Cone beam computed tomography evaluation of root and root canal system of permanent maxillary first and second molars in a sample of Iraqi Kurdistan patients

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Abstract

Background and objectives: Anatomy of the root canal system and determining the number and form of the canals are the most important steps for a successful root canal therapy without post-operative complications. The evidence supports the variability and complexity of maxillary molars. The aim of this study was to evaluate the prevalence of the additional mesiobuccal canals in the mesiobuccal roots, root canal configuration and root numbers of first and second permanent maxillary molars through the cone beam computed tomography (CBCT) technique. **Methods:** One hundred patients' images taken of maxillary first and second molars bilaterally by cone beam computed tomography technique. Classification of first and second molar root canals was performed in accordance with Vertucci's classification system. The patterns of anatomical variations in contralateral molars were classified according to the Zhang classification system. **Results:** The present study found that three roots were the most prevalent numbers of roots in the right and left, first and second molars, 96.0%, 75.0%, 97.0%, and 72.0%, respectively. In addition, the prevalence of additional mesiobuccal canals in both the right and left, first and second molars were 45.0%, 20.0%, 40.0%, and 27.0%, respectively. **Conclusions:**Tooth variant type I of Zheng et al classification and type I of Vertucci's classification of the root canal system was the most prevalent type.

Key words: Canal configuration, Cone-beam computed tomography, Maxillary molar.

Introduction

It is important to determine the root canal system, the number and form of the canals in order to have a successful root canal therapy without post-operative complications[1]. The evidence supports the variability and complexity of maxillary molars[2]. Therefore, dentists need to take several radiographs with changed horizontal angulations in order to enhance the outcome of diagnosis. Accordingly, it exposes the patients to a more radiation without sharpness radiographs. In addition, it does not present the complete information about the canal system and root morphology[3]. Morphology of root canals has been studied with a new technique called cone beam computed tomography (CBCT)[4-6]. In contrast with conventional CT scans, the CBCT technique reduces the acquisition time and lowers radiation doses and has a very good spatial resolution in all planes, resulting in the 3-D diagnostic images with a high quality of the maxillofacial region. Moreover, images taken by CBCT are readable using different representations (3-D surface rendering and multiplanar reformation) without superimposition of the anatomic structures[7], unlike the periapical radiography which was the most used technique for investigation of the tooth anatomy prior to an endodontic treatment. However, this technique does not obtain the complete detailed presentation of the root canal anatomy[8]. Ability of CBCT to detect the root canal morphology is as accurately as canal staining and clearing techniques which had been reported by Neelakantan et al[9] possibly due to three-dimensional images and in detail morphological information. The CBCT technique has shown to be suitable for the endodontic field owing to the higher accuracy of the device compared to conventional techniques[9]. A wide range of anatomical variations of mesiobuccal roots of maxillary permanent first and second

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molars have reported in the literature. It was hypothesized that failure to detect, debride, and fill a second mesiobuccal canal (MB2) of first permanent maxillary molars was one of the main reason for poor long-term prognosis following root canal treatment in these teeth. The aim of this study was to determine the prevalence of the mesiobuccal canal in the mesiobuccal roots, root canal configuration and root numbers of first and second permanent maxillary molars through the CBCT technique.

Machines and Methods

In the present retrospective clinical study, 100 images taken of maxillary first and second molars through the CBCT technique (about 1136 roots) were analyzed. Images were taken as a part of the clinical examination, diagnosis, and treatment planning for patients requiring endodontic, or orthognathic treatment or during the preoperative assessment for dental implants. The settings of image collection were taken from tow private dental clinics in Erbil, and Sulaymaniyah. The images were collected for the study analysis between November 2017 and May 2018.

The copy of images was collected for the present study following taking ethical review form the Kurdistan Board for Medical Specialists (KBMS) and the administrative permission from the mentioned private clinics. The confidentiality of the personal information of the patients was protected. The clinics administrations de-identified the patients' personal information prior to giving to the authors. The following inclusion criteria were applied to the study: 1) fully erupted permanent maxillary first molars or second molars bilaterally and 2) maxillary first or second molars with fully formed apexes and no previous root canal treatment. The following exclusion criteria were applied: CBCT images that were unclear or had artifacts, maxillary first and second molars with root filling, resorption or calcification, or crown restorations interfering with image analysis. All the CBCT scans were acquired using the NewTom Giano CBCT 3D imaging (QR s.r.l., via silvestrini,20-37135 Verona, Italy) with the following parameters:

Table (1): Image parameters.

Mode	x-ray source; High Frequency, Stationary Anode: 60-90 kV; 1-10 mA (pulsed mode)
Focal spot	0.5 mm
sensor type	Flat Panel Amorphous Silicon
scanning time	Min: 18 s
reconstruction time	15s
Single grayscale	Dynamic range 16-bit
Voxel Size Options	75 microns. Minimum slice thickness 75 micron
FOV Sizes in cm	5x5, 5x8, 8x8, 8x11
Power required	15A @ 115 V~, 10A @ 240 V~, 50/60 Hz
Software	NNTTM with the free viewer and sharing application version 9

Four licensed radiologists carried out imaging, according to the ALARA radiation safety principle in the mentioned two clincis. Reconstructed axial cross-sectional images were obtained using dental computed tomography software (NewTom Giano; QR s.r.l., Verona, Italy) examined in a dark room with a thin-film transistor monitor at a resolution of 1600-1200 pixels. Two dental radiologists independently with at least 5 years clinical experience analyzed the images. CBCT images of the teeth included in the study were examined and enumerated to determine the number of roots, number of canals per root, root canal configurations using Vertucci's, and pattern of the concurrence of anatomical variations in contralateral molars. The variants were classified according to the classifications described by Zheng et al[6] as follows, Figure 2.

Variant 1: Three separate roots, including MB, distobuccal, and palatal roots (one canal in each root). Variant 2: Three separate roots (one canal in each of the distobuccal and palatal roots and two canals in the MB root).Variant 3: Two separate roots, including a buccal root and a palatal root (one canal in each root). Variant 4: Two separate roots, including a mesial root and a distal root (with one canal in each root). Variant 5: Two separate roots, including a mesial root with two canals and a distal root with one canal. Variant 6: One root with a single canal. Variant 7: One root with two canals. Variant 8: One root with three canals. Variant 9: Three separate roots, (two canals in each MB and distobuccal roots and one canal in the palatal root).
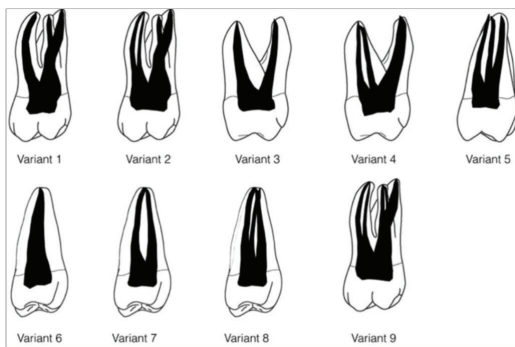
Figure (1): Categorization of the nine variants in the maxillary molars.

The classification of first and second molars was performed in accordance with Vertucci's classification system 10 as follows, Figure 3.

Type I: a single canal (from the pulp chamber to the apex); Type II: two separate canals (leave the pulp chamber and attach the apex short to create one canal). Also, type III: one canal in which leaves the pulp chamber, separating into two canals within the root and join together in one canal; Type IV: two separate distinct canals (from the pulp chamber to the apex).

Type V: single canal (leaves the pulp chamber and separate into two independent canals with two separate apical foramina; Type VI: two separate canals (leaves the pulp chamber to join the midpoint and separate into two canals with two separate apical foramina. In addition, type VII: one canal (leaves the pulp chamber and separate within the canal and re-divides into two clear canals with two separate apical foramina.
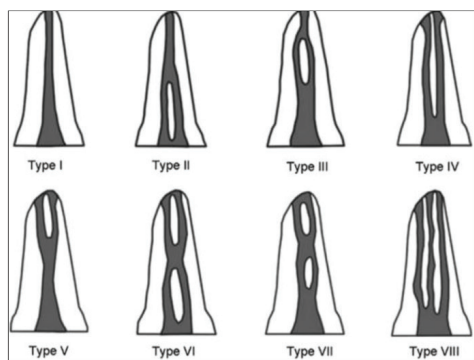
Figure (2): Classification of the root canal system Vertucci.

The Statistical Package for Social Sciences (SPSS) version 25:00 was used for statistical calculations. The information of the study was presented as frequency and percentage. The differences in root numbers and anatomical variations were examined through Pearson Chi-square tests. The P-value ≤ 0.05 was considered to confirm the statistically significant difference.

Results

The results showed that 61 images out of the100 images that included in the study were of females while the remaining 39 were of males and the majority was in the age categories of 18-29 years old, Table 2.

Table (2): Baseline characteristics of patients.

Patients' characteristics (n=100)	No.	%
Gender		
Male	39	39.0
Female	61	61.0
Age categories		
18-29 years	48	48.0
30-39 years	37	37.0
40-49 years	13	13.0
50-59 years	2	2.0

The root numbers and variations of right first and second molars are shown in Table 3. The radiological examination of teeth showed that the majority of them were multi-rooted. The study showed that 3 roots were the most prevalent number in the first and second molars (had 96.0% and 75.0%, respectively), followed by 2 roots (3.0% in first molars and 21.0% in second molars) with the significant difference (p-value=0.010). The minimum numbers were 1 root in both first and second molars (1.0% and 4.0% respectively). The variant 1 in tooth anatomy was the most prevalent variant in both first (51.0%) and second molars (61.0%) followed by variant 2; 45.0% and 13.0%, respectively.

Type 1 was the most prevalent root canal system in accordance with Vertucci's classification system; 52.0 and 69.0% for first and second molars, respectively followed by type 2; 32.0% and 13.0%, respectively. Type 5 and type 6 were not found in first and second molars, respectively as shown in Table 3.

The MB2 was more prevalent in right first molars (45.0%) compared to 20.0% in the second molars (p-value =0.003). Type 1 of root canal systems of DB and P was more prevalent in first molars compared to second molars, while type 1 of root canal systems of B had the lowest percentage in both first and second molars (p-value =1.00), Table 3.

Table (3): Root number and variations between right first and second molar roots.

Root and Variation (n=100)	Right First Molar	Right Second Molar	p-value (Two-sided)
No. of Roots			0.010
1 root	1 (1.0)	4 (4.0)	
2 roots	3 (3.0)	21 (21.0)	
3 roots	96 (96.0)	75 (75.0)	
Variants of tooth Anatomy			<0.0001
Variant 1	51 (51.0)	61 (61.0)	
Variant 2	45 (45.0)	13 (13.0)	
Variant 3	1 (1.0)	9 (9.0)	
Variant 4	2 (2.0)	7 (7.0)	
Variant 5	0 (0.0)	6 (6.0)	
Variant 6	0 (0.0)	1 (1.0)	
Variant 7	0 (0.0)	2 (2.0)	
Variant 8	1 (1.0)	1 (1.0)	
Root canal system (Vertucci's classification)			0.001
MB1	3 (3.0)	12 (12.0)	
0	52 (52.0)	69 (69.0)	
Type 1	32 (32.0)	13 (13.0)	
Type 2	2 (2.0)	0 (0.0)	
Type 3	10 (10.0)	5 (5.0)	
Type 4	0 (0.0)	1 (1.0)	
Type 5	1 (1.0)	0 (0.0)	
Type 6			
Prevalence of MB2			0.003
No MB2 canal	55 (55.0)	80 (80.0)	
MB2 canal present	45 (45.0)	20 (20.0)	
Distobuccal root			0.321
0	3 (3.0)	12 (12.0)	
Type 1	97 (97.0)	88 (88.0)	
Palatal root			0.004
0	3 (3.0)	17 (17.0)	
Type 1	97 (97.0)	83 (83.0)	
Mesiobuccal root			1.00
0	97 (97.0)	93 (93.0)	
Type 1	3 (3.0)	7 (7.0)	

The root number and variations of tooth anatomy of left first and second molars were shown in Table 4. The study showed that 3 roots were the more prevalent in both left first (97.0%) and second molars (72.0%). The left first molars had no single, and/or four roots, left second molars had no single and/or four roots; 4 roots was seen in 3 images in left second molars.

The variant 1 of tooth anatomy was the most prevalent in both left first (57.0%) and second molars (52.0%) followed by variant 2; 39.0% and 21.0%, respectively. The type 1 of root canal was the most prevalent in both left first (59.0%) and second molars (62.0%). Type 6 was the less prevalent in first molar (1.0%) in contrast with type 3 in second molar (1.0%); p-value =0.003.

There was no significant difference in the prevalence of an MB2 canal system between left first (40.0%) and second molars (27.0%); p-value =0.053. Type I was the only root canal system of DB in both first (99.0%) and second molars (89.0); p-value =1.000. Type 1 was the most prevalent of root canal of P in both first (98.0%) and second molars (81.0%). Also, the majority of root canal systems of B did not follow the Vertucci's classification system in both first (99.0%) and second molars (91.0%); p-value =1.00, see Table 4.

Table (4): Root number and variations between left first and second molar roots.

Root and Variation (n=100)	Left First Molar	Left Second Molar	p-value (Two-sided)
No. of Roots			0.007
1 root	0 (0.0)	7 (7.0)	
2 roots	3 (3.0)	18 (18.0)	
3 roots	97 (97.0)	72 (72.0)	
4 roots	0 (0.0)	3 (3.0)	
Variants of tooth Anatomy			0.002
0%	0 (0.0)	1 (1.0)	
Variant 1	57 (57.0)	52 (52.0)	
Variant 2	39 (39.0)	21 (21.0)	
Variant 3	2 (2.0)	6 (6.0)	
Variant 4	0 (0.0)	5 (5.0)	
Variant 5	2 (2.0	8 (8.0)	
Variant 6	0 (0.0)	1 (1.0)	
Variant 7	0 (0.0)	3 (3.0)	
Variant 8	0 (0.0)	3 (3.0)	
Root canal system (Vertucci's classification) MB1			0.003
0	1 (1.0)	12 (12.0)	
Type 1	59 (59.0)	62 (62.0)	
Type 2	0 (0.0)	14 (14.0)	
Type 3	28 (28.0)	1 (1.0)	
Type 4	9 (9.0)	9 (9.0)	
Type 5	2 (2.0)	2 (2.0)	
Type 6	1 (1.0)	0 (0.0)	
Prevalence of MB2			0.053
No MB2 canal	60 (60.0)	73 (73.0)	
MB2 canal present	40 (40.0)	27 (27.0)	
Distobuccal root			1.00
0	1 (1.0)	11 (11.0)	
Type 1	99 (99.0)	89 (89.0)	
Palatal root			0.035
0	2 (2.0)	19 (19.0)	
Type 1	98 (98.0)	81 (81.0)	
Mesiobuccal root			1.00
0	99 (99.0)	91 (91.0)	
Type 1	1 (1.0)	7 (7.0)	
Type 2	0 (0.0)	1 (1.0)	
Type 5	0 (0.0)	1 (1.0)	

Discussion

In the current study, root number, and canal anatomy were examined in line with Vertucci's classification system.

In the present study, 3% of four roots in the left second molar were found. Other studies have found the similar percentage of four roots. Alrahabi et al[11] found only 6% of maxillary first molars have four roots, also an Iranian study found that 1.6% in each maxillary first and second molars had four roots[12]. In addition, the variant 1 in tooth anatomy was the most prevalent variant in both first and second molars followed by variant 2.

Vertucci's class 1 was the most prevalent in palatal, distobuccal, mesiobuccal roots. The small percentages of classes 2 and 5 were in the mesiobuccal root of left second molars. While Alrahabi et al[11] found only type 1 in all of the palatal, distobuccal and mesiobuccal roots.

A number of canals inside each root will remain the key concern of Endodontists. This study found that palatal, distobuccal, and mesiobuccal root contains a single root canal except for mesiobuccal root with Vertucci's classes 2 and 5. Two palatal root canals have been found, but they are so rare[13]. A comprehensive review of the permanent maxillary first molar conducted which included 8400 teeth and reported the rare incidence of two palatal root canals. Results showed one single canal in distal roots in this study. Other studies have found similar findings with some different percentages[10, 11, 14], However15, the low incidence (between 0.1 and 4%) of two or more canals in Kuwaiti population were reported in the literature[16, 17].

The incidence of more than one canal in the mesiobuccal root is the main focus of the morphological studies. It has a substantially wide range of variations. In this study, second

and fifth Vertucci's class in the left second root molars (1% in each) was found. Alrahabi et al[11] reported 29.4% of single root and 70.6% of two canals in mesiobuccal root. This is significantly different findings compared to our study as the highest incidence of the second canal has been reported in Saudi populations as well[18]. However, the different incidence of two or more canals were reported; 25%[18]; 55%[19]; 73.6%[16]; and 78%[17].

The internal anatomy of maxillary first molar in the mesiobuccal root is hard to be examined. The findings are different in line with racial ethnicity, populations, and configuration system. The second canals in the MB roots are the most common missed canals[20]. Therefore, we recommend that the Endodontists be aware of the possible presence of two or more root canals prior to starting endodontic treatment. In particular, that type II and IV make facilitation in chemical debridement upon canal instrumentation[9]. We did not find the C-shaped root canal configuration in this study, while one Chinese[21] and Caucasian study[22] found C-shaped root canal configuration.

The strong point of the present study must be traced in the inclusion of a configuration system and the variation in tooth anatomy. Caution must be paid in the interpretation of the findings reported in the present study owing to study design and setting (only 100 images out of 450 images were compatible to our inclusion criteria). The present study was conducted retrospectively facing us to difficulties to determine the incidence of root canal numbers and variation. In addition, the study was conducted in tow clinical settings in two cities in Iraqi Kurdistan precluding us to generalize the findings to the rest of the country owing to the ethnicity difference.

Conclusions

The present study showed that three roots in both the right and left first and second molars were the most prevalent number of roots. In addition, tooth variant type I of Zheng et al classification was the most prevalent type in both the right and left first and second molars. Type I of Vertucci's classification of the root canal system was shown to be the most prevalent type in Distobuccal, Palatal, and Mesiobuccal roots.

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