ORIGINAL RESEARCH

Anatomical Evaluation of Maxillary Premolars in a Saudi Population: An *In-vivo* Cone-beam Computed Tomography Study

Mohammed Mashyakhy

Abstract

Aim and objectives: Evaluation of the root canal morphology of maxillary premolars was the primary objective of this study, on the criteria of the roots present, canals detected in the roots, and anatomical canal patterns according to Vertucci's classification observed in the Saudi population using cone-beam computed tomography (CBCT) radiographic analysis comparing them to previous reports in the same population.

Materials and methods: A total of 710 maxillary 1st and 2nd premolars were considered in this research; of which 351 were 1st premolars and 359 were 2nd premolars. These premolars were investigated for their external and internal anatomy using CBCT. Teeth with apical closure and complete root development were included in the study. Endodontically treated teeth, teeth with calcified canals or resorbed roots, as well as unclear teeth on CBCT images were excluded.

Results: Among the 351 maxillary 1st premolars, 40.7% of teeth had 1 root, 57.5% had 2 roots, and 1.7% had 3 roots. Around 93.2% of teeth had 2 canals, 3.7% had 1 canal, 2.6% had 3 canals, and 0.4% had 4 canals. According to Vertucci's classification, 63.8% of teeth had class IV configuration, 14.8% had class V configuration, 7.7% had class III configuration, and 6.8% had class II configuration. Likewise, among the maxillary second premolars, 88% of teeth had 1 root and 12% of teeth had 2 roots. Around 38.2% of teeth had a single canal while 61.0% of teeth had 2 canals, and 3 teeth were found with the extra canal (had 3 canals). More than one-third (38.2%) of teeth had Vertucci type I, 19.2% had Vertucci type IV, 15.3% had Vertucci type III, and 12.3% had Vertucci type V.

Conclusion: Maxillary first premolars had a higher prevalence of 2 roots, whereas one root was predominant in second premolars. Most of the maxillary premolars had 2 canals with the majority having Vertucci type IV in the first premolars and type I in the second premolars.

Clinical significance: Maxillary premolars present with external and internal anatomical variations, so clinician should be aware about these varieties by taking small field of view CBCT when needed which will be of great value.

Keywords: Anatomy, Cone-beam computed tomography, Maxillary premolars, Root canal morphology, Saudi population.

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Introduction

An adequate understanding of the anatomy of the pulp chamber, root canals present within the root, the canal configuration is of prime importance for the successful outcome of endodontic therapy.[1] The motto of endodontic therapy is decontamination, a comprehensive biomechanical preparation, and accomplishing a three-dimensional hermetic seal of the root canal system (RCS).[2] A dearth of knowledge and conception of the anatomy of the tooth can cause improper cleaning and shaping and obturation of the RCS resulting in failure of the treatment. According to Ingle and Bakland, 58.66% of letdowns of endodontic therapy can be credited to obturation of the root canal space.[3] In addition, an incidence of 42% of missed canals has been reported in teeth that were re-treated by Hoen and Pink.[4] Pre-treatment analysis of the RCS is of prime importance before beginning the root canal treatment to avoid such problems. Intra oral periapical radiographs (IOPAR) provide an inadequate view of the root canals, and the clinician attempts to apprehend, visualize a three-dimensional (3D) object using a two-dimensional (2D) imaging modality, which is a drawback. Cone-beam computed tomography (CBCT) with new image analysis and reconstruction advancements have been introduced all the more as of late that provides a 3D image to the clinician for routine preoperative endodontic and surgical treatment planning and as post-operative evaluation. It is a helpful diagnostic tool in endodontic treatment where IOPARs and clinical assessment cannot give adequate data concerning the tooth and the encompassing structures. The blend of sagittal, coronal, and axial views takes out the superimposition of anatomic structures and provides a better view of external root morphology, the number of root canals presents inside them, and their subdivisions in three dimensions.[5] Root canal anatomy can have noticeable racial effects, therefore necessitating the understanding of the root canal morphologies in the general public from various ethnic backgrounds.[6] A search for reviews on maxillary premolars anatomy of the Saudi Arabian population showed few studies,[7–12] as shown in Table 1, two of which are *in-vivo* CBCT studies.[7,8] One retrospective clinical study on both maxillary premolars utilizing conventional IOPAR,[9] and the rest were *in-vitro* studies on maxillary first premolars (one utilizing CBCT and the other using clearance technique).[10,11] While only one *in-vitro*

Department of Restorative Dental Sciences, College of Dentistry, Jazan University, Jazan, Saudi Arabia

Corresponding Author: Mohammed Mashyakhy, Department of Restorative Dental Sciences, College of Dentistry, Jazan University, Jazan, Saudi Arabia, Phone: +966 557224154, e-mail: dr.mashyakhy@gmail.com

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Table 1: Previous studies in Saudi population

Tooth type	Study	No. of teeth	Methods	No. of roots (%)			No. of canals (%)[!]			Vertucci types (%)							
				1	*2*	*3*	*1*	*2*	*3*	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*
1st premolars	Alqedairi et al.[7]	334	*In-vivo* CBCT	23.7	75.1	1.2	NA			10.8	8.4	1.8	69.1	3.9	2.1	0.3	2.1
	Elkady and Allouba[8]	120	*In-vivo* CBCT	28.3	71.7	0				5	5	10	70	6.7	0	3.3	0
	Al-Nazhan et al.[9]	463	*In-vivo* digital PA radiography and magnifying loupe	NA			3.7	93.9	2.4	NA							
	Maghfuri et al.[10]	100	*In-vitro* CBCT	36	61	3	0	97	3	0	7	0	75	13	2	0	3
	Atieh[11]*	246	*In-vitro* clearing	17.9	80.9	1.2	8.9	89.9	1.2	NA							
	Current study	351	*In-vivo* CBCT	40.7	57.5	1.7	3.7	93.2	2.6	3.7	6.8	7.7	63.8	14.8	0.3	0	0
2nd premolars	Alqedairi et al.[7]	318	*In-vivo* CBCT	85.2	14.5	0.3	NA			49.4	25.8	5	11.6	5.7	1.6	0	0.9
	Elkady and Allouba[8]	110	*In-vivo* CBCT	76.4	23.6	0				36.3	10.9	12.7	23.6	10.9	0	5.4	0
	Al-Nazhan et al.[9]	431	*In-vivo* digital PA radiography and magnifying loupe	NA			39.7	59.4	0.9	NA							
	Elnour et al.[12]	100	*In-vitro* micro CT	67	30	3	30	65	5	17	7	9	23	23	0	20	
	Current study	359	*In-vivo* CBCT	88	12	0	38.2	61	0.8	38.2	10.9	15.3	19.2	12.3	1.1	2.2	0

*Weine classification; [!]11 additional types of canal configurations

microcomputed tomography (micro CT) study evaluated maxillary second premolars.[12] These studies are inconsistent regarding the variables, where some of them did not assess the number of roots and others did not mention the number of canals, in addition to the small sample size and different methodologies.

Thus, this study aimed to assess the anatomy of maxillary premolars and differences by sides using *in-vivo* CBCT in a Saudi population to support and compare to the previous reports in the same population and other international studies utilized the same methodology.

Materials and Methods

A total of 710 maxillary first and second premolars (351—first and 359—second premolars) were evaluated in this study. Teeth were screened from CBCT radiographs of 208 subjects (48% males and 52% females) with ages ranging from 17 to 59 years (mean = 28.74 ± 9.56 years). CBCT images were collected from the database of Jazan University, Jazan city, Sothern region of Saudi Arabia from 2016 to 2017. The study was approved by the Institute Ethical Committee (Ref#: CODJU-1920F; Date: May 03, 2019). Teeth, to be included, should have fully developed roots and closed apices. Endodontically treated teeth, teeth with calcified canals or resorbed roots, as well as unclear teeth on CBCT images were excluded. 3D Accuitomo 170 (MORITA, Japan) CBCT machine was used in this study with the following scanning parameters: 90 kV, 5–8 mA, 17.5 s exposure time, and 0.25 mm voxel size. Morita's i-Dixel 3D imaging software was used for processing and reconstruction of the CBCT images. Three sections (serial axial, coronal, and sagittal) were acquired to evaluate the external and internal morphology of the maxillary premolars. The following parameters were evaluated: number of roots, number of canals, and canal configurations (Fig. 1) according to Vertucci's classification.[13] Differences between the right and left sides were also considered.

Statistical Analysis

The collected data were coded and analyzed using the statistical software program for Windows (SPSS V25; IBM, Chicago, IL, USA). The results were expressed as frequencies and percentages. A Chi-square (contingency coefficient) test was used to determine the differences between both sides (right and left). A *p*-value of less than 0.05 was considered significant for all tests. For reliability, one observer evaluated 40% of the total sample twice with an interval period of 3 weeks. Results of Cohen's Kappa test revealed an excellent agreement between observations with a value of 89.6%.

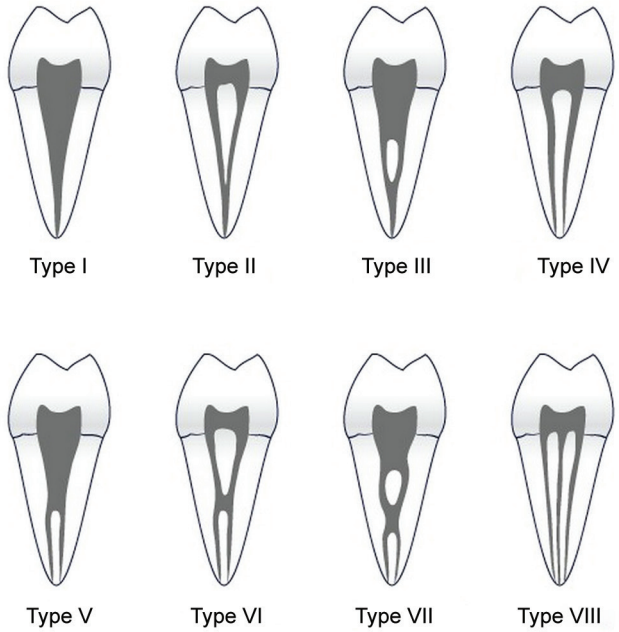

Fig. 1: Representation of Vertucci's root canal system classification

Results

Maxillary First Premolars

Among all 351 maxillary first premolars investigated, there were 143 (40.7%) teeth that had one root, 202 (57.5%) teeth had 2 roots,

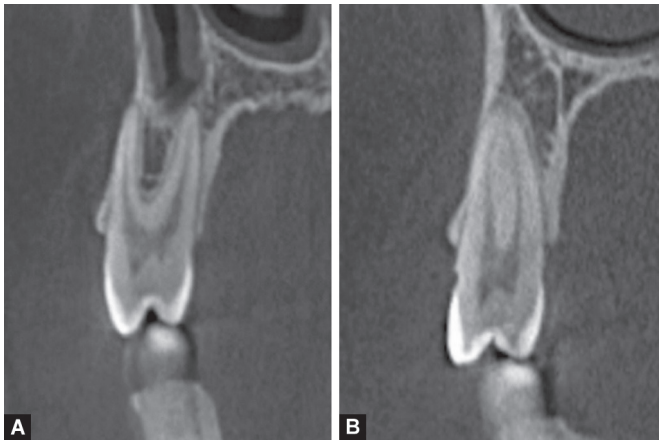

Fig. 2: CBCT sagittal slides of maxillary first premolars showing; (A) 2-rooted 1st premolar with 2 canals and Vertucci type IV, (b) first premolar with 1 root and 2 canals, and type II Vertucci

Table 2: Frequency of number of roots, number of canals, and Vertucci type among maxillary first premolars

	Frequency	*Percent*
Number of roots (*N* = 351)		
1 root	143	40.7
2 roots	202*†	57.5
3 roots	6‡	1.7
Number of canals (*N* = 351)		
1 canal	13	3.7
2 canals	327	93.2
3 canals	9*	2.6
4 canals	2†‡	0.6
Vertucci types (*N* = 351)		
Type I	13	3.7
Type II	24	6.8
Type III	27	7.7
Type IV	224	63.8
Type V	52	14.8
Type VI	1	0.3
Other	10*	2.8

*3 teeth had 2 roots, 3 canals; †1 tooth had 2 roots and 4 canals; ‡1 tooth had 3 roots and 4 canals

and 6 (1.7%) teeth had 3 roots. Regarding the number of canals, the majority of teeth (93.2%) had 2 canals, 3.7% had one canal, 2.6% had 3 canals, and only 0.6% (2 teeth) had 4 canals (Fig. 2). Different Vertucci types were observed in the maxillary first premolars. About two-thirds (63.8%) of teeth had Vertucci type IV, 14.8% had Vertucci type V, 7.7% had Vertucci type III, and 6.8% had Vertucci type II. Other different types of canal configuration were found in 2.8% of teeth (Table 2).

As shown in Table 3, no significant difference ($p = 0.919$) in the distribution of the number of roots between both right and left sides. Teeth with 1 root were found more on the right side (41.8% on the right side compared to 39.7% on the left side). However, teeth with 2 roots were found more on the left side. Similarly, no significant difference ($p = 0.620$) between both sides regarding the number of canals. Teeth with 1 canal and 2 canals were found more on the left side. However, only 1 tooth was found on the right side with 4 canals. Regarding Vertucci types, teeth with Vertucci types II, IV, and V were found more on the left side. Only one tooth on the right side was found with Vertucci type VI. No significant differences between both sides were found ($p = 0.931$).

Table 3: Comparison between right and left sides among maxillary first premolars

	Right n(%)	*Left n(%)*	*p*
Number of roots			
1 root	74 (41.8)	69 (39.7)	0.919
2 roots	100 (56.5)	102 (58.6)	
3 roots	3 (1.7)	3 (1.7)	
Total	177 (50.4)	174 (49.6)	
Number of canals			
1 canal	8 (4.5)	5 (2.9)	0.620
2 canals	164 (92.7)	164 (94.3)	
3 canals	4 (2.3)	5 (2.9)	
4 canals	1 (0.6)	0 (0.0)	
Total	177 (50.4)	174 (49.6)	
Vertucci types			
Type I	8 (4.5)	5 (2.9)	0.931
Type II	11 (6.2)	13 (7.5)	
Type III	14 (7.9)	13 (7.5)	
Type IV	112 (63.3)	112 (64.4)	
Type V	26 (14.7)	26 (14.9)	
Type VI	1 (0.6)	0 (0.0)	
Other	5 (2.8)	5 (2.9)	
Total	177 (50.4)	174 (49.6)	

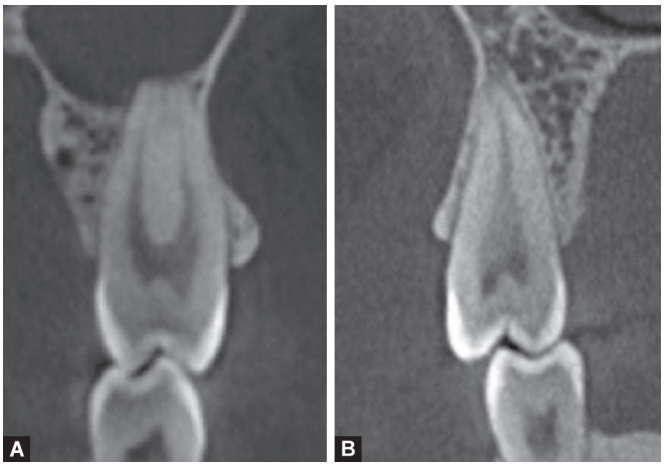

Fig. 3: CBCT sagittal slides of maxillary second premolars showing; (A) one-rooted 2nd premolar with 2 canals and Vertucci type IV, (B) second premolar with one root, one canal, and type I Vertucci

Maxillary Second Premolars

Out of 359 evaluated maxillary second premolars, 316 (88.0%) teeth had one root and 43 (12.0%) teeth had 2 roots. One canal was observed in 137 (38.2%) teeth while, 2 canals in 219 (61.0%) teeth, and 3 teeth were found with the extra canal (had 3 canals; Fig. 3).

Table 4: Frequency of number of roots, number of canals, and Vertucci type among maxillary second premolars

	Frequency	*Percent*
Number of roots (*N* = 359)		
1 root	316	88.0
2 roots	43	12.0
Number of canals (*N* = 359)		
1 canal	137	38.2
2 canals	219	61.0
3 canals	3*	0.8
Vertucci types (*N* = 359)		
Type I	137	38.2
Type II	39	10.9
Type III	55	15.3
Type IV	69	19.2
Type V	44	12.3
Type VI	4	1.1
Type VII	8	2.2
Other	3*	0.8

*3 teeth had extra canals

Table 5: Comparison between right and left sides among maxillary second premolars

	Right	*Left*	*p*
Number of roots			
1 root	162 (88.0)	154 (88.0)	1.000
2 roots	22 (12.0)	21 (12.0)	
Total	184 (51.3)	175 (48.7)	
Number of canals			
1 canal	71 (38.6)	66 (37.7)	0.847
2 canals	111 (60.3)	108 (61.7)	
3 canals	2 (1.1)	1 (0.6)	
Total	184 (51.3)	175 (48.7)	
Vertucci types			
Type I	71 (38.6)	66 (37.7)	0.991
Type II	19 (10.3)	20 (11.4)	
Type III	27 (14.7)	28 (16.0)	
Type IV	34 (18.5)	35 (20.0)	
Type V	24 (13.0)	20 (11.4)	
Type VI	2 (1.1)	2 (1.1)	
Type VII	5 (2.7)	3 (1.7)	
Other	2 (1.1)	1 (0.6)	
Total	184 (51.3)	175 (48.7)	

More than one-third (38.2%) of teeth had Vertucci type I, 19.2% had Vertucci type IV, 15.3% had Vertucci type III, and 12.3% had Vertucci type V. Three teeth (0.8%) had different types of canal configuration. More details are presented in Table 4.

The number of teeth with one (88.0%) or two roots (12%) was similar on both sides ($p = 1.000$). Similarly no significant difference between both sides regarding the number of canals ($p = 0.847$). There were 2 teeth (1.1%) on the right side and one tooth (0.6%) on the left side with 3 root canals. A higher number of teeth on both sides, with no significant difference ($p = 0.991$), was found with Vertucci types I, II, III, IV, and V while a fewer number were found with Vertucci types VI and VII (Table 5).

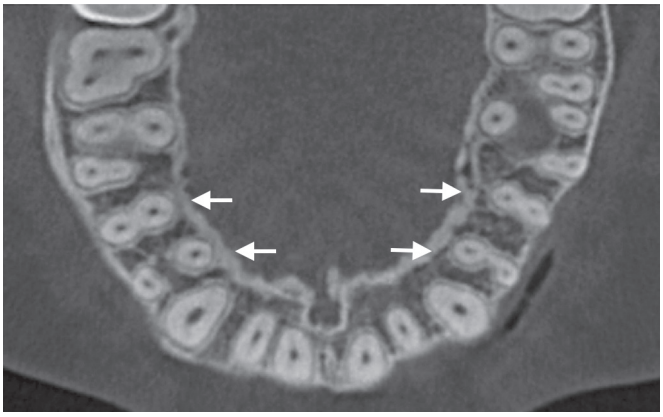

Fig. 4: CBCT axial view at mid-root level showing all maxillary first and second premolars have 2 canals (arrows)

Discussion

This study investigated the root canal morphology of maxillary first and second premolars in a Saudi Arabian sub-population utilizing *in-vivo* CBCT. Various diagnostic methods have been utilized that helped practitioners recognize aberrant root canal anatomy.[14] IOPAR was priorly used to find the location, number, and apical end of canals. Conventional radiographs from various angles helped the dentists to detect the existence of extra canals, roots, etc., which cause increased radiation exposure and is time-consuming.[15]

IOPAR applied in diagnosis during endodontic therapy produced with its inherited poor diagnostic quality image due to geometric distortion, anatomical noise, and 2D nature of the technology. Thus, there are drawbacks in the use of IOPARs, so other diagnostic tools like tuned aperture computed tomography (TACT), magnetic resonance imaging (MRI), ultrasound, computed tomography (CT), and CBCT have been recommended as aides to conventional radiographs. Amongst these diagnostic tools, CBCT has been proven to be a safe and effective *in-vivo* technique to overcome the drawbacks associated with conventional radiography.[16] CBCT yields undistorted 3D imaging of the teeth and surrounding tissues with an expressively lower effective radiation dose in comparison to conventional CT.[17] Therefore, in the present study, anatomical evaluation of maxillary premolars was performed using CBCT for more accurate and applicable clinical results.

Maxillary First Premolars

The permanent maxillary 1st premolar is a problematic tooth to be treated endodontically. There is a significant disparity in the number of canals, the number of roots, and the incidence of apical curvature, the shape of the roots with the deep longitudinal grooves, and difficult apical visualization.[18,19]

Many *in-vitro* and *in-vivo* studies were performed on the human maxillary 1st premolar. The dissimilarities in canal configuration, anatomy, and structure have been described from diverse populations with inconstant percentages of prevalence. Maxillary premolars have vastly variable root canal morphologies and generally presents with one or two roots. In a recent literature

review,[20] maxillary first premolars presented a higher percentage of two roots (56.6%), followed by one root (41.7%) and 3-rooted is also reported (1.7%). In regards to the number of canals, the majority showed 2 canals (86.6%), and the most common internal canal configurations were type IV, II, and I (64.8, 13.5, and 11.4%, respectively).

In the present study, among the maxillary 1st premolars 2 roots were predominant with 57.5% followed by one root 40.7% and 3 roots had 1.7%. These findings are consistent with a previous study in the same population from the same area where it reported a 61% prevalence of 2 roots.[10] Whereas other reports from a different area in the same population showed higher numbers of 2-rooted maxillary first premolars ranging (71.7–80.9%).[7,8,11] Other recent studies from different populations using CBCT showed big differences in the prevalence of 2-rooted maxillary first premolars: 29.8% in Chinese,[21] 51.4% in Spanish,[22] 54.1% in South African,[23] and 80.2% in Brazilian populations.[24]

With regard to the number of canals in this study, the majority 93.2% of maxillary first premolars presented with 2 canals, regardless of the number of roots (Fig. 4). This finding is in agreement with previous reports in the same populations ranging from 89.9 to 97%.[9–11] Recent findings from different populations utilized CBCT showed almost similar results.[23–25]

The most common canal configuration found in the present maxillary first premolars sample was Vertucci's type IV (63.8%), which is slightly lower than the outcome of previous studies in the same populations (69.1–75%).[7,8,10] Other studies in different populations using CBCT reported a wide range from 42.7 to 82.2% of Vertucci type IV as the most prevalent.[21–24]

Maxillary Second Premolars

Maxillary second premolars have wide variations in internal morphology with a concavity of the root, pulp cavity outline, and it is difficult to get apical details with conventional radiographs.[26] In a recent micro CT study in a Saudi population,[12] maxillary second premolars showed complex and variable RCS with 11 extra canals configurations other than the 8 types defined by Vertucci.[13] In contrast to maxillary first premolars, the prevalence of single-rooted maxillary 2nd premolars is predominant (69.6–91.9%), the occurrence of two roots was 8.1–29.7%, and that of three roots was 0–1.6%.[27–30]

In the present study, we found that one root is prominent with 88%, followed by 12% 2-rooted maxillary second premolars, no 3 roots were detected. Our results were consistent with Alqedairi et al. (85.2%) and higher than Elnour et al. (67%) and Elkady and Allouba (76.4%) in Saudi sub-populations. Recent CBCT studies from different populations on the number of roots of maxillary second premolars reported a range with high prevalence almost similar to our finding: 96.2% in Chinese,[21] 82.9% in Spanish,[22] 78.2% in South African,[23] and 71.2% in Brazilian populations.[24]

In regards to the number of canals, we reported 2 canals with a higher prevalence Figure 4 of 61% compared to one canal 38.2% and a small percentage of 3 canals 0.8%, which is in agreement with previous findings in a Saudi sub-population (2 canals were 59.4 and 65%).[9,12] Recent studies in Brazilian and Chinese populations[21,24] showed a lower but close prevalence of one canal (49.9 and 50.3%, respectively) compared to our findings. Whereas, in South African one[23] teeth with one canal were very low (37.5%).

Type I Vertucci canal configuration was the highest (38.2%) in maxillary second premolars, followed by Vertucci type IV (19.2%), type III (15.3%), and Vertucci type V (12.3%). The high prevalence of type I was in-between compared to other studies in the same population (36.3 and 49.4%).[7,8] Whereas, a way higher than the number reported in Elnour et al.[12] study (17%), and that could be explained by the higher sensitivity of a micro CT devise that used in their study which increases the ability to detect RCS details more accurately. Other findings from international studies reported that Vertucci type I is more prominent to ranging from 37.5 to 50.3%.[21–24] These differences in first and second maxillary premolars in the Saudi population might be related to the areas where the samples were collected and the methodologies as well. In contrast, varieties between different populations are better explained by racial and geographic differences.

Evaluation of Anatomy by Sides

In the present study, the differences in maxillary first and second premolars root canal morphology were assessed, and we found no significant differences for the number of roots, number of canals, and canal configuration between right and left sides. Findings shown in Tables 3 and 5 are consistent with other studies in the same Saudi sub-population,[7,8] as well as international ones from different populations.[22–24] This variable seems to be clinically significant, which means that if treating the patient with contralateral maxillary premolars, you are expected to have more similarities in the external and internal anatomy.

Our finding generally goes with the mainstream and confirmed results from previous studies in the same Saudi sub-population regardless of methodologies. Generally speaking, understanding external morphology and internal anatomy for a particular population are essential for the clinicians before performing any endodontic procedure on these teeth. One of the main limitations of our study might be the sample size, and more studies on larger sample sizes are necessary for generalizing our study outcomes.

Conclusion

Within the limitation of our study, the majority of maxillary first premolars had two roots with Vertucci's type IV being the most common canal configuration. Whereas in maxillary second premolars, single-rooted with type I canal configuration was the most predominantly witnessed. Both maxillary premolars share a common trait of higher presence of 2 canals regardless of the number of roots, with first premolars having higher prevalence.

Highlights

- Maxillary first premolars had a higher prevalence of two roots.
- Maxillary second premolars had a higher prevalence of one root.
- Most maxillary premolars have two canals regardless of the number of roots.

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