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Original Research

Symmetry in root canal number and morphology between contralateral premolars and molars using cone-beam-computed-tomography

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Aim: This study aimed to evaluate the symmetry of root canal number and morphology between opposite premolars and molars in each jaw using Cone-Beam Computed Tomography. **Methods:** 100 CBCT images of patients aged 18-65 were analyzed for diagnostic or therapeutic purposes. 96 premolars and mandibular molars, as well as 98 premolars and maxillary molars, were examined separately by two endo- and radiologists. Parameters such as canal numbers and root numbers in each root, and shape, and morphology of the canals were evaluated using NNT software. The symmetry of similar teeth in each jaw was also determined. **Results:** This study found that most mandibular premolars have one root and one canal with a type I Vertucci, while there are two roots and three canals in mandibular molars. Mostly, there is one root, two canals, and a type IV canal in maxillary premolars, while maxillary molars have three roots and three or four canals. The jaws have symmetry in terms of canal type, root numbers, and canal numbers. The mandible has greater symmetry than the maxilla in all cases. **Conclusion:** Assessing the symmetry of the canal numbers and premolars and molars morphology on both sides of each jaw using CBCT showed a significant correlation on both sides particularly between the first and second premolars and second molars, which can help dentists in comprehending root canal treatments and enhancing outcomes.

Keywords: Bicuspid. Molar. Dental pulp cavity. Cone-beam computed tomography.

Introduction

Dentists should know the root canal morphology[1,2] to obtain successful root canal treatment (RCT) and reduce the number of RCT failures that can be caused by events like missing canals or endodontic procedural error[3]. In addition, it helps in timely referral to an endodontist[4]. Since genetic factors affect on variability of the number of roots and the configuration of the root canals, It is important to study the different root canal morphology in different races[5-8]. There are various methods to evaluate root canal morphology such as clearing, decalcification, sectioning, and radiographs. However, the first three methods can only be used on extracted teeth[9-11]. The method utilized in this study was the cone-beam computed tomography (CBCT) system because of its advantages, such as being a non-invasive technique, providing 3D visualization unlike 2D radiography, having high resolution, having lower radiation exposure and cost than CT[12,13]. There were studies about root and canal morphology of posterior teeth in various population. Most of the maxillary first premolars possess a pair of canals, although one canal is more common in Asia. In addition, they may have one, two, or three roots, with two roots being the most common type[14]. The maxillary second premolars may have one, two, or three roots and canals, and they can have two or three canals in one root[14]. The maxillary first molar is one of the most complex teeth. It commonly has three roots and four canals but additional canals can also be found. The maxillary second molar can be like the maxillary first molar in terms of canals and roots, but the prevalence of MB2 is less than in the first molar. It commonly has three canals and three roots and its roots may be fused[14,15]. Mandibular first premolars may have one, two, or three toots and canals but commonly have one root and one canal. Mandibular second premolars may have one, two, three roots and one, two, three, or four canals but commonly have one root and canal[14,15]. The mandibular first molars may have two or three roots and up to six canals in mesial and distal roots, but commonly there are two roots and three canals[14,15]. The mandibular second molars may have one or two roots and one, two, three, or four canals. Commonly it has two roots and three canals. If it has one canal, the form of the access cavity is oval in the center of the occlusal surface[14,15]. However, due to the lack of studies on the symmetry of posterior teeth canal morphology and number, particularly in the Iranian population, the present study's aim was to evaluate the root canal number and morphology symmetry between opposite premolars and morals in each jaw by means of CBCT.

Materials and Methods

The ethical committee of Qazvin University of Medical Sciences has granted approval for this study with the ethical number of IR.QUMS.REC.1400.008. It was a descriptive analytical study conducted on CBCT scans obtained from the oral and maxillofacial radiology clinic in Qazvin city, Iran. For every category of tooth, the sample size was determined to be 100 (α=0.05, p=0.95, d=0.043). The samples consisted of 96 pairs of mandibular premolars, 96 pairs of mandibular molars, 98 pairs of maxillary premolars,and 98 pairs of maxillary molars with ages ranging from 18-65. The

teeth chosen for the study were fully developed and free from any signs of apical radiolucency or internal and external root resorption. Exclusion criteria for the study included teeth with extensive coronal restoration or prosthetic crowns, as well as those that had undergone endodontic treatment. CBCT images were obtained using a NewTom VG (QR srl, Verona, Italy) and assessed in the axial, coronal, and sagittal planes by using the NNT program (version 5.3.0.0; Image Works, Elmsford, NY, USA) to determine the number of canals of root and roots of each tooth, as well as the morphology of canals as seen in Figure 1[14,16].

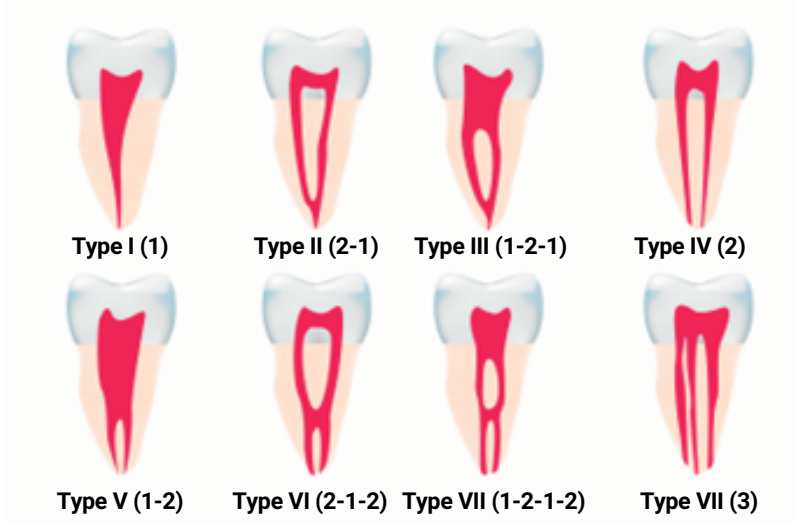

Figure 1. Classification of Vertucci of root canal systems.

Afterward, the symmetry of similar teeth in terms of the above items was determined in each jaw. The evaluation of all CBCT images and assessing the number of roots and canal configurations for each tooth was conducted by two endodontists and With the presence of a consultant oral-maxillofacial radiologist. Any discrepancies in opinion were discussed with the help of a radiologist as a third person to reach a similar opinion. Calibration was repeated at two separate time points during the study, with intervals of two weeks between each, as noted in various studies[17] (Figures 2, 3, and 4).

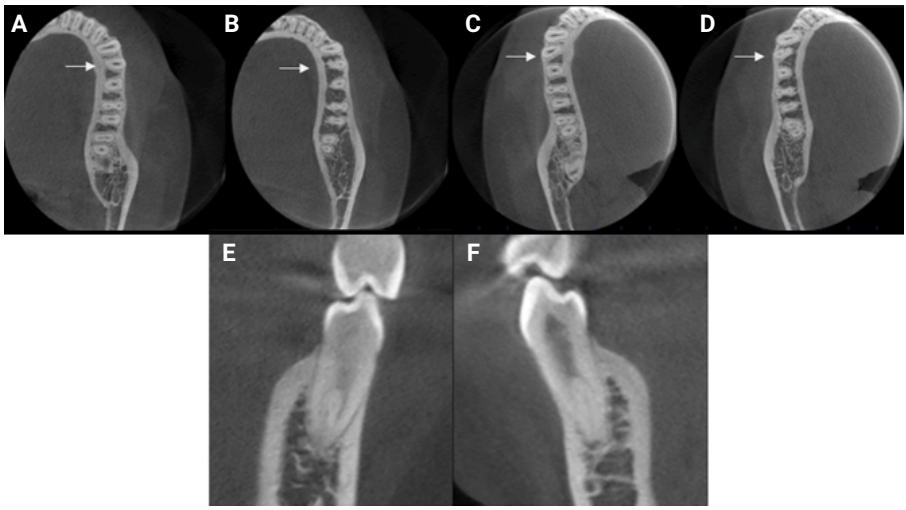

Figure 2. Maxillary premolars. A, B: The first and second left premolars with two roots and two canals. C, D: The first and second right premolars with two roots and two canals. E, F: Coronal view of the first and second left premolars. G, H: Coronal view of the first and second right premolars.

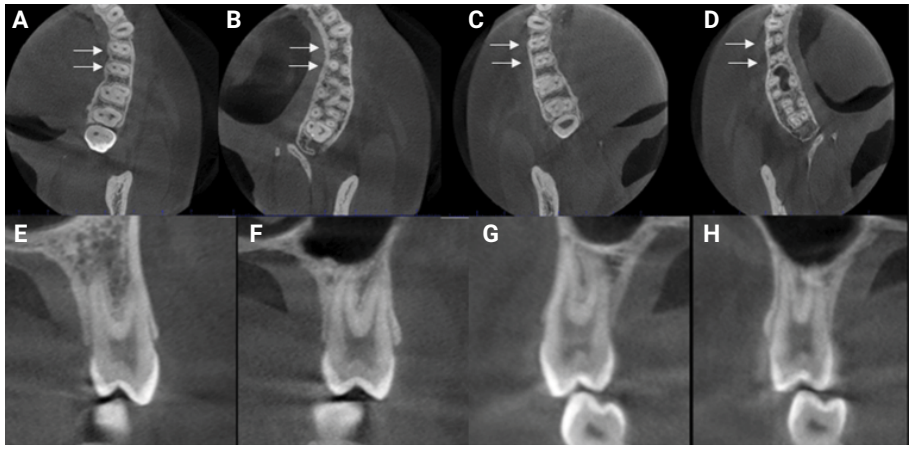

Figure 3. Mandibular premolar. A, B: The first left premolar with one root and type V canals (arrow). C, D: the first right premolar with one root and type V canals (arrow). E: Coronal view of the first left premolar. F: Coronal view of the first right premolar.

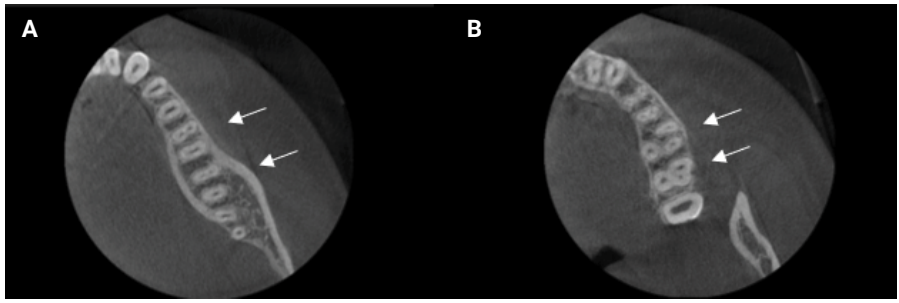

Figure 4. Mandibular and maxillary molars. A: Axial view of the first and second left mandibular molar with two roots and three canals. B: Axial view of the first left maxillary molar with three roots and four canals and the second left maxillary molar with three roots and three canals.

Statistical data analysis

Version 20 of SPSS (SPSS Inc.,IL, USA) was used for analyzing the data. The chi-square, one-way ANOVA, and independent t-test were applied. A less than 0.05 P-value was considered significant for all tests.

Results

Maxillary first premolars

Out of the 196 first premolars, one root (58.7%) had the highest frequency followed by two roots (40.3%) and three roots (1%). In addition, two canals were predominant with 82.7% followed by one canal (15.8%), three canals (1%), and four canals (0.5%). According to the root canal configuration, in one-rooted first premolars, type I of Vertucci, type IV, type II, Type V, and type III were 27.2%, 25.4%, 17.5%, 16.7%, and 13.2%, respectively. In the buccal root, 98.7% and 1.3% were type I and type IV, respectively. The configuration of the mesiobuccal, distobuccal, and palatal canal was type I of Vertucci in all teeth.

Maxillary second premolars

Among the 196 second premolars, 88.8% had one root and the rest had two roots. In addition, 59.7% and 40.3% had one canal and two canals, respectively. In one-rooted teeth, type I (66.7%) was predominant, followed by type III, type II, Type V, type IV, and type VI with percentages of 11.5%, 9.8%, 6.9%, 4.6%, and 0.6%, respectively. All buccal and palatal roots had Vertucci type I configuration.

Maxillary first molars

Among the 196 first molars, three roots (95.9%) had the highest frequency, followed by two roots (3.1%) and one root (1%). Additionally, four canals (57.7%) and three canals (38.8%) had the highest frequency. In one-rooted teeth, type I and type III were equally prevalent at 50%. In two-rooted teeth, the buccal root had a prevalence of 83.3% for type I and 16.7% for type II. In three-rooted teeth, the mesiobuccal root had a prevalence of 38.3% for type I, 32.4% for type II and 22.3% for type IV. Type I was included as the configuration of the distobuccal and palatal roots in all teeth.

Maxillary second molars

Among the 196 second molars, three roots (80.1%) had the highest frequency followed by one root (10.27%) and two roots (9.7%). Three canals were predominant with 59.7%, followed by four canals (24.5%), two canals (10.2%) and one canal (5.6%). In one-rooted second morals, 55% was for type I, 20% was for type VIII, 10% for type V and VI, and 5% was for type III. In the buccal root, 78.9% was for type I, and 21.1% was for type II. Type I with 72% and type IV with 15.9% were the most numbers in the mesiobuccal root. The distobuccal and palatal roots had type I in all teeth.

Mandibular first premolars

Among the 192 first premolars, 98.4% had one root, while the remaining 1.6% had two roots. In addition, one canal was predominant in 78.6% of the teeth, and two canals were present in 21.4%. Among the teeth with one root, 79.9% had type I configuration, 17.7% had type V, 1.6% had type III, and 1.1% had type II. Type I was included as the configuration of the buccal and palatal roots.

Mandibular second premolars

Among the 192 second premolars, all of them had one root. 96.9% had one canal, while 3.1% had two canals. Additionally, 96.9% had type I, 1% had type III, and 2.1% had type V.

Mandibular first molars

Among the 192 first molars, two roots had the most significant percentage of 98.4, followed by three roots (1.6%). The highest frequency of canals was three canals at 72.9%, followed by four canals at 22.9%, and two canals at 4.3%. Type IV and type II were for mesial canals at 49.5% and 43.8%, respectively, however, type I at 77.1%, followed by type II at 7.8% appeared for the distal canals.

Mandibular second molars

Among the 192 mandibular second molars, 96.4% had two roots and 3.6% had one root. The highest frequency of canals was three canals at 75.5%, followed by two canals at 17.2%. In one-rooted teeth, all of them were type I. In the mesial canal, type II was predominant with 46.5%, while type IV, type I, type V, and type III were 29.7%, 17.8%, 3.2%, and 2.7%, respectively.

Correlation between canal number, root number, and canal type, with sex

As shown in Table 1, teeth with one canal were higher in females than males, unlike two, three, and four canals.

Table 1. Correlation between canal number, root number, and canal type with sex

Number of canals	Gender		Number of roots	Gender		Type of canal	Gender	
	Male	Female		Male	Female		Male	Female
1	225 (29%)	280 (36.1%)	1	336 (43.3%)	363 (46.8%)	I	224 (66.7%)	280 (76.9%)
2	190 (24.5%)	164 (21.1%)	2	256 (33%)	247 (31.8%)	II	20 (6%)	19 (5.2%)
3	249 (32.1%)	231 (29.8%)	3	184 (23.7%)	166 (21.4%)	III	24 (7.1%)	19 (5.2%)
4	112 (14.4%)	101 (13%)				IV	22 (6.5%)	15 (4.1%)
						V	43 (12.8%)	27 (7.4%)
						VI	3 (0.9%)	0

	VII	0	0
	VIII	0	4 (1.1%)

Also, one root was higher in females than two and three roots. The highest canal configuration in both males and females was type I and then type V.

As shown in Table 2, Type I was the most prevalent configuration in buccal and distal roots.

Table 2. Correlation between type of canal in each root with sex

Tooth canal type	Buccal root		Mesiobuccal root		Distobuccal		Palatal root		Mesial root		Distal root	
	Gender		Gender		Gender		Gender		Gender		Gender	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
I	65 (97%)	58 (93.5%)	96 (52.2%)	91 (55.8%)	184 (100%)	163 (100%)	250 (100%)	225 (100%)	14 (7.4%)	27 (14.4%)	166 (87.8%)	160 (85.1%)
II	2 (3%)	3 (4.8%)	38 (20.7%)	36 (22.1%)					77 (40.7%)	93 (49.5%)	6 (3.2%)	13 (6.9%)
III	0	0	2 (1.1%)	2 (1.2%)					1 (0.5%)	7 (3.7%)	9 (4.8%)	4 (2.1%)
IV	0	1 (1.6%)	39 (21.2%)	28 (17.2%)					91 (48.1%)	59 (31.4%)	2 (1.1%)	8 (4.3%)
V	0	0	7 (3.8%)	6 (3.7%)					6 (3.2%)	2 (1.1%)	6 (3.2%)	3 (1.6%)
VI	0	0	2 (1.1%)	0					0	0	0	0
VII	0	0	0	0					0	0	0	0
VIII	0	0	0	0					0	0	0	0

All distobuccal and palatal roots were Type I. The most frequent type of Vertucci in the mesiobuccal roots was Type I in males and Type IV in females. In mesial roots, more males had Type IV and more females had Type II.

Symmetry of roots and canals number and canal type in bilateral posterior teeth

Table 3 shows the symmetry of the root number, canal number, and canal type in bilateral premolars.

Table 3. The symmetry of the root number, canal number, and canal type in bilateral premolars

Tooth type	Symmetry	Root number		Canal number		Canal type	
		Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla
	Yes	93 (96.9%)	91 (92.9%)	90 (93.7%)	90 (91.8%)	87 (90.6%)	79 (80.6%)

First premolar	No	3 (3.1%)	7 (7.1%)		6 (6.3%)	8 (8.2%)		9 (9.4%)	19 (19.4%)
	P=0.33			P=0.53			P=0.047		
	Yes	96 (100%)	92 (93.9%)		94 (97.9%)	85 (86.7%)		94 (97.9%)	74 (75.5%)
Second premolar	No	0	6 (6.1%)		2 (2.1%)	13 (13.3%)		2 (2.1%)	24 (24.5%)
	P=0.014			P=0.005			P=0.00		

For the first premolars, an important correlation between the number of roots and canals on both sides (P>0.05) was not found. However, there was a significant association in terms of canal type (P<0.05) on both sides, with a higher occurrence in mandibular teeth. For second premolars, there was a significant association between the root number, canals, and canal type on both sides, with a higher occurrence in mandibular teeth.

Table 4 shows the symmetry of the root number, canal number, and canal type in bilateral molars.

Table 4. The symmetry of the root number, canal number, and canal type in bilateral molars

Tooth type	Symmetry	Roots number		Canals number		Canals type	
		Mandible	Maxilla	Mandible	Maxilla	Mandible	Maxilla
First molar	Yes	96 (100%)	96 (98%)	75 (78.9%)	86 (87.8%)	66 (68.8%)	74 (75.5%)
	No	0	2 (2%)	20 (21.1%)	12 (12.2%)	30 (31.3%)	24 (24.5%)
	P=0.15		P=0.10		P=0.29		
	Yes	95 (99%)	89 (90.8%)	80 (83.3%)	72 (73.5%)	68 (70.8%)	68 (69.4%)
Second molar	No	1 (1%)	9 (9.2%)	16 (16.7%)	26 (26.5%)	28 (29.2%)	30 (30.6%)
	P=0.01		P=0.09		P=0.82		

In the first molars, there was no significant relation among roots number, canal number, and type of canal on both sides (P>0.05). In second molars, the number of roots had a significant relation on both sides (P<0.05), with a higher number in the mandible than in the maxilla. However, there was no significant association between the canal number and the type of canal on both sides (P>0.05).

Discussion

Evaluation of the root number, canal number, and canal morphology is important in endodontic treatment. Additionally, studying the symmetry of the jaws can improve the prognosis of our treatment by increasing the accuracy of our guesswork regarding

teeth anatomy. In this study, CBCT scans were used, because of their ability to evaluate the anatomy of teeth without the need for tooth extraction.

Mandibular premolars

In the first and second premolars, the highest amount of root and canal number was one, which had Vertucci's type I. These findings aligned with previous studies conducted by Alghamdi et al.[17] in Saudi, Martins et al.[18] in Caucasio, Jahromi et al.[19] in Esfahan, Hasheminia et al.[20] in Iran, Razian et al.[21] in Mazandaran, and Baybars et al.[22] in Turkey. In contrast, Burklein et al.[23] in Germany reported that type V was the most prevalent configuration found in both first and second premolars.

Mandibular molars

The most frequently observed configuration in the first and second molars study was two and three roots and canals, respectively. Mesial roots of the first molars and second molars mostly had type IV and II configurations, respectively. Meanwhile, most of the distal roots had type I. These results were similar to those of other studies[6,24-26] regarding the first molar. However, Martins et al.[18] in Caucasian, like Jamshidi et al.[27] in Iran, reported that type II was the most common configuration in mesial roots. Other studies confirmed the prevalence of the roots and canals' number in second molars[24,26,27,28]. However, the most observed canal configuration in mesial roots, according to Demirbuga et al.[24] in Turkish and Celikten et al.[26] in Cypriot and in distal canals, was type IV and type I, respectively. In contrast, Martin et al and Jamshidi et al reported that type II was the most occurred configuration in mesial root canals and that distal root canals were type I, which aligns with the present results[18,27].

Maxillary premolars

In the study of first premolars, the highest incidence of the roots' number was one, and the canals' number was two, which commonly had type IV. These findings were consistent with the study conducted by Asheghi et al. in Iran[29]. The number of canals and canal morphology were also in agreement with the studies of Martins et al.[18], Burklein et al.[23], and Mashyakhy et al.[28] in the Saudi population. In contrast, they found that two roots had the maximum prevalence. Baybars et al.[22] concluded that most maxillary premolars had two roots, all of which had type I, while in single-rooted type IV was the most common.

In the study of second premolars, one root and canal were the most common. The canal configuration was mostly type I. These results were similar to Martins et al.[18], Baybars et al.[22], and Asheghi et al.[29] findings. Mashyakhy et al.[28] reported that second premolars mostly had one root and two canals with type I morphology.

Maxillary molars

In the study of first molars, the configuration with three roots and four canals had the highest frequency, while for second molars, three roots and three canals were most common. these findings were similar to the results of other studies[18,30-32]. In the canal morphology study, the mesiobuccal, distobuccal, and palatal roots mostly had type

I, which was aligned with Ratanajirasut et. al's study[33] in Thailand and Rouhani et al in Iran[34]. In contrast, Allawi et al.[32] reported in the Syrian subpopulation the distobuccal and palatal roots predominantly exhibited type I canal configuration, whereas the most frequent configuration in the mesiobuccal root was type II. Also, Martins et al.[18] reported that in first molars, type II, type I, and type I were mostly found in the mesiobuccal, distobuccal, and palatal roots, respectively. However, all of the second molars' roots mostly had type I, as we reported in our study.

In general, it can be concluded that there was a lot of similarity between the studies about the morphology of molar and premolar teeth in the mandible and maxilla. Some differences observed between these studies can be attributed to race, sample size, study protocols, and techniques used to identify canal configuration.

Symmetry of premolar teeth

In the first premolars, there was no significant correlation between root number and canal number on both sides. However, there was a significant association in terms of canal type on both sides, with 80.6% in the maxilla and 90.6% in the mandible, which was higher in mandibular teeth. In the second premolars, there were significant associations in root number, canal number, and canal type on both sides, which were aligned with Alghamdi et al.'s study[17] in Saudi. Also, the similaritywas greater in mandibular teeth. Li et al.[35] in China reported anatomical symmetry between the maxillary premolars of both sides, which was higher in the second premolars. The symmetry of root and canal numbers was 80.2% and 81.8% between bilateral premolars, respectively. Bilateral symmetry in both the number and morphology of roots and canals was 72.3% and 73.2% in the first and second premolars, respectively[35]. The degree of symmetry of the present study was higher than these teeth. The reason for the discrepancy may be due to the existence of different ethnicities and races in China, resulting in several morphologies in that country.

Symmetry of molar teeth

Table 4 shows that, there was no significant relation between the root and canal number, and the type of canal on both sides of the first molars. However, in the second molars, the root number had a significant relation on both sides, with a greater number in the mandible than in the maxilla. Plotino et al.[36] carried out a study among a white population in Italy and concluded that, in terms of root and root canal morphology, the first molars in both jaws had more asymmetry than the second molars. Maxillary first molars were 71.1% symmetrical, while maxillary second molars were 79.6% symmetrical. Mandibular first molars were 70.6% symmetrical, and mandibular second molars had 81% symmetry[36]. Allawi et al.[32] in the Syrian subpopulation reported the number of roots unlike canals' number and canals' type were 100% symmetrical. The amount of symmetry found in these studies was different from the current research, which could be due to differences among races.

Felsypremila et al.[37] in India found that the percentage of symmetry for maxillary first and second premolars was the same. The mandibular second premolars exhibited more symmetry than the first premolars, as shown in our study. The first molar showed more symmetry than the second molars in maxillary as well as mandib-

ular jaws, as shown in our studies[37]. M. Sroczyk-Jaszczyńska et al.[38] in a Polish population investigated root symmetry and morphology of root canal in mandibular anterior teeth. They concluded that there was an important compatibility between the left and right sides[38]. Hafezi et al. found a significant symmetry between the right and left mandibular third molars, which helps clinicians treat one side by observing the contralateral third molar[39]. Kayaoglu et al.[40] in Turkey reported that 45%, 29%, and 28% of crucial incisors, lateral incisors, and canines had symmetry in terms of root and canal symmetry. The lower symmetry in that study could be because of different teeth and races than in our study. Knowing about the prevalence of symmetry helps to look for canals more precisely in the access cavity, and by seeing the number of canals on the opposite side, we can consider the possibility of the same number of canals and roots on the other side. However, we should always consider less common anatomies. Further studies about symmetry in Iran and other countries with larger sample sizes are required to compare with the obtained results.

In conclusion, one root, one canal, and type I were the most prevalence in the root numbers, canal numbers, and morphology of canals in the first mandibular premolars, respectively. while, In the second mandibular premolars, it was one root, one canal, and type I. In the first mandibular molars, there were two roots and three canals. In the second mandibular molars, it was two roots and three canals. In the first maxillary premolars, it was one root, two canals, and type IV. In the second maxillary premolars, it was one root, one canal, and type I. In the first maxillary molars, it was three roots and four canals. The second maxillary molars, had three roots and three canals. In the study of symmetry, there was a significant relationship in terms of the type of canal in the first premolars and the root number, canal number, and canal type in the second premolars and the root number in the second molars. Symmetry was higher in the mandible than in the maxilla for all of the above items.

Conflict of Interest

The authors have no conflict of interest to disclose.

Data Availability

Datasets related to this article will be available upon request to the corresponding author.

Author Contribution

Mohsen Naderi: analyzed the data and performed statistical analyses. MN, SS, MM, and MI drafted the initial manuscript. **Razieh Salehi:** designed the study; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript. **Mamak Adel:** designed the study; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript. **Sahar Shafagh:** analyzed the data and per-

formed statistical analyses. MN, SS, MM, and MI drafted the initial manuscript; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript. **Maryam Tofangchiha:** designed the study; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript. **Maryam Isazadeh:** designed the study. **Monirsadat Mirzadeh:** analyzed the data and performed statistical analyses. MN, SS, MM, and MI drafted the initial manuscript; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript. **Francesco Pagnoni:** analyzed the data and performed statistical analyses. MN, SS, MM, and MI drafted the initial manuscript; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript. **Rodolfo Reda:** analyzed the data and performed statistical analyses. MN, SS, MM, and MI drafted the initial manuscript; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript**. Luca Testarelli:** analyzed the data and performed statistical analyses. MN, SS, MM, and MI drafted the initial manuscript; critically edited and revised the initial draft of the manuscript, reviewed the drafted manuscript for critical content and approved the final version of the manuscript. All authors participated in the manuscript's findings, revised, and approved the final version of the manuscript.

Data availability

Datasets related to this article will be available upon request to the corresponding author.

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