the therapeutic and diagnostic value of cone beam computed tomography is difficult (6). Also although conventional radiographs provide general information to clinician, there are situations where they may be insufficient. Extra roots, extra canals, branches in the root canal anatomy, internal and external root resorptions may not be detected on routine radiographs can be factors that make endodontic treatments more complex. These factors are very important

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and must be fully understood by the clinician before starting root canal treatment to ensure a successful intervention (7). In such cases, cone beam computed tomography is useful for a more accurate diagnosis and subsequent successful treatment.

Mandibular first premolar teeth are generally single-rooted and single-canal teeth known in the Turkish population. However, today, variations of these teeth have become more common, especially in the younger generation. Age and gender (8,9) as well as research design, canal identification methods, and ethnic differences all contribute to such differences (10). A study on the Saudi population published in 2019 (11) found that mandibular premolars exhibited one root in 96.4% of first premolars and 95.6% of second premolars. Similarly, many studies have reported that single-rooted lower premolars constitute 98% of the Thai population (12), 100% of the Spanish population (13), and 85.7 – 94.8% of the Iranian population (14). Various classifications have been made to classify the anatomical and morphological structures of teeth. The Vertucci classification (15-18), widely used in anatomy studies, uses eight types of root canal configurations and is based on the examination of transparent samples. The aim of the present study is to evaluate the morphology and anatomy of lower first premolar teeth in a Turkish subpopulation, based on common classification using cone beam computed tomography.

2. METHODS

Ethics committee approval for the present study was obtained from Clinical Research Ethics Committee (Annex 1). In the present study CBCT images obtained as part of the patients' diagnosis and treatment planning were retrospectively examined. No informed consent was required for this type of study based on institutional review board.

All images were taken using Galileos Machine (Sirona Dental Systems, Bensheim, Germany)

with image capture parameters set at 90 Kv and 6.0 mA, and an exposure time of 2.3 s. The voxel size of the images was 0.3 mm and the field of view (FOV) was 15 cm. The inclusion criteria were as follows:

-Patients between the ages of 18-65,

-Teeth with complete root formation,

-Lower first premolar teeth,

-Fully erupted teeth,

-Each patient had to have at least one (or two) mandibular first premolar,

The exclusion criteria were as follows:

-Teeth with periapical lesions,

-Teeth with root resorption,

-Previously endodontically treated teeth,

-Teeth with incomplete root development and open apex

All scans were evaluated separately by two endodontists to ensure objectivity and no data was recorded until a consensus was reached. In case of discrepancies between the two researchers, the image was randomly re-evaluated by both researchers on three different days. A majority vote resolved disagreements. For each image, the classification that achieved the majority was accepted as the answer. To assess inter-examiner reliability of the researchers, 15% of the radiographs randomly assigned by the investigators were randomly reviewed each day for 10 days. Results were analyzed using Wilcoxon matched pairs signed-rank test showed no statistically significant differences. After recording the demographic data of the patients, the mandibular first premolar teeth of each patient in both quadrants were examined by tomography. For each tooth, its presence in the mouth, tooth number, number of roots and canal morphology were recorded according to the Vertucci Classification. The data were confirmed by examining each tooth separately in coronal, axial and sagittal sections. Classifications of anatomical and morphological findings were made as follows:

2.1. Number of roots

The number of roots was determined as follows:

Single-rooted tooth: A tooth with a single distinct root.

Double-rooted tooth: A tooth with roots separated by bifurcation (regardless of whether the root is partially or completely separated).

Triple-rooted tooth: A tooth with three separate roots (regardless of whether the root is partially or completely separated).

2.2. Root bifurcation

According to sagittal and coronal section images, each root was examined in three sections.

-Coronal third: From the cementoenamel junction to 1/3 of the root length (CT)

-Middle third: From 1/3 to 2/3 of the root length (MT)

-Apical third: From 2/3 of the root length to the radiographic apex. (AT)

2.3. Root Canal Morphology

2.3.1. Root canal configuration

Root canal configurations were classified according to the Vertucci classification. The configuration classification and coding made according to this classification are as follows:

– Type I (1): V1
– Type II (2-1): V2
– Type III (1-2-1): V3

– Type IV (2): V4
– Type V (1-2): V5
– 2 Roots 2 Canals: V6
– 3 Roots 3 Canals: V7

2.3.2. Canal branching level

The branching levels of the root canals were also evaluated as ''coronal third'' (CT), ''middle third'' (MT) and ''apical third'' (AT). If there was no branching in the canal, it was recorded as ''no branching'' (N).

2.3.3. Canal branching direction

When there is branching in the root canals, if the branching canal is buccal, it is evaluated as ''buccal'' (B), if it is lingual, it is evaluated as ''lingual'' (L), if there is central and equal branching, it is evaluated as ''central'' (C). If there is no branching in the canal, it is recorded as ''no branching'' (N).

2.4. Statistical analysis

The results were statistically analyzed using SPSS 20.0 (SPSS, Inc., Chicago, IL, USA). Power analysis was performed to determine a sufficient number of samples and a minimum sample population of 500 was found to be sufficient at a significance level of .05 at a 95% power scale. Data were analyzed using Fisher's Excat and Chi-square tests.

3. RESULTS

308 patients were evaluated for the study. 51 of these patients were excluded from the study because of not having the teeth to be examined. 257 patients (131 female, 126 male), 505 teeth were examined. Of these, 254 were lower left first premolars (MLFP), 251 were lower right first premolars (MRFP). Of the 254 MRPLs, 1 had 3 roots, 33 had 2 roots, and 220 had 1 root. Of the lower right first premolars, 39 had 2 roots, and 212 had a single root. Information and percentage distributions regarding gender, tooth position and root number of the evaluated patients are shown in Table 1. Some of CBCT images are shown in Figure 1, Figure 2, and Figure 3.

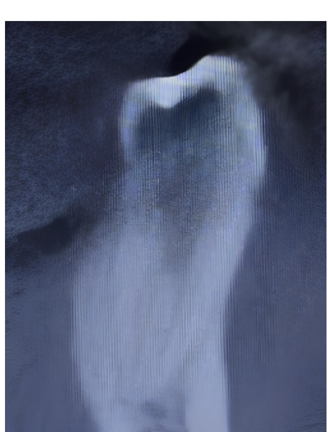

Figure 1. *The canal divided into two at the middle third level of the root.*

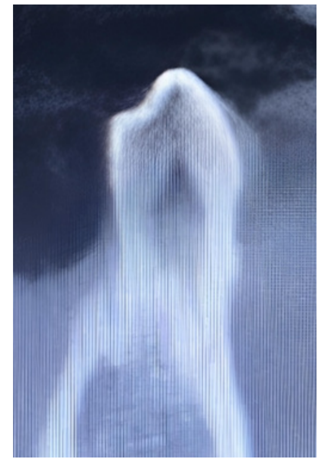

Figure 2. *Double-rooted tooth.*

Figure 3. *Vertucci type V.*

Table 1. *Frequency distribution of root number (percentage of teeth) in mandibular first premolars (MFP) according to gender and tooth position*

	MFP	One root (%)	Two root (%)	Three root (%)	Total (%)
	Female	237 (%92.57)	19 (%7.03)	1 (%0.4)	257
Gender	Male	195 (%78.62)	53 (%21.38)	0 (%0)	248
	Total	432 (%85.54)	72 (%14.25)	1 (%0.19)	505
Tooth Position	Right	212 (%84.8)	39 (%15.2)	0 (%0)	251
	Left	220 (%86.61)	33 (%12.99)	1 (%0.4)	254
	Total	432 (%85.71)	72 (%14.09)	1 (%0.2)	505

According to the findings of the study, the most common morphology in both tooth groups was Vertucci Type 1. The second most common morphology was Vertucci Type 5. Vertucci distribution according to tooth localization, gender and age group is shown in Table 2. The distribution of canal number, root number, branching level and branching direction according to tooth localization is shown in Table 3.

Table 2. *Vertucci distribution according to tooth localization, gender and age group*

	Group	Vertucci Type														P*
		V1		V2		V3		V4		V5		V6		V7		
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Tooth localization	Right (44)	153	60.95	3	1.19	3	1.19	5	1.99	48	19.12	39	15.53	0	0	.07
	Left (34)	145	5.08	1	0.39	4	1.57	0	0	70	27.55	33	12.99	1	0.39	
Gender	Male	132	53.22	2	0.80	3	1.20	2	0.8	56	22.58	53	21.37	0	0	.01
	Female	166	64.59	2	0.77	4	1.55	3	1.16	62	24.12	19	7.39	1	0.38	
Age group	18-35	194	59.32	2	0.61	4	1.22	2	0.61	74	22.62	50	15.29	1	0.30	.19
	36-50	54	54.54	1	1.01	0	0	2	2.02	25	25.25	17	17.17	0	0	
	51-65	50	63.29	1	1.26	3	3.78	1	1.26	19	24.05	5	6.32	0	0	

** significance level<.05, V1:Vertucci Type I, V2:Vertucci Type II, V3:Vertucci Type III, V4:Vertucci Type IV, V5:Vertucci Type V, V6: 2 Roots 2 Canals, V7:3 Roots 3 Canals*

Table 3. *Distribution of canal number, root number, branching level and direction according to tooth localization*

	Group	Tooth localization				p*
		Right		Left		
		n	%	n	%	
Canal number	One Canal	152	51.18	145	48.82	.47
	Two Canal	99	47.80	108	52.20	
	Three Canal	0	0	1	100	
Root number	1	212	49.07	220	50.92	.45
	2	39	54.16	33	45.84	
	3	0	0	1	100	
Branching level	CT	15	62.50	9	37.50	.41
	MT	52	46.85	59	53.15	
	AT	32	44.44	40	55.56	
	N	151	51.01	145	48.99	
Branching direction	B	3	30	7	70	.22
	L	15	37.50	25	62.50	
	C	80	51.61	75	48.39	
	N	152	51.18	145	48.82	

** significance level<.05, CT: coronal third, MT:Middle third, AT:Apical third, N:No branching, B:Buccal, L:Lingual, C:Central,*

4. DISCUSSION

The present study provides a detailed report on the root canal anatomy and morphology of mandibular first premolars in a Turkish subpopulation. Images obtained from tomography sections were used to examine root canal anatomy and morphology. Studies have reported that variations in root canal anatomy are frequently observed (19). For successful root canal treatment, it is necessary to have sufficient knowledge about the morphology and anatomy of the relevant tooth (17). Causes of failure in root canal treatment are inadequate disinfection, untreated canals, and insufficient obturation. When all canals have been found, irrigated, shaped and obturated, the treatment can considered as successful. Having knowledge aboout the number of roots and canals commonly seen in the relevant tooth will increase the success of the treatment. Therefore, accurate radiographic and clinical evaluation is essential for the success of root canal treatment (11). Clinical evaluation is integrated with diagnostic imaging. Two-dimensional imaging techniques always may not be sufficient for accurate diagnosis. In cases where two-dimensional imaging is not sufficient, three-dimensional imaging techniques should be used. CBCT is a three-dimensional imaging technique used to evaluate teeth before and after treatment. CBCT images are important for diagnosis and treatment as well as for future treatment plans (20). CBCT has some advantages over other conventional methods. One of them is that it provides a three-dimensional image of the region of interest. In addition, conditions such as broken instruments in the canal, existing perforations and their locations, and overfillings can be accurately diagnosed with CBCT. Additionally, CBCT provides images of interested region in a smaller area with less radiation, and the image quality is also better. Traumatic injuries, inadequate information obtained from clinical examination and periapical radiographs, determination of the extent and boundaries of resorption in the presence of resorption, imaging of suspected extra canals, three-dimensional evaluation of the neighborhoods to anatomical landmarks, determination of the depth and location of the fracture line in root fractures can be listed as endodontic indications for the use of CBCT. The findings obtained with CBCT can guide us in the clinical applications of endodontic treatments. Variations, extra roots, and canals that cannot be determined in two-dimensional imaging can be clearly visualized with CBCT. Thus, treatment failures that may occur due to incomplete treatment of canals that cannot be found can be prevented. In resorptions with unclear boundaries, the spread of existing pathology in lesions can be determined with CBCT and the necessary treatment plan can be made more accurately. Different techniques have been developed for the evaluation of root canal morphology. CBCT is a highly reliable clinical tool that has recently been used for this purpose. While CBCT is considered reliable and reproducible, lower image resolution compared to micro-CT may hinder its capacity to detect more complex anatomical structures (21). However, in one study (22), micro-CT and CBCT were used simultaneously in mandibular premolars and a consistency of 85.2% was determined between the results when the Vertucci classification was considered. In addition, another study (23) showed that the CBCT method is as reliable as the clear tooth method, which is considered the gold standard in this regard. The current study is a retrospective study based on image analysis, and since it was not performed on extracted teeth, the clearing method was not used in the evaluation. For these reasons, CBCT, which provides a high reliability rate, was used as the evaluation method in the current study.

There are various classifications regarding root canal anatomy. Vertucci classification is the most valid of these, and it classifies the anatomy of the root canals into eight groups (24). This classification was used in the current study. According to the findings of the current study, 59% of the patients examined had Vertucci Type I configuration. The second most common configuration was Vertucci Type V. Similarly, in a study examining the morphology of lower premolar teeth in the Spanish population in 2014 (25), the most common configuration was Vertucci Type I, while the second most common configuration was Vertucci Type V. Similarly, in a retrospective CBCT study in the Saudi population (11), the most common root canal configuration in mandibular first premolars was Type I. The second most common configuration was Type II. In another study conducted in a selected German population (26), morphology varied to varying degrees, with the most common morphology being Type V (55.7%) and the second most common morphology being Type I (21.9%). Considering these results, it can be said that the two most common morphologies in mandibular first premolars in different populations are Type I and Type V.

Considering the findings of the current study, no statistically significant relationship was found between Vertucci classification and tooth localization (right-left) and age group ($p>.05$). In a study conducted in another Turkish population in 2014 (8), it was similarly stated that root canal configurations did not show any significant difference between the right and left sides ($p>.05$). Although not specific to the mandibular first premolar tooth, some studies (27,28) have mentioned that there are differences in the root canal system structure between different age groups in permanent teeth. Additionally, no statistically significant relationship was found between tooth localization and canal number, root number, branching level and branching direction. ($p>.05$)

The relationship between gender and root structure has been discussed in some studies on dental anatomy (8,29-31). In these studies, according to the results obtained from Spanish (29), Nepalese (30) and Turkish (8) populations, no statistically significant difference was shown in the number of roots in male and female teeth. However, according to the findings of the current study, a statistically significant relationship was found between the number of roots and gender. ($p<.05$) Accordingly, the number of double-rooted MFPs in males was approximately three times higher than in females. According to a study (32), the X chromosome contains genes related to root canal structure. This may explain the effect of gender on root number. A systematic review (34) also reported that single-rooted premolars were more common in females and double-rooted premolars were more common in males. These findings are consistent with the current study. In addition, according to the findings of the current study, a statistically significant relationship was found between Vertucci classes and gender. ($p<.05$) However, no significant difference was shown between the number of roots and tooth localization, and age group. ($p>.05$)

It is necessary to consider the existence of some limitations in the present study. As the current study is a retrospective study, data may not have been recorded consistently or accurately as they were not designed to be a part of the present study. Since the study was based on existing records, control over the study design may be limited. Existing records may have been recorded with different equipment and procedures, which may cause inconsistencies. The quality of images may vary depending on how the image was initially obtained. It may also be more prone to bias because it relies on historical data that may be incomplete or inaccurate. Vertucci classification in the present study defines the main root canal configuration, but this classicification ignores the accessory canals, apical deltas and isthmuses, which are important for the completion of treatment.

Although CBCT is a suitable imaging technique for clinical use and provides detailed information, there may be artifacts such as scattering, motion artifacts, and noise that can reduce image quality (35,36).

5. CONCLUSION

Clinicians should have extensive knowledge about the variations that can be seen in root canal morphology in premolar teeth. In cases where clinical and conventional methods are not sufficient, the use of CBCT will positively affect the success and prognosis of the treatment. While the most common morphology in the population is Vertucci Type 1, the frequency of two roots in mandibular first premolars in males is 3 times higher than in females.

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Design of the study: HS
Acquisition of data for the study: HS, EGB
Analysis of data for the study: HS
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