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Original Article

Evaluation of root and canal morphologies of permanent canines in a Saudi Arabian sub population using cone-beam computed tomography

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Abstract *Background/purpose:* Failure to identify and treat the root canal system in its entirety has been known to be one of the leading causes of unsuccessful root canal treatment (RCT). This study aims to retrospectively assess the permanent canines in a Saudi Arabian sub population for the number of roots, root canal morphologies and the presence of symmetry among them using cone-beam computed tomography (CBCT).
Materials and methods: CBCT scans belonging to 945 patients were screened. A total of 1880 permanent canines, 928 pertaining to maxilla and 952 pertaining to mandible were analyzed for the number of roots, root canal morphologies and the presence of symmetry among them. Comparative evaluation between genders was done using Fisher's exact test, since majority of the groups had expected count of less than 5. A calculated *P*-value of less than 0.05 was considered significant. Chi square test was used for statistical analysis of the data. Intra operator variability was observed using Cohen's Kappa test.
Results: Single root was observed in 100% and 98.7% of the maxillary and mandibular canines respectively. Two roots were identified in 1.3% of the MnC's. Type I (97.48%), Type II (0.21%), Type III (1.05%) and Type V (1.26%) Vertucci canal configurations (VC) were observed in MnC's. Statistical significant difference was observed concerning the number of roots and canal morphology according to Vertucci in the mandibular canines. No difference was observed according to Ahmed et al. classification system. Moreover, there was no gender based difference seen among them.

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Conclusion: More variable root and canal morphologies are observed in MnC's, although single root with Type I VC is the most common.

Introduction

The attainment of successful outcome is dependent on various aspects during the procedure of root canal treatment. One such factor of immense significance is the ability of the clinician to effectively debride, prepare and fill the root canals three dimensionally (3D).[1] Failure to negotiate the root canal space and debride it in its entirety, can lead to persistence of infection resulting in the inability to restore the periodontium to a healthy state.[1,2] Familiarity with the internal morphology of all the teeth is imperative, as many roots with relatively simple external surfaces, may mask a more complex root canal system.[3,4] Therefore, in order to attain effective results, an in-depth understanding and knowledge pertaining to the complexities of the root canal system is necessary.[5–9] Moreover, differences regarding the morphologies of root canal system among different populations, races and regions have been well established.[10] A thorough understanding of canal morphologies along with the commonly expected variations among races can benefit the operator in detecting, negotiating and treating root canals.[11]

Traditionally, clinicians tend to rely on the intra oral radiographs for the assessment of internal anatomy of teeth which only provides a two dimensional image and additionally are known to have shortcomings like image distortion and superimposition.[12] Many other modalities for assessment of root canal morphology have been used over time[13] like the tooth clearing and staining techniques,[14,15] teeth sectioning and visualization under microscope[16] all of which are invasive procedures and suitable only for in vitro studies on extracted teeth. More recently, micro computed tomography (micro-CT) has been shown to provide remarkable visualization and reproduction of internal anatomies and is being considered as gold standard in studies related to root canal morphologies.[4,17] However Micro-CT itself is an invasive procedure, appropriate for lab research and therefore not suitable for studies which aim to study differences in root canal morphologies among different genders and ethnicities.[17] Cone beam computed tomography (CBCT) has evolved as an accurate and non-invasive system for 3D assessment of internal morphology of teeth in three planes without the superimposition of anatomical structures.[18] Its advantages include; lower radiation exposure compared to traditional CT, more accurate than traditional radiography, excellent image resolution, automated image analysis and ergonomics.[19]

The root canal configuration of teeth has been classified by various investigators, although the classification given by Vertucci et al. has been more commonly followed in majority of the studies.[20] Recent studies have suggested that the use of a newer classification given by Ahmed and Dummer in 2018, better represents the root and root canal morphologies of different teeth. Moreover it was also found to be more accurate and widely acceptable.[21]

Canines are essential both aesthetically due to the position it occupies in the mouth and functionally due to its role in the development of occlusion.[9] Majority of the studies report the presence of a single root with single canal in maxillary canines (MxC's). However literature suggests greater variations in the mandibular canines (MnC's) compared to their maxillary counterparts.[12,17] The present study was undertaken to observe the morphology of root and root canals of permanent MxC's and MnC's in Saudi Arabian sub population and to examine for any gender related differences among them.

Materials and methods

The sample

Retrospectively the CBCT scans existing in the database of the Department of Radiology, College of Dentistry, Prince Sattam Bin Abdulaziz University (PSAU) was analyzed. The ethical approval of the study (Approval no REC-HSD-101-2021) was granted by the Deanship of Scientific Research, PSAU. The root and canal morphology related to 928 MxC's and 952 MnC's were collected based on the following inclusion criteria: fully erupted canines with complete root development having non-distorted images of patients aged between 15 and 65 years. Teeth with metallic restorations and previous endodontic treatment were excluded.

CBCT examination

The CBCT machine used was Carestream CS9300 (Carestream Dent LLC, Atlanta, GA, USA) having a voxel size of 180—300 mm. All scans had been taken with a field of view (FOV) of 10*10 cm. The data was recorded by an experienced Endodontist based on the classification of root and canal given recently by Ahmed and Dummer in 2018. According to the authors, this new system is more incorporative and descriptive which can be easily recorded and understood. It includes the FDI code for tooth number and superscripted codes for the number of roots and configuration of canals.

The data was also classified for comparative analysis, based on Vertucci classification (VC) system which is still one of the most commonly used systems. In VC system, the canals are recorded from its commencement at the orifice to its termination at the apex and grouped from Type I to Type VIII. One canal from the orifice to the apex is Type I, two canals from the orifice and the merging into one before the apex is Type II, initiating as one canal at the orifice then dividing into two along its course and merging into one before exiting is Type III, two canals from the orifice to the apex is Type IV, initiating as one canal and dividing and exiting as two canals is Type V, two canals initiating from the orifice, merging into one before dividing again in two is Type VI, initiating as one canal at the orifice, dividing into two then merging into one and dividing again into two before exiting the root is Type VII, three canals initiating from the orifice to the apex is Type VIII.

Statistical analysis

Comparative evaluation was done using Fisher's exact test, since majority of the groups had expected count of less than 5. A calculated *P*-value of less than 0.05 was considered significant. Chi square test was used for statistical analysis of the data. Intra operator variability was observed using Cohen's Kappa test.

Results

CBCT images of 928 MxC's (467 Right MxC's and 461 Left MxC's) and 952 MnC's (478 Right MnC's and 474 Left MnC's) were observed, assembled based on quadrants, grouped based on gender and classified according to the number of roots and canal morphologies according to VC and Ahmed et al. classification systems.

Distribution of canines based on the number of roots

The MxC's on either side (n = 928) were identified to have a single root (100%) in all the observed scans. In the mandible, single rooted canines were seen in 98.7% of the scans and two rooted canines were identified in 1.3% of the scans. Statistical significant difference was observed regarding the number of roots when comparing the right and the left mandibular quadrants as seen in Table 1. When the distribution of MnC's were compared according to gender, slightly higher percentage of two rooted mandibular canines were seen in females than males but the data was not statistically significant as represented in Table 2.

Table 2 Distribution of teeth according to number of roots and sex.

Tooth number	Sex	Total	1 root	2 root	Fisher exact test
43	Male	255	253 (99.2%)	2 (0.8%)	0.501 NS
	Female	223	223 (100%)	0	
	Total	478	476 (99.6%)	2 (0.4%)	
33	Male	249	246 (98.8%)	3 (1.2%)	0.204 NS
	Female	225	218 (96.9%)	7 (3.1%)	
	Total	474	464 (97.9%)	10 (2.1%)	
Total	Male	504	499 (99%)	5 (1%)	0.564 NS
	Female	448	441 (98.4%)	7 (1.6%)	
	Total	952	940 (98.7%)	12 (1.3%)	

Notes: 43, Right mandibular canine; 33, Left mandibular canine. NS Non significant at $P \leq 0.05$.

Distribution of canine's canal morphology according to Vertucci and Ahmed et al. classification

According to VC system, Type I canal configuration was observed unanimously (100%) in all the MxC scans (n = 928). According to the new classification system, all the MxC's (n = 928) were classified into two codes $^{1}13^{1}$ for canines in the right quadrant (n = 467) and $^{1}23^{1}$ for the canines in the left quadrant (n = 461).

In the MnC's (n = 952) the root canal morphology was more variable and statistically significant difference was observed among them. Vertucci Type I, II, III and V were identified. Single rooted MnC's were observed to have Type I (97.48%), Type II (0.21%) and Type III (1.05%) configuration and two rooted canines were observed to have Type V (1.26%) canal configuration as seen in Table 3. The sample CBCT images of the same is represented in Fig. 1. The results were statistically significant when comparing the canal morphologies according to VC, however there was no gender based significance as seen in Table 4. According to the new classification system the MnC's were classified as $^{1}43^{1}$ (98.74%), $^{1}43^{2-1}$ (0.21%), $^{1}43^{1-2-1}$ (0.63%) and $^{2}43B^{1}L^{1}$ (0.42%) for the teeth in the right quadrant and $^{1}33^{1}$ (96.20%), $^{1}33^{2-1}$ (0.21%), $^{1}33^{1-2-1}$ (1.48%) and $^{2}33B^{1}L^{1}$ (2.11%) for the teeth in the left quadrant as seen in Table 5. The need for use of the newer classification method can be appreciated in Fig. 2 which shows two rooted MnC's (n = 12) classified as Type V according to VC but does not actually represent individual canal configuration in each

Table 1 Distribution of teeth according to number of roots.

Maxilla		Mandible			Fisher exact test
Tooth number	1 root	Tooth number	1 root	2 root	
13 (n = 467)	467 (100%)	43 (n = 478)	476 (99.58%)	2 (0.42%)	0.021*
23 (n = 461)	461 (100%)	33 (n = 474)	464 (97.89%)	10 (2.11%)	
Total (n = 928)	928 (100%)	Total (n = 952)	940 (98.74%)	12 (1.26%)	

Notes: 13, Right maxillary canine; 23, Left maxillary canine; 43, Right mandibular canine; 33, Left mandibular canine; n, Number of teeth.
*Significant at $P \leq 0.05$.

Table 3 Root canal Morphology — Vertucci Classification.

Maxilla (n = 928)		Mandible (n = 952)					
Tooth number	Type I	Tooth number	Type I	Type II	Type III	Type V	Fisher exact test
13 (n = 467)	467	43 (n = 478)	472 (98.74%)	1 (0.20%)	3 (0.62%)	2 (0.41%)	0.013*
23 (n = 461)	461	33 (n = 474)	456 (96.20%)	1 (0.21%)	7 (1.48%)	10 (2.11%)	
Total	928 (100%)	Total	928 (97.48%)	2 (0.21%)	10 (1.05%)	12 (1.26%)	

Notes: 13, Right maxillary canine; 23, Left maxillary canine; 43, Right mandibular canine; 33, Left mandibular canine; Type I, one canal from orifice to apex; Type II, initiates as two canals merges and terminates at apex as one canal; Type III, initiates as one canal divides into two along its course and later merges into one before exiting the apex; Type V, Initiates as one canal from the orifice and terminates as two canals.
* Significant at $P \leq 0.05$.

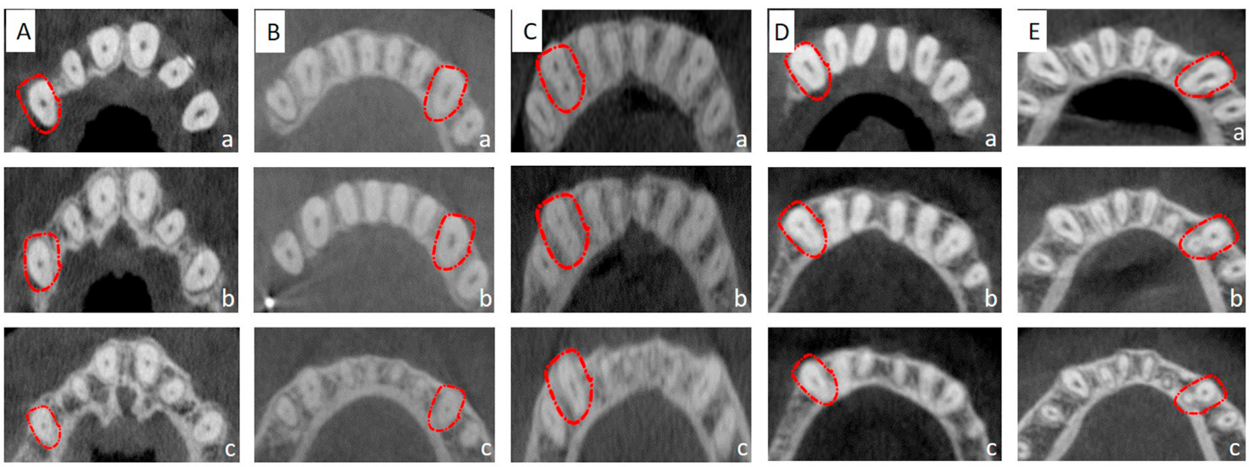

Figure 1 CBCT axial views representing different types of Vertucci classifications. (A) Anterior maxilla showing Vertucci type I (one canal from orifice to apex) classification (a: Coronal third; b: Middle third; c: Apical third). (B) Anterior mandible showing Vertucci type I (one canal from orifice to apex) classification (a: Coronal third; b: Middle third; c: Apical third). (C) Anterior mandible showing Vertucci type II (initiates as two canals, merges and terminates at apex as one canal) classification (a: Coronal third; b: middle third; c: apical third). (D) Anterior mandible showing Vertucci type III (initiates as one canal, divides into two along its course and later merges into one before exiting) classification (a: Coronal third; b: middle third; c: apical third). (E) Anterior mandible showing Vertucci type V (initiates as one canal from the orifice and terminates as two canals) classification (a: Coronal third; b: middle third; c: apical third).

Table 4 Vertucci classification of root canal morphology of mandibular canines according to tooth type and sex.

Tooth number	Sex	Total	Type I	Type II	Type III	Type V	Chi square test
43	Male	255	251 (98.4%)	1 (0.39%)	1 (0.39%)	2 (0.78%)	0.417 NS
	Female	223	221 (99.1%)	0	2 (0.89%)	0	
	Total	478	472 (98.74%)	1 (0.21%)	3 (0.62%)	2 (0.41%)	
33	Male	249	242 (97.2%)	1 (0.4%)	3 (1.2%)	3 (1.2%)	0.381 NS
	Female	225	214 (95.1%)	0	4 (1.78%)	7 (3.12%)	
	Total	474	456 (96.2%)	1 (0.21%)	7 (1.48%)	10 (2.11%)	
Total	Male	504	493 (97.82%)	2 (0.39%)	4 (0.79%)	5 (0.99%)	0.214 NS
	Female	448	435 (97.09%)	0	6 (1.35%)	7 (1.56%)	
	Total	952	928 (97.48%)	2 (0.21%)	10 (1.05%)	12 (1.26%)	

Note: 33, Right mandibular canine; 33, Left mandibular canine; Type I, one canal from orifice to apex; Type II, initiates as two canals merges and terminates at apex as one canal; Type III, initiates as one canal divides into two along its course and later merges into one before exiting the apex; Type V, initiates as one canal from the orifice and terminates as two canals.
NS - Non significant at $P \leq 0.05$.

Table 5 Root and canal Morphology — Newer Classification.

Tooth number	Maxilla (n = 928)	Tooth number	Mandible (n = 952)				Chi square test
13 (n = 467)	$^{1}13^{1}$	43 (n = 478)	$^{1}43^{1}$	$^{1}43^{2-1}$	$^{1}43^{1-2-1}$	$^{2}43B^{1}L^{1}$	X^2 value 7.19
	467 (100%)		472 (98.74%)	1 (0.21%)	3 (0.63%)	2 (0.42%)	P-value 0.066 NS
23 (n = 461)	$^{1}23^{1}$	33 (n = 474)	$^{1}33^{1}$	$^{1}33^{2-1}$	$^{1}33^{1-2-1}$	$^{2}33B^{1}L^{1}$	
	461 (100%)		456 (96.20%)	1 (0.21%)	7 (1.48%)	10 (2.11%)	

Note: 13, Right maxillary canine; 23, Left maxillary canine; 43, Right mandibular canine; 33, Left mandibular canine; n, total number of teeth;$^{1}13^{1}$, maxillary right canine with one root and one canal;$^{1}23^{1}$, maxillary left canine with one root and one canal;$^{1}43^{1}$, mandibular right canine with one root and one canal;$^{1}33^{1}$, mandibular left canine with one root and one canal;$^{1}43^{2-1}$, mandibular right canine with one root initiating as two canals but merging into one canal before exiting;$^{1}33^{2-1}$, mandibular left canine with one root initiating as two canals but merging into one canal before exiting;$^{1}43^{1-2-1}$, mandibular right canine with one root initiating as one canal bifurcating into two along the root length but merging into one canal before exiting;$^{1}33^{1-2-1}$, mandibular left canine with one root initiating as one canal bifurcating into two along the root length but merging into one canal before exiting;$^{2}43B^{1}L^{1}$, mandibular right canine with two roots B (Buccal) and L (Lingual) with one canal in each root; $^{2}33B^{1}L,^{1}$, mandibular left canine with two roots B (Buccal) and L (Lingual) with one canal in each root.
X^2 value 7.19; P-value 0.066 NS - Non significant with significance level $\leq$0.05.

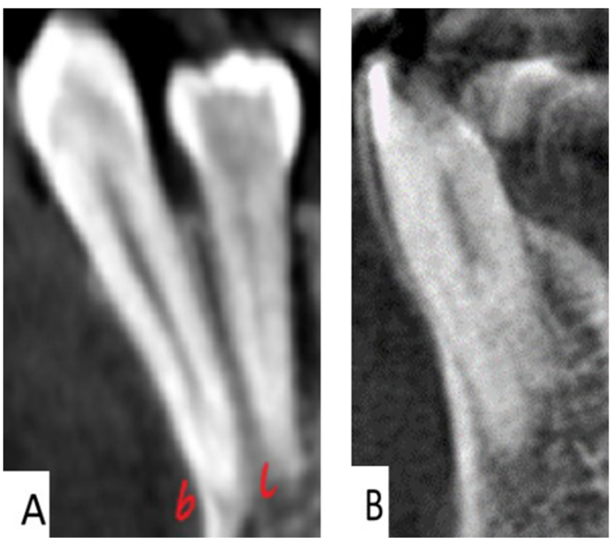

Figure 2 Need for new root and canal classification system. (A) Right mandibular canine showing Vertucci type V classification one canal dividing into two before exiting. (B) The newer classification $^{2}43B^{1}L^{1}$ for a similar tooth clearly explains the right mandibular canine has two root and two canals, one buccal and one lingual.

root whereas in the newer classification it is represented as $^{2}43B^{1}L^{1}$ which gives a clear picture showing two rooted left MnC's with two canals. No significant difference was observed when the data was analyzed statistically according to Ahmed et al. classification system (see Table 5).

Bilateral symmetry

When the CBCT scans showing bilateral MxC's (n = 456 scans) were observed for symmetry, the root (single root) and root canal morphology (Type I) was symmetrical in 100% of the scans. When scans of bilateral MnC's were observed for symmetry, 97.6% symmetry was observed in roots and with regards to root canal morphology, symmetry was seen in 93.5% of the scans as seen in Table 6.

Discussion

The preference of using CBCT over other methods for identifying the internal anatomy of teeth stems from the fact that it is non-invasive, provides a 3D view and its accuracy is comparable to the clearing and staining techniques which were previously considered as gold standard.[19] More recently micro CT has attained popularity

Table 6 Bilateral symmetry of maxillary and mandibular canines.

Root canal				Root		
Maxillary canines (n = 456)		Symmetry	No symmetry	Maxillary canines (n = 456)	Symmetry	No symmetry
Symmetry (n = 456) 100%	Type I	456 (100%)	0	Symmetry (n = 456) 100%	456 (100%)	0
Mandibular canines (n = 462)		Symmetry	No symmetry	Mandibular canine (n = 462)	Symmetry	No symmetry
Symmetry (n = 432) 93.5%	Type I	428 (92.6%)	14 (3.03%)	Symmetry (n = 451) 97.6%	451 (97.6%)	11 (2.4%)
	Type II	1 (0.21%)	0			
	Type III	2 (0.43%)	6 (1.31%)			
	Type V	1 (0.21%)	10 (2.16%)			

Note: n, bilateral accepted scans; Type I, one canal from orifice to apex; Type II, initiates as two canals merges and terminates at apex as one canal; Type III, initiates as one canal divides into two along its course and later merges into one before exiting the apex; Type V, initiates as one canal from the orifice and terminates as two canals.

as it offers higher resolution images compared to CBCT, however it is an invasive procedure and more appropriate for in-vitro studies in the laboratory.[17,22]

Canines are known to be the longest teeth in the mouth and vary externally in shape and size. In the present study the internal anatomy of maxillary and mandibular canines among Saudi sub population was visualized using CBCT and a detailed morphological description of its root and root canal morphology was presented.

All the scans of MxC's were observed to have a single root in the present study. Although a few studies, mostly case reports[23,24] have shown some variations regarding the number of roots, results obtained in majority of the studies conducted in different parts of the world are in accordance to results seen in this study.[8,9,22,25,26] Previous research in Saudi Arabia have also shown MxC's to be one rooted in 100% of the tested population.[27,28]

The present study also exhibited a single canal with Type I VC in all the MxC's. Such cent percent presence of single canal was reported previously by Vertucci[5] and was more recently seen in Malaysian,[8] Brazilian[25] and Iranian[26] populations. Most of the other studies too show a predominance of single canal in MxC's and minimal percentages of two canals.[9–11] Studies related to Saudi population have also reported single canal in MxC's in a range of 98–99%.[27,28] A case report of MxC with two root canals have also been reported in the same population.[29]

Several studies indicate that Type I VC is most prevalent canal configuration seen in MxC's which is in accordance to our study.[5,8,10,11,25] In contrast, some of the other studies reported its presence in a range of 76.9–81.6%.[9,30] Other canal morphologies reported in these studies were Type II, III, IV and V. Amardeep et al.[9] in his study on Indian population, using CBCT, reported, other than the aforementioned types, the presence of a new Type XIX, according to the classification given by Sert and Baylis. In this type, the canals originates as two then merges into one along its course, again divides into two and then merges into one before exiting the root (2-1-2-1).[9] Among Saudi sub population, Mashyakhy[27] reported Type I configuration in 99% and observed four maxillary canines to have Type III VC pertaining to 1% of the population. These results were consistent with our results presenting very high percentages of Type I VC. In another study in the capital Riyadh, Almohaimede et al.[28] reported the presence of Type I (97.94%), Type II (0.47%), Type III (0.47%) and Type V (1.1%) VC. Such differences within the same population could be due to various factors like sample size, evaluation tools, regional difference and differences in ethnic background among them.

In general, MnC's tend to have more variable results regarding roots and root canals compared to their maxillary counterparts.[9,25,27] The occurrence of two rooted MnC's in several countries have been reported to be around 0.3–4.79%.[1,12,31–35] In the present study as well, while majority of the MnC's (n = 940) had a single root (98.74%), twelve teeth (1.26%) {Ten in the left quadrant (2.11%) and two on the right quadrant (0.42%)} were identified to have two roots, a buccal and a lingual. The results were also in accordance to previous studies in other sub populations in Saudi Arabia which report the prevalence of biradicular canines in 0.2–2.88%.[27,28,36] The highest reported percentage of two rooted MnC's (12.1%) was seen in a study among Iranian population using the staining and clearing technique.[15] On the contrary, Amardeep et al.[9] in a CBCT study among Indian population did not find any two rooted MnC's. However, other studies in the aforementioned populations reported percentages similar to those observed in majority of the studies worldwide.[7,37] When comparing between different genders, females presented with more tendency of having two rooted canines compared to males although the results were not significant.

More variable canal morphology was identified in MnC's than those observed in the maxillary counterparts with majority of the canals having Type I VC (97.48%). This was followed by Type V VC (1.26%), Type III VC (1.05%) and Type II VC (0.21%). Similar morphologies were previously reported in Iranian, Chinese, Iraqi and Syrian populations.[7,31–33] Numerous other studies on MnC's reported various other types of configurations in addition to those found in our study. On the other hand studies in Malaysian, Iranian and Indian populations reported the presence of only two types of canal morphologies.[6,8,37]

Higher prevalence of Type I VC was also reported in Chinese,[13,31] Iranian,[6,7,15] Brazilian,[1,25] Turkish,[10] Syrian,[33] Polish,[34] Malaysian populations,[8,35] and Portuguese populations.[38] On the other hand studies from India reported much lower percentages 79.6%–81% of Type I VC.[9,37] In previous Saudi Arabian studies, in addition to Types I, II, III and V as seen in our study, Type IV and VII VC were reported by Almohammedie et al.[28] and Type IV VC was reported by Al-Dahman et al.,[36] albeit in lower percentages. On the contrary Mashyakhy[27] in his study from Jizan region of Saudi Arabia reported the presence of only Type I, III and V VC. Such differences may possibly be ascribed to variances in sample size and ethnicities. Regional variances among the same populations was also observed in Brazilian[1,25] and Malaysian[8,35] populations previously.

When comparing between different genders, male and females had similar percentages of Type I VC. Type III and Type V VC were seen more in females compared to males, corresponding to the observation identified by Mashyakhy[27] among Saudis. Type II VC in our study was only seen among males. However no specific sex correlation was seen in our study which is in accordance with most of the previously reported studies.[7,12,27,32] On the contrary, gender based differences were noticed in few studies involving Turkish populations.[10,11]

When scans displaying bilateral MxC's which met the inclusion criteria (n = 456 scans) were analyzed for bilateral symmetry, perfect symmetry (100%) was seen between the roots and root canal morphologies among them. When bilateral MnC's (n = 462 scans) were analyzed for symmetry, 97.6% symmetry was seen between roots. In the remaining 11 scans (2.4%) a lack of symmetry was observed. Regarding root canal configuration bilateral symmetry was seen in 93.5% of the scans. Of the 6.5% asymmetrical scans, 3.03% asymmetry was seen with Type I VC, 1.31% asymmetry was seen with Type III VC and 2.16% asymmetry in Type V VC.

The results obtained in this study was in accordance to previous studies in Saudi Arabia and other parts of the world regarding symmetry of roots and canal morphologies.[7,27,28,31,36] On the contrary, contrasting reports were observed in a Turkish study where the symmetry in mandibular canines was reported at 28%.[39]

In conclusion, canines with single roots was most commonly observed in both the maxillary and mandibular arches, however two rooted canines were also noticed in the mandible. All the MxC's presented with Type I VC which was also the predominant canal configuration seen in the MnC's. Other variations of canal morphology observed in MnC's were Types II, III and V. Although differences were observed in canal morphologies among different genders, the results were not significant. Roots and root canals in MxC's were perfectly symmetrical. Regarding the MnC's, bilateral symmetry was also observed in majority of the scans.

Declaration of competing interest

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

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References

1. Candeiro GTM, Monteiro Dodt Teixeira IM, Olimpio Barbosa DA, Vivacqua-Gomes N, Alves FRF. Vertucci's root canal configuration of 14,413 mandibular anterior teeth in a Brazilian population: a prevalence study using cone-beam computed tomography. *J Endod* 2021;47:404–8.
2. Costa FFNP, Pacheco-Yanes J, Siqueira Jr JF, et al. Association between missed canals and apical periodontitis. *Int Endod J* 2019;52:400–6.
3. Gulabivala K, Aung TH, Alavi A, Ng YL. Root and canal morphology of Burmese mandibular molars. *Int Endod J* 2001; 34:359–70.
4. Wolf TG, Anderegg AL, Haberthur D, et al. Internal morphology of 101 mandibular canines of a Swiss-German population by means of micro-CT: an ex vivo study. *Sci Rep* 2021;11:21281.
5. Vertucci FJ. Root canal anatomy of mandibular anterior teeth. *J Am Dent Assoc* 1974;89:369–71.
6. Naseri M, Ahangari Z, Bagheri N, Jabbari S, Gohari A. Comparative accuracy of cone-beam computed tomography and clearing technique in studying root canal and apical morphology of mandibular canines. *Iran Endod J* 2019;14: 271–7.
7. Soleymani A, Namaryan N, Moudi E, Gholinia A. Root canal morphology of mandibular canine in an Iranian population. *Iran Endod J* 2017;12:78–82.
8. Pan JYY, Parolia A, Chuah SR, Bhatia S, Mutalik S, Pau A. Root canal morphology of permanent teeth in a Malaysian subpopulation using cone-beam computed tomography. *BMC Oral Health* 2019;19:14.
9. Somalinga Amardeep N, Raghu S, Natanasabapathy V. Root canal morphology of permanent maxillary and mandibular canines in Indian population using cone beam computed tomography. *Anat Res Int* 2014;2014:731859.
10. Altunsoy M, Ok E, Nur BG, Aglarci OS, Gungor E, Colak M. A cone-beam computed tomography study of the root canal morphology of anterior teeth in a Turkish population. *Eur J Dent* 2014;8:302–6.
11. Sert S, Aslanalp V, Tanalp J. Investigation of the root canal configurations of mandibular permanent teeth in the Turkish population. *Int Endod J* 2004;37:494–9.
12. Aminsobhani M, Sadegh M, Meraji N, Razmi H, Kharazifard MJ. Evaluation of the root and canal morphology of mandibular permanent anterior teeth in an Iranian population by cone-beam computed tomography. *J Dent* 2013;10:358–66.
13. Zhengyan Y, Keke L, Fei W, Yueheng L, Zhi Z. Cone-beam computed tomography study of the root and canal morphology of mandibular permanent anterior teeth in a Chongqing population. *Therapeut Clin Risk Manag* 2015;12:19–25.
14. Pecora JD, Sausa Neto MD, Saquy PC. Internal anatomy, direction and number of roots and size of human mandibular canines. *Braz Dent J* 1993;4:53–7.
15. Rahimi S, Milani AS, Shahi S, Sergiz Y, Nezafati S, Lotfi M. Prevalence of two root canals in human mandibular anterior teeth in an Iranian population. *Indian J Dent Res* 2013;24: 234–6.
16. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration of the mesio buccal root of maxillary first molar and its endodontic significance. *Oral Surg Oral Med Oral Pathol* 1969; 28:419–25.
17. Versiani MA, Pécora JD, Sousa-Neto MD. Microcomputed tomography analysis of the root canal morphology of single-rooted mandibular canines. *Int Endod J* 2013;46:800–7.
18. Patel S, Dawood A, Whaites E, Pitt Ford T. New dimensions in endodontic imaging: part 1. Conventional and alternative radiographic systems. *Int Endod J* 2009;42:447–62.
19. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. *J Endod* 2007;33:1121–32.
20. Karobari MI, Parveen A, Mirza MB, et al. Root and root canal morphology classification systems. *Int J Dent* 2021;2021: 6682189.
21. Buchanan GD, Gamieldien MY, Tredoux S, Vally ZI. Root and canal configurations of maxillary premolars in a South African subpopulation using cone beam computed tomography and two classification systems. *J Oral Sci* 2020;62:93–7.
22. Mazzi-Chaves JF, Silva-Sousa YTC, Leoni GB, et al. Micro-computed tomographic assessment of the variability and morphological features of root canal system and their ramifications. *J Appl Oral Sci* 2020;28:e20190393.
23. Barkhordar RA, Nguyen NT. Maxillary canine with two roots. *J Endod* 1985;11:224–7.
24. Weisman MI. A rare occurrence: a bi-rooted upper canine. *Aust Endod J* 2000;26:119–20.
25. da Silva EJ, de Castro RW, Nejaim Y, et al. Evaluation of root canal configuration of maxillary and mandibular anterior teeth using cone beam computed tomography: an in-vivo study. *Quintessence Int* 2016;47:19–24.
26. Kuzekanani M, Jafari AM. Root canal anatomy and morphology of permanent maxillary canine teeth in an Iranian population. *Ital J Anat Embryol* 2020;124:403–8.
27. Mashyakhy M. Prevalence of a second root and canal in mandibular and maxillary canines in a Saudi Arabian population: a cone-beam computed tomography study. *J Contemp Dent Pract* 2019;20:773–7.
28. Almohaimede AA, Alqahtani AA, Alhatlani NM, Alsaloom NS, Alqahtani SA. Interpretation of root canal anatomy of maxillary and mandibular permanent canines in Saudi subpopulation: a cone-beam computed tomography (CBCT) Study. *Int J Dent* 2021;2021:5574512.
29. Mohammed NMA, Mandorah AO, Alqashqari. Maxillary canine with two root canals. *Saudi Endod J* 2015;5:146–8.
30. Weng XL, Yu SB, Zhao SL, et al. Root canal morphology of permanent maxillary teeth in the Han nationality in Chinese

Guanzhong area: a new modified root canal staining technique. *J Endod* 2009;35:651—6.
31. Han T, Ma Y, Yang L, Chen X, Zhang X, Wang Y. A study of the root canal morphology of mandibular anterior teeth using cone-beam computed tomography in a Chinese subpopulation. *J Endod* 2014;40:1309—14.
32. Mahmood Talabani R. Assessment of root canal morphology of mandibular permanent anterior teeth in an Iraqi subpopulation by cone-beam computed tomography. *J Dent Sci* 2021;16: 1182—90.
33. Doumani M, Habib A, Alhalak AB, Al-Nahlawi TF, Al Hussain F, Alanazi SM. Root canal morphology of mandibular canines in the Syrian population: a CBCT Assessment. *J Fam Med Prim Care* 2020;9:552—5.
34. Poland Sroczyk-Jaszczyńska M, Kołecki J, Lipski M, et al. A study of the symmetry of roots and root canal morphology in mandibular anterior teeth using cone-beam computed tomographic imaging in a Polish population. *Folia Morphol* 2020;79: 835—44.
35. Karobari MI, Noorani TY, Halim MS, Ahmed HMA. Root and canal morphology of the anterior permanent dentition in Malaysian population using two classification systems: a CBCT clinical study. *Aust Endod J* 2021;47:202—16.
36. Al-Dahman Y, Alqedairi A, Alfawaz H, Alnassar F, Al-Jebaly A. Cone-beam computed tomographic evaluation of root canal morphology of mandibular canines in a Saudi subpopulation. *Saudi Endod J* 2019;9:113—8.
37. Raman S, Kumar VJ. A cone-beam computed tomography study of the prevalence of two or more canals in mandibular anteriors in the Chennai population. *J Adv Pharm Educ Res* 2017;7:92—5.
38. Martins JNR, Marques D, Mata A, Caramês J. Root and root canal morphology of the permanent dentition in a Caucasian population: a cone-beam computed tomography study. *Int Endod J* 2017;50:1013—26.
39. Kayaoglu G, Peker I, Gumusok M, Sarikir C, Kayadugun A, Ucok O. Root and canal symmetry in the mandibular anterior teeth of patients attending a dental clinic: CBCT study. *Braz Oral Res* 2015;29:1—7.