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ORIGINAL ARTICLE

Evaluation of root canal morphology of mandibular premolars in a Saudi population using cone beam computed tomography: A retrospective study

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KEYWORDS

Root canal morphology;
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Abstract *Objective:* To investigate the root canal morphology of mandibular first and second premolars using Cone-Beam Computed Tomography (CBCT) in a Saudi population.

Methods: CBCT images of 707 patients, number of roots and canal configuration were identified and categorized according to Vertucci classification. Bilateral symmetry and association between gender and number of roots, as well as gender and root canal configuration were investigated.

Results: Majority of the patients had one root and type I root canal configuration in mandibular first (96.4%) and second premolar (95.6%). All types of canal configurations were observed except Type VII for the mandibular first premolar, and Types VI and VII for the mandibular second premolar. High degree of bilateral symmetry was seen in both mandibular first and second premolars in terms of the number of roots and canal configuration; 93.8% and 97.8%, respectively. There was an association between gender and number of roots ($P = 0.04$) and gender and root canal configuration in mandibular first premolar ($P = 0.030$).

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Conclusions: Single-root with type I canal configuration was the most prevalent of mandibular premolars in the Saudi population. However, incidence of more than one root with different canal configurations was detected.

1. Introduction

A thorough knowledge of root canal morphology is crucial for the success of root canal treatment (RCT) (Vertucci, 2005). Internal root canal complexities are genetically determined and have a definite importance in anthropology, thereby necessitating the identification of root canal morphologies of different ethnic populations (Neelakantan et al., 2010a). Such complexities, including the number of canals in each root, distances of orifices, and canal types, are more difficult to detect (Neelakantan et al., 2010b).

Studies of the internal and external anatomy of teeth have shown that anatomic variations can occur in all types of teeth and can be extremely complex (Vertucci, 2005). Numerous factors contributing to the variations include ethnicity (Gulabivala et al., 2001), age (Neaverth et al., 1987), gender (Sert and Bayirli, 2004), and study design (Neaverth et al., 1987).

Weine et al. (1969), Vertucci (1984), and Gulabivala et al. (2001) have classified and described the root canal system of human permanent teeth. Vertucci classification is the most commonly used. He classified the root canal configuration into eight categories: Type I (1), Type II (2-1), Type III (1-2-1), Type IV (2), Type V (1-2), Type VI (2-1-2), Type VII (1-2-1-2) and Type VIII (3) (Vertucci, 1984).

Root canal configuration had been identified using different methods such as 2D radiography, root canal staining, hard tissue section, micro-CT and Cone-beam computed tomography (CBCT) scanning. Cone-beam computed tomography scanning is a non-invasive 3D imaging technique. Tachibana and Matsumoto (1990) introduced it in the field endodontics. It provides images of root morphology with more details than those obtained by conventional periapical radiography that will help in improving the endodontic treatment outcomes (Patel et al., 2007).

Cone-beam computed tomography has been used to evaluate the root canal morphology of maxillary premolars and first molar as well as mandibular molars of Saudi population (Alfawaz et al., 2018; Alqedairi et al., 2018; Al-Shehri, 2017; Elkady and Allouba 2013). The root canal morphology of mandibular premolars has not evaluated yet. Therefore, the aim of the study was to investigate the root canal morphology of mandibular first and second premolars using CBCT in the Saudi population.

2. Materials and methods

All procedures performed were in accordance with the ethical standards of the local institutional review board. Seven hundred and seven CBCT images of patients (396 female, 311 male) aged between 16 and 78 years who required routine dental treatment, and were subsequently referred to the Radiology Department were subsequently referred to the Radiology Department of College of Dentistry, King Saud University between 2015 and 2017, were collected. No informed consent was required for this type of study based on institutional review board.

The inclusion criterion was the existence of at least one mandibular first or second premolar with fully developed roots. Exclusion criteria included unclear or distorted CBCT images, previous endodontically treated or initiated teeth, posts or crowns, periapical lesions, and the presence of physiological or pathological process such as root resorption. In total, 391 first mandibular premolar teeth and 343 mandibular second premolar teeth were evaluated in terms of the root number and canal configuration.

The following data was observed and recorded: number of roots, number of canals per root and canal configuration based on Vertucci's classification. The gender and age of the patients were also recorded.

Two independent endodontists assessed the root and root canal system configuration using the Planmeca Romexis Viewer software (Planmeca, Roselle IL). The CBCT machines used were CS9300 3D digital imaging system (Carestream, USA) with a voxel size of 90–500 μm and Planmeca ProMax 3D (PLANMECA, USA) with a voxel size of $\leq$200 μm.

To ensure the reliability of the research results, 30 images of CBCT were drawn randomly to measure inter-examiner reliability by recording the root canal numbers and identifying the type of root canal system configuration according to Vertucci's classification. Intra-examiner reliability was measured using the same images after 1 week. Both inter- and intra-examiner reliability were calculated using Interclass Correlation Coefficient (ICC). Data was analyzed with the chi-square test using SPSS, and the significance was set at a 95% confidence level.

3. Results

For Inter-examiner reliability, the ICC was 0.886 (excellent) for the number of roots and 0.625 (good) for canal configuration. For Intra-examiner reliability, ICC was 1 for the first examiner in regard to number of root and canal configuration and 1 and 0.95 for the second examiner in regard to number of root canal configuration; respectively. The ICC demonstrated that the procedure was standardized for the evaluations and measurements performed by the two observers.

The number of roots recorded in mandibular first and second premolars was up to three roots (Fig. 1). The majority had one root; 96.4% in mandibular first premolar and 95.6% in mandibular second premolars.

The frequency and percentage of the number of roots and canal configuration in mandibular first and second premolar teeth are shown in Tables 1 and 2 respectively.

Type I was the most prevalent canal configuration in mandibular first premolar and in mandibular second premolar teeth. In mandibular first premolars, 94.7% had one canal apically (type I, II, III), 3.8% had two canals apically (type IV, V, VI) and 1.5% had three canals apically (type VIII). In mandibular second premolars, 94.8% had one canal apically (type I, II, III), 3.5% had two canals apically (type IV,V) and 1.7% had three canals apically (type VIII).

Fig. 1 a: The axial plane of CBCT of mandibular Second premolar showing the three roots. b: The coronal plane of CBCT image. c: The sagittal plane of CBCT image.

Chi-Square and fisher exact tests for mandibular first premolars demonstrated an association between gender and number of roots ($P = 0.046$), and gender and root canal configuration ($P = 0.030$). The prevalence of two-rooted mandibular first premolars in men was higher than that for women, while three-rooted mandibular first premolars were seen in women only ($P \leq 0.05$). However, single-rooted mandibular first premolars were the most predominant root morphology in both genders. Interestingly, canal configuration Type VIII was seen in women only (2.9%).

In mandibular second premolars, there was no association between gender and number of roots nor gender and root canal configuration ($P > 0.05$). However, types II, III, and IV canal configurations were more likely to be observed in men, while types V and VIII were found more frequently in women ($P = 0.069$).

Among the 210 patients having right and left mandibular first premolar teeth, 93.8% of teeth showed a symmetrical number of roots and canal configuration, while 5.2% showed a symmetrical number of roots, but a different canal configuration, and 0.5% showed a symmetrical canal configuration but a different number of roots. However, 0.5% did not show any type of symmetry.

Among 181 patients where mandibular right and left second premolar teeth were present, 97.8% of teeth showed a symmetrical number of roots and canal configuration, while 1.7% showed a symmetrical number of roots, but a different canal configuration. Only 0.5% lacked any type of symmetry.

4. Discussion

Successful root canal treatment is achieved when all the canals are located, debrided, shaped, disinfected, and obturated completely (Al-Dahman et al., 2018; Nallapati, 2005). Reasons related to the failure of root canal treatment include untreated canals, incomplete disinfection, and inadequate obturation (Gulabivala et al., 2001). Therefore, proper clinical and radiographical examinations are mandatory for successful root canal treatment.

Different techniques have been used for the evaluation and assessment of root canal morphology. Recently, the use of CBCT has been considered an excellent clinical tool for this purpose due to its three-dimensional evaluation of the tooth anatomy (Alfawaz et al., 2018; Alqedairi et al., 2018; Al-Shehri et al., 2017; Patel et al., 2009). In addition, it is more reliable and yielded a high level of reproducibility regardless of changes in tooth positions (Lund et al., 2010; Michetti et al., 2010).

The number of root canals in mandibular first premolar teeth was reported to be one canal in 69.3–86%, two canals in 14–25.5% (Green, 1973; Pineda and Kuttler, 1972; Vertucci, 1978; Zillich and Dowson, 1973), and three canals in 0.5% (Zillich and Dowson, 1973), and 0.4% (Vertucci, 1978). In mandibular second premolar teeth, the number of root canals was reported to be one canal in 97.5% and two canals in 2.5% of the teeth studied (Vertucci, 1978), while the incidence of three root canals was ranging from 0 to 0.4% (Vertucci, 1978; Zillich and Dowson, 1973). Findings of the current study of second premolar fall in the same range of the previous studies while it is different concerning first premolar. This could be attributed to ethnicity and method of evaluation. Moreover, case reports of mandibular second premolars with four and five root canals have been published (Al-Abdulwahhab and Al-Nazhan, 2015; Macri and Zmener, 2000).

In mandibular first premolars, the most predominant root morphology observed in this study was single-rooted (96.4%), followed by double-rooted (3.1%), and then three-rooted (0.5%). The prevalence of two rooted mandibular first premolars was higher in this study when compared to other studies using the clearing method of extracted teeth in Turkey (0%) (Çalişkan et al., 1995), Iran (2%) (Rahimi et al., 2007), and Jordan (3%) (Awawdeh and Al-Qudah, 2008). Investigations of root canal morphology of extracted teeth considered as invasive studies compared to CBCT. A higher prevalence was reported in Caucasians (10.9%) using radiographs (Trope et al., 1986), Egyptian (3.2%) (Alhadainy, 2013), South Asians (6%) (Singh and Pawar, 2014), and South Saudi subpopulations (18%) (Chourasia et al., 2017), where the clearing technique was the method used. Moreover, a study from a Kuwait population using two-dimensional radiographic evaluation reported a high incidence of two rooted mandibular first premolar teeth (15%), however it evaluated a small

Table 1 The frequency and percentage of the number of roots and canal configuration in mandibular first premolar teeth.

Number of Roots									
			One Root		Two Roots		Three Roots		Total
Frequency (%)		Female	200 (97.5%)		3 (1.5%)		2 (1%)		205 (100%)
		Male	177 (95.2%)		9 (4.8%)		0 (0%)		186 (100%)
		Total	377 (96.4%)		12 (3.1%)		2 (0.5%)		391 (100%)
Canal Configuration									
		Type I (1)	Type II (2-1)	Type III (1-2-1)	Type IV (2)	Type V (1-2)	Type VI (2-1-2)	Type VII (1-2-1-2)	Type VIII (3)	Total
Frequency (%)	Female	180 (87.8%)	7 (3.4%)	8 (3.9%)	1 (0.5%)	3 (1.5%)	0 (0%)	0 (0%)	6 (2.9%)	205 (100%)
	Male	164 (88.2%)	7 (3.8%)	4 (2.2%)	7 (3.8%)	3 (1.6%)	1 (0.5%)	0 (0%)	0 (0%)	186 (100%)
	Total	344 (88%)	14 (3.6%)	12 (3.1%)	8 (2%)	6 (1.5%)	1 (0.3%)	0 (0%)	6 (1.5%)	391 (100%)

Table 2 The frequency and percentage of the number of roots and canal configuration in mandibular second premolar teeth.

Number of Roots									
			One Root		Two Roots		Three Roots		Total
Frequency (%)		Female	164 (95.3%)		6 (3.5%)		2 (1.2%)		172 (100%)
		Male	164 (95.9%)		7 (4.1%)		0 (0%)		171 (100%)
		Total	328 (95.6%)		13 (3.8%)		2 (0.6%)		343 (100%)
Canal Configuration									
		Type I (1)	Type II (2-1)	Type III (1-2-1)	Type IV (2)	Type V (1-2)	Type VI (2-1-2)	Type VII (1-2-1-2)	Type VIII (3)	Total
Frequency (%)	Female	155 (90.1%)	6 (3.5%)	0 (0%)	3 (1.7%)	2 (1.2%)	0 (0%)	0 (0%)	6 (3.5%)	172 (100%)
	Male	154 (90.1%)	9 (5.3%)	1 (0.6%)	6 (3.5%)	1 (0.6%)	0 (0%)	0 (0%)	0 (0%)	171 (100%)
	Total	309 (90.1%)	15 (4.4%)	1 (0.3%)	9 (2.6%)	3 (0.9%)	0 (0%)	0 (0%)	6 (1.7%)	343 (100%)

sample size of twenty teeth (Zaatar et al., 1997). Conventional radiograph does not provide an adequate amount of information when dealing with complicated endodontic cases in clinical practice as the CBCT does. This approach was strongly supported by the American and European association (AAE and AAOMR joint position statement, 2015; European Society of Endodontology, 2014).

The prevalence of three rooted mandibular first premolars (0.5%) was higher in comparison to the study using Radiovisiography on an Indian population (0.2%) (Iyer et al., 2006), and lower than the study of the South Saudi subpopulation (2%) (Chourasia et al., 2017). In general, the occurrence of three rooted canals is rare in mandibular premolars.

Most of the mandibular first premolar teeth had type I canal configuration followed by type II, and type III. Type VIII canal morphologies in which there were three distinct canals were observed in 6 teeth. According to Vertucci's classification (Vertucci, 1984), type I was more frequent (67.39%) than the other canal configurations. The occurrence of multiple canals in mandibular first premolar teeth was reported in a range from 0.2% to 39.5% (Alhadainy, 2013; Chourasia et al., 2017; Green, 1973; Park et al., 2013; Pineda and Kuttler, 1972; Rahimi et al., 2007; Sert and Bayirli, 2004; Vertucci, 1984; Yoshioka et al., 2004). Velmurugan and Sandhya (2009) reported that the incidence of type II canal configuration was 16.6%, while Parekh et al. (2011) reported an incidence of 5%. Only one study dealing with the morphology of first mandibular premolar of Saudi population was published (Chourasia et al., 2017). The findings of the present study are different from Chourasia et al., 2017 study due to differences of methodology of evaluation and number of teeth.

In mandibular second premolar teeth, the major root morphology observed was single-rooted, followed by two-rooted, then three roots. Moreover, most of these teeth exhibited type I canal configuration, followed by type II, and type VIII. These findings were similar to other studies where the incidence of type I was reported to be 93.63% and 98.5% in a Turkish population, respectively (Çalişkan et al., 1995; Ok et al., 2014). Cleghorn et al have reviewed the morphology of root canal system studies in mandibular second premolars and reported an overall incidence of 91% with one canal and 9% with two canals (Cleghorn et al., 2007).

In comparison to a recent CBCT study in a selected German population, one root was found more prevalent in both mandibular first and second premolars, 90.76% and 98.16%, respectively, and with one canal, 77.9% and 96%, respectively (Bürklein et al., 2017), which coincides with the findings in our study. Also, case reports have been published for two rooted mandibular second premolars with 3 root canals (Al-Attas and Al-Nazhan, 2003), and three roots with three root canals (Alenezi et al., 2015).

Ok et al. (2014) and Bürklein et al. (2017) reported that men had significantly more roots and root canals than women in mandibular first premolars. Moreover, Martins et al. (2018) reported that a lower number of roots and higher type I canal configurations were detected in women, while three root canal

system configurations were more prevalent in men with few differences found between the two genders. In the current study, there was an association between gender and number of roots ($P = 0.046$), and gender and root canal configuration ($P = 0.030$) in mandibular first premolars while there was no association between gender and number of roots nor gender and root canal configuration ($P > 0.05$) in the second premolars.

Three studies have compared the degree of symmetry in root canal morphology in contralateral premolars (Johnsen et al., 2017, 2016; Xu et al., 2016). Two of these studies assessed the symmetry using μ-CT and concluded that contralateral premolars can be viewed as a mirror image of each other on the basis of geometrical analysis (Johnsen et al., 2017, 2016). In the other study (Xu et al., 2016), CBCT was used and the results found that few matching contralateral premolars were observed. In our study, however, a high degree of symmetry was seen in both mandibular first and second premolars in terms of the number of roots and canal configuration (93.8% and 97.8%, respectively).

5. Conclusion

Within the limitation of this study, in a Saudi population, the majority of mandibular first and second premolar teeth exhibited a single root with type I canal configuration. However, incidence of more than one root with different canal configurations was detected. Further studies are recommended with a larger sample size for greater representation of a Saudi population. Clinicians should be aware of the complexity of root canal anatomy using the most recent and reliable armamentarium to achieve favorable treatment outcomes.

Ethical statement

The study was independently reviewed and approved by the local institutional review board (No. E-18-3091) at King Saud University and conducted in full accordance with the World Medical Association Declaration of Helsinki.

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Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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