Original Article

Root Canal System and Morphology of Mandibular Second Molar Using Cone Beam Computed Tomography

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Abstract

Objectives: As human 2nd molar teeth demonstrate considerable anatomic complexities and abnormalities in the number of roots and root canals, this study aimed to determine and investigate the root canal system of the mandibular 2nd molar teeth of a sample using cone-beam computed tomography. Variation can be found among different ethnic backgrounds. However, cone-beam computed tomography (CBCT) images eliminate the superimposition of anatomic structures.

Methods: A total of 350 CBCTs were examined in this study. The analysis was conducted using the GALILEOS Viewer computer software program equipped with a disk containing the CBCT data. The Vertucci classification was used to categorize the data and the chi-square test to compare age groups, gender, and mouth sides.

Results: Twenty-one two-handed CBCTs met the study criteria. Mandibular 2nd molar teeth were examined, and type 2 canal configuration was the most prevalent in the mesial root (57.1%), whereas type 1 canal configuration was the most prevalent in the distal canal (96.5%). Gender had no significant effect on the root canals' configuration except for the distal root of the right side. In contrast, age had a significant effect on root canal type, except for the right mesial root. There was a strong correlation between root canal types on the right and left sides.

Conclusions: Type 1 and 2 root canal types were most prevalent in the distal and mesial root canal. Age was found to affect root canal type, and a correlation between right and left side root canal types was detected.

Keywords: *Mandibular 2nd molar, CBCT, Vertucci classification, Root canal system.*

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Introduction

Human molar teeth demonstrate considerable anatomic complexities and abnormalities in the number of roots and root canals. Many reports have identified unusual morphology both in maxillary and mandibular molar teeth[1]. The roots and root canals of mandibular second molars (MSM) are usually closer together. They can be fused to a single conical root with varying internal anatomy or C-shaped canal systems[2]. Such features are genetically and racially determined[3,4].

Accurate diagnosis of the root canal system before undertaking endodontic therapy is crucial; more than one radiograph is necessary to assess the roots and root canals[5]. Limitations in two-dimensional conventional radiography emphasize the need for three-dimensional imaging, known as cone-beam computerized tomography (CBCT) (also known as cone-beam volumetric tomography or as cone-beam volumetric imaging (CBVI)[6].

Endodontic treatment usually fails when the treatment is carried out inadequately[7]. The anatomy of the root canals is one of the factors affecting endodontic treatment[8]. CBCT can provide the clinician with the ability to observe three different planes[9] and thus to acquire three-dimensional (3D) information. The combination of sagittal, coronal, and axial CBCT images eliminates the superimposition of anatomic structures. Root morphology can be visualized in three-dimensional images with the number of root canals and their orientation. These advantages allow the clinician more accurate information on the true morphology of root canal systems[10]. Thus, this study aims to determine the number and morphology of root canals in MSM.

Materials and methods

Study design and sample

A total of 350 CBCT radiographs by Sirona 3D machine (GALILEOS comfort plus; model 2016) with the following parameters (98KV, 25mA, 14 second exposure time, and field of view of 8.5cm*8.5cm), taken for various reasons (mainly for examination, pathologies, and dental implant), were screened in this retrospective cross-sectional study from June 2020 to August 2020. This study obtained ethical approval from the Faculty of Medicine (ethical approval number: 402), University of Sulaimani.

Measurements and study outcome

The observations were done using the GALILEOS Viewer computer software program equipped with a disk containing the CBCT data.

The inclusion and exclusion criteria were as follows: age ≥ 15 years old, as the MSM, erupt after the age of 11 years and root growth is complete by the age of 14.8 years[11], no contrast media in the image as that could affect the appearance of tissues, no endodontically treated teeth, no fixed prosthesis on the MSM and no post supported prosthesis in the roots[10].

The images were reworked according to the panoramic view (to adjust the view), axial plane (to assess the number of canals), cross-sectional plane (to assess the morphology of the canals), and tangential "lateral" plane (to assess the number of roots and adjust the inclination of the cross-sectional view). The computer mouse cursor was scrolled in the coronal apical direction first, and then in the apical coronal, to obtain a detailed view of the root canal system of the MSM. This action was repeated three times, and when the images in the axial plane were unclear, the teeth were also inspected in a three-dimensional view. During the examination of the teeth, the root canals in each root, and the configuration of the root canal system were determined and recorded according to the Vertucci classification (Figure 1)[5,9]. Figure 2 shows the root canal types observed in the study.

The Vertucci classification of root canal configurations is as follows[10,12]:

1. Type I is a single canal that extends from the pulp chamber to the apex (1-1).
2. Type II is two separate canals leaving the pulp chamber and joining near the apex, forming a single canal (2-1).
3. Type III is one canal, with the pulp chamber dividing into two within the root and uniting again in a single canal (1-2-1).
4. Type IV is two separate and distinct canals that extend from the pulp chamber to the apex (2-2).
5. Type V is one canal within the pulp chamber divided into two near the apex, with distinct apical foramen (1-2).
6. Type VI is two separate canals from the pulp chamber, united in the root's body and re-dividing close to the apex, with distinct apical foramen (2-1-2).

7. Type VII is one canal in the pulp chamber, dividing into two, then uniting in the body of the root, and finally re-dividing into two canals near the apex (1-2-1-2).

8. Type VIII is three separate and distinct canals that extend from the pulp chamber to the apex (3-3).

This classification was used to assess single roots and therefore applied more than once in each tooth (for mesial and distal roots). Both the right and left side of each patient's mouth was examined. When the tooth had only one root, it was considered as one mesial root in the analysis. The subjects were divided into six age groups: 16-19, 20-29, 30-39, 40-49, 50-59, and above 60.

Statistical analysis

The collected data were analyzed by statistical software package SPSS 26 (SPSS Inc., Chicago, IL, USA); the frequencies of each type were recorded and tabulated (mean, standard deviation, and totals). The chi-square test was used to examine the relation of number and shape of canals vs. age, gender, and side (right and left).

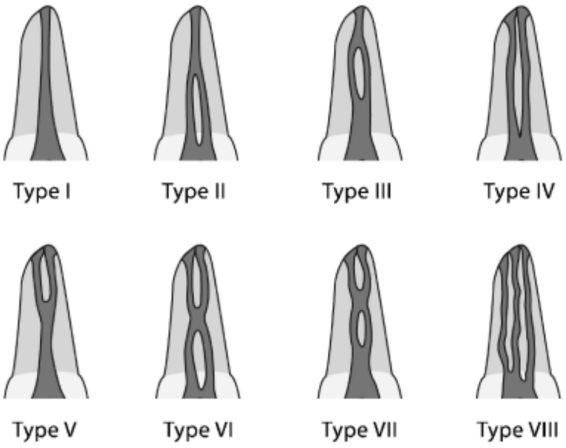

Figure 1: Vertucci classification of the number and morphology of root canals.

Results

The sample initially comprised 350 CBCT radiographs; 221 met the study criteria (129 radiographs were excluded).

The examined CBCTs included 87 (39.4%) males and 134 (60.6%) females, and the age group distribution is shown in Table 1.

The most common type of MSM root canal configuration for the mesial root was type 2 (229 teeth, 57.1%) for both sides, and for the distal root was type 1 (359 teeth, 96.5%) for both sides (Table 2).

The result of this study shows no statistically significant differences in root canal type between males and females except for the right distal root (p-value = 0.04, Table 3).

Subject's age was shown to have a statistically significant impact on root canal type in the right distal (p = 0.03, left mesial (p = 0.05) and left distal (p = 0.006) root canals. However, no statistical differences based on age were found in the right mesial root canal types (p = 0.37) (Table 4).

Finally, there were statistically significant correlations of root canal types between right and left sides for both mesial root (r= 0.47, p = 0.000.1) and distal root (r= 0.3, p=0.0001) as shown in Table 5.

Discussion

As the configuration of the root canal system is not always predictable, especially for molar teeth, this can lead to missed canals during endodontic treatment and subsequent endodontic failure. This study was conducted to identify the most frequent types and configurations of mandibular 2nd molar teeth in a Kurdish population as an addition to previous studies done worldwide.

Classification of the root canal system may be based on the following morphological features:

1. the number of canals from orifice to the apex.

2. the number of roots and the number of canals in each root.

3. the number of isthmuses.

Vertucci classification is based on the 1st feature, as this method is more rational and convenient to apply.[13]

The current study is based on the rationale that there is variation in root canal types of MSM in different populations. Thus, this study aimed to identify the root canal types within a Kurdish population. CBCT images provide three-dimensional images that overcome many of the limitations of conventional radiographs, such as panoramic and periapical views[14]. In addition, because the reconstruction of CBCT data is performed natively

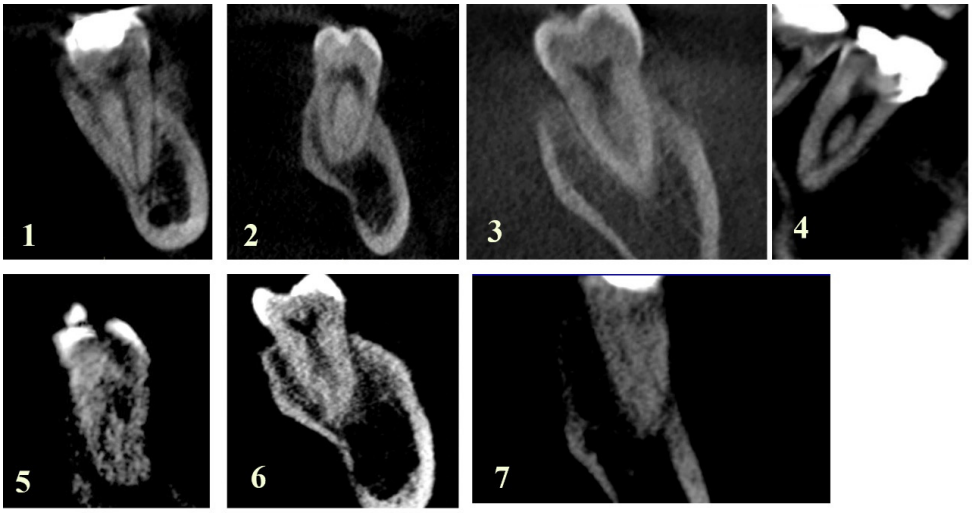

Figure 2: Showing all root canal types observed in this study: (1) Type 1, (2) Type 2, (3) Type 3 in the distal root, (4) Type 3 in the mesial canal, (5) Type 4, (6) Type 5, (7) Type 6.

Table 1: Study sample according to age group distribution.

Age groups	Range	Frequency	Percentage
Age group 1	15-19 years	14	6.3
Age group 2	20-29 years	62	28
Age group 3	30-39 years	64	29
Age group 4	40-49 years	52	23.5
Age group 5	50-59 years	19	8.6
Age group 6	Above 60 years	10	4.5
Total		221 (100%)	

Table 2: Frequency distribution by root canal type.

Side	Root canal classification					
	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6
Mesial root both sides (Total 401)	48 (12%)	229 (57.1%)	29 (7%)	88 (22%)	2 (0.7%)	5 (1.2%)
Distal root both sides (Total 372)	359 (96.5%)	4 (1%)	6 (1.7%)	0 (0%)	3 (0.8%)	0 (0%)
Total	407	233	35	88	3	5

Table 3: Comparison of root canal shapes between males and females.

Side	Gender	Root canal types						*p-value
		Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	
Right mesial	Male	8	43	5	20	0	0	0.34
	Female	14	73	11	24	1	3	
Right distal	Male	65	3	1	0	0	0	**0.04**
	Female	113	0	1	0	0	0	
Left mesial	Male	10	46	3	20	0	0	0.6
	Female	16	67	10	24	1	2	
Left distal	Male	71	1	2	0	1	0	0.5
	Female	110	0	2	0	0	0	

* chi-square test

Table 4: Root canal shapes according to age group distribution.

Side	Age group	Root canal type						*p-value
		1	2	3	4	5	6	
Right mesial	1	1	8	1	4	0	0	0.37
	2	6	32	6	13	0	0	
	3	7	34	4	15	1	1	
	4	4	32	2	8	0	1	
	5	1	7	3	2	0	1	
	6	3	3	0	2	0	0	
Right distal	1	13	0	0	0	0	0	**0.03**
	2	49	1	0	0	0	0	
	3	56	0	2	0	0	0	
	4	41	0	0	0	0	0	
	5	12	1	0	0	0	0	
	6	7	1	0	0	0	0	
Left mesial	1	2	7	1	4	0	0	**0.05**
	2	5	32	5	19	0	0	
	3	9	31	4	14	1	1	
	4	7	29	2	5	0	0	
	5	1	11	1	1	0	1	
	6	2	3	0	1	0	0	
Left distal	1	14	0	0	0	0	0	**0.006**
	2	54	0	0	0	1	0	
	3	56	0	2	0	0	0	
	4	39	0	1	0	0	0	
	5	12	1	1	0	0	0	
	6	6	0	0	0	0	0	

* chi-square test

Table 5: Correlation between right and left side and mesial and distal root canal types.

Variables		N	r	Sig.
Mesial root	Right and left side	221	0.47	.0001
Distal root	Right and left side	200	0.3	.0001

using a personal computer, data can be reoriented in their true spatial relationships[15]. This three-dimensional reconstruction provides the only means for visualizing the morphology of the root canal system.

Within the root canal system, this study identified more variability in the mesial root than the distal root. This result is in line with previous studies[3,4,9,16,17] which found that the distal root had only one canal. One apical

foramen with two canals was the most frequently recorded mesial root type.

The results show a strong correlation between the right and left sides, which can be explained by the genetic determination of the root canal configuration[11].

The type of variability is crucial when the dentist is dealing with the mandibular 2nd molar, and the best tool to ensure correct diagnosis and treatment is CBCT. Six types of root canal system variability have been recorded in this study, which provides a sufficient basis for clinicians to use CBCT as a tool before or during endodontic treatment.

Limitations regarding the use of CBCT include the fact that it is not available in all dental clinics or, consequently, to all dentists; additionally, there are cost implications as this type of imaging is expensive.

Conclusions

1. Type 1 root canal was the most common in the distal root, whereas type 2 was the most common type in the mesial root.
2. Right distal root canal types differed between males and females.
3. Types of root canals in MSM varied among the different age groups except in the case of the mesial root on the right side.
4. Root canals in the mesial root tend to be of the same type on the right and left sides. Furthermore, root canals in the distal root tend to be of the same type on both the right and left sides.
5. A systematic review is necessary to establish strong evidence about the number and morphology of the root canal system for all teeth, especially the posterior teeth.

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