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Root Canal Morphology of Maxillary First and Second Molars in a Qatari Population: A Cone-Beam Computed Tomography Study

Maryam Mohammed Al-Obaid[1] Fatima Abdullah Al-Sheeb[1]

[1]Hamad Medical Corporation, Hamad Dental Centre, Doha, Qatar

Address for correspondence Maryam Mohammed Al-Obaid, DDS, DMS, Hamad Medical Corporation, Hamad Dental Centre, Doha, Qatar (e-mail: malobaid@hamad.qa).

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Abstract

Objective The purpose of this study was to evaluate the number of roots and canal configuration of maxillary first and second molars in Qatari population.

Materials and Methods A total of 544 cone-beam computed tomography (CBCT) records of Qatari patients were included in this study. The CBCT images were reviewed by two endodontists. The age, sex, bilateral symmetry, root number, and canal configuration according to Vertucci were tabulated.

Results About 97.5% maxillary first molars had three roots and 2.5% had two roots. Maxillary second molar showed 88.2% three roots, 7.3% two roots, 3.3% single root, and 1.2% four roots. For maxillary first molars, the most common Vertucci classifications for the mesiobuccal root were type IV (2–2, 35.9%) and type II (2–1, 21.1%). For maxillary second molars, the most common Vertucci classifications for the mesiobuccal root were type IV (2–2, 27%), type III (1–2-1, 21.3%), type I (1, 19.6%), and type II (2–1, 18.9%). In maxillary first molar, 53.1% right is different from the left and in maxillary second molars, 60.2% right is different from the left.

Conclusions In Qatari population, three roots are common in maxillary molars. Mesiobuccal root of maxillary first molars is predominant with Vertucci type IV (2–2) and type II (2–1). Maxillary second molars showed variable Vertucci classification. High bilateral asymmetry was found in canal configuration of the same individuals that should be considered during root canal treatment of two opposite molars.

Keywords
- Qatari population
- maxillary molars
- morphology

Introduction

Successful root canal therapy depends on thorough debridement and complete obturation of the root canal system.[1] For this to be achieved, it is necessary to locate all root canals. The inability to locate and consequently treat all these canals will lead to posttreatment disease.[2,3] A clinician should be aware of the internal morphology of the teeth and the wide range of anatomical variations possibly encountered during the root canal therapy.

The root canal system of the maxillary first and second molars is usually complex and variable.[2,4,5] The mesiobuccal root was reported to be showing the most variations especially regarding the prevalence of a second mesiobuccal canal and the types of canal configurations.[2,4-11] Certain factors contribute to the wide variations reported in the incidence

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of second mesiobuccal canal in maxillary molars and these include race, age, and gender of the population studied.[4-18]

The introduction of cone-beam computed tomography (CBCT) has significantly improved the understanding of root canal morphology.[19] The advantages of CBCT scans are non-destructive way to study root canal morphology at lower radiation doses and higher resolution compared with other methods that studied the root canal anatomy of human teeth which make it more favorable for clinical application as well as a reliable method of research.[20-22]

The aim of this study was to identify the root canal morphology of the maxillary first and second molars in Qatari population using CBCT imaging in vivo.

Materials and Methods

This retrospective descriptive study was performed with the approval of the Medical Research Center and the Institutional Review Board at Hamad Medical Corporation in Doha, Qatar. The study population is a sample of the Qatari population, who were referred for dental treatment. A total of 544 CBCT records of Qatari patients who attended Hamad Dental services were included in this study. The CBCT images were requested for different treatment purposes including examination, diagnosis, or treatment planning, and they were performed by expert radiologists. I-CT CBCT scanner (Imaging Sciences International, Hatfield, Pennsylvania, United States) was used operated with 120 kVp (eff) tube voltage, 20 mA tube current, 14.7 second, Voxel size 0.4 to 0.2 mm, with field of view of 160 × 40 mm.

The CBCT images were reviewed by two endodontists with more than 10 years of clinical experience independently. The images were scrutinized through the sagittal, coronal, and axial views, and three-dimensional reconstruction of the jaws was applied when needed using Infinite software version 11.4 and Xelis dental three-dimensional viewer software version 1.0 (Infinitt, Seoul, South Korea) to extract the wanted information. In the beginning, 20% of the sample was viewed by each viewer alone twice and with 3 weeks apart, and the data collected were used to measure interexaminer and intraexaminer agreement.

For the data collection, patient's identification was not revealed where each patient was given a specific code. The data collection was as follows: age and gender of the patient, inclusion or exclusions and the reason of exclusion, each tooth type and location, the number of roots, canal configuration type according to Vertucci classification[1]; in addition to incidental findings such as the presence of anatomical variations, congenital anomalies, or pathologic changes.

The teeth included in this study were selected according to the following criteria: (1) permanent teeth with fully formed root; (2) no intracanal or extraradicular restorations; (3) no apical pathosis; (4) no calcification of the canals or resorption, and (5) clear CBCT images with no artifact. When one of these criteria was not applicable, the teeth were excluded mentioning the reason.

The statistical analysis was performed using Statistical Product and Service Solutions (SPSS), version 20 (SPSS Inc, Chicago, Illinois, United States). A descriptive analysis was implemented in this study to describe a detailed characteristic of the root anatomy and root canal configuration of the permanent teeth including frequency, percentages, and mean. Chi-squared test was used to compare right teeth to the left. Kappa agreement analysis was performed to assess the interexaminer and intraexaminer agreement.

Results

A total of 544 CBCT records were evaluated that included 1,088 examined teeth. The interexaminer agreement result was 95.13% (range: 74–100%) and the intraexaminer agreement was 91.7% (range: 87.4–98.1%).

Out of 1,088 examined teeth, 277 maxillary first molars teeth were included (25%) in this study.

One-hundred sixty-one (58.2%) teeth belong to females, while 116 (41.9%) teeth belong to males. The average age was 32.2 years (range: 10–70). The number of roots most commonly observed were three roots in 270 teeth (97.5%). Only seven teeth (2.5%) had two roots, and in three teeth, the roots were located in buccal and palatal position, while in 4 teeth, the roots were located in mesial and distal position (►**Table 1**).

The root canal configuration of maxillary first molar, Vertucci type I classification was always observed in the palatal root (100%) and most of the distobuccal root (97%) except for eight teeth, five (1.9%) had Vertucci type III and three (1.1%) had type V classification. Different Vertucci classifications were observed in the mesiobuccal root, in which Vertucci type IV was the predominant configuration (35.9%) followed by type II (21.1%), type III (17%), type I (12.9%), type

Table 1 Summary of gender, age, and root number of maxillary first and second molars

Tooth type	No. of patients included (%)	No. of patient excluded (%)	Female (%)	Male (%)	Age mean	4 roots (%)	3 roots (%)	2 roots (%)	1 root (%)
Maxillary first molar	277 out of 1,088 (25.5)	811 (74.5)	161 (58.2)	116 (41.9)	32.2 (10–70)	0	270 (97.5)	7(2.5)	0
Maxillary second molar	330 out of 1,088 (30.3)	758 (69.7)	207 (62.7)	123 (37.3)	32.5 (12–69)	4 (1.2)	291 (88.2)	24 (7.3)	11 (3.3)

V (9.3%), and type VI (2.6%). Three (1.2%) mesiobuccal roots had complex anatomy. Two rooted maxillary first molars with buccal and palatal roots and one of which had mesial and distal root had Vertucci type I classification in all the roots. Two mesial roots had type III and one root had type IV. Three distal roots had type IV (►**Table 2**).

The comparison between the upper right and left maxillary first molars in the same individuals found to be symmetrical in 96.9% and dissimilar in 3.1%, while the root canal configuration was found to be symmetrical in 46.9% and asymmetrical in 53.1% (►**Table 3**).

For maxillary second molar, 330 teeth (30.3%) were included, in which 62.7% of teeth belong to females and 37.3% of teeth belong to males. The age ranged from 12 to 69 years with an average of 32.5 years. The number of the roots most commonly observed were three (88.2%), two (7.3%), one (3.3%), and four roots (1.2%) (►**Table 1**). The two rooted maxillary second molars were found to be either in mesial and distal or buccal and palatal position.

In the three rooted maxillary second molars, the root canal configuration was mainly Vertucci type I classification in the palatal root (99.7%) except for one palatal root that had type V. Distobuccal roots were type I (99.3%) except for two distobuccal roots that had Vertucci type III. Mesiobuccal root showed almost all different types of Vertucci classification and the most predominant types were type IV (27%), type III (21.3%), type I (19.6%), type II (18.9%), followed by type V (9.3%), type VI (3.1%), and type VII (0.7%). The two rooted maxillary second molars with buccal and palatal roots showed Vertucci type I classification in all palatal and nine buccal roots, three buccal roots showed type III and three buccal roots showed type V, two buccal roots showed type II, and one buccal root showed complex canal configuration. In the four rooted maxillary second molars, Vertucci type I classification was predominant in all the canals except in one mesiobuccal root that was type II. Four teeth with single root second molar were type II, three teeth type I, two type VIII, and one showed complex anatomy (►**Table 4**).

The number of roots in maxillary second molars in the right and left were symmetrical in 89.4% and dissimilar in 10.6%, while the root canal configuration was symmetrical in 39.8% and asymmetrical in 60.2% (►**Table 3**).

Discussion

The aim of this study was to provide detailed root canal morphology of the maxillary first and second molars in Qatari population based on a retrospective analysis of CBCT images. The study revealed that the predominant number of roots in the maxillary first molars was three (97.5%) while (2.5%) of the first molars with two roots. The results are consistent with previous findings of different populations.[4,6,7,9,12] The maxillary second molar showed more variations in root number with the majority of three roots in 88.2%. However, three other variants were observed in the maxillary second molars; two roots (7.3%), one root (3%), and four roots (1.2%) were less frequently observed. This is common finding in many studies of root canal anatomy.[5,7,16]

Understanding the correct number of roots and canal morphology is essential in root canal therapy. Accurate knowledge of possible variations in root canal system before root canal therapy is crucial for endodontists with high rates of variation in maxillary molars. In line with other studies,[5,7,10,18,23,24] mesiobuccal roots of maxillary first and second molar teeth had more variation in their root canal configuration compared with distobuccal and palatal roots that had been mostly one canal in this study. The incidence of two separated canals, Vertucci type IV, was 35.9% of the maxillary first molar and 21.1% started with two canals even if it will rejoin somewhere in the root trunk, Vertucci type II. It was demonstrated that root canal treatment of maxillary molars has the highest rates of clinical failure probably because complexity in root canal anatomy and not easily detected during root canal treatment.[24-28] Wolcott et al examined 3,578 root canals treated first molars during a 5-year period and found that the overall prevalence of second mesiobuccal canal was 60% suggesting that failure to find and treat existing second canal will decrease the long-term prognosis. As a result, these anatomic variations should be considered during root canal treatment of maxillary molars.[28] The important factors

Table 2 Number and percentage of root canal system in maxillary first molar

Maxillary first molar	Root	Type I (1), *n* (%)	Type II (2–1), *n* (%)	Type III (1–2-1), *n* (%)	Type IV (2–2), *n* (%)	Type V (1–2), *n* (%)	Type VI (2–1-2), *n* (%)	Complex anatomy	
3 roots	MB	35 (12.9)	57 (21.1)	46 (17)	97 (35.9)	25 (9.3)	7 (2.6)	3 (1.1)	2–1-2–1[a]
	DB	262 (97)	0 (0)	5 (1.9)	0	3 (1.1)	0 (0)		2–1-2–1-2[a]
	P	100	0	0	0	0	0		2–3-1[a]
2 roots	B	3	0	0	0	0	0		
	P	3	0	0	0	0	0		
	M	1	0	2	1	0	0		
	D	1	0	0	3	0	0		

Abbreviations: B, buccal; D, distal; DB, distobuccal; M, mesial; MB, mesiobuccal; P, palatal.
[a]Complex anatomy of mesiobuccal root.

Table 3 Symmetry of maxillary first and second molars

Maxillary first molar	Symmetry	Asymmetry	Maxillary second molar	Symmetry	Asymmetry
Root number	96.9% Rt and Lt the same	3.1% Rt and Lt different	Root number	89.4% Rt and Lt the same	10.6% Rt and Lt different
Root canal configuration	46.9% Rt and Lt the same	53.1% Rt and Lt different	Root canal configuration	39.8% Rt and Lt the same	60.2% Rt and Lt different

Abbreviations: Lt, left; Rt, right.

Table 4 Number and percentage of root canal system in maxillary second molar

Maxillary second molar	Root	Type I (1), *n* (%)	Type II (2–1), *n* (%)	Type III (1–2-1), *n* (%)	Type IV (2–2), *n* (%)	Type V (1–2), *n* (%)	Type VI (2–1-2), *n* (%)	Type VII (1–2-1–2), *n* (%)	Type VIII (3), *n* (%)	Complex anatomy	
3 roots	MB	57 (19.6)	55 (18.9)	62 (21.3)	79 (27)	27 (9.3)	9 (3.1)	2 (0.7)	0 (0)		
	DB	289 (99.3)	0 (0)	2 (0.7)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		
	P	290 (99.7)	0 (0)	0 (0)	0 (0)	1 (0.3)	0 (0)	0 (0)	0 (0)		
2 roots	M	0 (0)	0 (0)	1 (4)	4 (16.6)	0 (0)	0 (0)	0 (0)	1 (4%)	1	B2–1-3–2[a]
	D	5 (20.8)	0 (0)	0 (0)	1 (4)	0 (0)	0 (0)	0 (0)	0 (0)		
	B	9 (37)	2 (8)	3 (12)	0 (0)	3 (12)	0 (0)	0 (0)	0 (0)		
	P	18 (75)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		
4 roots	MB	3	1	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		
	DB MP DP	4	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)		
One root		3	4	1	0 (0)	0 (0)	0 (0)	0 (0)	2	1	2–3[b]

Abbreviations: B, buccal; D, distal; DB, distobuccal; M, mesial; MB, mesiobuccal; MP, mesiopalatal; P, palatal.
[a]Complex anatomy of Buccal root.
[b]Complex anatomy of single root maxillary second molar.

that help in treating second mesiobuccal canal in routine practice is the clinician's knowledge of its presence and always allocating sufficient time and use of sophisticated tools to locate these canals. It has been observed that mesiobuccal root of the maxillary second molar represents technical challenge for the clinician with substantial variations in root canal anatomy. In the present study, almost all Vertucci type classifications were detected particularly in this root (►**Table 4**).

There are few studies that have compared the right and left teeth of the same individual.[29-32] In the present study, it was interesting to find out that more than half of root canal configuration of maxillary first and second molars were not alike in both sides of the same patient (53.1 and 60.2%). These data are important from a clinical perspective as these variations in symmetry should be considered when treating two opposite molars in the same patient.

Conclusion

In vivo CBCT study showed that Qatari population has a higher prevalence of three roots in first and second molars. The root canal configuration of the maxillary first and second molars was variable. The incidence of two canals in the mesiobuccal root was higher in the maxillary first molar than in maxillary second molar. High bilateral asymmetry was found in configuration of canals in the same individuals. These variations should be taken into consideration during root canal treatment.

Conflict of Interest
None declared.

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