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Incidence and effect of an extra root on the crown morphometry of the maxillary second molars among Malaysian Mongoloids

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ABSTRACT

Background: This study aimed to investigate whether the presence of two palatal roots on permanent maxillary second molars (MSMs) can affect the crown size and crown's buccolingual and mesiodistal diameters.

Materials and methods: A retrospective study was conducted using 592 CBCT scans to investigate 1120 MSMs of Mongoloid Malaysians. 3D models were created to assess the four-

rooted MSMs and other related teeth carefully. Crown size and crown's buccolingual and mesiodistal diameters were measured for the four-rooted MSM, the adjacent maxillary first molar (MFM), and their antimeres to investigate the effect of the presence of an extra root on the size and morphological features of the crown of these associated teeth.

Results: Only six out of the 1120 MSMs displayed four roots (0.53%). The incidence was 0.67% (2/298) for the Malay males and 0.4% (1/247) for the Malay females, with the Malay male having a bilateral occurrence of four-rooted MSM. The incidence was 0.34% (1/294) for the Chinese males, while 0.71% (2/281) was detected in Chinese females. Interestingly, the four-rooted MSMs showed a wider mesiodistal distance than their three-rooted antimeres in three out of four cases. The presence of two palatal roots may also increase the crown's buccolingual diameter.

Conclusions: The presence of anatomical variations and the dramatic change in crown measurements can be good indicators of the presence of extra roots, including in some of their related neighbours. This might help dentists to take precautionary measures when performing tooth extractions and endodontic therapy.

Keywords: crown morphometry; maxillary second molars; Malaysian

INTRODUCTION

Maxillary second molars (MSMs) are reported to have one palatal root and two buccal roots. However, they are also known to have more variability in root canal configuration than maxillary first molars (MFMs) and occasionally emerge with an accessory root [2, 6, 10, 17, 25, 27]. The number of maxillary molars' roots can range from one to five. In maxillary molars, the prevalence of four-rooted maxillary molars is 0.4% [10] to 1.4% [1, 3], which is considered an anomaly due to its low incidence in the population (less than 2.5%) [12]. Despite the low incidence, this anomaly should be considered when planning root canal treatment [15].

Dentists generally agree that it is impossible to achieve a 100% success rate in root canal treatment. However, successful root canal treatment can be increase with increase awareness on, of the diversity and variance in the number of the roots and the root canal anatomy [5, 6, 17, 25, 27, 32]. Several reasons are provided for this failure; One of the reasons that may contribute to root canal treatment failure is untreated extra root canal [28]. Although, periapical radiographs/images are acquired before starting root canal treatment, this technique is less

reliable in identifying extra roots and root canals [10]. In addition, the posterior position, the complex root canal system, and the superimposition of maxillary second molars by surrounding anatomical structures have caused enormous challenges during the radiographic identification [9, 10]. Therefore, a high-resolution cone-beam computed tomography (CBCT) scan is recommended to obtain detailed multiplanar reformatted images to assess the roots and root canal system accurately [6, 9, 10, 32] as done in this study (*see methods*).

It is well known that the MFMs represent wider mesiodistal diameters than the MSMs. However, the opposite happens when MSMs develop with four roots [8]. Many studies have reported that two palatal roots in maxillary molars can co-exist with crown anomalies such as wider mesiodistal measurements, Carabelli's trait, prominent palatal indentations, palatal enamel extensions, palato-radicular grooves, and enamel pearls. Cases where anatomical variations occur in both crown and root is termed as corono-radicular anomaly [3, 8, 10, 14].

Molar teeth have four to five lobes as essential developmental units on their occlusal surfaces. The highest spot on the lobe is called a cusp. Teeth can also be composed of accessory lobes that may or may not exhibit accessory cusps [26]. This crown complexity contributes to the direct increase in crown size, which is believed to enhance teeth mastication performance [11]. Also, crown size can affect root structure, as Alexandersen [2] found that two palatal root structures on the permanent maxillary molars had already been formed when root formation started. All anatomical variations are important for dental anthropologists, as their prevalence can differ from one ethnicity to another [16, 27]. Thus, it is necessary to know and master anatomical differences in shape, and functional form, as normal phenotypic expertise is insufficient in some cases. Among the Mongoloids residing in Southeast Asia, the occurrence of accessory root in mandibular molars have been studied. However, the same has not been done for the maxillary molars.

Thus, the current study aimed to investigate the incidence of four-rooted MSMs among the Malaysians of Mongoloid ancestry and determine the difference in crown morphology and morphometry between three rooted and four rooted maxillary second molars.

MATERIALS AND METHODS

Institutional approval for this dental research was obtained from Medical Ethics Committee, Faculty of Dentistry, University of Malaya, (Reference Number: DF OS2002/0003 (L). A

retrospective study used 592 CBCT images to investigate 1120 MSMs of Mongoloid Malaysians aged 14 to 65 years. These patients attended the Oral and Maxillofacial Imaging Division from 2010 to 2019. i-CAT Cone Beam 3D Dental Imaging System (version 3.1.62 supplied by Imaging Sciences International, Hatfield, USA) was used to acquire the CBCT data. All CBCT images were acquired using a voxel size of 0.30 mm and a scanning time of 20 seconds. In addition, the selected scans had exposure parameters of 120 kV and 18 mA. Using the Materialise Interactive Medical Image Control System (MIMICS) 21.0 software (Materialise NV, Belgium), the targeted teeth were segmented slice by slice, and 3D models were created to assess the four-rooted MSMs using Mimics software. The inclusion criteria for the retrospective study in which 592 CBCT images were analysed were good quality CBCT images belonging to Mongoloid (Malays and Chinese) patients aged 14 to 65 years with both (or at least one) MSM radiographically present. The patient must be at least 14 years of age as the root formation would have initiated. CBCT images were surveyed to investigate the incidence of four-rooted MSMs among Malays (156 males, 134 females) and Chinese (158 males, 144 females) ethnicities. Any case with caries or any pathology associated with maxillary and mandibular second molars or obliterated cemento-enamel junctions was excluded. In case of uncertainty the CBCT image were also examined separately by an oral and maxillofacial radiologist.

In the study, the following items were examined in case four rooted MSM was found:

1. The prevalence of four-rooted MSMs and their types in Malaysians of Mongoloid ancestry.
2. Distribution of four-rooted MSMs according to gender and ethnicity.
3. Canal morphology according to the Vertucci classification for the four-rooted MSMs.
4. Crown size, crown’s buccolingual and mesiodistal diameters of the four-rooted MSMs.
5. Crown size, crown’s buccolingual and mesiodistal diameters of the four-rooted MSMs’ antimeres.
6. Crown size, crown’s buccolingual and mesiodistal diameters of the adjacent MFMs to four-rooted MSMs.
7. Any co-existing anatomical variations and anomalies to four-rooted MSMs.

The demographic data of four-rooted MSMs in Malaysian population with Mongoloid ancestry (Malay and Chinese)

CBCT images were studied to investigate the incidence of four-rooted MSMs among Malay (156 males, 134 females) and Chinese (159 males, 146 females) ethnicities. To obtain the best view, the brightness and contrast settings were adjusted. Then the axial, coronal and sagittal views were inspected to investigate the root numbers of the targeted teeth. The CBCT images were also examined separately by an oral and maxillofacial radiologist in case of uncertainty.

Image analysis and 3D model reconstruction

Initially, the images were appropriately adjusted in the axial, coronal, and sagittal planes. After selecting various grayscale threshold values for each of the studied teeth, threshold masks were manually reviewed slice by slice for segmentation and isolation from the surrounding tissues throughout the multiple slice editing phase. The teeth were generated in the software's Region Growing Phase. Then, 3D models of the targeted teeth were created.

Morphometric evaluation of unusual radiological findings

After three-dimensional models of the targeted teeth were reconstructed, the plane was created first by selecting three points on the cementoenamel junction (CEJ) in sagittal view. The plane was adjusted in both coronal and axial views. The plane on the 3D model was dragged to the bifurcation area of the pulp. After that, the crown was separated from the root using 3D tools at the plane’s level, as the floor of the pulp chamber in the coronal view was chosen as a landmark to separate the anatomical crown from the root - according to Azim et al. [4] (Fig. 1).

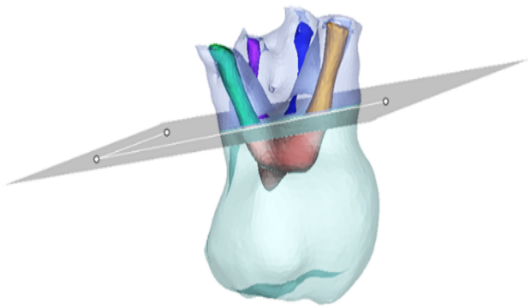

Figure 1. The crown and pulp chamber are separated from the roots and the root canals by the created plane.

The buccolingual (BL) and mesiodistal (MD) crown diameters were measured using the Feret's diameter (Fig. 2). Ferret's diameter was determined by creating two-dimensional lines parallel to the cementoenamel junction plane and adjacent to the highest curvature on the four surfaces of the crown, then measuring the distance between the mesial lines and the distal line and between the buccal and the lingual lines. The software automatically calculated the volume of the crown. These measurements were applied and statistically analysed for four-rooted maxillary second molars, their antimeres and the adjacent three-rooted maxillary first molar. If the three-rooted antimere or the three rooted adjacent MFM had not been available for analysis and comparison, the four-rooted MSM was not included in the statistical analysis. Only one examiner (postgraduate student) analysed all the measurements.

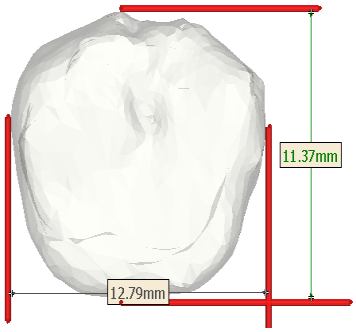

Figure 2. Feret's diameter for mesiodistal and buccolingual measurements of the crown.

Classification of morphological variations

The morphological variations observed in this study were evaluated and categorized as follows: Maxillary molars with two palatal roots were classified according to the descriptions by Christie et al [8], Baratto-Filho et al. [5] and Versiani et al. [29]. Type I of Christie's classification shows four separate roots, of which the palatal two are long and widely divergent, while buccal roots are cow-horn shaped. According to Christie's classification, Type II has four separate, parallel, and approximately equally long roots. Type III of the Christie's classification; with this type, the distobuccal root stands alone and the other three roots are united together by a dentine net. Type IV, which was identified and added to Christie's classification by Baratto-Filho et al. [5], displays mesiopalatal root fused to the mesiobuccal root up to the apical third. Versiani et al. [29] classified four-rooted maxillary molars into three types according to the divergence of their roots. The first form is type I that is presented with wide diverging palatal roots and cow-horn shaped

buccal roots, while type II displays parallel roots with blunt apices, in type III, buccal roots were more divergent than palatal roots. Vertucci [30] classification was used to identify the root canal configuration. Dahlberg's classification put the trait of Carabelli into eight categories depending on its degree of expression. These categories were graded from C0 (no Carabelli expression) to C7 (a cusp form with obvious mesial and distal cusp ridges) Madhuram et al. [21].

Statistical analysis

Microsoft Excel 2016 was used to store data for anatomical variations. Cohen's Kappa was calculated using Microsoft Excel 2016 as well. All the measurements and the data were analysed using SPSS statistical software (version 26) (IBM, 2019). Cohen's Kappa analysis was performed to determine the intraexaminer and interexaminer reliability for anatomical variations inspection. Visual inspection of the three planes (sagittal, axial and coronal) was performed on 20 randomly selected teeth in three months for intraexaminer reliability.

Similarly, a second examiner conducted a visual inspection of the three planes to test the interexaminer reliability on the same sample. The intraclass correlation coefficient (ICC) analysis was performed to determine the intraexaminer and interexaminer reliability of the morphometric analysis. For intraexaminer reliability, the volumetric analysis was performed twice by the same examiner on five randomly selected maxillary second molars in a span of three months. Similarly, a second examiner (postgraduate dental student) carried out a volumetric analysis to test the interexaminer reliability on the same sample. Both the examiners were postgraduate dental students and had more than two years of experience using CBCT images. For the cases that showed an increase in the crown's mesiodistal diameter, Paired t-test was used to find any statistically significant difference between the crown's size and buccolingual and mesiodistal diameter of four-rooted maxillary second molars, three-rooted maxillary first and second molars.

RESULTS

In this study, 595 patients were examined. A total of 1120 MSM teeth (561 right, 559 left) were included. Cohen's Kappa value was 0.80 for intraexaminer reliability and 0.79 for the interexaminer reliability. The results suggested that the reliability was good according to Cohen's Kappa. The obtained ICC value was 0.973 for intraexaminer reliability and 0.981 for

interexaminer reliability. The results suggested that the reliability was almost very good for morphometric measurements reliability.

The demographic data of this four-rooted MSMs study

Upon investigating 247 teeth, only 1 four-rooted MSM (0.4%) was observed in a Malay female, while bilateral four-rooted MSMs (0.67%) were noted in a Malay male among 298 teeth. Therefore, the total percentage of four-rooted MSMs can be considered to be 0.55% among the Malay population. Among 281 teeth, 2 four-rooted MSM (0.71%) were observed in Chinese females, and only 1 four-rooted MSMs was noticed in a Chinese male (0.34%) (293 teeth examined) (Tab. 1).

Table 1. The sample size and the distribution of four-rooted MSMs.

Ethnicity and gender	Numbers of patients	Right MSM	Left MSM	Total MSM	Four-rooted MSM	%
Malay males	156	150	148	298	2	0.67%
Malay females	134	125	122	247	1	0.4%
Malay Both genders	290	275	270	545	3	0.55%
Chinese males	159	145	149	294	1	0.34%
Chinese females	146	141	140	281	2	0.71%
Chinese Both genders	305	286	289	572	3	0.52%
Total	595	561	559	1120	6	0.53%

Analysis of morphometric changes in four-rooted MSMs compared to their three-rooted antimeres and the adjacent three-rooted MFMs

A total of six maxillary second molars with an extra root were detected. However, two cases were excluded for not meeting the inclusion criteria. Four-rooted MSMs showed a wider crown's mesiodistal diameter than three-rooted antimeres and the adjacent three-rooted MFMs in 75% and 66.6% of the investigated teeth respectively. Interestingly, 100% of the investigated four-rooted MSMs showed a wider crown's buccolingual diameter than the adjacent three-rooted MFMs, and larger crowns than the three-rooted antimeres (Tab. 2).

Table 2. Prevalence of distinguishing morphometric traits in the investigated four-rooted maxillary second molars.

Morphometric trait	Compared to	No.	No.	%
Wider mesiodistal diameter	Three-rooted antimere	4	3	75%
	Three-rooted adjacent MFM	3	2	66.6%
Wider buccolingual diameter	Three-rooted antimere	4	3	75%
	Three-rooted adjacent MFM	3	3	100%
Larger crown	Three-rooted antimere	4	4	100%
	Three-rooted adjacent MFM	3	2	66.6%

No. — number of the investigated four-rooted MSMs; no. — number of four-rooted MSMs with a distinguishing trait.

Using paired t-test, the increase in crown's mesiodistal and buccolingual diameters in four-rooted MSMs was insignificant compared to their three-rooted antimeres and the adjacent three-rooted MFMs (Tab. 3). However, the crowns of four-rooted MSMs were significantly larger than their three-rooted antimeres (Tab. 4).

Table 3. Paired t test of crown's mesiodistal and buccolingual diameters.

Morphometric variable	The investigated teeth	Mean	Std. error mean	t	P-value
Mesiodistal	**four-rooted MSM**	11.9300	0.56191	2.355	0.143

	three-rooted MSM (antimeres)	10.6067			
Mesiodistal	**four-rooted MSM**	12.2100	0.22500	3.356	0.184
	three-rooted MFM	11.4550			
Buccolingual	**four-rooted MSM**	12.9125	0.28441	1.679	0.192
	three-rooted MSM (antimeres)	12.4350			
Buccolingual	**four-rooted MSM**	12.9533	0.35101	1.975	0.187
	three-rooted MFM	12.2600			

Table 4. Paired t test of crown's size.

The investigated teeth	Mean	Std. Error Mean	t	P-value
four-rooted MSM	810.6350	33.06477	4.108	0.026*
three-rooted MSM (antimeres)	674.7900			
four-rooted MSM	868.8700	29.91500	5.328	0.118
three-rooted MFM	709.4750			

*P is significant at the 0.05.

Analysis of morphological features of four-rooted MSMs and the co-existing anatomical variations and anomalies

The authors studied the morphology of the roots and root canals of four-rooted maxillary second molars. They also investigated if the extra root(s) are associated with an unusual development on the crown of the particular tooth or any co-existing anatomical variations and anomalies.

Root and root canal morphology in four-rooted MSMs

All roots of four-rooted maxillary second molars exhibited Vertucci's type I root canal morphology, representing one root canal in every root. In two (33.33%) bilateral four-rooted MSM, the distobuccal root was separated from the other three roots (Type III). Two (33.33%) four-rooted MSM had unseparated mesiopalatal and mesiobuccal roots (Type IV) (Fig. 3), whereas one (16.66%) tooth had more divergent buccal roots and less divergent palatal roots and was classified as Versiani (Type III) and the remaining one (16.66%) had more divergent palatal roots and less divergent buccal roots which was not included in both classifications (Fig. 4).

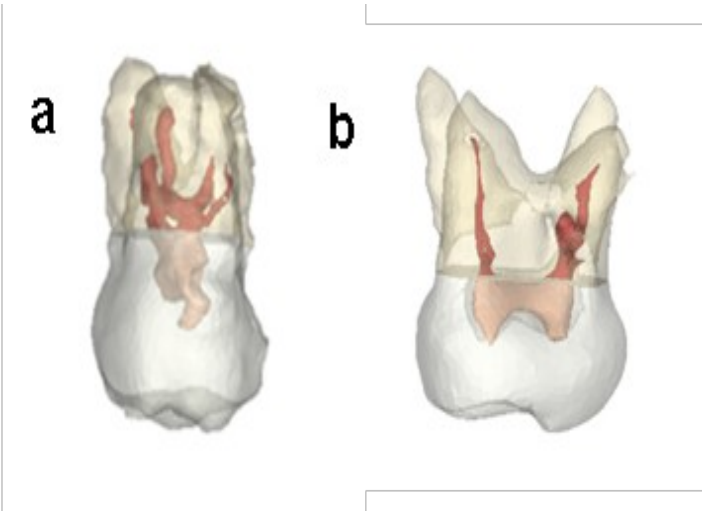

Figure 3. Four-rooted MSMs. **A.** Baratto-Filho type IV four-rooted MSM; **B.** Christie type III four-rooted MSMs.

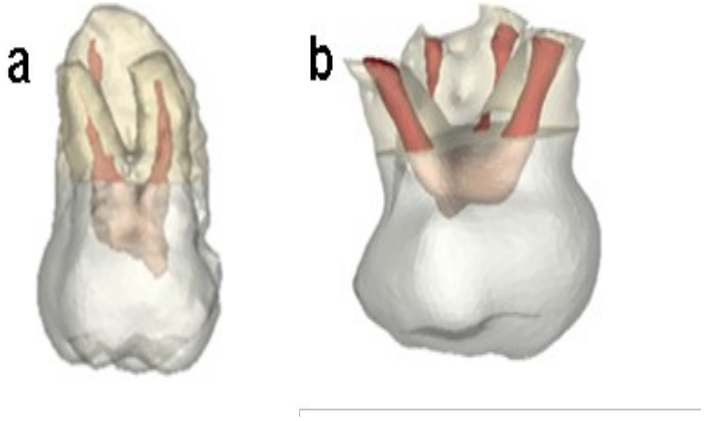

Figure 4. Four-rooted MSMs. **A.** It is not included in both classifications; **B.** Versiani type III.

The crown's co-existing anatomical variations and anomalies in four-rooted MSMs

It was noticed that only one (16.6%) four-rooted maxillary second molar had cusp of Carabelli, and another one (16.6%) four-rooted maxillary second molar had a palatal enamel extension (Fig. 5).

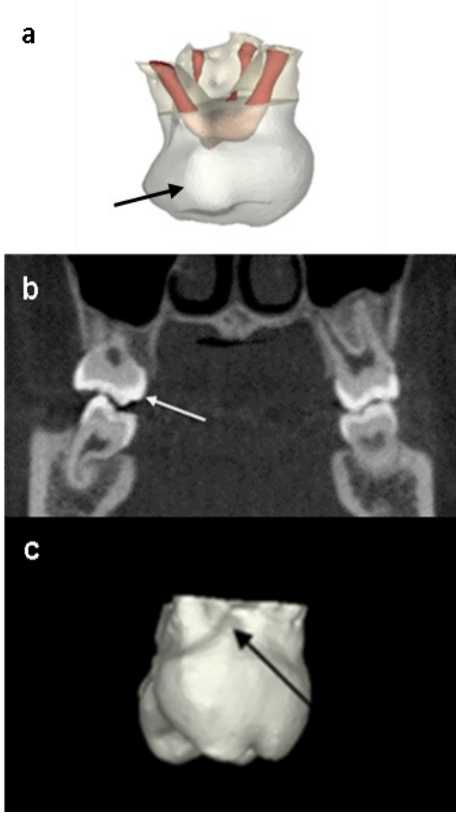

Figure 5. Four-rooted MSMs' crown anomalies. **A.** and **B.** Cusp of Carabelli; **C.** Enamel extension.

The co-existing anatomical variations and anomalies to four-rooted MSMs

Bilateral four-rooted maxillary second molars were accompanied by five rooted maxillary third molar (MTM) (Fig. 6).

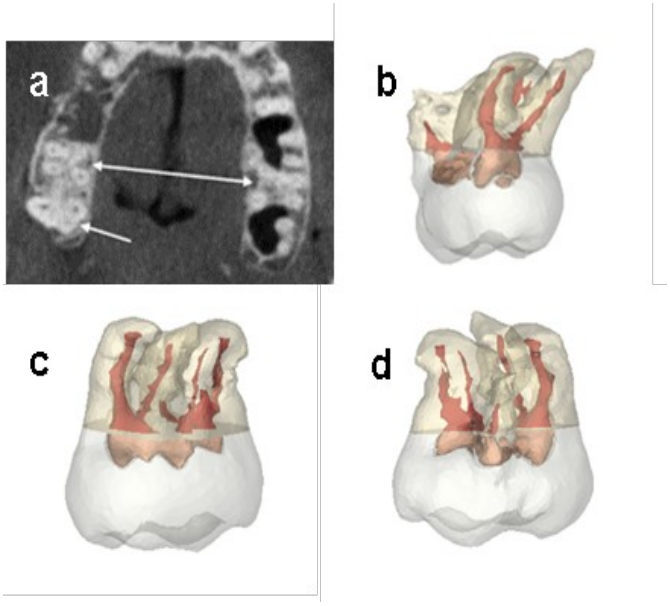

Figure 6. Five-rooted MTM. **A.** The double arrow heads shows bilateral four-rooted MSMs while the single arrow points to five-rooted MTM; **B.** Buccal view of five-rooted MTM; **C.** Distal view of five-rooted MTM; **D.** mesial view of five-rooted MTM.

DISCUSSION

Conventional radiographs/images display three-dimensional (3D) anatomy into a two-dimensional (2D) image, resulting in some important features of the tooth and its surrounding tissues being visualized only in the mesiodistal or buccolingual plane. Thus, 3D anatomical features presented on two dimensional (2D) images may not be fully appreciated [31]. Nowadays, CBCT scan provides a less invasive technique to produce a detailed 3D image of a tooth, providing a reliable life-size image to evaluate anatomical structures with minimum superimposition effect [15].

The incidence of four-rooted MSMs varies among different populations. Likewise, the current results showed a slightly higher incidence (0.53%) of four-rooted MSMs in the Malaysian population in comparison to a Korean (0.49%) [17] and a study reported (0.4%) by Libfeld and Rotstein [20]. However, in this study, only one MSM with two palatal roots (0.35%) was noticed in Chinese males. Few studies on other populations showed slightly higher percentage of four-rooted maxillary second molars in comparison to the current study such as among Brazilian population reported by Candeiro et al. [7] They reported 9 four-rooted MSMs in 801 teeth with a percentage of 1.12%. Similarly, Gu et al. [10] reported 1.85% among mainland Chinese males.

On the other hand, the percentage of four-rooted maxillary second molars in Chinese females (0.71) in this study was similar to that of mainland Chinese females (0.74%) [10].

Gu et al. [10] and Libfeld and Rotstein [20], reported that all four-rooted MSMs were unilateral. However, an unusual finding is the presence of bilateral MSMs in a Malay male. Hitij and Štamfelj [14] also reported that two out of 15 patients had a bilateral occurrence of two palatal roots, while only two patients with a bilateral occurrence of two palatal roots (out of 30 patients) were reported by Aydın [3]. All findings from previous studies and along with our study indicated that the occurrence of bilateral two palatal maxillary molars is a rarity.

All four-rooted teeth in the current study had one root canal in every root — Type I root canal morphology of Vertucci root canal classification. These findings are also supported by the findings of Gu et al. [10] and Madhuram et al [21]. Interestingly, the incidence of five root canals (two canals in the mesiobuccal root) in four-rooted MSMs has been reported in the Korean population by Kim et al. [17]; this was also reported by Aydın [3], with a percentage of 27.78% among 33 maxillary four-rooted first and second molars.

Christie et al [8] classified the four-rooted maxillary molars into three types, they reported that six out of sixteen teeth are identified as Type I. Many studies identified two palatal roots in maxillary molars and classified them according to Christie's classification. Nikhil et al. [24] reported two cases of Type I maxillary first molars. In addition, Manjunatha and Soni [23] reported that 52.83% of case reports identified their cases of four-rooted MFMs as Christie's Type I. However, in this study, 33.3% displayed Type III of Christie's classification. Another 33.3% of our cases exhibited Type IV. While only one tooth was beyond both classification (16.66%), and no Type I was identified in our study.

Versiani et al [29] classified the four-rooted maxillary molars into three types based on a sample of 25 extracted maxillary second molars. In their study they classified 16 teeth as type I (64%), seven as type II (28%), and two as type III (8%). In our study, only one MSM displayed Type III (16.66) of Versiani's classification. However, in a related study, Gu et al [10] reported that amongst 12 maxillary second molars, five cases showed Type I and only one Type III was detected of Versiani's classification. They further added that Type III is considered the most challenging for the endodontic treatment.

Although the diameter of the mesiolingual cusps is generally greater in MFMs than in MSMs, MSMs with two palatal roots have been reported to have wider mesiodistal distance than three-

rooted MFMs [8]. In addition, Alexandersen [2] reported that overdeveloped palatal part of the crown can be seen in case of maxillay molars with two palatal roots. However, similarities in crown size and shape between three-rooted and four-rooted MSMs have been stated by Libfeld and Rotstein [20], which was in agreement with 33.3% of our sample. In fact, narrower mesiodistal distance of four-rooted MSMs was observed than the adjacent three-rooted MFMs. In contrast, 66.6% in the current study showed wider mesiodistal diameter, similar to the findings reported by Christie et al [8]. However, mesiodistal diameter changes in the current study were not statistically significant compared to their three-rooted antimeres (P = 0.143) and the adjacent three-rooted MFMs (P = 0.184) (Tab. 3). Interestingly, four-rooted MSMs' crowns showed a statistically significant increase in size compared to the crowns of their antimeres (P = 0.026) (Tab. 4). Conversely, four-rooted MSMs showed no significant morphometric increase compared to three-rooted MFMs, and this was unexpected.

The co-existing anomalies and anatomical variations with four-rooted maxillary molars have been reported by Christie et al. [8], Aydın [3], Hitij and Štamfelj [14] and Gu et al. [10]. Magnucki and Mietling [22] reported that 15.1% of MFMs in case reports were accompanied by other anomalies.

The cusp of Carabelli's correlation with factors influencing the total crown magnitude, including the distance between cusp tips, was reported by Harris [11]. Madhuram et al. [21] reported that four rooted MFM with the cusp of Carabelli displayed large mesiodistal and buccolingual measurements. A study from Australia also reported that the teeth represented with Carabelli cusp or tubercle had larger crowns than the ones with a milder type of Carabelli traits [18]. Aydın [3] and Hitij and Štamfelj [13] reported that the percentage of four-rooted MSMs exhibiting cusp of Carabelli was 15% and 6.7%, respectively. In the current study, only one MSM with two palatal roots had a cusp of Carabelli, which represents 16.6% of the sample. In the current study, the cusp of Carabelli matched the C6 category of Dahlberg's classification and therefore contributed to the increase tooth size.

Another finding of particular significance was that the five-rooted MTM was detected distal to the bilateral four-rooted MSMs in our study. The five-rooted MTM showed normal mesiodistal diameter but a clear increase in the buccolingual diameter and crown volume, compared with the three-rooted antimere.

Enamel extensions in the palatal surface of maxillary molars with two-palatal roots was reported by Aydın [3] and Hitij and Štamfelj [13] in 45% and 16.7% of their cases respectively. In the current study, enamel extension was noticed on the palatal surface of 16.6% of the sample, a finding similar to Hitij and Štamfelj [14]. In contrast to our study, some studies reported that four-rooted maxillary molars manifested enamel pearls in their roots [8, 14, 29].

Pits, grooves, and slight tubercles (Carabelli's trait) are more common among unmixed Mongoloids than Whites or Negroes, which means that the Mongoloid population rarely express the cusp – the maximum grade of the Carabelli trait [19]. In addition, it is agreed that minor structures such as the less prominent forms of Carabelli's trait may not be manifested by the images in the CBCT scanning modality.

Given the results of this study and notwithstanding its limitations, larger crowns and the occurrence of any crown anomalies might be good indicators for the dentist to investigate the potential presence of accessory roots in the maxillary second molars (MSM). Further research should be undertaken on other ethnic groups residing in Malaysia to investigate population specific link between the crown's morphological features and accessory roots that might help dentists in certain dental treatment procedures.

CONCLUSIONS

This study depicted a low incidence of four-rooted maxillary second molars among the Malaysian population with Mongoloid ancestry. The crown's morphological features play an important role in accessory roots detection, making it clinically possible to predict the presence of extra roots when performing teeth extraction and endodontic therapy. Subsequently, CBCT scans can be performed to confirm the morphology of the extra root.

ARTICLE INFORMATION AND DECLARATIONS

Data availability statement

Original contributions presented in the study are included in the and that further inquiries can be directed to the corresponding author.

Ethics statement

Institutional approval for this dental research was obtained from Medical Ethics Committee, Faculty of Dentistry, University of Malaya, (Reference Number: DF OS2002/0003 (L).

Author contributions

Rasha Ibrahim Alghali: manuscript draft, data collection and analyses. **Phrabhakaran Nambiar:** conceptualization, methodology. **Wei Cheong Ngeow:** conceptualization, methodology, reviewing draft. **Norliza Ibrahim:** resources, analyses. **Muhammad Khan Asif:** methodology, validation, data analyses. **Abeer Saad Al-Mouallad:** statistical analyses and interpretation of results.

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Conflict of interest

None declared.

REFRENCES

1. Ahmed HMA, Abbott PV. Accessory roots in maxillary molar teeth: a review and endodontic considerations. Aust Dent J. 2012; 57(2): 123–131; quiz 248, doi: 10.1111/j.1834-7819.2012.01678.x, indexed in Pubmed: 22624750.
2. Carlsen O, Alexandersen V. Radix mesiolingualis and radix distolingualis in a collection of permanent maxillary molars. Acta Odontol Scand. 2000; 58(5): 229–236, doi: 10.1080/000163500750051782, indexed in Pubmed: 11144874.
3. Aydın H. Relationship between crown and root canal anatomy of four-rooted maxillary molar teeth. Aust Endod J. 2021; 47(2): 298–306, doi: 10.1111/aej.12478, indexed in Pubmed: 33314382.

4. Azim AA, Azim KA, Deutsch AS, et al. Acquisition of anatomic parameters concerning molar pulp chamber landmarks using cone-beam computed tomography. J Endod. 2014; 40(9): 1298–1302, doi: 10.1016/j.joen.2014.04.002, indexed in Pubmed: 25146010.

5. Baratto-Filho F, Fariniuk LF, Ferreira EL, et al. Clinical and macroscopic study of maxillary molars with two palatal roots. Int Endod J. 2002; 35(9): 796–801, doi: 10.1046/j.1365-2591.2002.00559.x, indexed in Pubmed: 12449032.

6. Borghesi A, Michelini S, Tononcelli E, et al. Five-rooted permanent maxillary second molar: CBCT findings of an extremely rare anatomical variant. Radiol Case Rep. 2019; 14(9): 1113–1116, doi: 10.1016/j.radcr.2019.06.024, indexed in Pubmed: 31338137.

7. Candeiro GT, Gonçalves SD, Lopes LL, et al. Internal configuration of maxillary molars in a subpopulation of Brazil's Northeast region: A CBCT analysis. Braz Oral Res. 2019; 33: e082, doi: 10.1590/1807-3107bor-2019.vol33.0082, indexed in Pubmed: 31460608.

8. Christie WH, Peikoff MD, Fogel HM. Maxillary molars with two palatal roots: A retrospective clinical study. J Endod. 1991; 17(2): 80–84, doi: 10.1016/s0099-2399(06)81613-4.

9. Nardo DDi. 3D clinical evaluation of unusual anatomy of a maxillary second molar: a case report. Biomed J Sci & Tech Res. 2018; 2(1), doi: 10.26717/bjstr.2017.01.000648.

10. Gu Y, Wang W, Ni L. Four-rooted permanent maxillary first and second molars in a northwestern Chinese population. Arch Oral Biol. 2015; 60(6): 811–817, doi: 10.1016/j.archoralbio.2015.02.024, indexed in Pubmed: 25791326.

11. Harris EF. Carabelli's trait and tooth size of human maxillary first molars. Am J Phys Anthropol. 2007; 132(2): 238–246, doi: 10.1002/ajpa.20503, indexed in Pubmed: 17078037.

12. Hennekam R, Biesecker L, Allanson J, et al. Elements of morphology: General terms for congenital anomalies. Am J Med Genet A. 2013; 161(11): 2726–2733, doi: 10.1002/ajmg.a.36249, indexed in Pubmed: 24124000.

13. Hitij T, Štamfelj I. The role of clinical examination in the detection of permanent maxillary molars with two palatal roots. Folia Morphol. 2020; 79(1): 127–133, doi: 10.5603/FM.a2019.0054, indexed in Pubmed: 31063199.

14. Hitij T, Štamfelj I. The role of clinical examination in the detection of permanent maxillary molars with two palatal roots. Folia Morphol. 2015; 79(1): 127–133, doi: 10.5603/fm.a2019.0054, indexed in Pubmed: 31063199.

15. Inoue T, Saito M, Nishimura F, et al. Unusual root canal anatomy in a maxillary second molar. Int J Case Rep Imag. 2017; 8(5): 352–354, doi: 10.5348/ijcri-201712-cl-10122.

16. Kanazawa E, Sekikawa M, Ozaki T. A quantitative investigation of irregular cuspules in human maxillary permanent molars. Am J Phys Anthropol. 2005; 83(2): 173–180, doi: 10.1002/ajpa.1330830205.

17. Kim Y, Lee SJ, Woo J. Morphology of maxillary first and second molars analyzed by cone-beam computed tomography in a korean population: variations in the number of roots and canals and the incidence of fusion. J Endod. 2012; 38(8): 1063–1068, doi: 10.1016/j.joen.2012.04.025, indexed in Pubmed: 22794206.

18. Kondo S, Townsend GC. Associations between Carabelli trait and cusp areas in human permanent maxillary first molars. Am J Phys Anthropol. 2006; 129(2): 196–203, doi: 10.1002/ajpa.20271, indexed in Pubmed: 16323183.

19. Kraus B. Occurrence of the carabelli trait in southwest ethnic groups. Am J Phys Anthropol. 2005; 17(2): 117–123, doi: 10.1002/ajpa.1330170207.

20. Libfeld H, Rotstein I. Incidence of four-rooted maxillary second molars: literature review and radiographic survey of 1,200 teeth. J Endod. 1989; 15(3): 129–131, doi: 10.1016/S0099-2399(89)80134-7, indexed in Pubmed: 2691624.

21. Madhuram K, Dhanavel C, Naveen V, et al. Corono radicular anomaly in a maxillary first molar – a rare case report. 2012. J Integr Dent. 2012; 1: 41–44.

22. Magnucki G, Mietling SVK. Four-Rooted maxillary first molars: a systematic review and meta-analysis. Int J Dent. 2021; 2021: 8845442, doi: 10.1155/2021/8845442, indexed in Pubmed: 33542735.

23. Manjunatha BS, Soni NK. Estimation of age from development and eruption of teeth. J Forensic Dent Sci. 2014; 6(2): 73–76, doi: 10.4103/0975-1475.132526, indexed in Pubmed: 25125911.

24. Nikhil V, Jha P, Mishra P, et al. Two palatal roots in maxillary first molar, a rare entity: report of two cases. J Dent. 2024; 25(2): 178–182, doi: 10.30476/dentjods.2023.98649.2101, indexed in Pubmed: 38962080.

25. Ramasamy S. A rare clinical phenomenon of four rooted maxillary second molar: A case report. Saudi J Dent Res. 2015; 6(1): 30–32, doi: 10.1016/j.sjdr.2014.04.001.

26. Scott GR, Irish J. Human tooth crown and root morphology. 2017, doi: 10.1017/9781316156629.

27. Silva EJ, Nejaim Y, Silva AIV, et al. Evaluation of root canal configuration of maxillary molars in a Brazilian population using cone-beam computed tomographic imaging: an in vivo study. J Endod. 2014; 40(2): 173–176, doi: 10.1016/j.joen.2013.10.002, indexed in Pubmed: 24461399.

28. Slowey RR. Radiographic aids in the detection of extra root canals. Oral Surg Oral Med Oral Pathol. 1974; 37(5): 762–772, doi: 10.1016/0030-4220(74)90142-x, indexed in Pubmed: 4524384.

29. Versiani MA, Pécora J, Sousa-Neto Mde. Root and root canal morphology of four-rooted maxillary second molars: a micro–computed tomography study. J Endod. 2012; 38(7): 977–982, doi: 10.1016/j.joen.2012.03.026.

30. Vertucci FJ. Root canal morphology and its relationship to endodontic procedures. Endodontic Topics. 2005; 10(1): 3–29, doi: 10.1111/j.1601-1546.2005.00129.x.

31. Yu X, Guo B, Li KZ, et al. Cone-beam computed tomography study of root and canal morphology of mandibular premolars in a western Chinese population. BMC Medical Imaging. 2012; 18: 1–5, doi: 10.1186/1471-2342-12-18, indexed in Pubmed: 22817397.

32. Zhao J, Li Y, Yang Z, et al. Three-dimensional computed topography analysis of a patient with an unusual anatomy of the maxillary second and third molars. Int J Oral Sci. 2011; 3(4): 225–228, doi: 10.4248/ijos11078, indexed in Pubmed: 22010581.