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ORIGINAL ARTICLE

Root canal morphology of maxillary second molars in a Saudi sub-population: A cone beam computed tomography study

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Abstract *Introduction:* Root morphology and canal anatomy of maxillary molars shows several complexities and variations. Knowledge of these is essential for successful endodontic treatment. This study aimed to investigate the morphology of the maxillary second molars in a Saudi Arabian sub-population in relation to gender, age, and nationality, as well as to analyze the anatomical symmetry between the left and right side in each individual.

Methodology: 420 digitized cone-beam computed tomography (CBCT) scans were collected, of which 351 scans met the inclusion criteria. Number of roots and canals at three different levels of the root in each case was counted at all available sides and compared on the basis of the study variables. Statistical significance was set at $P \leq 0.05$.

Results: Most of the patients (n = 323, 92%) had three roots, while two roots (n = 23, 6.6%), four roots (n = 4, 1.1%), and one root (n = 1, 0.3%) were less frequently observed. A significant correlation between female patients and the presence of two canals, while male patients showed a higher correlation with the presence of four canals at all levels. There also was a correlation between

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Saudi participants and the presence of four canals at all levels. No significant correlation in symmetry between the left and right side root canal anatomy was found. There was an inverse relation between the number of canals and age.

Conclusion: Considering the limitations in this study, it appears that the Saudi population is more likely to have three- and two-rooted maxillary second molars, with males and females showing greater tendencies to having three and two roots, respectively.

1. Introduction

Endodontic treatment aims to disinfect the root canals and to seal the root canal system using an inert filling material. However, in many cases, this objective is not achieved due to the presence of bacteria in missed and untreated canals (Nair, 2006). The root canal anatomy found in maxillary molars is highly complex and variable (Badole et al., 2012; Zheng et al., 2010). Failure to acknowledge these variations while treating patients is reflected by the fact that maxillary molars showed the highest rates of endodontic treatment failures (Zhang et al., 2011). Therefore, adequate knowledge of the common anatomy and meticulous radiographic interpretation are essential to provide a successful endodontic treatment.

Many methods in the literature were described to evaluate the root canal anatomy of teeth. The golden standard for *in vitro* assessments is the sectioning technique (Eskoz and Weine, 1995). Other studies have illustrated the use of the clearing technique (Vertucci, 1984), and recent studies have used micro-computed tomography (Ordinola-Zapata et al., 2017). On the other hand, *in vivo* studies rely on either clinical findings obtained under an operating microscope after the preparation of the access cavity (Sempira and Hartwell, 2000), or using cone-beam computed tomography (CBCT) (Robinson et al., 2002). CBCT became an effective adjunctive tool that aids in treatment planning, diagnosis, and follow-up (Patel et al., 2015). It has been considered as accurate as using the modified staining techniques and tooth sectioning in studying the root canal morphology (Neelakantan et al., 2010b; Zheng et al., 2010).

The anatomy of maxillary second molars has been the focus of many studies in different countries (Fernandes et al., 2014; Han et al., 2012; Neelakantan et al., 2010a; Pecora et al., 1992). The anatomical variations in maxillary second molars have a higher incidence than those in first molars (Rwenyonyi et al., 2007). Many studies have highlighted the presence of anatomical variations among different ethnicities and age groups and between genders (Al-Fouzan et al., 2013; de Souza-Freitas et al., 1971; Kim et al., 2012; Lee et al., 2011; Peiris et al., 2008; Plotino et al., 2013; Reis et al., 2013). Most maxillary second molars exhibit three separate roots, with root fusion being the most common variation (Kim et al., 2012; Peikoff et al., 1996; Plotino et al., 2013; Zhang et al., 2014). Symmetry of the anatomy between the right and left sides has also been discussed in the literature, but this aspect has not been thoroughly investigated since most of the published articles were case reports and accounts of incidental findings (Alavi et al., 2002; Plotino et al., 2013; Tian et al., 2016).

Thus, this study aims to investigate the number of roots and root canal anatomy of maxillary second molars using CBCT in a Saudi Arabian sub-population on the basis of gender, nationality, and age, and to assess the anatomical in the same population.

2. Methodology

420 digitized CBCT scans that depicted the maxillary second molars were collected from the Radiology Department, College of Dentistry, Prince Sattam bin Abdulaziz University, Al-Kharj, from December 2015 to February 2019. The records were evaluated retrospectively. All records that were reviewed belonged to patients treated at the College of Dentistry's clinics, all patients have signed a consent stating that, "Any images, radiographs, or test results obtained during the course of treatment may be used for research and academic purposes, however, no personal information will be revealed". 351 scans met the inclusion criteria and were included in the study: non-distorted CBCT scans showing either or both maxillary second molars with fully formed roots in patients aged 18–65 years. Images of teeth treated endodontically or with full-coverage restorations or metallic restorations creating artifacts in the scans were excluded. The number of roots and canals in the coronal, middle, and apical thirds were tabulated. Scans that included teeth from both-sides were compared for anatomical symmetry.

2.1. Image acquisition and evaluation

The CBCT machine used for the scans was the Carestream CS 9300 (Carestream Dent LLC, Atlanta, G, USA), which had the following parameters: a TFT sensor with a continuous mode, scan time of 12–28 s, field of view (FOV) of 10 × 10 cm, and voxel size of 180–300 μm. Analyzing the images was done using the CS 3D imaging software (Carestream Dent LLC, Atlanta, G, USA) in all three planes independently by two experienced endodontists, and a consensus was reached for any disagreement.

2.2. Statistical analysis

Statistical analysis was carried on using SPSS (V20.0, SPSS, Inc., Chicago, IL, USA). Chi-square test was used to determine statistical significance. Pearson correlation coefficients were used to evaluate symmetrical correlation. Statistical significance was set at $P \leq 0.05$.

3. Results

176 patients (mean age 34.89 ± 11.92 years) met the inclusion criteria, yielding 351 scans that were included for analysis. The scans were distributed according to gender (57.8% males and 42.2% females), nationality (69.2% Saudis and 30.8% non-Saudis), and sides (50.1% right side and 49.9% left side). Most scans (n = 323, 92%) showed three roots, while the remaining scans showed two roots (n = 23, 6.6%), four roots (n = 4, 1.1%), or one root (n = 1, 0.3%). The number of canals found at three different levels along with the number of roots is presented in (Table 1, Fig. 1).

A significant correlation between gender and the anatomy was found ($p \leq 0.05$). More females had two roots compared to males ($p = 0.004$). Females had higher tendency to have two canals, while males had four canals at the levels of the coronal third ($P = 0.004$), middle and apical thirds ($P = 0.00$).

A statistically significant correlation was observed between the nationality and the anatomy in terms of the number of canals but not with the number of roots ($p \leq 0.05$). Saudi participants showed the highest number of cases with four canals while the non-Saudi participants mainly showed three canals at the coronal level, with the difference being statistically significant ($P = 0.005$). At the middle third, Saudis showed a higher number of cases having four canals while non-Saudis were showed only two canals; the difference was statistically significant ($P = 0.013$). The same correlation was found in the apical third ($P = 0.012$).

No significant difference was found between the number of roots or canals when comparing both sides of the same patient ($P > 0.05$). As for the age variable, the number of canals decreased with age.

4. Discussion

To our knowledge, no CBCT study assessing the anatomy of maxillary second molars in a Saudi sub-population has been done. Our results showed that the most common number of roots found in maxillary second molars is three (92%), which is in agreement with the findings of studies done on other populations. Plotino et al. conducted a study on a Caucasian population using CBCT and showed that 88.5% of the studied maxillary second molars had three roots (Plotino et al., 2013). In another study investigating a Korean population, the percentage of participants with a three-rooted maxillary second molar was 74.79% (Lee et al., 2011). In a Chinese population, the incidence of the same finding was reported to be 66.1% (Tian et al., 2016). Our results also showed that a four-rooted anatomy was present in 1.1% of the sample, which is considered to be a very low percentage. Different studies have reported similarly rare incidences of this anatomy, ranging from 0.049% to 1.20% (Kim et al., 2012; Tian et al., 2016).

Table 1 Number of canals found in the maxillary second permanent molar roots at three different levels. Data presented as frequency (n) and percentage (%).

Count	Coronal third		Middle third		Apical third	
	n	%	n	%	n	%
1	2	0.6	1	0.3	1	0.3
2	45	12.8	26	7.4	25	7.1
3	262	74.6	227	64.7	257	73.2
4	42	12.0	97	27.6	68	19.4
Total	351	100.0	351	100.0	351	100.0

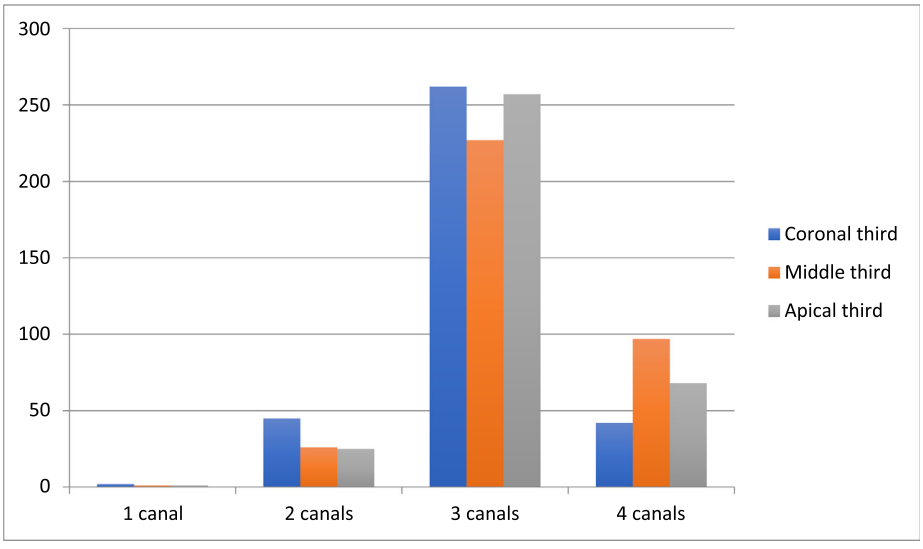

Fig. 1 Column chart showing the number of canals found in each third along the roots of examined data.

CBCT was used to investigate the number of canals present at different root levels. The most common number of canals found in this study was three canals. The prevalence of four canals was seen in 12% (coronal third), 27.6% (middle third), and 19.4% (apical third), while two canals were found in 12.8% (coronal third), 7.4% (middle third), and 7.1% (apical third). In a study done on a Chinese population, it was reported that a second mesiobuccal canal was found in 18% of the sample studied (Zhang et al., 2011), while it was found to be 55% in a Thai population (Alavi et al., 2002). Comparison of the findings between the right and left sides did not show a statistically significant difference ($P < 0.05$), and this morphological symmetry has been reported in previous studies as well (Wu et al., 2017; Zhang et al., 2011).

When considering the gender variable, this study found the difference to be statistically significant in the number of roots and canals between both genders. Lee et al. (2011) found that MB2 occurrence in maxillary second molars is more frequent in males (48.7%) compared to females (30.8%). Betancourt et al. also reported a higher incidence of MB2 canals in men compared to women (Betancourt et al., 2016). In contrast, Nikoloudaki et al. didn't find any differences in the number of roots or canals between both genders (Nikoloudaki et al., 2015).

The average patient age in this study was 34.89 years. Our results showed a decrease in the number of canals with the increase of age. The literature contains different results related to age and upper molars. Zheng et al. conducted a study on the Chinese population (Zheng et al., 2010) and reported that the presence of an MB2 canal in maxillary first molars was higher in patients aged 20–30 years. Another study on maxillary second molars in a Chinese population by Wu et al. (2017) reported a higher prevalence of MB2 in patients aged 31–40 years compared to those aged ≥51 years. In contrast, a study on an Egyptian population involving maxillary molars revealed that MB2 prevalence was not affected by age (Ghobashy et al., 2017).

Due to the importance of the subject, root canal anatomy studies were done on several teeth in the Saudi Population. Elnour et al. published a microcomputed tomography (micro-CT) study on maxillary second premolar and they concluded that the canal anatomy is complex and needs meticulous evaluation before endodontic treatment (Elnour et al., 2016). The micro-CT produces high quality images that is of better quality compared to CBCT, however, it's application is limited as the teeth have to be extracted in order to be scanned. Al Fouzan et al. conducted a study on Maxillary molars (first and second) in a Saudi population, however, their focus was on the number of canals found in the mesio-buccal roots and did not assess the number of roots or the total number of canals found in the tooth (Al-Fouzan et al., 2013). Alqedairi et al. (2018) published a study on canal morphology in maxillary premolars, CBCT was also used and the canal morphology followed the Vertucci's Classification.

The data in the present study were obtained from a single center, which may be considered as a limitation of the methodology. The findings of future multicenter studies can thus better represent the population. Furthermore, due to the complex nature of the upper second molar root anatomy, studying each root separately would result in more accurate information that will further improve the clinicians' familiarity with the anatomy of the upper second molar in the Saudi population. Moreover, we recommend performing this anatomical study over a wide geographic range with ethnic variables, since this approach may yield stronger conclusions.

Detailed data regarding root and canal anatomy in the Saudi population have been described in this study. CBCT is an effective tool for obtaining accurate anatomical information. However, its clinical application is limited by the high cost and radiation dose. Therefore, the clinician should be familiar with different root and canal morphological variants to improve the outcome of endodontic treatment.

5. Conclusion

Within the limitations of this study, the findings showed that three- and two-rooted maxillary second molars are more prevalent in the Saudi population, with males and females showing a greater tendency to have three and two roots, respectively. However, in addition to considering these results, meticulous radiographic interpretation and the importance of using adequate magnification and illumination remain the standard of care for endodontic treatments.

Ethical statement

Ethical approval for this retrospective study was waived by the Institutional Ethical Committee of the College of Dentistry, Prince Sattam Bin AbdulAziz University, Al-Kharj, Saudi Arabia (PSAU) since no risks to participant confidentiality breach and informed consent was obtained from all participants.

Declaration of Competing Interest

The authors declare no conflicts of interest.

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