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Anatomy assessment of permanent mandibular premolar teeth in a selected Iranian population using cone-beam computed tomography

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ABSTRACT

Background: Appropriate cleaning and shaping and three-dimensional obturation of the root canal system lead to a successful endodontic treatment. To achieve this, complete knowledge of the internal anatomy of root canals is necessary. Therefore, this study evaluated the number and shape of mandibular premolar roots and canals and classified their Vertucci classification using cone-beam computed tomography (CBCT) images of an Iranian sample population.

Materials and Methods: This *in vivo* study was performed on CBCT images of patients aged 20–70 years who had attended a dental radiology center in Isfahan. CBCT images were examined in coronal, sagittal, and especially axial dimensions. Descriptive statistics were calculated. Groups were compared using the Chi-square of the Statistical Package for the Social Sciences. The level of significance was predetermined as 0.05.

Results: In both first and second premolars, the most common classes were Type I followed by Type V. The Chi-square did not show significant differences between males and females in terms of Vertucci classes in the first ($P = 0.305$) or second premolar ($P = 0.315$).

Conclusion: Since a thorough knowledge of root canal anatomy is necessary for successful root canal treatment and almost one out of ten mandibular premolars has additional canal in their root canal system, accurate evaluating of preoperative radiographs, taking CBCT images if necessary, and probing the root canal system with fine and precurved files should be done to negotiate the entire canal system.

Key Words: Bicuspid, cone-beam computed tomography, root canal therapy

INTRODUCTION

Appropriate cleaning and shaping and three-dimensional (3D) obturation of the root canal system lead to a successful endodontic treatment. To achieve this, complete knowledge of the internal anatomy of root canals is necessary.[1-3] Anatomical variations cause difficulties in the process of proper debridement of root canals. Mandibular incisors, premolars, and second molar are reported among teeth with the highest incidence of root canal variation. For instance, the incidence of the second canal in mandibular incisors was reported 27.5% by Vertucci,[4] 15% by Miyashita,[5] and 26.2% by Al-Qudah and Awawdeh.[6] The incidence of canal variation in mandibular premolars was reported

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16.5% by Liao *et al*.,[7] 12.9% by Yu *et al*.,[8] and <8% by Ok *et al*.[9] Mandibular first molar is typically reported as a two-rooted tooth in ≥85% of cases,[10] whereas mandibular second molar shows a wider range of anatomic variation. The incidence of C-type mandibular second molar was reported 43.3% by Chen *et al*.,[11] and it is reported as the most common teeth with C-type canal configuration.[12]

Ethnic background can affect root canal anatomy; therefore, documenting the incidence of root canal variation seems necessary. There are plenty of studies conducted on the Iranian population to report anatomical classification of root canals,[2,3,13,14] but their results are somehow controversial and their report is not comprehensive. Many of these studies used conventional radiograph that is less accurate than 3D imaging[15] or clearing and staining technique that requires tooth extraction and is not applicable in the clinic.

Therefore, this study evaluated the number and shape of mandibular premolar roots and canals and classified their Vertucci classification using cone-beam computed tomography (CBCT) images of an Iranian sample population.

MATERIALS AND METHODS

This *in vivo* study was performed on CBCT images of patients aged 20–70 years who had attended a dental radiology center in Isfahan. All CBCTs had been retrospectively taken solely for clinical purposes. No X-ray was emitted to patients for this study. All CBCTs had been taken with the same unit (Soredex, Tuusula, Finland), with a similar field of view (8 cm × 5 cm), focal size (0.3 mm), current (10 mA), peak kilovoltage (90 kVp), and time (0.4 s). Inclusion criteria were availability of at least three premolar teeth for each patient, and full patient information was obtained. Exclusion criteria were teeth with previous root canal treatment, resorption, open apex, agenesis, and dental fractures. A total of 213 patients with full arch mandibular CBCT scans were included.

All measurements were done by two observers (an oral radiologist and an endodontic resident), using an OnDemand3D software program (Cybermed Inc., Korea Rep.). CBCT images were examined in coronal, sagittal, and especially axial dimensions [Figure 1]. The radiographic measurements were repeated 1 week later for the evaluation of inter- and intraobserver reliability.

Evaluated parameters were the number of roots, number of canals in each root and in each tooth, and shapes of canals according to the Vertucci classification and its modifications [Figure 2].[16] Vertucci[5] classified root canal configurations of human permanent teeth into eight types: Type I – a single canal extends from the pulp chamber to the apex. Type II – two separate canals leave the pulp chamber and join short of the apex to form one canal. Type III – one canal leaves the pulp chamber, divides into two within the root, and then merges to exit as one canal. Type IV – two separate and distinct canals extend from the pulp chamber to the apex. Type V – one canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina. Type VI – two separate canals leave the pulp chamber, merge into the body of the root, and redivide short of the apex to exit as two

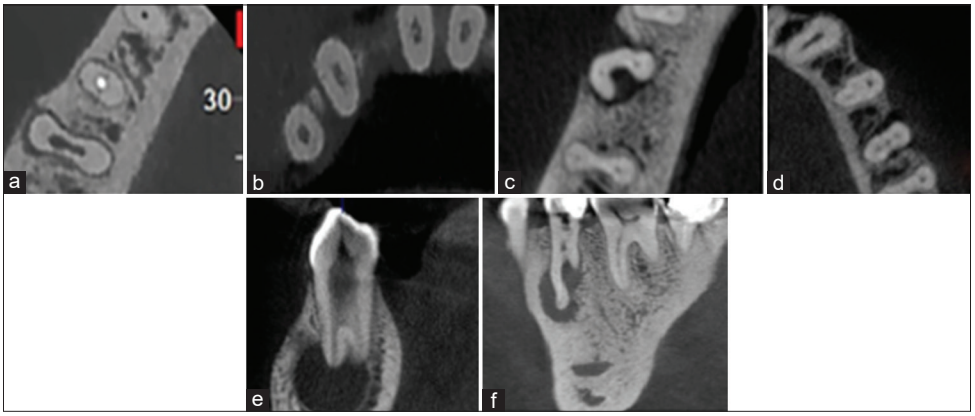

Figure 1: CBCT images in axial view (a) mandibular first premolar with one canal, (b) mandibular premolar with one large canal, (c) mandibular premolar with two root canals and cortical bone destruction due to periapical lesion, (d) mandibular premolars with three root canals, (e) coronal view of a mandibular second premolar with periapical lesion, (f) sagittal view of a mandibular second premolar with periapical lesion.

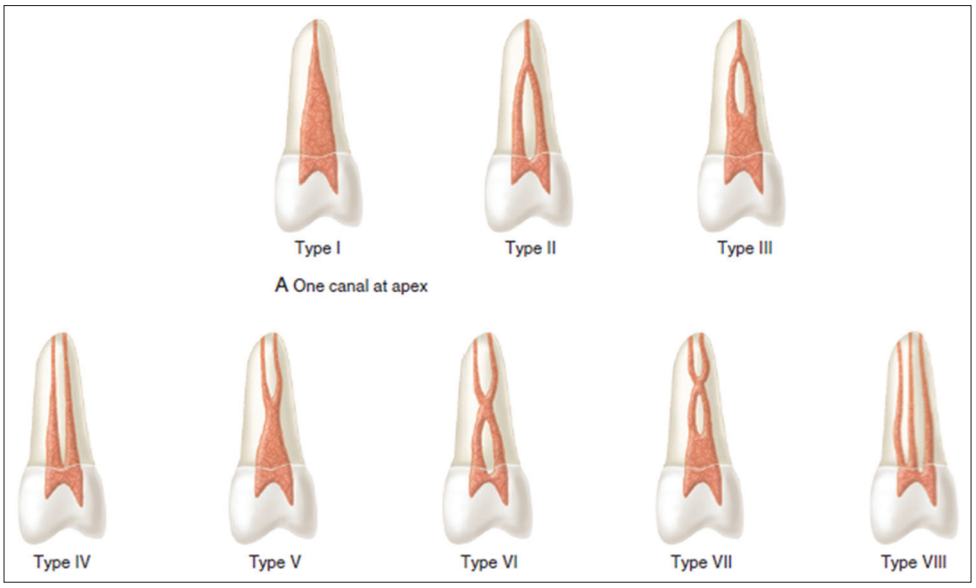

Figure 2: Vertucci classification.[16]

distinct canals. Type VII – one canal leaves the pulp chamber, divides and then rejoins within the body of the root, and finally, redivides into two distinct canals short of the apex. Type VIII – three separate and distinct canals extend from the pulp chamber to the apex.[17]

The radiographic measurements were made in the axial and coronal sections by two observers. Descriptive statistics were calculated. Groups were compared using the Chi-square of the Statistical Package for the Social Sciences (SPSS, version 24.0, SPSS, Chicago, IL, USA). The level of significance was predetermined as 0.05.

RESULTS

The statistical analysis showed high inter- and intraobserver reliability ($\kappa = 0.987$) ($P \leq 0.05$) [Table 1].

There were two cases of disagreement between observers; in these two particular cases, readings from the maxillofacial radiologist were selected as the correct result.

Of 213 enrolled patients, 106 were male and 107 were female. Patients' average age was 32.6 ± 13.23 years. Of these patients, 153 (71.84%) were aged between 20 and 49 years, whereas 60 (28.16%) were aged between 50 and 70 years.

Among 773 assessed teeth, 389 (50.32%) were first premolar and 384 (49.68%) were second premolar.

Table 1: Interobserver reliability test result

Symmetric measures				
Measurements	**Value**	**Asymptotic standard error**	**Approximate *T***	**Approximate significance**
Measure of agreement (κ)	0.987	0.009	30.598	0.000
Number of valid cases	773			

Number of roots and canals

Table 2 summarizes the number of roots and canals in each tooth. 88.69%, 10.54%, and 0.77% of first premolars had one, two, and three roots, respectively. 88.8%, 9.11%, and 2.09% of second premolars had one, two, and three roots, respectively [Table 2]. There were no significant differences between males and females in terms of the number of roots in first ($P = 0.175$) and second premolars ($P = 0.195$).

Vertucci classification

Table 3 presents Vertucci classes and Vertucci modifications. In both first and second premolars, the most common classes were Type I followed by Type V. The Chi-square did not show significant differences between males and females in terms of Vertucci classes in the first ($P = 0.305$) or second premolar ($P = 0.315$).

DISCUSSION

The findings of the current study showed that 88.69% of mandibular first premolars had one root and

81.49% of them had one root canal. Our findings were almost similar to other studies conducted in Iran. Khedmat *et al*.[18] reported that 88.5% of mandibular first premolars had a single root canal. Sobhani *et al*.[19] reported that 87.3% of these teeth had one root canal, whereas Rahimi *et al*.[20] stated that 70.6% of mandibular first premolars had one canal. In studies conducted in India and India[21,22] and Spain[23] the prevalence of single canal mandibular first premolar was reported 88.4%, 80.8%, and 83.3%, respectively. Table 4 summarizes some studies analyzing mandibular first premolar roots, and Table 5 summarizes studies analyzing mandibular first premolar root canals. The most common canal configuration in the first premolars in our study was Vertucci Type I which was similar to other studies conducted in Iran and the rest of the world.[18-23,26,25,29,30,32-34]

Data on mandibular second premolar are less than the first premolar. Our study showed that 88.80% of mandibular second premolars had one root canal and 83.6% of them had a single root canal.

Our findings were not consistent with Rahimi *et al*. findings[20] since they reported all of their second premolar samples had a single root and 80.5% of them had a single canal. Iyer *et al*.[28] in a study conducted in Syria reported that 97% of second premolars had one root and the rest of them had two roots. Singh and Pawar[23] reported that 92% of second premolars had one root and 8% showed two roots. Table 4 summarizes some studies analyzing mandibular second premolar roots, and Table 5 summarizes studies analyzing mandibular second premolar root canals. The most common canal configuration in the second premolars in our study was Vertucci Type I, which was similar to other studies conducted in Iran and the rest of the world.[20,24-26]

The findings of the current study on the number of two- and three-rooted second premolars were inconsistent with other studies, which may be a result of different sample sizes and racial differences.

Table 2: Distribution (%) of number in roots of mandibular first and second premolars

Number of roots	Tooth class		
	1	2	3
First premolar, *n* (%)	345 (88.69)	41 (10.54)	3 (0.77)
Second premolar, *n* (%)	341 (88.80)	35 (9.11)	8 (2.09)

CONCLUSION

Since a thorough knowledge of root canal anatomy is necessary for successful root canal treatment and

Table 3: Distribution of canal types according to Vertucci Classes (I-VIII) and its modification (IX) in mandibular first and second premolars

Tooth type	I	II	III	IV	V	VI	VII	IX
First premolar, *n* (%)	317 (81.49)	24 (6.17)	4 (1.02)	2 (0.51)	34 (8.74)	3 (0.79)	2 (0.51)	3 (0.77)
Second premolar, *n* (%)	321 (83.6)	17 (4.42)	3 (0.79)	1 (0.26)	30 (7.8)	4 (1.04)	0	8 (2.09)

Table 4: Percentage for number of roots in mandibular premolars

Reference	Examined tooth	Method	Population	Number of roots			
				1	2	3	4
Geider *et al*.[24]	First premolar	Sectioning and radiography	France	90.6	6.4	2.4	0.6
Peiris[25]	First premolar	Clearing	Sri Lanka	98.8	1.2	0	0
Rahimi *et al*.[20]	First premolar	Clearing	Iran	98	2	0	0
Llena *et al*.[22]	First premolar	Radiography	Spain	100	0	0	0
Jain and Bahuguna[21]	First premolar	Clearing	India	97.11	2.89	0	0
Singh and Pawar[23]	First premolar	Clearing	India	94	6	0	0
Cleghorn *et al*.[27]	First premolar	Review article	Worldwide	97.9	1.8	0.2	0.1
Iyer *et al*.[28]	First premolar	Radiography	India	95.9	3.9	0.2	0
Geider *et al*.[24]	Second premolar	Sectioning and radiography	France	97.6	0.4	-	-
Zillich and Dowson[26]	Second premolar	Radiography	USA	96.6	-	0.4	-
Rahimi *et al*.[20]	Second premolar	Clearing	Iran	100	0	0	-
Singh and Pawar[23]	Second premolar	Clearing	India	92	8	0	-
Cleghorn *et al*.[27]	Second premolar	Review article	Worldwide	99.6	0.3	0.1	-
Current study	First premolar	Radiography	Iran	88.69	10.54	0.77	-
Current study	Second premolar	Radiography	Iran	88.80	9.11	2.09	-

Table 5: Percentage for number of canals in mandibular premolars

Reference	Examined tooth	Method	Population	Number of root canals	
				1	>1
Pineda and Kuttler[29]	First premolar	Radiography	Mexico	69.3	30.7
Khedmat *et al*.[18]	First premolar	Radiography	Iran	88.47	11.53
Rahimi *et al*.[20]	First premolar	Clearing	Iran	70.6	29.4
Llena *et al*.[22]	First premolar	Radiography	Spain	83.3	16.7
Jain and Bahuguna[21]	First premolar	Clearing	India	88.4	11.6
Singh and Pawar[23]	First premolar	Clearing	India	76	24
Huang *et al*.[30]	First premolar	Radiography	Taiwan	65.7	34.3
Zillich and Dowson[26]	First premolar	Radiography	USA	75.1	24.9
Sabala *et al*.[31]	First premolar	Reviewing records	USA	81.1	18.2
Yoshioka *et al*.[32]	First premolar	Clearing	Japan	80.6	19.4
Lu *et al*.[33]	First premolar	Radiography and sectioning	China	54	46
Peiris[25]	First premolar	Clearing	Sri Lanka	95.1	4.9
Alhadainy[34]	First premolar	Clearing	Egypt	80.8	19.2
Cleghorn *et al*.[27]	First premolar	Review article	Worldwide	75.8	24.2
Rahimi *et al*.[20]	Second premolar	Clearing	Iran	80.5	19.5
Pineda and Kuttler[29]	Second premolar	Radiography	Mexico	98.8	1.2
Singh and Pawar[23]	Second premolar	Clearing	India	76	24
Zillich and Dowson[26]	Second premolar	Radiography	USA	87.5	12.5
Zaatar *et al*.[35]	Second premolar	Radiography	Kuwait	95.3	4.7
Cleghorn *et al*.[27]	Second premolar	Review article	Worldwide	90.1	9.9
Current study	First premolar	Radiography	Iran	81.49	18.51
Current study	Second premolar	Radiography	Iran	83.6	16.4

almost one out of ten mandibular premolars has additional canal in their root canal system, accurate evaluating of preoperative radiographs, taking CBCT images if periapical radiograph demonstrates atypical anatomy, and probing the root canal system with fine and precurved files should be done to negotiate the entire canal system.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or nonfinancial in this article.

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