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RADIOGRAPHICAL EVALUATION OF ROOT CANAL MORPHOLOGY OF THE MAXILLARY AND MANDIBULAR PREMOLAR TEETH BY USING CONE-BEAM COMPUTED TOMOGRAPHY IN KURDISTAN REGION, IRAQ

RAZ R. TAWFEEQ SALIH[*] and **MAYSALOON S. SHAMAN**[**]
[*]Ministry of health, General health of Duhok, Kurdistan Region-Iraq
[**]College of Medicine, University of Duhok, Kurdistan Region-Iraq

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ABSTRACT

BACKGROUND: THE CBCT TECHNOLOGY HAS A VERY EXCELLENT SPATIAL RESOLUTION IN ALL PLANES WITH HIGH QUALITY, minimizes the acquisition time, lowers radiation doses and it's proved for the variability and complexity of the anatomy of the root canal system premolar teeth. The aim of this cross-sectional study was to discover root canal morphology of premolar teeth regarding Vertucci and Weine classification and also to determine number of roots and location of apical foramen among population in Kurdistan region of Iraq.

Methods: One hundred and three images taken of maxillary and mandibular first and second premolars through the CBCT technique were analyzed. The images were taken from private dental clinics and were collected for the study analysis between November 2021 and May 2022 according to inclusive criteria.

Results: In accordance to Vertucci classification despite to maxillary first premolar teeth type IV was the commonest type (26.0%) and in maxillary second premolar teeth type II is the highest rate (12.0%) and whereas for mandibular first and second premolar teeth type I is the most prevalent type (18.0%), (17.0%) respectively. Regarding to Weine classification for maxillary first premolar teeth type III was the most prevalent type 26.0%, in maxillary second premolar teeth type II is the highest rate (12.0%), Whereas to mandibular first and second premolar teeth type I is the most common (18.0%), (17.0%) respectively. According to root numbers for maxillary first premolar teeth two rooted number is the highest rate (26.0%) and for maxillary second and mandibular first and second premolar teeth one rooted teeth are the commonest root number (19.0%), (20.0%), (26.0%), respectively. Despite to the location of apical foramen for all maxillary and mandibular first and second premolar teeth the center location is the most prevalent location (15.0%), (16.0%), (15.0%), (15.0%), respectively.

Conclusions: This cross-sectional study illustrate that the type IV is the most widespread for maxillary first premolar teeth, and type II to maxillary second premolar teeth and for mandibular first and second premolar teeth type I is the most common type. But in Weine classification for maxillary first premolar teeth type III was the most widespread type, for maxillary second premolar teeth type II and in mandibular first and second premolar teeth type I is the most common type. Regarding number of roots, in maxillary first premolar teeth two rooted teeth are more common but in all maxillary second and mandibular first and second premolar teeth one rooted teeth is the most prevalent root number. About the location of apical foramen, the center is the highest ratio among all the other locations for premolar teeth.

KEYWORDS: Maxillary. Mandibular; Root canal morphology, Radiograph, CBCT.

INTRODUCTION

Effective root canal treatment requires good knowledge of tooth anatomy and root canal morphology to access and remove microorganisms and pulp tissue and manage root canals[1] In order to improve the accuracy of the diagnosis, dentists must take many radiographs using various horizontal angulations. As a result, the patients are exposed to more radiation without getting sharper radiographs and it eliminates key details regarding the root anatomy and canal structure[2].

Because of the number of roots and canals, the direction and longitudinal depressions of the roots, the varied pulp cavity configurations, and the difficulty in visualizing the apical on periapical radiographs, maxillary premolars are

among the most challenging teeth to endodontically treat [3]Throughout their progression, root canals offer a variety of configurations from tooth to tooth in various people as well as the same person and because of this, the premolar teeth were classified according to Weine[4] and Vertucci[5].

Investigations of the anatomy of root canals have been carried out using a variety of approaches, including in vivo and in vitro methods. In vivo techniques include clinical evaluation during root canal treatment, retrospective assessment of patient records, conventional radiographic evaluation, and advanced radiographic techniques such as cone-beam computed tomography (CBCT)[6] [7].In vitro techniques include canal staining and tooth clearing, root sectioning, microscopic examination, examination of conventional radiographs, and the use of three-dimensional modalities such as microcomputed tomography. In vivo techniques include clinical evaluation during root canal treatment, retrospective assessment of patient records[8].

The cone beam computed tomography (CBCT) are introduced so as to get the correct analysis for the root canal morphology and also lowers radiation doses, shortens acquisition times, and provides excellent spatial resolution in all planes, all of which produce high-quality 3-D diagnostic pictures of the craniofacial region. Additionally, the CBCT images can be read using a variety of representations (including 3-D surface rendering and multiplanar reformation) without superimposing the anatomical features[9] .

The CBCT method was created in the 1990s with the goal of creating three-dimensional images of the maxillofacial anatomy while using less radiation than traditional computed tomography. Neelakantan et al. in (2010)[10] found that the CBCT method is useful in the field of endodontics because the device is more accurate than traditional methods[10].

The aim of this current study was to realize root canal morphology of premolar teeth regarding Vertucci and Weine classification and also to determine number of roots and location of apical foramen among population in Kurdistan region of Iraq.

MATERIAL AND METHODS

Sample selection

This study was approved by the Ethics Committee of the Duhok health directorate. Between November 2021 and May 2022, CBCT pictures of maxillary and mandibular premolars were collected from patients who required a preoperative evaluation as part of their routine checkup, or preoperative evaluation of dental implant dental examination, diagnosis, and endodontic or orthodontic treatment planning at an imaging diagnostic center in Duhok and Sulaymaniyah governorates. A total 103 patients (52 female and 51 male) were registered in this cross-sectional study.

Inclusion and exclusion criteria

The total of the patient's selection based on the following criteria: the presence of CBCT images of maxillary and mandibular premolars teeth with complete root formation, the absence of root canal treatment or any crown restoration, and the absence of any periapical lesion, as well as the absence of any impacted tooth in the premolar region and the incidence of high-quality CBCT images. While the exclusion criteria include teeth with root resorption or calcification, premolar teeth with root canal fillings, low-quality CBCT images, extracted premolars or missing.

Cone-Beam Computed Tomography

The images of CBCT were taken by "Orthophos SL" from Dentsply Sirona -Germany, this machine has the following parameters as shown in table 1 in below:

Table (1): Parameters for the CBCT Image

Mode	**X-ray source: High Frequency, Stationary Anode: 60-90 kV; 1-10 mA (pulsed mode)**
Focal spot	0.5 mm
Scanning time	Min: 18 s
Sensor type	Flat Panel Amorphous Silicon
Single gray scale	Dynamic range 16-bit
Voxel Size Options	75 microns
Reconstruction time	15 s
FOV Sizes in cm	5x5, 5x8, 8x8, 8x11
Power required	15A @ 115 V~, 10A @ 240 V~, 50/60 Hz
Software	NNTTM with free viewer and sharing application

These radiograph images were captured by specialized radiographical technician and checked by specialized dental radiologists with un experience at least 4 years to reach an agreement in the interpretation of the radiographic findings and according to the ALARA radiation safety principle. The cross-sectional images were found using dental computed tomography software and (NewTom Giano; QR s.r.l., Verona, Italy) observed in a dark room with a thin-film transistor monitor at a resolution of 1600-1200 pixels. CBCT images of the teeth involved in the study were inspected and counted to determine the: number of roots, root canal configuration according to Vertucci and Weine classification and to determine the location of apical foramen.

Vertucci classification

The classification of first and second maxillary and mandibular premolar teeth were achieved in accordance with system as shown in next page in figure 1.

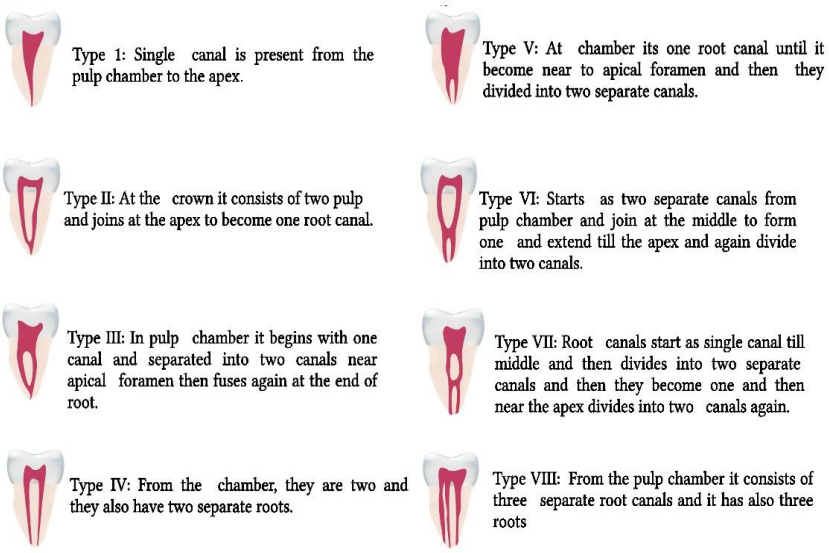

Fig. (1): Eight types of Vertucci classification[11] .

Weine classification:

S. Weine classified root canal morphology to a set of type which start from I to IV in 1969 as described in figure 2 in below:

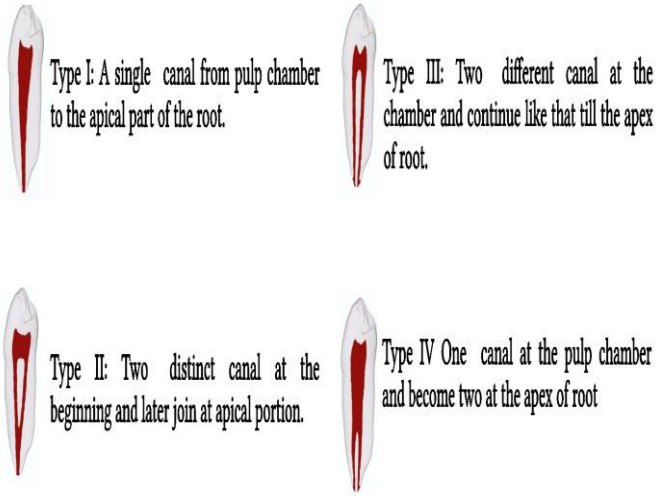

Fig. (2): Weine classification showing all four Types[4] .

Statistical analysis

The statistical Package for Social Science (SPSS) version 26.0 was applied to examine the results. The study's data was displayed as frequency and percentage. The Chi-square tests were used to assess the variances in anatomical structures and root numbers. The statistically significant difference was assumed when the P-value <0.05.

RESULTS

In this study, 103 patients with inclusive criteria ranging in age from 16 to 60 years old were included. The majority of them were long-term citizens of Iraq's Kurdistan region. The patients were classified as either male or female, with the men being 51 and the females being 52 as seen in table 2.

Table (2): Frequency of patient's distribution.

Feature of patients (n=103)	Frequency	Percentage
Gender		
Male	51	49.51%
Female	52	**50.49%**
Age categories		
16-30	45	**44%**
31-45	42	41%
46-60	16	15%

The bold numbers show the highest percentage.

While examining maxillary first premolar teeth by CBCT it illustrates that the type IV is the majority in accordance to Vertucci classification in both male and female and there is no difference between either its right or left and two teeth recorded for type VIII in male but no tooth has been recorded for type VIII in female as shown in table 3 in next page. And for maxillary second premolar teeth type II is the most prevalent type without big difference between male and female. Then for both mandibular first and second premolar teeth type I is the commonest and none of the cases were reported for VIII, but in mandibular first premolar some of the teeth were belong to type IV. In figure 3 in next page, we can see some types of Vertucci classification which were reported in the research.

Table (3): Distribution of root canal types according to Vertucci's classification

Gender	**Male**					**Female**					
Type	I	II	IV	V	VIII	I	II	IV	V	VIII	p-value
Maxillary right first premolar	0	2 (4.3)	44 (93.6)	0	1 (2.1)	0	1 (2.2)	44 (97.8)	0	0	IV= 1.000*
Maxillary left first premolar	0	3 (6.5)	42 (91.3)	0	1 (2.2)	0	3 (6.3)	45 (93.8)	0	0	VIII= 0.835*
Maxillary right second premolar	10 (25.6)	14 (35.9)	15 (38.5)	0	0	11 (24.4)	25 (55.6)	9 (20.0)	0	0	IV= 0.120**
Maxillary left second premolar	9 (24.3)	16 (43.2)	12 (32.4)	0	0	10 (25.6)	24 (61.5)	5 (12.8)	0	0	IV= 0.106**
Mandibular right first premolar	29 (70.7)	9 (22.0)	3 (7.3)	0	0	35 (81.4)	6 (14.0)	2 (4.7)	0	0	IV= 0.565*
Mandibular left first premolar	31 (73.8)	9 (21.4)	1 (2.4)	1 (2.4)	0	34 (77.3)	7 (15.9)	3 (6.8)	0	0	V= 0.560*
Mandibular right second premolar	25 (62.5)	14 (35.0)	0	1 (2.5)	0	40 (81.6)	8 (16.3)	1 (2.0)	0	0	V= 0.041*
Mandibular left second premolar	24 (60.0)	15 (37.5)	0	1 (2.5)	0	36 (76.6)	10 (21.3)	1 (2.1)	0	0	V= 0.099*

*By Fisher's exact test. **By Chi square test.

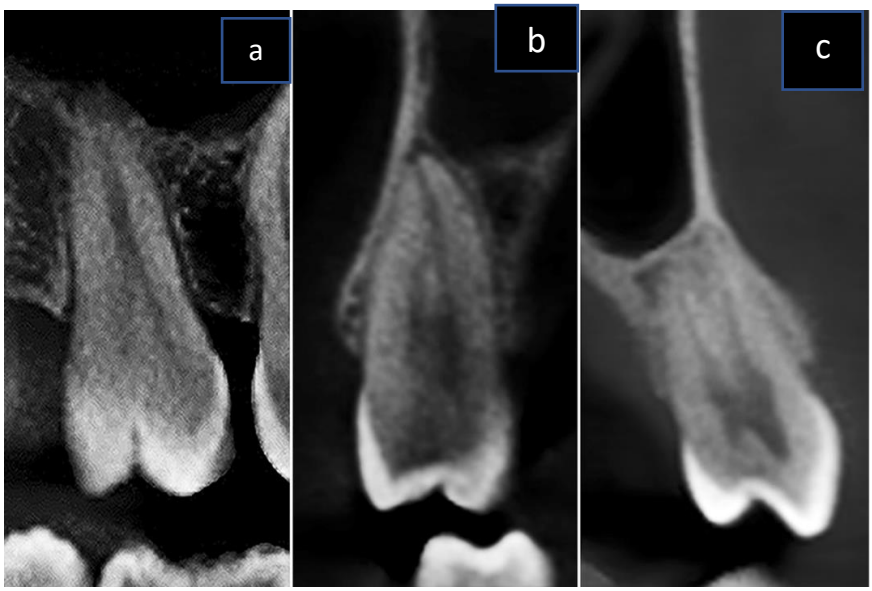

Fig. (3): Maxillary first premolar teeth shows three different types of Vertucci; (a) sagittal view illustrate type I, (b) coronal view show type II, (c) coronal view show type IV.

While looking at the radiological image of CBCT to determine root canal morphology regarding Weine classification we see that for the maxillary first premolar in male and female type III is the most prominent type which are 93.4%, 95.8%, respectively and none of the cases were reported for type IV. According to maxillary second premolar teeth type II is the commonest type for male and female which are 39.5%, 58.5%, respectively. Then about mandibular first and second premolar teeth type I is the most common type in male and female which are 71.9%, 79.3%, 60.7%, 79.1%, respectively. As seen in table 4 in below. Likewise in figure 4 there is example of Weine classification in the reported cases in next page.

Table (4): Distribution of root canal types according to Weine's classification

Gender	Male				Female				
Type	I	II	III	IV	I	II	III	IV	p-value
Maxillary right first premolar	0	2 (4.3)	44 (95.7)	0	0	1 (2.2)	44 (97.8)	0	III = 1.000*
Maxillary left first premolar	1 (2.2)	3 (6.7)	41 (91.1)	0	0	3 (6.3)	45 (93.8)	0	III = 0.833*
Maxillary right second premolar	10 (25.6)	14 (35.9)	15 (38.5)	0	11 (24.4)	25 (55.6)	9 (20.0)	0	III = 0.120**
Maxillary left second premolar	9 (24.3)	16 (43.2)	12 (32.4)	0	10 (25.6)	24 (61.5)	5 (12.8)	0	0.106**
Mandibular right first premolar	28 (70.0)	9 (22.5)	3 (7.5)	0	35 (81.4)	6 (14.0)	2 (4.7)	0	III = 0.565*
Mandibular left first premolar	31 (73.8)	9 (21.4)	1 (2.4)	1 (2.4)	34 (77.3)	7 (15.9)	3 (6.8)	0	IV= 0.560*
Mandibular right second premolar	25 (62.5)	15 (37.5)	0	0	40 (81.6)	8 (16.3)	1 (2.0)	0	III = 0.030*
Mandibular left second premolar	23 (59.0)	15 (38.5)	0	1 (2.6)	36 (76.6)	10 (21.3)	1 (2.1)	0	IV = 0.083*

*By Fisher's exact test. **By Chi square test.

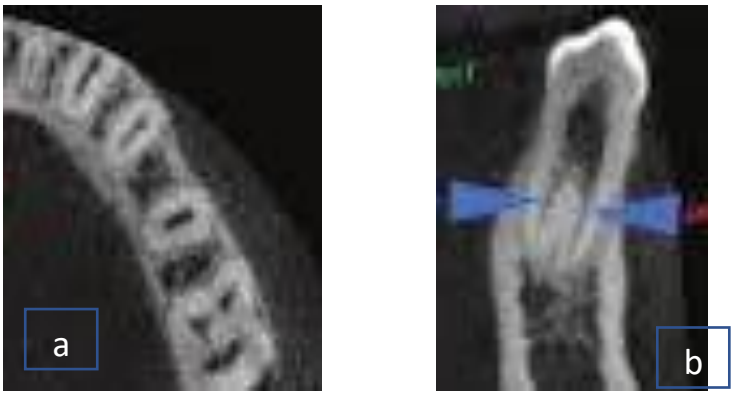

Fig. (4): Maxillary first premolar teeth shows different types of Weine; (a) axial view show type II, (b) coronal view show type III.

In concern to the number of roots as shown in table 5 below, for maxillary first premolar teeth in male and female two rooted teeth are the most prominent which are 92.4%, 95.8%, respectively but also there is one cases reported for three rooted only in male which is 0.2%. About maxillary second premolar teeth one rooted teeth are the most common in both male and female which are 64.5%, 83.6%, respectively. Likewise in mandibular first and second premolar teeth in individually male and female one rooted are also the commonest which are 95.1%, 94.2%, 100%,97.9%, respectively. And there is an example for root numbers and location of apical foramen from the reported cases like seen in figure 5 and 6 in next page.

Table (5): Number of roots and location of apical foramen

Gender	**Male**								**Female**							
Root No. and location	Root number				Location				Root number				Location			
	1	2	3	p-value	Mesial	Center	Distal	p-value	1	2	3	p-value	Mesial	Center	Distal	p-value
Maxillary right first premolar	2 (4.3)	44 (93.6)	1 (2.1)	1.000*	2 (4.2)	28 (58.3)	18 (37.5)	C= 0.738*	1 (2.2)	44 (97.8)	0	1.000*	3 (6.7)	23 (51.1)	19 (42.2)	C = 0.738*
Maxillary left first premolar	3 (6.5)	42 (91.3)	1 (2.2)	0.835*	1 (2.1)	25 (53.2)	21 (44.7)	C = 0.540*	3 (6.3)	45 (93.8)	0	0.835*	0 (0.0)	23 (47.9)	25 (52.1)	C = 0.540*
Maxillary right second premolar	24 (61.5)	15 (38.5)	0	0.062**	1 (2.6)	27 (69.2)	11 (28.2)	C = 0.906*	36 (80.0)	9 (20.0)	0	0.062**	1 (2.2)	30 (66.7)	14 (31.1)	C = 0.906*
Maxillary left second premolar	25 (67.6)	12 (32.4)	0	0.040**	2 (5.4)	20 (54.1)	15 (40.5)	C =0.577*	34 (87.2)	5 (12.8)	0	0.040**	3 (7.3)	26 (63.4)	12 (29.3)	C =0.577*
Mandibular right first premolar	38 (92.7)	3 (7.3)	0	0.672*	5 (11.6)	25 (58.1)	13 (30.2)	C = 0.343**	41 (95.3)	2 (4.7)	0	0.672*	10 (23.3)	23 (53.5)	10 (23.3)	C = 0.343**
Mandibular left first premolar	41 (97.6)	1 (2.4)	0	0.616*	9 (22.0)	20 (48.8)	12 (29.3)	C =0.067**	41 (93.2)	3 (6.8)	0	0.616*	4 (9.1)	32 (72.7)	8 (18.2)	C =0.067**
Mandibular right second premolar	40 (100)	0 (0.0)	0	1.000*	8 (20.0)	26 (65.0)	6 (15.0)	C = 0.765**	48 (98.0)	1 (2.0)	0	1.000*	13 (26.0)	29 (58.0)	8 (16.0)	C = 0.765**
Mandibular left second premolar	40 (100)	0 (0.0)	0	1.000*	3 (8.1)	28 (75.7)	6 (16.2)	C =0.872*	46 (97.9)	1 (2.1)	0	1.000*	4 (8.3)	33 (68.8)	11 (22.9)	C =0.872*

*By Fisher's exact test. **By Chi square test. C means center location.

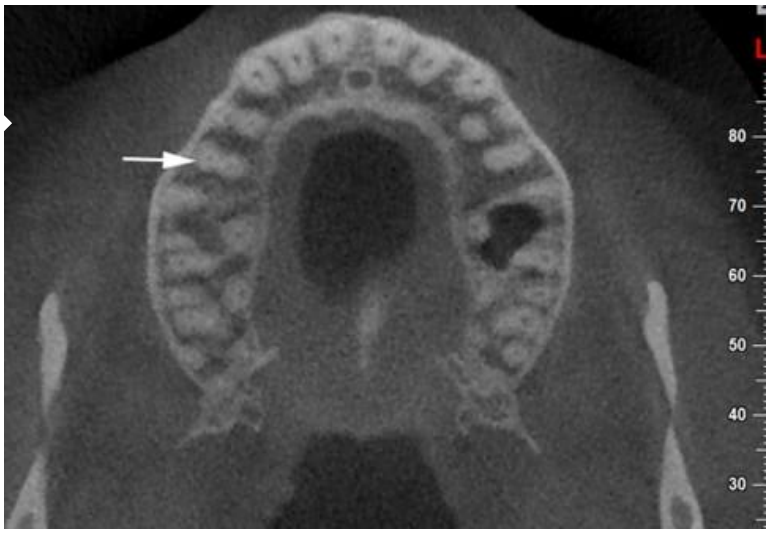

Fig. (5): The arrows show two roots of maxillary first and second premolar in axial view.

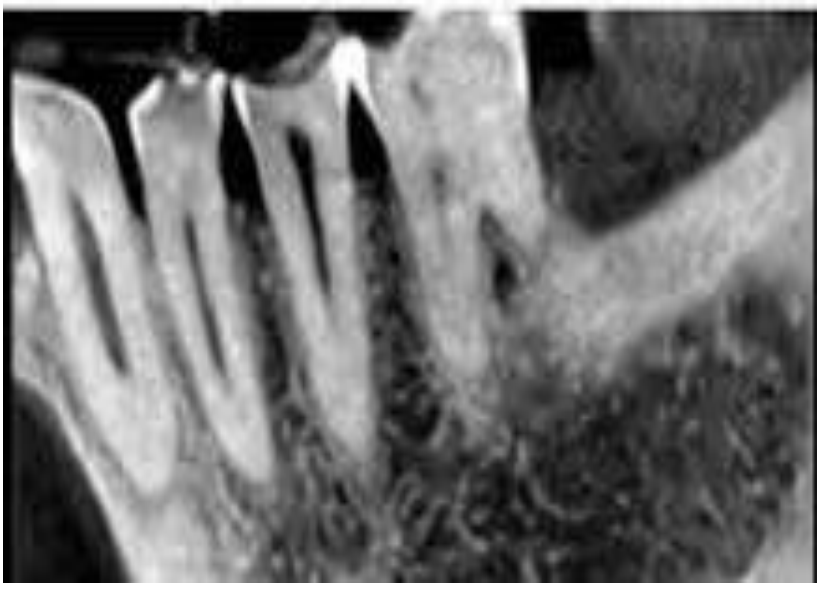

Fig. (6): Sagittal view shows apical foramen of mandibular first premolar is distally and mandibular second premolar tooth is at the center.

DISCUSSION

This study gives well description about root and canal morphology of maxillary and mandibular premolars in some governorate in Kurdistan region of Iraq by using three-dimensional radiograph (CBCT). The difficult challenges encountered during access cavity planning, cleaning, shaping, and filling processes of the root canal system can be significantly reduced with a thorough conceptual description and an understanding of root canal morphology. CBCT was selected as the assessment method because it provides an advanced effective method for examining tooth external and interior anatomy because of the significant information gathered from its coronal, sagittal, and axial plans[12]. Based on the pattern of division of a tooth's major root canal along its length from the base of the pulp chamber to the root apex, Weine et al. identified four types[4] , while Vertucci in 1984[11] divided root canal morphology into eight categories.

In the present study for maxillary first premolar teeth, two rooted tooth is the most occurrence in (26.0%) and then one rooted and three rooted (1.0%), (0.3%), respectively. While in maxillary second premolar teeth one rooted number is the most common (19.0%) and then two rooted (6.0%). For the meantime in mandibular first premolar teeth one rooted is the most occurrence (20.0%) followed by two rooted (1.0%). Whereas in mandibular second premolar teeth; one rooted number is most prevalent (26.0%) followed by two rooted (0.7%).

Single rooted number has been recorded as an incidence up to 100% in mandibular first and premolar teeth in Spanish population[13] . In Asian population, the occurrence of one rooted was

reported as 22 to 66% in maxillary first premolars, 33 to 84% in two roots, and zero to 6% in three roots[14] .In another study in Spanish population, the ratio of number of roots was reported as 69.6 to 90.3% for one rooted, 9.7 to 29.7% in two roots, and 0 to 1.6% in three roots in maxillary second premolar teeth[15].Among Saudi population[16], the majority (80.9%) of maxillary first premolars had two roots although one and three roots were reported in 17.9% and 1.2%, respectively). Cleghorn et al. in (2007)[17] found out three and four roots in mandibular first premolars.

Meanwhile in this current study the most prominent type for maxillary first premolar teeth according to Vertucci is type IV in 26.0% followed by type I (1.0%), and type VIII (0.3%) which is very rare type. But in maxillary second premolar teeth type II is the highest rate which was (12.0%) followed by type I and type IV (6.0%). Whereas in mandibular first premolar teeth type I is most prevalent (18.0%), followed by type II (5.0%), type IV (1.0%), type V (0.1%), respectively. Regarding mandibular second premolar teeth; type I is most occurrence (17.0%), and then type II (7.0%), type IV (0.3%), type V (0.1%), respectively.

Alqedairi et al., found that the Type IV Vertucci classification with the (57.8%)[18] was the prominent type in a Saudi population for maxillary first premolar teeth., while Chourasia et al., found that the Type II was most common configuration in both the first (17.56%) and second (19.92%) premolars, followed by I (14.1%) and type III (14.1%), however type VIII is not existed in the South region of the Saudi Arabia[19].

For this present study despite to Weine classification for maxillary first premolar teeth type III was the commonest type which was 26.0% and then type II (1.0%), and type I (0.1%) which is very rare type. whereas in maxillary second premolar teeth type II is the most prevalent which is (12.0%) and then type I and type III (6.0%) for each type. Meantime for mandibular first premolar teeth type I is the most occurrence (18.0%), followed by type II, III, IV (5.0%), (1.0%), (0.1%), respectively. And finally for mandibular second premolar teeth; type I is the most common (17.0%), followed by type II, III, V (7.0%), (1.0%), (0.1%), respectively.

In a Saudi population for maxillary first premolar teeth regarding to Weine classification Type III (57.8%) is the prominent type[18]. Meantime in another study in Saudi Arabian southern region Type II was the most common configuration in both the first (17.56%) and second (19.92%) premolars, followed by I (14.1%)[19] .

And finally in concern to locate apical foramen of the root in this cross-sectional study; the center position is the most prevalent location among all the four premolar teeth, for maxillary first premolar teeth in this present study the commonest deviation in location of apical foramina was center (15.0%) for maxillary first premolar teeth followed by distally (11.0%), mesial (0.1%). Whereas for maxillary second premolar teeth the most common location is center which is (16.0%) followed by distally (5.0%), mesial (4.0%). Then for mandibular first premolar teeth center is widely present which is (15.0%) and then distally (8.0%), mesial (1.0%). In meantime for mandibular second premolar teeth center position is the commonest which is (15.0%) followed by distally (6.0%), mesial (4.0%).

The current study offered a theoretical background for clinical therapy and reflected the internal root structure of first and second premolars in people from the Kurdistan region. We may say that the morphology of the root canals may be influenced by the ethnic disparity across people. These findings highlight the importance of a thorough radiographic assessment for root canal therapy success.

CONCLUSION

Within the limitations of this study, in the Kurdistan region, the root canal morphology of maxillary first and second premolars revealed significant variance across Iraqi groups. Throughout knowledge about the root canal morphology of maxillary and mandibular premolar teeth in a Kurdistan region population is provided for dentists by this study. The CBCT was a therapeutically effective technology that facilitates successful endodontic therapy. Most of the premolar teeth have one root which is the prominent among them.

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