

## RESEARCH

# Root Canal Morphology of Mandibular First and Second Premolars Using Cone-Beam Computed Tomography in A Selected Turkish-Population and Literature Review

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### ABSTRACT

#### Root Canal Morphology of Mandibular First and Second Premolars Using Cone-Beam Computed Tomography in A Selected Turkish-Population and Literature Review

**Background:** To investigate the root canal anatomy (RCA) of permanent mandibular premolars using cone-beam computed tomography (CBCT) in a group of population and to review previous studies regarding other Turkish subpopulations.

**Methods:** The sample for this retrospective study included 1048 CBCT images of 672 females and 376 males representing 1613 mandibular first and 1461 second premolars. Pubmed and Google Scholar were used to search previous literature with selected keywords.

**Results:** The incidence of single root in mandibular first and second premolars was 99.75% and 99.38%, respectively. Complex RCA was evident in the first premolars compared to second premolars and in males than females ( $P < 0.05$ ). According to the results of this study, 17.82% of male patients ( $n = 67$ ) and 12.5% of female patients ( $n = 84$ ) had at least 1 mandibular premolar with 2 or more root canals ( $P < 0.05$ ). Eight studies had previously evaluated the RCA of mandibular premolars of other Turkish subpopulations by clearing or CBCT images. The prevalence of 2 or more root canals was found between 5.8-39.5% in mandibular first premolars and 1.1-29% in mandibular second premolars in these studies.

**Conclusion:** More attention should be paid to the detection of additional canals during root canal treatment of mandibular premolars, especially in male patients. The symmetrical morphology of the premolars may guide the practitioners during the root canal treatment. Evaluation methods could affect the results regarding RCA.

### KEYWORDS

Max bicuspid, Cone-beam computed tomography, Mandible, Retrospective studies

### ÖZ

#### Seçilen Bir Türk Popülasyonunda Koni-Işınlı Bilgisayarlı Tomografi Kullanılarak Mandibular Birinci Ve İkinci Premolarların Kök Kanal Morfolojisi Ve Literatür Taraması

**Amaç:** Bir grup popülasyonda konik-ışınli bilgisayarlı tomografi (KIBT) kullanarak mandibular premolarların kök kanal morfolojisini incelemek ve Türk alt popülasyonları ile ilgili önceki çalışmaları gözden geçirmektir.

**Gereç ve Yöntemler:** Bu retrospektif çalışma, 1613 alt birinci ve 1461 alt ikinci küçük azı dişine sahip 672 kadın ve 376 erkeğin toplam 1048 KIBT görüntüsünü içermektedir. Literatür taraması Pubmed ve Google Scholar veri tabanlarında seçilen anahtar kelimelerle yapılmıştır.

**Bulgular:** Alt birinci ve ikinci küçük azı dişlerinde tek kök görülme sıklığı sırasıyla %99,75 ve %99,38 idi. Karmaşık kök kanal anatomisine, alt birinci küçük azı dişlerinde de erkeklerde daha sık rastlandı ( $P < 0,05$ ). Bu çalışmanın sonuçlarına göre, erkek hastaların %17,82'si ( $n = 67$ ) ve kadın hastaların %12,5'i ( $n = 84$ ) 2 veya daha fazla kök kanallı en az 1 mandibular premolar dişe sahipti ( $P < 0,05$ ). Daha önceki 8 çalışma diğer Türk alt popülasyonlarının mandibular premolarlarının kök kanal anatomisini şeffaflaştırma veya KIBT görüntüleri ile değerlendirmiştir. Bu çalışmalarda 2 veya daha fazla kök kanalının prevalansı mandibular birinci premolarlarda %5,80-%39,50 arasında ve mandibular ikinci premolarlarda ise %1,1-%29 arasında bulunmuştur.

**Sonuç:** Özellikle erkek hastalarda mandibular premolarların kök kanal tedavisi sırasında ek kanalların tespitine daha fazla dikkat edilmelidir. Küçük azıların simetrik morfolojisi, kök kanal tedavisi sırasında hekimlere yol gösterebilir. Değerlendirme yöntemleri kök kanal anatomisi sonuçlarını etkileyebilir.

### ANAHTAR KELİMELEER

Alt çene, Koni-ışınli bilgisayarlı tomografi, Küçük azı, Retrospektif çalışmalar

The success of root canal therapy (RCT) is essential for the survival of endodontically treated teeth. There are many parameters that affect the success of the treatment, such as the patient's systemic condition, the operator's experience, the presence of preoperative persistent infection, and root canal anatomy (RCA).<sup>1,2</sup> Complex RCA can affect the quality of RCT.<sup>3</sup> According to Hoen and Pink<sup>4</sup> 42% of RCTs are due to undetected canals. Several anatomic variations have been reported for both mandibular premolars, demonstrating their susceptibility to complex RCA<sup>5</sup>, and RCT of these teeth is considered

one of the more time- and effort-intensive treatments.<sup>6,7</sup>

Different methods have been used to detect and evaluate RCA, such as 2D radiographs, clearing teeth, cone beam computed tomography (CBCT) or micro-computed tomography ( $\mu$ CT).<sup>8-12</sup> CBCT has been reported to show reliable and accurate information about RCA.<sup>8,12</sup> CBCT and  $\mu$ CT were compared to determine the RCA of mandibular first premolars, and  $\mu$ CT and CBCT were reported to have high consistency in determining RCA.<sup>12</sup> In previous studies<sup>13-21</sup> the prevalence of 2 or more root canals in mandibular first

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premolars was reported as 5.8- 39.5%, and 1.1-29% in mandibular second premolars.

Age, gender, and ethnicity have been reported to affect RCA.<sup>15,17,20,22-24</sup> In addition to these factors, evaluation methods may also affect the results of root canal configurations.<sup>8-12</sup> The aim of this study was to examine the morphology of the root and root canals of permanent mandibular first and second premolars in a patient population that applied to the University hospital between January 1- December 31, 2018 using CBCT and to review the previous studies<sup>13-21</sup> reported canal configurations of mandibular premolars in other Turkish subpopulations.

## MATERIALS AND METHODS

The retrospective study protocol was approved by the University's ethics committee (GO 19/406). CBCT images were scanned from the archives of the Oral and Maxillofacial Radiology Department. Patients who applied to the hospital for different reasons between January 1-December 31, 2018 were included in the study sample. Both sagittal and axial sections were evaluated by 2 calibrated endodontists. The inclusion criteria were as follows: presence of at least one first and/or second mandibular with fully developed roots and mature apices. Exclusion criteria were low-quality CBCT images or scans with artifacts, impacted teeth, teeth with open apices, and the presence of internal or external root resorptions. Scans were obtained using i-CAT Next Generation (International Imaging Sciences, Hatfield, PA; USA). The scan parameters were 120 kV, 5 mA and 7 s, with 0.20 mm voxel size and a 16x4 field of view (FOV). Coronal, axial, sagittal, and cross-sectional planes (1-mm slice thickness and interval) were reconstructed using i-CAT vision version 1.9.3.14 (International Imaging Sciences). The root was sliced from the cemento-enamel junction (CEJ) to the apex at 1-mm intervals along the long axis of the tooth. The cross-sectional shape of root canal was evaluated and recorded by dividing into 1-mm slices. In addition to patients' gender and age, the following parameters of mandibular premolars were recorded using CBCT scans:

- Root and root canal numbers,
- Presence of symmetrical anatomy,
- Root canal morphology according to the Vertucci's classification<sup>25</sup>,
- Number of extracted premolars in the case of 2-rooted/canalled unilateral premolar.

The data were statistically analyzed using the chi-square test via SPSS version 20 (SPSS Inc, Chicago, IL). Furthermore, previous studies<sup>13-21</sup> on the other Turkish populations were evaluated and reviewed using Pubmed and Google Scholar databases using the keywords "mandibular premolar", "Turkish", "lower premolar", "canal configuration" and "canal anatomy".

## RESULTS

CBCT images of 1048 patients (672 females, 376 males) were evaluated. There were a total of 1613 first premolars (females: 1044, males: 569) and 1461 second premolars (females: 933; males: 528). Since female patients had 1 first premolar and 3 second premolars impacted, these teeth were excluded. The number of extracted first premolar teeth was 482 (23.04%) and the number of extracted second premolars was 632 (30.30%). The ages of the patients were between 16-73 and 14-72 in females and males, respectively.

The percentage of symmetrical premolar anatomy in males was statistically higher than in females (Table 1) ( $P < 0.05$ ).

Considering the anatomy of 2 or more root canals, bilateral symmetry was observed in 5 female and 4 male patients for both premolars. One female and one male patient had symmetrical second premolars with 2 roots and 3 canals (Figure 1).

Five female and 4 male patients had 1 first premolar with 2 root canals, while the contralateral premolar was extracted. The mean age of male patients with premolars with 2 or more root canals was 38.61 years, the mean age of female patients was 34.27 years. According to the results of this study, 17.82% of male patients ( $n = 67$ ) and 12.5% of female patients ( $n = 84$ ) had at least 1 mandibular premolar with 2 or more root canals ( $P < 0.05$ ). Table 2 shows the distribution of the root canals of premolars according to gender and side.

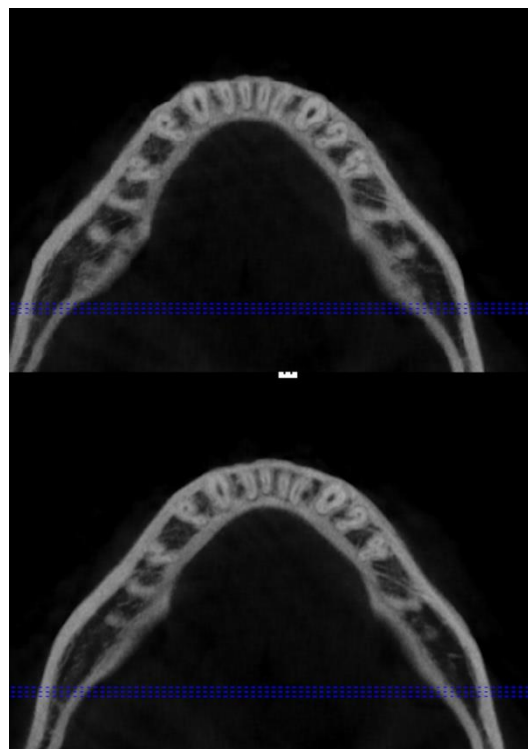
According to the database search, 9 studies were found.<sup>13-21</sup> Two of these studies<sup>15,16</sup> reported exactly the same data for mandibular premolars, so only 1 article<sup>15</sup> was included in the review, and a total of 8 studies were reviewed.<sup>13-15,17-21</sup> Only 1 study has not classified premolars as first and second<sup>13</sup>; the remaining ones made this classification.<sup>14,15,17-21</sup> Table 3 and Table 4 show the classification of root canal morphology of first and second premolars of current and previous studies<sup>13-15,17-21</sup> according to Vertucci.<sup>25</sup> In current and previous studies, type 1 configuration was the most common type for both premolars ( $P < 0.05$ ). In this study, the incidence the type V in first premolars followed the type 1 configuration (Figure 2).

Three of the previous studies evaluated the extracted premolars with clearing technique<sup>13-15</sup> and the remaining 5 evaluated CBCT images of the patients.<sup>17-21</sup> The number of root canals was distributed according to gender in 4 studies<sup>15,17,19,20</sup> and side in 3 studies<sup>17,19,20</sup> as in the current study. In 4 studies<sup>13,15,18,21</sup>, additional classifications to Vertucci were used. Radicular grooves and C-shaped root canals were also investigated in 2 studies.<sup>18,21</sup> The age of included patients was between 13-84.<sup>17-21</sup>

**Table 1.**

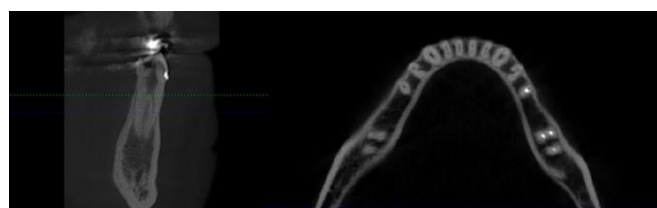
**Representative CBCT images symmetric premolar teeth with 2 and more root canals.**

Recorded Parameters	1st premolars		2nd premolars	
	FEMALE	MALE	FEMALE	MALE
Number of patients	672	376	672	376
Number of existent teeth	1044	569	933	528
Number of absent (extracted or impacted) teeth	300 (1 impacted)	183	411 (3 impacted)	224
Percentage of absent teeth	22.32%	24.34%	30.58%	29.79%
Total percentage of absent teeth	23.04%		30.30%	
Number of patients with two or more canals	78/672 (11.61%)	65/376 (17.29%)	17/672 (2.53%)	10/376 (2.66%)
1 Root and 2 root canals (number of teeth)	121	107	19	11
2 Roots and 2 root canals (number of teeth)	2	2	2	3
2 Roots and 3 root canals (number of teeth)	-	-	2	2
Total number of teeth with 2 or more root canals (percentage)	123/1044 (11.78%)	109/569 (19.16%)	23/933 (2.47%)	16/528 (3.03%)
Number of patients revealed symmetric root canal anatomy for 2 and more canals (percentage)	45/78 (57.69%)	44/65 (67.69%)	6/17 (35.29%)	5/10 (50%)
Number of patients had premolar with two and more canals while the contralateral premolar was extracted	5/78 (6.4%)	4/65 (6.15%)	2/17 (11.77%)	0 0%



**Figure 1**

Representative CBCT images symmetric premolar teeth with 2 and more root canals



**Figure 2**

Representative CBCT images of axial and sagittal sections of first premolar with a type V configuration

**Table 2.**

**Distribution of root canals of premolars according to gender and side.**

Number of Canals	Mandibular first premolar				Mandibular second premolar			
	Right		Left		Right		Left	
	Female	Male	Female	Male	Female	Male	Female	Male
1 canal	450	226	471	234	460	254	450	258
2 canals	64	59	59	50	12	5	9	9
3 canals	0	0	0	0	1	1	1	1

**Table 3.**

**The canal morphology of mandibular first premolars of current and previous Turkish subpopulations according to Vertucci's classification as number and percentage.**

Vertucci's Studies	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type VIII	Others	Total	Evaluation Method
Kartal et al. <sup>13</sup> (premolars)	135	-	8	18	11	7	2	-	6	187	Clearing Technique
	72.19%	-	4.28%	9.63%	5.88%	3.74%	1.07%	-	3.21%	100%	
Çalışkan et al. <sup>14</sup>	64.15	7.55	3.77	7.55	9.43	1.89	-	5.66	-	100	Clearing Technique
	64.15%	7.55%	3.77%	7.55%	9.43%	1.89%	-	5.66%	-	100%	
Sert et al. <sup>15,16</sup>	121	37	21	14	5	-	-	2	-	200	Clearing Technique
	60.5%	18.5%	10.5%	0.07	2.5%	-	-	0.01	-	100%	
Ok et al. <sup>17</sup>	1366	4	14	21	65	-	-	1	-	1471	CBCT
	92.86%	0.27%	0.95%	1.43%	4.42%	-	-	0.07%	-	100%	
Arslan et al. <sup>18</sup>	110	2	4	-	31	-	-	-	7	154	CBCT
	71.43%	1.30%	2.60%	-	20.13%	-	-	-	4.55%	100%	
Bulut et al. <sup>19</sup>	585	4	7	5	20	-	-	-	-	621	CBCT
	94.20%	0.64%	1.13%	0.81%	3.22%	-	-	-	-	100%	
Çelikten et al. <sup>20</sup>	453	2	18	2	31	-	-	-	-	506	CBCT
	89.53%	0.40%	3.56%	0.40%	6.13%	-	-	-	-	100%	
Kaya Büyükbayram et al. <sup>21</sup>	274	-	10	-	40	-	-	-	3	327	CBCT
	83.79%	-	3.06%	-	12.23%	-	-	-	0.92%	100%	
Current Study	1389	2	35	1	190	-	-	-	-	1617	CBCT
	85.90%	0.12%	2.16%	0.06%	11.75%	-	-	-	-	100%	

**Table 4.**

**The canal morphology of mandibular second premolars of current and previous Turkish subpopulations according to Vertucci's classification as number and percentage.**

Vertucci's Studies	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	Type VIII	Others	Total	Evaluation Method
Kartal et al. <sup>13</sup> (premolars)	135	-	8	18	11	7	2	-	6	187	Clearing Technique
	72.19%	-	4.28%	9.63%	5.88%	3.74%	1.07%	-	3.21%	100%	
Çalışkan et al. <sup>14</sup>	93.62	-	-	-	6.38	-	-	-	-	100	Clearing Technique
	93.62%	-	-	-	6.38%	-	-	-	-	100%	
Sert et al. <sup>15,16</sup>	142	14	7	18	14	3	2	-	-	200	Clearing Technique
	71%	7%	3.5%	9%	7%	1.5%	1%	-	-	100%	
Ok et al. <sup>17</sup>	1325	1	1	8	7	-	-	3	-	1345	CBCT
	98.51%	0.07%	0.07%	0.59%	0.52%	-	-	0.22%	-	100%	
Arslan et al. <sup>18</sup>	123	3	1	-	2	-	-	-	4	133	CBCT
	92.48%	2.27%	0.75%	-	1.50%	-	-	-	3.00%	100%	
Bulut et al. <sup>19</sup>	549	1	2	-	3	-	-	-	-	555	CBCT
	98.92%	0.18%	0.36%	-	0.54%	-	-	-	-	100%	
Çelikten et al. <sup>20</sup>	433	5	5	-	5	-	-	-	-	448	CBCT
	96.65%	1.12%	1.12%	-	1.12%	-	-	-	-	100%	
Kaya Büyükbayram et al. <sup>21</sup>	258	-	3	-	1	-	-	-	2	264	CBCT
	97.73%	-	1.14%	-	0.38%	-	-	-	0.76%	100%	
Current Study	1436	1	1	2	30	-	-	-	-	1470	CBCT
	97.69%	0.07%	0.07%	0.14%	2.04%	-	-	-	-	100%	

## DISCUSSION

The aim of this study was to evaluate the RCA of mandibular premolars in a Turkish subpopulation and to review previous studies<sup>13-15,17-21</sup> on this topic with different Turkish subpopulations. Since mandibular premolars have been reported to have complex RCA<sup>5</sup>, the RCA of these teeth has been widely studied. The literature review revealed that there were 8 studies<sup>13-15,17-21</sup> evaluating the RCA of mandibular premolars of different Turkish subpopulations. The number of teeth evaluated in the current study was higher than the number of teeth evaluated in the previous studies. Classification of RCA was performed according to the Vertucci classification in the present study, which is 1 of the most widely used classification systems in previous studies.<sup>13-21</sup> According to this classification, the type I configuration and incidence of 1 canal in the apex was the most common in mandibular first and second premolars in this study as in previous ones.<sup>13-21</sup> Other types such as II, III, IV and V were also detected in the present study for both premolars.

Complex RCA with extra root canals has a significant effect on the success of RCT.<sup>2,4,26,27</sup> The prevalence of the second canals could be as high as 40% for the first mandibular premolars.<sup>14</sup> Hence, the difficulties in detecting additional root canals resulted in higher failure rates.<sup>4,28</sup> Knowledge of RCA can contribute to the detection practitioners' rates of extra canals, so studies evaluating RCA can be beneficial for improving RCA knowledge.<sup>26,29</sup> There are many different studies evaluating the RCA of teeth depending on populations.<sup>17,22-24</sup> These studies reported gender, age, and ethnicity as parameters influencing the complexity of the RCA.<sup>17,22-24,30,31</sup> Furthermore, Ok et al.<sup>17</sup> reported that regional changes in the same country may also affect the RCA. Patients included in the current and reviewed studies were from different regions of Turkey. However, the percentage of root canal numbers of first and second premolars in the current study was within previously reported ranges.<sup>13-21</sup> Mean age of male and female participants were similar, so the effect of age could not be observed in present study. On the other hand, premolars with complex RCA were higher in males compared to females as

previous studies.<sup>17,20</sup> It should be considered that complex RCA might be present, especially during RCT of lower premolars of male patients.

If the presence of complex RCA is suspected, symmetry can be another guiding parameter in the final decision. In the present study, over 50% of the patients with at least 2 canals have bilateral symmetrical root canal configurations, as previously reported for Korean and Taiwanese populations.<sup>30,31</sup> Evaluation of the periapical X-ray of the contralateral tooth and taking radiographs from different angles can help decide on the root canal configuration. In addition, CBCT should be taken when the roots seem irregular in periapical X-ray films. However, besides individual differences, the evaluation method may also affect the results of root canal configurations. The results also differ according to the “gold standard” technique preferred in comparison studies.<sup>9-12</sup> CBCT, experimental  $\mu$ CT, clearing technique could be used for extra canal detection<sup>8-12</sup>, among these CBCT could be used clinically, while the remaining were used with extracted teeth. Considering 8 studies evaluating the RCA of mandibular premolars of different Turkish subpopulations, it was determined that clearing techniques<sup>13-15</sup> or CBCT<sup>17-21</sup> were preferred. However, it is important to mention that studies using clearing technique reported more complex anatomy for the first premolars<sup>13-15</sup>; while studies using CBCT reported higher percentages than 80% for type I configuration<sup>17,19-21</sup> except 1 study.<sup>18</sup> CBCT has been reported to have higher accuracy in determining C-shaped RCA and less accuracy in diagnosing lateral root canals than the clearing technique.<sup>10</sup> Furthermore, the detection of type I configuration in the cleared teeth was significantly lower than the teeth evaluated by CBCT, while the type II configuration could be detected by either method.<sup>9</sup> In the present study, CBCT images were evaluated and results were consistent with previous studies. However, it is important to note that results may also be affected by subpopulation characteristics and assessment methods.

Under the limitations of this study, it could be concluded that mandibular first premolars revealed more complex RCA than the second premolars in both genders, especially in male patients. However, extraction percentage of second premolars were higher than first premolars in both genders in this selected population. Evaluation of both sides could be helpful in detecting canal configuration before access cavity planning during the RCT.

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