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RESEARCH ARTICLE

Prevalence of Root Canal Configuration of Mandibular Second Molar Using Cone-Beam Computed Tomography in a Sample of Iraqi Patients

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ABSTRACT

Introduction: The purpose of this study was to find out the prevalence of C-shaped canals configurations in mandibular 2nd molar and to investigate the gender prevalence. **Materials and Methods:** A sample of 1200 patients' cone beam computed tomography (CBCT) scans were screened and evaluated by a maxillofacial radiologist assessed the axial, sagittal, and coronal sections. Inclusion criteria applied to 801 patients (452 females and 349 male) aged 14–75 years were included in this study with total of 1567 mandibular 2nd molar was evaluated. Inclusion criteria: Available CBCT images of mandibular posterior teeth with at least one mandibular 2nd molar in the scan, absence of root canal treatment, absence of coronal or post coronal restorations, absence of root resorption or periapical lesions, and high-quality images. Canal configuration was classified by criteria's which described by Fan et al. (2004): (i) Fused roots, (ii) a longitudinal groove on the buccal or lingual surface of the root, and (iii) at least one cross-section of the canal belongs to the C1, C2, or C3 configuration. **Results:** Considering 801 patients, 97 (12.1%) patients females 57 (7.1%) and 40 (5%) males had a C-shaped canal with no statistical difference between females and males ($P > 0.05$). **Conclusion:** The occurrence of C- shaped canal mandibular 2nd molar is approximately 12.1% and no significant difference was found by gender.

Keywords: C-shaped canal; Cone-beam computed tomography; Mandibular 2nd molar; Root canal morphology; Root canal treatment

INTRODUCTION

C-shaped canal morphology is based on the cross section of the root and canal which resembles the shape of a letter C (Fan et al., 2004). As it would be expected, this morphological complexity creates considerable challenges with respect to debridement, disinfection and canal filling procedures, which eventually may influence the prognosis of the root canal treatment (Amoroso-Silva et al., 2015).

Historically, the presence of C-shaped canal anatomy in teeth was first identified in the 18th century (Malpighi, 1743; Hunter and Combe, 1778) and described in details at the beginning of the 20th century (Keith and Knowles, 1911; Keith, 1913). However, it took several decades of technological improvement in endodontics until this knowledge could be applied for the efficient clinical management of C-shaped anatomy (Cooke and Cox, 1979).

Etiology of C-shaped canal belongs to failure of the Hertwig's epithelial root sheath to fuse on the buccal or lingual root surface is the main cause of C-shaped roots, which always include a C-shaped canal. The C-shaped root may also be formed by coalescence because of deposition of the cementum with time (Manning, 1990).

Cone beam computed tomography (CBCT) considered to be sufficient precisely to perform root canal morphological analysis and is a valuable tool to evaluate the C-shaped root canal configuration *in vivo* (Neelakantan et al., 2010; Zhang et al., 2011; von Zuben et al., 2017). Its features allow the clinician a more profound understanding of true morphology of the root canal systems (Wang et al., 2010).

The prevalence of a C-shaped canal in mandibular 2nd molars has been estimated to range from 2.7% to 44.5%, depending on the population and ethnic groups: 2.7–7.6% for American (Cooke and Cox, 1979; Weine, 1998), 3.5% for Brazilian population (Silva, 2013), 8% for Turkish (Cimilli et al., 2005; Helvacioglu-Yigit and Sinanoglu, 2013), 10.6% for Saudi Arabian (Al-Fouzan, 2002), 19.1% for Lebanese (Haddad et al., 1999), 31.5% for Chinese (Yang et al., 1988), and 32.7–44.5% for Korean populations (Seo and Park, 2004; Jin et al., 2006).

Understanding of root canal anatomy and variation between ethnic groups is a fundamental for clinicians to assist carrying out an effective root canal treatment (RCT) (Vertucci, 1984).

The aim of this study was to use CBCT images to evaluate the prevalence of C-shaped canals in the permanent mandibular 2nd molars of members of an Iraqi Kurdish subpopulation and its prevalence in accordance to gender.

MATERIALS AND METHODS

Evaluation was made for the radiographs of the patients' mandibular 2nd molars who were referred to DENTA Radiologic Center at Erbil, Kurdistan region, Iraq between 2013 and 2015, regardless of gender or age, thus characterizing a convenience sample.

The inclusion criteria were as follows:
1. Mandibular second molars with fully developed roots
2. No periapical lesions
3. No root canal treatment
4. No roots with open apices or resorption, no root canals with calcification
5. CBCT images of a good quality.

A sample of 1200 patients' CBCT images were screened and evaluated by a maxillofacial radiologist. Inclusion criteria applied to 1567 mandibular 2nd molar which belongs to 801 patients (452 females and 349 male) aged 14–75 years. The images were analyzed for unilateral and/or bilateral occurrences of C-shaped canals.

The CBCT images were performed using NewTom GiANO CBCT (Bologna, Italy), operating at high frequency 60–90 KV; 1–10 MA pulse mode and 0.5 mm focal spot. All CBCT exposures were taken by an appropriately licensed radiologist.

NNT software was used to analyze the CBCT images. The brightness and contrast of the images were adjusted using the image processing tool in the software to insure the optimal visualization in the axial sections of the roots. The images were evaluated by a maxillofacial radiologist with 5 years' experience in performing CBCT under suitable light conditions.

Determining of the C-shaped canal configuration in a mandibular 2nd molar required that the tooth manifest all of the following features listed from those described by Fan et al. (2004).
i. Fused roots,
ii. A longitudinal groove on the lingual or buccal surface of the root
iii. At least one cross-section of the canal belongs to the C1, C2, or C3 configuration.

Fan's Classification (Anatomic Classification): Fan et al., in 2004 classified the C-shaped canal configuration into the following categories:
1. Category I (C1): The shape was an interrupted "C" with no separation or division [Figure 1a]
2. Category II (C2): The canal shape resembled a semicolon resulting from a discontinuation of the "C" outline [Figure 1b], but either angle ά or β [Figure 2] should be no less than 60°
3. Category III (C3): Two or three separate canals [Figure 1c and d] and both angles, ά and β, were less than 60° [Figure 3]
4. Category IV (C4): Only one round or oval canal in that cross-section [Figure 1e]
5. Category V (C5): No canal lumen could be observed (which is usually seen near the apex only) [Figure 1f].

A succession of axial images from the cervical third to the apical third of the root used to assess the presence of C-shaped canals. Figure 4a and b exhibits an example of a tooth considered as having a C-shaped canal, because it exhibits fused roots along the entire length of the root, a longitudinal groove on the buccal surface of the root, and at least one axial section of the canal that shows the C-shaped canal configuration as indicated by the arrows. While another tooth root as in Figure 5a exhibits a root that fused from the cervical third but it is separated at the apical third of the root [Figure 5b], in this case that tooth not classified as C-shaped canal.

Statistical Analysis

Data were analyzed using IBM SPSS version 25. Descriptive statistics (e.g. number and percentage) were used to represent prevalence of C-shape canal. Pearson's Chi-square test performed to assess the frequency of the

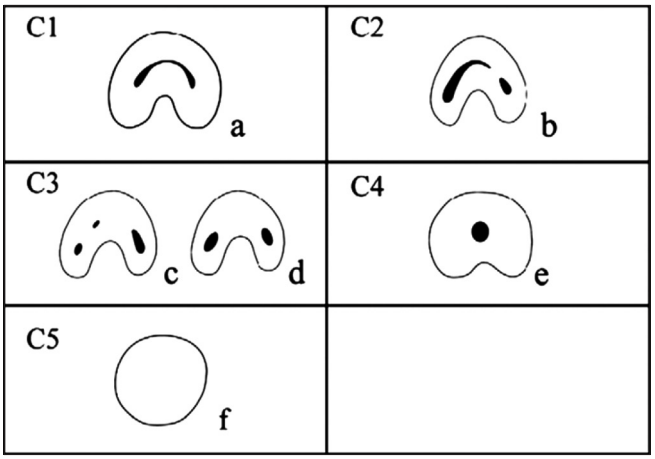

Figure 1: Classification of C-shaped canal configuration (Fan et al., 2004)

numbers of C-shaped canals and the correlations with gender at significant level of $\alpha = 0.05$.

RESULTS

Table 1 summarizes the overall results (in number and percentage) of the prevalence of C-shaped canal in mandibular second molars in which 801 patients had mandibular second molars (unilateral and/or bilateral) with inclusion criteria examined in CBCT images, 97 (12.1%) patients had a C-shaped root canal configuration and 704 patients (87.9%) without C-shaped canal. On the other hand, also as illustrated by Bar chart (Figure 6), the prevalence in accordance to the gender, 57(7.1%) females were presented with C-shaped canal while it was absent in 395(49.3%) about males 40(5%) with C-shaped canal while 309 (38.6%) without C-shaped canal).

Furthermore, Figure 2 which is a Bar chart illustrates the prevalence of presence and absence of C-shaped canal in accordance to gender.

To test the hypothesis of impact of gender on occurrence of C-shaped canal, Pearson's Chi-square test performed between the frequency of C-shaped canal in females and males, and no significant difference was found ($P > 0.05$)

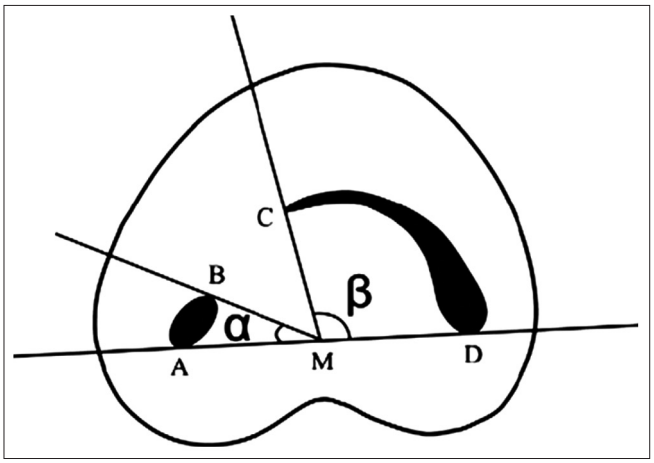

Figure 2: Measurement of angles for the C2 canal. Angle β is more than 60°. (A and B) Ends of one canal cross-section, (C and D) ends of the other canal cross-section; M, middle point of line AD; ά, angle between line AM and line BM; β, angle between line CM and line DM (Fan et al., 2004)

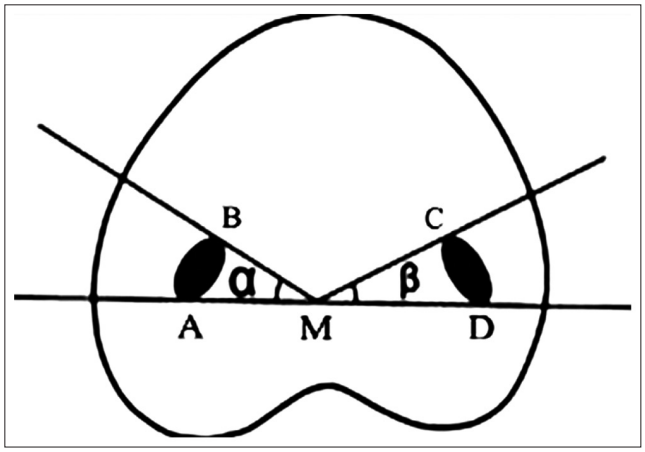

Figure 3: Measurement of angles for the C3 canal. Both angle ά and angle β are less than 60° (Fan et al., 2004)

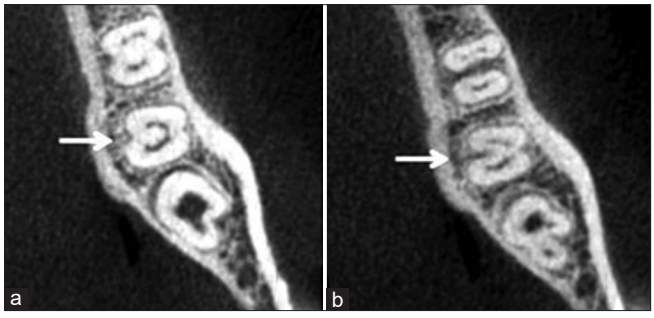

Figure 4: Succession of axial images of a mandibular second molar root. (a) C-shaped canal at cervical third. (b) C-shaped canal at apical third

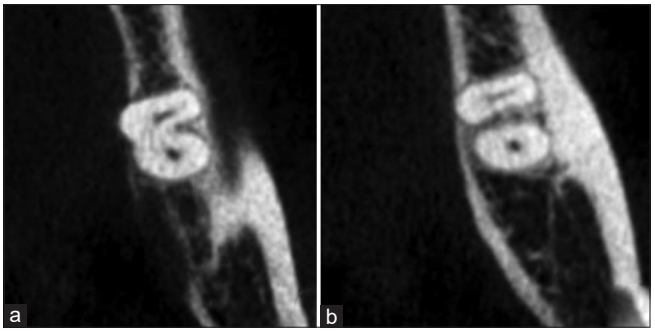

Figure 5: Succession of axial images of a mandibular second molar root: (a) Fused root with C-shaped canal at cervical third. (b) Roots separated at apical third

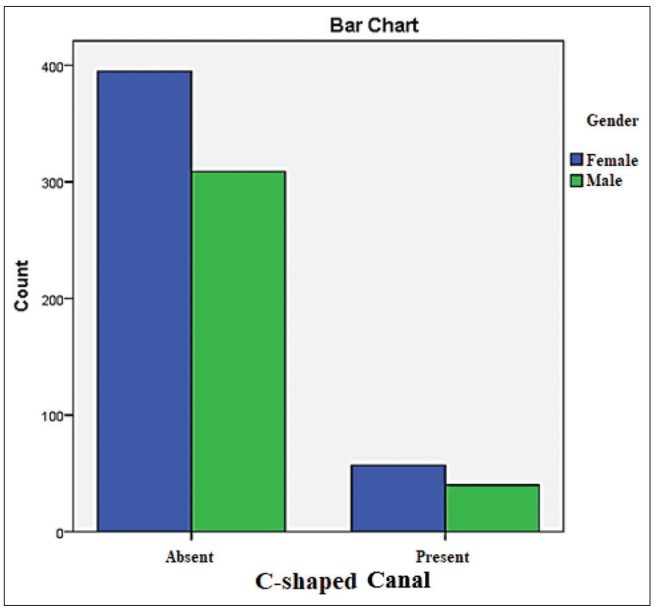

Figure 6: Prevalence of C-shaped canal by gender

Table 1: The prevalence of the C-shaped canal in mandibular second molars (%)

Valid	Frequency (percentage)	Frequency (percentage)
Absent		
Female	395 (49.3)	704 (87.9)
Male	309 (38.6)	
Present		
Female	57 (7.1)	97 (12.1)
Male	40 (5)	
Total	801 (100)	801 (100)

Table 2: Analysis the distribution of C-shaped canals in mandibular 2nd molars by gender

	Value	Df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-square	0.244[a]	1	0.621		
Continuity correction[b]	0.148	1	0.700		
Likelihood ratio	0.245	1	0.620		
Fisher's exact test				0.663	0.351
801					

Chi-square tests (P>0.05)

as shown in Table 2.

DISCUSSION

An ideal technique is one that is precise, uncomplicated, nondestructive, and most significantly, feasible in *in vivo* scenarios (Silva et al., 2013). Based on these components, radiography has been selected for as the foremost viable and as often as possible utilized way to anticipate the root canal anatomy in both laboratory and clinical studies (Neelakantan et al., 2010).

Some studies were utilized micro-CT to inspect root canal morphology. This assessment gives an exact data, but micro-CT cannot be used clinically yet (Liu et al., 2013). Therefore, this study utilized CBCT to assess the canal system configuration of 1567 mandibular 2nd molars in Iraqi individuals to distinguish the prevalence of C- shaped canals.

In literatures, C-shaped root canal configurations were hardly found in Caucasian populations (Cooke and Cox, 1979; Weine, 1998; Cimilli et al., 2005) reported a prevalence of 2.7%, 7.6%, and 8.1% of C-shaped canals, respectively, while Chinese population presented with high prevalence of C-shaped canals, as revealed by Yang et al. (1988), Zheng et al. (2011), and Zhang et al. (2011), (32%, 39%, and 29%, respectively). The C-shaped canal pointed to be the most common in a Korean subpopulation, with a 31%–45% prevalence (Seo and Park, 2004; Seo et al., 2012). These data enhance that canal shape was significantly related to race, with higher prevalence of C-shaped canals in Asians. This occurrence could be justified by presence of a high number of studies in Asian populations and the lack of studies in other populations. In the present study, 12.1% was the prevalence of the C-shaped canal. A study by Silva et al., in 2013, assessed the canal configurations in a Brazilian subpopulation; they found a 3.5% prevalence of C-shaped canals in the 2nd mandibular molars which was much less than our study finding.

In this study, no correlation was found between gender and the prevalence of C-shaped canals. These data are comparable to the findings of Zheng et al. (2011) and Shemesh et al. (2017) which they found no significant difference by gender. On the other hand, these data are in controversy to the findings of Sert and Bayirli, (2004) and Martins et al. (2019), which they stated that gender is an important factor to be take into account in the pre-operative evaluation of canal morphology for root canal treatment. Proper explanations for the impact of gender on canal configuration can only be found by tracing the genetic ancestry of human mankind 200,000 years ago (Hanihara, 2013). The hypothesis of a morphological genetic adaptation in the Asian populations to fit small-sized teeth into smaller jaws is also supported by several systematic studies reporting morphological differences between individuals of different gender in the same species (Karaman, 2006; Macaluso, 2011; Alvesalo, 2009) and helped to enlighten the high prevalence of C-shaped canal morphology in mandibular second molars of females.

The importance of this study should be highlighted, as it evaluated the configurations of C-shaped canals in a sample of the Iraqi Kurdish subpopulation; however, more studies are necessary, considering that a limitation of this study was conducted on a limited local region and population.

CONCLUSION

There was a significant prevalence (12.1%) of C-shaped canals in the mandibular 2nd molars, with no significant difference by gender. CBCT can be a valuable clinical device for carrying out endodontic diagnosis and treatment when conventional radiographic views create restricted information and further radiographic details are desired for endodontic diagnosis and treatment planning.

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