Original Article

Evaluation of Root Canal Morphology of Maxillary Single Root Premolars with Two Canals using Cone Beam Computed Tomography in an Iranian Population

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Abstract

Introduction: There are many anatomical maxillary premolars variants, which differ in different races. The lack of information on such variants adds to the failure of endodontic treatment. This aim of this study is to evaluate anatomy and morphology of such variants using cone-beam computed tomography (CBCT), and to evaluate dentin thickness of the buccal and lingual canals of maxillary single rooted premolars with two canals. **Methods**: In this in-vitro study fifty single rooted maxillary premolars with two canals were collected from medical centers in Mashhad, Iran. The number of canals was assessed using periapical radiography. CBCT was utilized to scan teeth and were evaluated within the axial section for the position of root canals with respect to outer root surfaces and canal variants based on Vertucci's classification in apical, intermediate, and coronal sections. **Result:** The smallest dentin thickness was 0.40 and 0.83 ± 0.25 mm for the apical third in mesial and distal direction, respectively. Also, the largest result was 3.10 mm for the coronal third buccal direction. The largest relative frequency of Vertucci class types was found to be type IV, while the smallest relative frequency was derived to be type III. The results revealed that seventeen cases had isthmus. **Conclusion**: Because of the thin dentin related to the mesial aspect, it is required to utilize low-taper files. It is not recommended to make use of orifice shapers.

Keywords: Anatomy, Cone-Beam Computed Tomography, Bicuspid.

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Introduction

It is important to understand the root canal system anatomy and different morphological variants throughout endodontic treatment (1-3). Hence, clinicians need to completely realize root canal anatomy so that they can have proper treatment methods and standards to improve success rate(4).

In endodontic treatment, anatomical root canal variants are very important. Remaining necrotic tissue and microorganisms in a possible missed canal that has not been treated could cause apical pathosis (5-6).

Different classifications have been introduced to describe root canal systems of human permanent teeth, e.g., the classifications of Vertucci[1] and Weine(7). We used Vertucci classification which is one of the most common classifications. The research has shown that premolar teeth root canal treatment could get very complicated due to anatomical variants in number of roots and and root canal configuration type (3,8-11).

Maxillary first premolar is considered one of the most difficult endodontic treatments due to various factors. Among them we can find roots and canals count, longitudinal root depressions, different configurations of the pulp cavity, and limited visualization on periapical radiographs (12). Furthermore, studies have shown the significant root canal morphology variations of the maxillary second premolar (1,13-15). Different in-vivo and in-vitro methods have been utilized to investigate root canal anatomy. The in-vivo techniques include clinical evaluation during root canal treatment, retrospective assessment of patient records, conventional radiographic evaluation, and more advanced radiographic techniques such as cone-beam computed radiography (CBCT) (16-18), while the in-vitro methods include root canal staining and tooth clearing[1,18] , root sectioning[6], microscopic examination, conventional radiographic examination, and using three-dimensional modalities such as microcomputed tomography (μ-CT) (19-23).

CBCT has the same accuracy level as that of root canal staining and root canal clearing methods in root canal morphology detection. Eventhough root canal staining and root canal clearing used to be believed to outperform conventional methods adopted in evaluation of root canal system due to the capability of presenting 3D views and detailed morphologic information (5).

Since a small number of studies were conducted on maxillary premolars, particularly those with single root and two canals, the present study primarily aims to assess dentin thickness around root canals by means of nondestructive CBCT technology to avoid possible future root canal treatment errors.

Materials and Methods

Total of fifty single rooted maxillary firt premolars with two canals that were verified radiographically were selected. Teeth that had fracture, root resorption, prosthetic abutment, and open apex were excluded from the study. The samples underwent a day of immersion in 5.25% sodium hypochlorite to remove periodontal tissues on the root surface and then were washed with filtered water (24). Later, superficial massaging skeletons were utilized for removal in order to avoid the thickening of cement and dentin (25). Next, in order to avoid CBCT image scatters, amalgam fillings were removed from teeth that had restorations.

For CBCT tooth preparation, teeth were mounted on sponge arch in ten groups. Teeth were all subjected to CBCT evaluation by using a ProMax 3D MAX device manufactured by Finnish Planmeca OY Company with a resolution of 160 μm and a view field of $5 \times 8 \times 8$ cm^3.

The Planmeca Romexis Software Pack was utilized to analyze the images. Then, a radiologist and an endodontist reviewed images on the sagittal, coronal, and axial planes (26). In each sample, minimum distance between the outer root surface and root canal walls in four directions (buccal, palatal, mesial and lingual) were measured. Also, the relationship of the root canals with each other and with the outer root surface in the apical, middle, and coronal sections of the root within the axial view was evaluated (Figure 1, 2) Root anatomical variants, intercostal canals, isthmus, at-risk dentin thickness, and canal segmentation were reported based on Vertucci's classification. Fisher's exact test was employed to analyze data in SPSS v.22. Statistical Significance was set at $P \leq 0.05$. Table I provides the statistical indexes of the regions and directions.

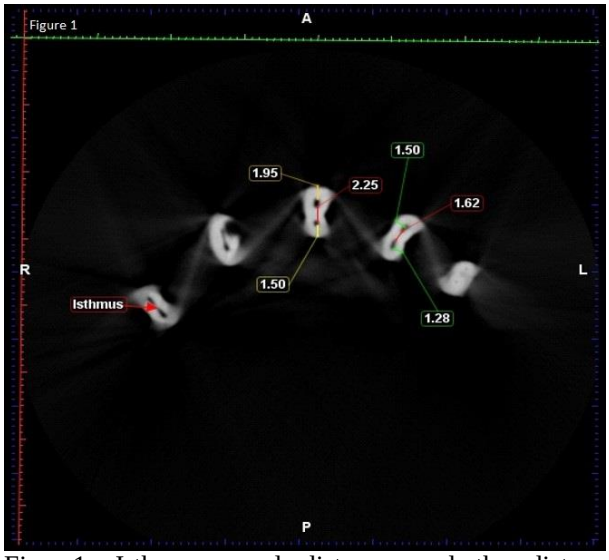

Figure1: Isthmus, canal distance, and the distance between the outer root surface and root canals in the axial CBCT view

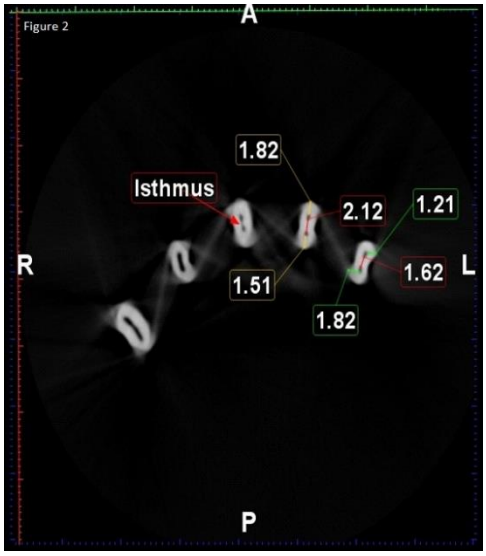

Figure 2: Isthmus, canal distance, and the distance between the outer root surface and root canals in the axial CBCT view

Table I: Statistical indexes of the regions, directions and canal distances.

Region	Direction&canal distances	No.	Mean(mm)	Standard Deviation	Minimum(mm)	Maximum(mm)	Median (mm)
Coronal	Buccal	50	2.17	0.45	1.35	3.10	2.00
	Palatal	50	2.14	0.38	1.20	3.02	2.09
	Mesial	50	2.14	0.34	0.90	2.40	1.72
	Distal	50	1.69	0.34	1.02	2.43	1.72
	canal distances	50	1.59	0.70	0.00	2.70	1.73
Middle	Buccal	50	1.79	0.39	1.06	2.70	1.69
	Palatal	50	1.70	0.32	0.95	2.65	1.64
	Mesial	50	1.24	0.33	0.35	1.93	1.20
	Distal	50	1.27	0.31	0.70	1.93	1.20
	canal distances	50	1.27	0.67	0.00	3.10	1.30
Apical	Buccal	50	1.22	0.36	0.76	2.10	1.09
	Palatal	50	1.21	0.29	0.80	2.00	1.09
	Mesial	50	0.84	0.27	0.40	1.42	0.79
	Distal	50	0.83	0.25	0.45	1.54	0.80
	canal distances	50	0.64	0.62	0.00	1.90	0.60

Results

The present laboratory work studied fifty maxillary premolar teeth with single root and two canals

evaluating root canal morphology and canal variants on the basis of Vertucci's classification in axial direction. The minimum distance between outer root surface and root canal walls in four directions within the apical, intermediate, and coronal sections are reported in Table I. The smallest value in apical region was obtained to be 0.40 mm in the mesial direction. In the same region, the smallest Mean and standard deviation was found to be 0.83 ± 0.25 in the distal direction. The largest value in the coronal region was 3.10 mm in the buccal direction, and the greatest Mean and standard deviation was 2.17 ± 0.45 in the buccal direction. As can be seen, the distance values were larger in the coronal region than in the apical and middle regions within the entire directions. Also, distances were greater in the middle region than in the apical region. Table I represents statistical indexes of canal distances. Also, Figure 3 summarizes Tables I.

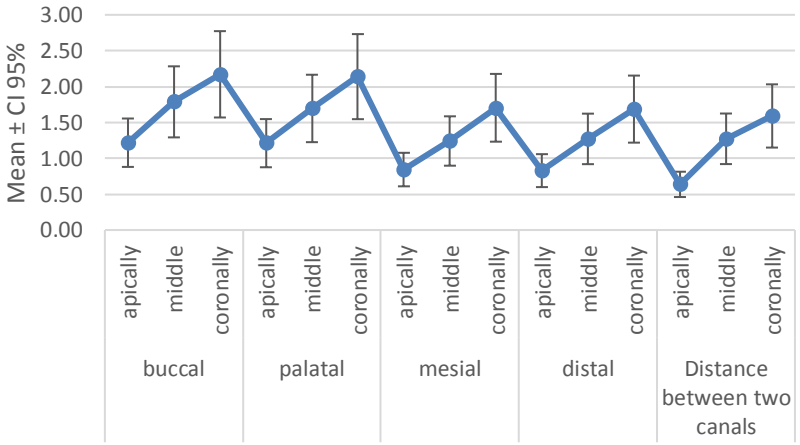

Figure 3: Average results of the regions and directions at a confidence level of 95%

Vertucci's classification types

Figure 4 illustrates relative frequencies of Vertucci's classification types. As can be seen, the largest and smallest relative frequencies were obtained to be 48% (24 cases) and 2% (1 case) for types 4 and 3, respectively.

Vertucci's classification type versus isthmus existence

The isthmus count and percentage within various root regions are reported for each Vertucci classification type in Table II. As can be seen, isthmus existed in seventeen cases. Vertucci's classification types 2 and 4 had seven items, while Vertucci's classification type 6 had three items with the isthmus. Among the seven isthmus cases of Vertucci's classification type 2, 28.6% (2 cases), 57.1% (4 cases), and 14.3% (1 case) were in the middle third, apical third, and both apical and middle third regions, respectively. Among the seven isthmus cases of Vertucci's classification type 4, 71.4% (**5** cases), 14.3% (1 case), and 14.3% (1 case) were found to be in the middle third, apical third, both middle and apical third regions, respectively. Among the three isthmus cases of Vertucci's classification type 6, 66.7% (2 cases), 33.3% (1 case), and 0.0% (no case) were identified to be in the middle third, apical third, and apical and middle third regions, respectively. Isthmus in various regions was found to have no statistically significant relationships with Vertucci's classification type (P = 0.190).

Figure 1, 2 showes Isthmus, canal distance, and the distance between the outer root surface and root canals in the axial CBCT view.

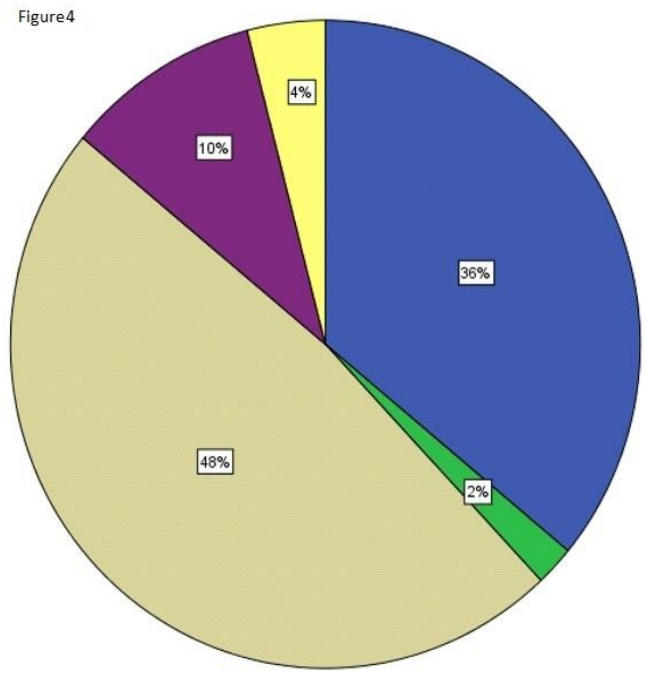

Figure 4: Percentage of Vertucci classification types

Discussion

It is essential to clearly realize the roots anatomy and the canal morphology of tooth for effective biomechanical cleaning and shaping to obtain endodontic results of predictability. Nonetheless, the canal morphology variants of roots bring clinical challenges that could result in undesirable endodontic treatment (26, 27). This study evaluated maxillary premolars of a group of Iranian individuals with one root and two canals and incorporated most of Vertucci's canal classification with differences from and similarities to earlier works conducted on various populations.

CBCT has been reported to be a prominent instrument to detect root canal anatomy at higher accuracy as compared to intraoral periapical radiography since it is capable of 3D root canal morphology evaluation (5, 28-32).

Concerning canal configuration, the most frequently identified Vertucci's classification types were IV, II, V, VI, and III, in descending order. Compared to earlier works in the literature (33), the highest configuration type frequencies were detected to be 48%, 36%, 10%, 14%, and 2% for types IV, II, V, VI, and III, respectively.

Abella F et al. (34) recently conducted a CBCT study on a Spanish population and reported that, concerning the maxillary first premolar, teeth mostly had a canal configuration of type IV. This is in agreement with the present study.

Saber et al. (35) used CBCT to conduct a root and canal morphology assessment of maxillary premolars for an Egyptian population. The canal configuration type IV was found to be the most frequent type in both the first and second maxillary premolars. This is in agreement with the present study.

As can be seen, consistent results were obtained in Iran, Egypt, and Spain. Thus, one can say that the most common canal configuration type is Vertucci's configuration type IV in the maxillary premolars.

Isthmus incidence in the present work was found to be 34%, which was mostly detected in the middle third region. Canal isthmus used to be commonly overlooked. In addition, its preparation was significantly difficult when located. Today, CBCT allows for resected root surface visualization and isthmus detection. It can be prepared using ultrasonic tips and filled with proper materials. Isthmus detection and treatment could diminish the rate of failure in endodontic treatment.

To obtain more reliable and extensive insights, more studies should be conducted on various races.The thinnest areas (0.5–1.0 mm) were always located towards the mesial aspect of the root specially in the apical third (Table I), with the lowest thickness values (0.35 mm) observed in the middle third of mesial aspect. These findings can be explained by the presence of a developmental concavity in the mesial walls of maxillary premolars. This information is important clinically as troughing has been suggested as a standardized protocol to access and prepare isthmus and in some situations, 34% in this study, the isthmus is located deeply in the middle third region. Therefore, because of the thin dentin layer on the mesial aspect, it is required to exploit low-taper files. Also, it is not recommended to employ Orifice Shapers. Furthermore, a smaller canal distance can be concluded to lead to a higher isthmus probability.

In the present study, patients' age was unknown. It could be a contributing factor for root and root canal

anatomy because the size of the canal decreases following dentin apposition on the canal walls with aging (36). According to Lim & Stock (1987), dentin thickness values less than 0.3 mm would endanger the integrity of roots, compromising their mechanical resistance. Additionally, it has been reported that resistance to fracture is closely related to the amount of residual tooth structure in cervical, that is the dentin near the alveolar crest extending 4 mm apical to the crestal bone (37, 38). Further studies are required to determine precisely what would be the critical dentin thickness values that might jeopardize the integrity of root structure in cases of excessive mechanical preparation or deep troughing procedures.

Besides, additional research testing different canal configurations in a large number of specimens would provide more comprehensive data about this topic.

Table II: Relationship of isthmus existence with the Vertucci's classification type

Isthmus			Total			
Middle Third	Apical Third	Middle and Apical Third				
2	4	1	7	Number	II	
28.6%	57.1%	14.3%	100.0%	Percentage		
5	1	1	7	Number	IV	Vertucci's type
71.4%	14.3%	14.3%	100.0%	Percentage		
2	1	0	3	Number	VI	
66.7%	33.3%	0.0%	100.0%	Percentage		
9	6	2	17	Number	Total	
52.9%	35.3%	11.8%	100.0%	Percentage		
P=0.190				Tau Bi Kendall test result		

Conclusion

Concerning the canal configuration, in Vertucci's classification, the most frequent canal configuration type was found to be type IV. The results of this study suggest the preoperative evaluation of root dentin thickness especially at the mesial side of the root prior to mechanical preparation is necessary to avoid over instrumentation or perforations. It is required to utilize low-taper files. It is not recommended to make use of orifice shapers.

Conflict of intrest

The authors have no conflict of interest related to this study.

Acknowledgments

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