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(RESEARCH ARTICLE)

Prevalence of C-shaped canal morphology of first and second mandibular molars using Cone-Beam Computed Tomography

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Abstract

Introduction: Due to the importance of familiarity with root canal morphology in order to completely clear the canal and achieve treatment success, the aim of this study was to use Cone-Beam Computed Tomography (CBCT) images to evaluate the frequency and anatomy of C-shaped canals in the first and second mandibular molars.

Materials and Methods: In this cross-sectional study, CBCT images of 209 patients (435 teeth) were evaluated to determine the presence of C-shaped canals and their anatomical morphologies along the root, based on Fan classification. Bilateral or unilateral occurrence of C-shaped canals and their relationship with gender, age and tooth location were examined and statistically analyzed using the chi-square test and SPSS 17 software. The significance level was $P < 0.05$.

Results: CBCT images from 209 patients, 103 patients (49.3%) were female and 106 (50.7%) were male. Out of 435 teeth (157 mandibular first molars and 278 mandibular second molars) evaluated, 33 specimens (7.5%) including the 2 first molars (1.27%) and 31 second molars (11.15%) had a C-shaped canal system which were from 25 patients (2 first molars in 2 patients and 31 second molars in 23 patients). The prevalence of bilateral C-shaped canals was among the 97 patients with bilateral second molars (6.18%). There was also no significant relationship between teeth position, gender and the prevalence of C-shaped canals.

Conclusion: The configuration of C-shaped canals extensively changes along the length of the root and should be considered during preparation and obturation of root canal system.

Keywords: C-shape; Cone-Beam Computed Tomography; Root canal morphology

1. Introduction

The main purpose of root canal treatment is to completely clean and debridement of root canals and unpredictable changes in the condition of the root canal can cause challenges in canal debridement, so dentists must be aware of different types of root canal morphology and have a mental image of the shape of the root canal from the coronal to the apical foramen (1, 2).

Among the morphologies of root canals, there are C-shaped canals, which debridement and obturation of this form of canals in endodontic treatments is complicated, and the most common cause of endodontic treatment failure in C-shaped canals is the existence of secondary canals isthmuses (3). C-shaped canals are one of the challenging variations of dental anatomy that are more commonly seen in mandibular second molars; in such a way that a groove or network

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connects the individual channels to each other in such a way that they form a shape similar to the English letter C at the opening of the channel (4, 5).

The studies conducted in the past towards the anatomy of C-shaped canals were invasive studies and performed on extracted teeth (6). Periapical radiographs can also be used to diagnose C-shaped canals, but since the two-dimensional image is not able to accurately represent the morphology of the root canal, other imaging modalities such as cone beam computed tomography (CBCT) are widely used due to their ability to reduce or eliminate superimpositions, and also allows the dentist to observe internal and external anatomical features, including buccal and lingual grooves (7). CBCT equipment is much smaller in size and occupying physical space compared to conventional CT and also costs about a quarter to a fifth less. These two characteristics make this technique available for the dental office (8).

The classification of these channels was introduced for the first time by Melton and his colleagues in 1991 (9), and by making changes in this classification, Fan and colleagues reported a new one (10).

A growing number of studies have investigated the prevalence of C-shaped canals in different populations, and two-dimensional, three-dimensional radiographs or clinical observations have been used in their study methods (11, 12).A systematic review by Martins et al. was conducted on 25445 teeth of 13142 patients and the prevalence of c-shaped canals in first and second molars were 0.3% and 12% respectively. (13). The purpose of this study was to investigate the frequency and anatomical configuration of C-shaped canals mandibular molars among a group of Iranian population by CBCT.

2. Material and methods

This cross-sectional study was conducted on 209 CBCT archive images of patients referred to the oral and maxillofacial radiology Center in Gorgan. Study was approved by the ethics committee of Golestan University of Medical Sciences (IR.GOUMS.REC.1399.217). Inclusion criteria were first and second mandibular molars with sound roots without caries, restoration or apical lesion and exclusion criteria were presence of periapical lesion, recession, metal post and core and endodontic treatment.

CBCT system (Carestream Health, USA) (voxel size: 150, kv: 90, mA: 15) was used. The cutting distance of 300 microns with a thickness of 1 mm was used and CS imaging software Kodak (version 7.0.20.1.d47) was used to reconstruct cross-sectional images. After data collection by an oral and maxillofacial radiologist and an endodontist, the results were confirmed with a correlation coefficient of 95%.

The C-shaped root canal was approved based on following criteria according to the Fan classification in transverse sectioning method (10):

- C1 = root canal in the form of an uninterrupted

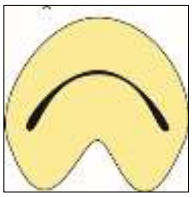

Figure 1 C1 root canal in the form of an uninterrupted

- C2 = root canal semicolon-shaped, with angle α smaller and angle β larger than 60°

Figure 2 C2 root canal

- C3 = root canal in the form of separate canals, with angles α and β smaller than 60°

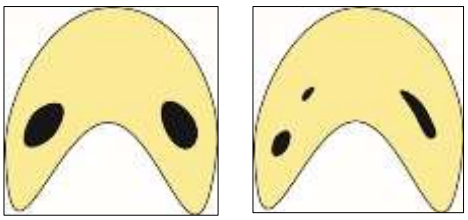

Figure 3 C3 root canal

- C4 = a single round or oval root canal
- C5 = absence of a root canal lumen

Criteria for C-shape root canals were also as follows:

- Cohesive roots,
- Longitudinal groove on the lingual or buccal surface,
- Canal located in one of the 3 shapes (C3, C2, C1) at least in one section.

The C-shaped canals were identified in five sections including the orifice (beginning of canal), middle coronal (2 mm below the orifice), middle (half length of the root), middle apical (2 mm above the apex) and apical (end of the root).

Statistical analysis was performed using SPSS17 software. Quantitative data were provided with mean and standard deviation and qualitative data was recorded as frequency (percentage). The presence of unilateral or bilateral C-shaped canals was recorded in patients with both mandibular second molars and the relationship between incidence, age and tooth position (right or left) was determined. A significance level of 0.05 was considered.

3. Results

CBCT images from 209 patients including 435 teeth (157 first molars and 278 mandibular second molars) were included in the study. 103 patients (49.3%) were female and 106 (50.7%) were male.

From 209 patients and 435 teeth, C-shaped canals were observed in 25 patients 33 teeth. From 435 teeth 33 teeth (7.5%) had a C-shaped canal (2 from 157 first molars (1.27%) in two patients and the 31 from 278 second molars (11.15%) in 23 patients).

Out of 25 patients with C-shaped canal, 14 patients had unilateral and C-shaped second molars and 11 patients had bilateral mandibular second molars, of which 6 (54.5%) had C-shaped canals Bilaterally and 5 (45.5%) had it unilaterally.

Table 1 97 patients with bilateral second mandibular molars having unilateral and bilateral C-shaped canals

Age	Bilateral c-shaped		Unilateral c –shaped				Bilateral second molars	
	Male	Female	Left		Right			
			Male	Female	Male	Female	Male	Female
≤20	1	0	1	0	0	0	10	6
21-30	1	0	0	0	0	1	6	10
31-40	1	1	0	0	0	1	19	16
41-50	0	2	0	0	1	1	13	9
≥50	0	0	0	0	0	0	5	3
Total	3 (5.7%)	3 (6.81%)	1 (1.8%)	0 (8.7%)	1 (1.8%)	3 (6.8%)	53	44
	6 (6.18%)		1 (1.03%)		4 (4.1%)		97	

According to table 1, from 209 patients, 97 patients had bilateral second mandibular molars, 6 (6.18%) had bilateral C-shaped canals and 5 (5.15%) had unilateral form.

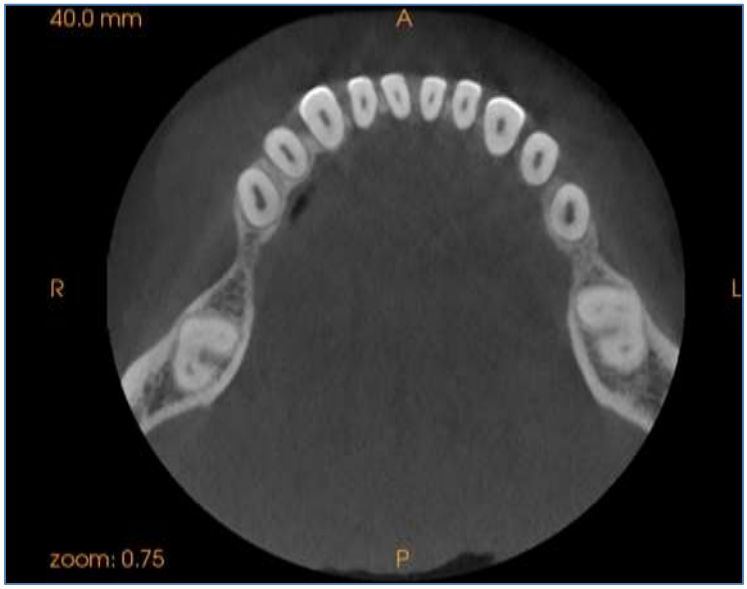

Figure 4 Bilateral C-shaped canal in bilateral second molar

According to Table 2, among all the C-shaped roots, there were 57.5% on the right side and 42.5% on the left side of the mandible. The relationship between the frequency of C-shaped canal and tooth position (left or right jaw) was not significant (p value = 0.121). Also, out of 33 teeth with C-shaped channels, the groove location was in 13 cases in buccal and lingual, 17 cases in lingual and 3 cases in buccal.

Table 2 Distribution of C-shaped roots based on tooth position

age	teeth position			
	left		right	
	male	female	male	female
≤20	1	1	1	0
21-30	2	0	2	2
31-40	4	0	4	3
41-50	1	2	2	3
>50	0	3	0	2
Total	8	6	9	10
N (%)	14 (42.42%)		19 (57.58%)	

The mean age of the patients was 52 years in the range of 12-81 years. C-shaped canal was more common in female patients with a prevalence of 13.5%, compared with a prevalence of 10.3% in men. There was no significant relationship between the occurrence of C-shaped canal with age (p value = 0.07) or sex (p value = 0.47) (Table 3).

Table 3 Distribution of C-shaped roots based on age and gender

	age				
	≤20	**21-30**	**31-40**	**41-50**	**>50**
Total (n)	**19**	**41**	**68**	**52**	**29**
Patients with C-shaped canals	2 (10.8%)	5 (12.9%)	8 (11.76%)	6(11.53%)	4 (13.79%)
	gender				
	male		female		
Total	106		103		
Patients with C-shaped canals	11 (10.37%)		14 (13.59%)		

In this study, changes in the anatomical shape of the 33 C-shaped canals from the orifice to the apex were also examined. Three teeth (9.09%) had the same canal shape from the orifice to the apex. Other teeth had different shapes of the Fan classification system at different cross-sections of their canal. Most of the C-shaped canals observed in Orifis, the middle part of the roots and apex were respectively C1, C3b and C4 shaped (Table 4).

Table 4 Canal morphology among 33 C-shaped canals based on Fan classification

teeth	**Canal morphology**	**Root sections**				
		Orifice (%)	**Coronal Middle (%)**	**Middle (%)**	**Apical Middle (%)**	**Apex (%)**
First molar	C1	2 (100%)	1 (50%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	C2	0 (0.0%)	1 (50%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	C3a	0 (0.0%)	0 (0.0%)	1 (50%)	0 (0.0%)	0 (0.0%)
	C3b	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
	C4	0 (0.0%)	0 (0.0%)	1 (50%)	2(100%)	2 (100%)
	C5	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Second molar	C1	28 (90.34%)	11 (35.48%)	5 (16.12%)	5 (16.12%)	5 (16.12%)
	C2	1 (3.22%)	11 (35.48%)	8 (25.81%)	4 (12.93%)	1 (3.22%)
	C3a	1 (3.22%)	3(9.68%)	8 (25.81%)	6 (19.35%)	2 (6.45%)
	C3b	0 (0.0%)	3(9.68%)	7 (22.58%)	5 (16.12%)	5 (16.12%)
	C4	1 (3.22%)	3(9.68%)	3(9.68%)	11 (35.48%)	16 (51.62%)
	C5	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (6.47%)

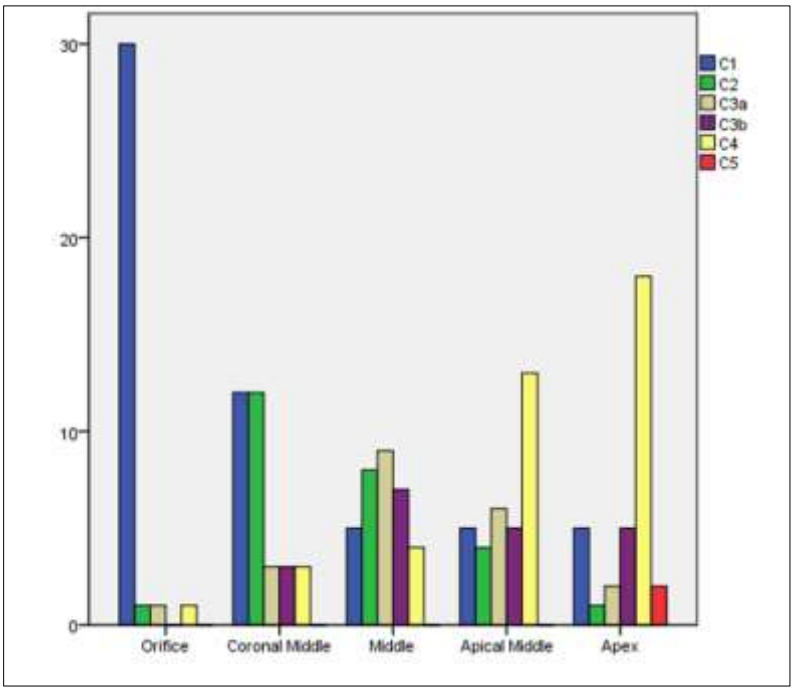

Figure 5 Prevalence of canal morphology among teeth with 33 C-shaped canals

4. Discussion

Various studies showed that C-shaped canals as a complex anatomical variation is more frequent in mandibular molars (14). Presence this phenomenon in root canals is one of the reasons for the failure in the root canal treatment of mandibular molars, and for this matter to be managed, dentists should select among the various instruments for canal preparation and use other devices such as: microscope for magnification and ultrasonic tips to activate different irrigation solutions and remove tissue from the branches of the dental canal (15).

In this study, we tried to use in-vivo images instead of in-vitro images in order to reconstruct the clinical conditions of the patient. Besides that, considering that one of the disadvantages of CBCT images is imposing a high dose of radiation on the patient, we used the CBCT images available in the radiology archive.

According to the results of the present study, the prevalence of C-shaped canals in this study was 1.27% in the first molars and 11.15% in the second molars, which is more than the number reported in the study of Shemesh et al. (8) which was 0.16% in mandibular first molar and 4.6% in the second molar. The study by Martins et al. (13) reported the prevalence of 0.6% in the first molar of the mandible and 8.5% in the second molar of the mandible. In the study of Helvacioglu et al. (16), which was conducted based on using CBCT on the population of Turkey, the prevalence of C-shaped canals in the second molar of the mandible was shown to be 8.9%, which is lower than the prevalence reported in this study.

In this study, out of 25 patients who had c-shaped canals, 54.5% of the cases of C-shaped canal system were bilateral, and this result was similar to Zheng's (5) study conducted in China and different from the results obtained by the study by Ladria et al. (17) which reported the prevalence of c-shaped canals bilaterally as 31.7%. Therefore, dentist must be aware of the high probability of a mandibular molar to have a c-shape canal in the opposite tooth if a patient has a C-shaped canal on the lower jaw.

In this study, C-shaped canal was more common in female patients with a prevalence of 13.5%, compared with a prevalence of 10.3% in men but there was no significant relationship between the occurrence of C-shaped canal with age or sex. Martins et al. (13) reported no significant relationship between the prevalence of c-shaped canals with age and gender.

Various studies have shown that C-shaped canals vary along the root canal system in terms of shape and number (18). According to Melton et al.'s study (9), the C3 canal configuration is the most common form. Based on this study, the most prevalent C-shaped canal observed in the orifice, middle section and apical section were C1 and C3b and C4 respectively.

Studies have shown that in comparison to C1 and C2, C3 and C4 canal types are more difficult to, therefore, using the alternative technique such as ultrasonic technique are more effective in cleaning the coronal part of C-shaped canals.

According to Fan's classification for dental grooves, knowing the location of the longitudinal groove is very important to prevent complications during root canal treatment. In this study, the location of the groove was found in 13 cases (39.39%) in buccal lingual position, 17 cases (51.52%) in lingual and 3 cases (9.09%) were in buccal, which is consistent with the study of Alfawaz (19), Helvacioglu (16) and Martin et al (13).

5. Conclusion

The present study showed that there is considerable variation in the number of roots and the morphology of mandibular first and second molar canals and the anatomy of C-shaped canals was different in along the root. Therefore, dentists should not assume that the molar and second mandible always have two roots and three canals. Considering the difference in the prevalence and anatomy of C-shaped canals in different parts of the world, further studies are needed to determine its prevalence and anatomy in different native populations. It is suggested to investigate the prevalence and anatomical diversity of C-shaped canals in other regions of Iran.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The present research work does not contain any studies performed on animals/humans subjects by any of the authors.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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