Abstract

Objective: This study aimed to look into how crown shape affected the architecture of the root canals.

Methods: Nine hundred and fifty-four CBCT scans of maxillary second molars were evaluated. The relation between the crown shape and sex, root number, and root canals was determined. The frequency of the second canal in the mesiobuccal root (MB2), its age relation, and the symmetry of the concurrence of anatomical variations in contralateral molars were analyzed. The chi-square test was used for the analysis of the outcomes. It was deemed significant at P< 0.05.

Results: Overall, rhomboidal-shaped crowns comprised 60.1% of all crowns, while heart-shaped crowns made up 39.9%. Three-rooted teeth were the most common (74.5%), followed by two-rooted teeth (11.9%) and one-rooted teeth (8.5%), while four-rooted teeth made up only 5% of all samples. The most prevalent result in terms of the canal number was three canals (67%), followed by four canals (24.8%), two canals (7.3%), one canal (0.6%), and five canals (0.4%). Males were less likely to have crowns with a heart-shaped structure than females. The rhomboidal crown (22%) had a higher occurrence of MB2 canals when compared to the heart-shaped crown (2.8%).

Conclusions: Given the constraints of this research, it would seem that the rhomboid form of the upper second molar crown is more prevalent, with a greater tendency to have three and four roots and the presence of MB2 than the heart-shaped form.

Keywords: Crown shape. CBCT. Maxillary second molar. MB2. Root canal configuration.

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Introduction

A thorough understanding of the root system's internal structure is required during root canal debridement and three-dimensional obturation of the root canal system to prevent posttreatment pathology. Based on the published findings, root canal treatments of the upper molars have been described as having the most intricate morphology, difficulty in visualization, and a chance of distortion and superimposition of the sinus floor and zygomatic arch by two-dimensional images. 

Evidence proved that the crown's size impacts the presence of additional root canals in mandibular incisors, premolars, distolingual roots in mandibular molars, and mesiobuccal roots in the maxillary first molar. 

Dental anatomy books show two different types of crowns on maxillary second molars when the occlusal aspect is considered. The first kind is the four-cusp type, which has an occlusal aspect that matches the first molar shape. The second kind is the three-cusp type, in which the distolingual cusp is extremely small or nonexistent, and the other three cusps grow more prominently. As a result, the occlusal aspect takes on a heart shape, which is more typical of the maxillary third molar. 

Regarding the root morphology of maxillary second molars, previous studies showed that the most frequently encountered type has three roots with a single canal in each. However, literature reviews frequently highlight the importance of identifying the second mesiobuccal canal as the most frequent variation found in the upper second molar. There have also been reports of less common varieties, such as maxillary second molars with two palatal canals, a c-shaped canal, or six distinct roots. 

In an attempt to overcome the limitation of traditional radiographs, CBCT provides clinicians with valuable information regarding the position of the canal orifice and the configuration of root canals by its unique ability to examine the root canal anatomy in slices of any desirable thickness, which can significantly help in non-surgical endodontic treatment of teeth. 

Numerous studies have used the CBCT method to investigate the second mesio-buccal canal (MB2) presence and its morphology in maxillary molars. However, no studies focus on the relationship between the shape of the crown and the root canal anatomy. Therefore, this retrospective study uses CBCT to investigate the relationship between the shape of the crown and the root and pulp anatomy of the maxillary second molars.

Methods

The present research study was carried out at the Department of Conservative Dentistry. This study was registered and approved by the College of Dentistry at Sulaimani University (registration no.116/22 on June 9, 2022).

Data acquisition

One thousand five hundred patients requiring CBCT examination for their dental diagnosis and treatment had CBCT scanning performed at different hospitals and clinics in Sulaimani city. From these CBCT scans, only 954 maxillary second molars fit the inclusion criteria.

Inclusion and exclusion criteria

As inclusion criteria, the Iraqi population over 18 years old with fully developed permanent maxillary second molars that had closed apices (fully formed), no root resorption or calcification (partial or complete radiographic obliteration of the pulp chamber and root canal cavity), and no root restoration, intracanal post, coronal restoration, or prosthetic crown were included.

Radiographic evaluation and techniques

The CBCT scan was selected using a CBCT machine (NewTom, Giano, Verona, Italy) with standard exposure settings (11×16 cm field of view, 0.3mm voxel size, 110kV, 3.6-5.4s). Milliamperage was automatically (safe-beam) adjusted based on the patient's anatomy from 1-20 mA. Two experienced endodontists evaluated data acquisition, reconstruction, and other test parameters for image quality. Computer software was used to evaluate these reproducible objective measures.

CBCT scans of the teeth included in the study were examined and enumerated to determine the shape of the anatomical crown, root number, number of canals per root at the canal orifice, number of apical foramina per root, and pattern of concurrence of anatomical variations in contralateral molars.

Statistical analysis

Statistical procedures were carried out in the SPSS 26.0 package program (IBM SPSS Statistics, Chicago, IL) at the significance level of P<0.05. After two weeks, 100
of the 954 teeth were reexamined, and the agreement between the measurements was evaluated with the Kappa test. The chi-square test was used to determine the relationship between the patient's sex, age, and crown-root-canal morphology.

**Results**

In this study, 954 maxillary second molars of patients with a mean age of 35.82 ± 10.28 (min-max; 18-75) comprising 465 women (48.7%) and 489 men (51.3%) were examined. A total of 539 right and 415 left molars were included. The interrater reliability was 0.957, with an asymptotic standard error of 0.30. Of the 954 maxillary second molars examined, 573 (60.1%) had rhomboidal-shaped crowns, and 381 (39.9%) had heart-shaped crowns (Figure 1).

Overall, the three-rooted teeth were the most predominant, with 711 (74.5%), followed by two-rooted teeth 114 (11.9%), one-rooted teeth 81 (8.5%), while four-rooted teeth comprised only 48 (5%) of all samples.

Regarding the canal number, the existence of three canals was the most frequent finding, 639 (67%), followed by four canals 233 (24.8%), two canals, 72 (7.3%), one canal 6 (0.6%), and five canals 4 (0.4%) (Figure 2).

A statistically significant relation between the crown's morphology and the number of roots, canals, and MB2 was found, as seen in Table 1. The occurrences of three-rooted and four-rooted teeth and MB2 were higher in rhomboidal-shaped crowns. On the other hand, in maxillary second molars with two mesiobuccal canals (MB1, MB2), about 12.6% had two apical foramina, and 12.2% had one apical foramen.

Regarding gender, the frequency of heart-shaped crowns was higher in females than males, while the rhomboidal crown was predominant in males, with a statistically significant correlation (p=0.001).

The one-rooted and two-rooted maxillary second molars were more frequently found in females. Conversely, the upper second molar with three or four roots was more recurrent in males, with a statistically significant relation \( \chi^2(3, N=954) =30.978, p=0.001 \) (Figure 3 a). In contrast, the existence of MB2 was more frequent in males, with a statistically significant relation \( \chi^2(2, N=954) =32.487, p=0.001 \) (Figure 3 b).

A statistically significant association was found between age and the existence of MB2 (p=0.02) (Fig. 4).

Regarding the pattern of concurrence of anatomical variations in contralateral molars, only 228 CBCTs had both maxillary right and left second molars that fitted the inclusion criteria; among the patients who had both bilateral maxillary second molars, 168 (73.68%) had perfect symmetry in both the number of roots, and canal configuration of the contralateral homonymous teeth. In comparison, 60 (26.32%) were not symmetrical either in the crown shape, number of roots, or number of canals per root.

**Discussion**

Clinicians generally recognize that the discrepancy in root canal morphology of multirooted teeth is a constant challenge for diagnosis and successful endodontic management. The shape of the crown can be evaluated before treatment with a careful clinical examination, which can provide a clue to the tooth's internal anatomy. Therefore, the null hypothesis was rejected since the crown's shape significantly impacts the number of roots and root canal anatomy of the upper second molar.

A rhomboidal-shaped crown was the most frequent form, resembling the maxillary permanent 1st molar. In contrast, the heart-shaped form resembles the maxillary 3rd molar, where the distolingual cusp is very tiny or absent, making the crown appear heart-shaped. According to this study, the existence of MB2 is more frequent in the rhomboidal crown form, as well as the existence of three and four-rooted teeth. Although there is no previous study on the relation between the crown shapes of maxillary second molars and root morphology, these results corroborate previous findings of Kim et al.\(^6\), who concluded that mandibular molars with additional roots had crowns with considerably wider buccolingual dimensions and greater intercuspal distances than those without the extra root. Dibaji et al.\(^5\) also established a correlation between the root canal number and the buccolingual breadth of the mesiobuccal root in the upper first molars.

Up to 74.5% of the upper second molars had three roots, although it was also possible to find teeth with four roots, two roots, or even one root. These results are in line with those of Lee et al.\(^2\), who examined the canal anatomy of upper second molars in a Korean population. Other prior studies\(^11,19,20\) revealed that the populations of Saudi Arabia and Poland had a higher prevalence of three roots in second maxillary molars. These observed variations demonstrate how ethnic origin affects the morphology of teeth.
Figure 1: A: Axial view and B: 3D reconstruction of heart-shaped and rhomboidal shape maxillary second molar teeth by CBCT.

Figure 2: Percentages of canal numbers in the tested maxillary second molars.

Figure 3: The relation of gender with the frequency of (a) the number of roots, (b) the presence of MB2.
Figure 4: The frequency of MB2, Figure 8, MB in different age groups.

Table 1: The frequency distribution and percentages of crown shapes in relation to the number of canals, the presence of MB2, the number of roots, and gender.

<table>
<thead>
<tr>
<th>Number of canals</th>
<th>Rhomboid al form No. (%)</th>
<th>Heart-Shape No. (%)</th>
<th>Total No. (%)</th>
<th>Apical portal of exit No. (%)</th>
<th>Chi-square P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3(0.3)</td>
<td>3(0.3)</td>
<td>6(0.6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>33(3.5)</td>
<td>39(4.1)</td>
<td>72(7.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>327(34.3)</td>
<td>312(32.7)</td>
<td>639(67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>204(21.4)</td>
<td>27(2.8)</td>
<td>231(24.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6(0.6)</td>
<td>0(0)</td>
<td>6(0.6)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Presence of MB2</th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>210(22)</td>
<td>27(2.8)</td>
<td>237(24.8)</td>
<td>116(12.2)</td>
<td>X² = 108.127 p &lt;0.001</td>
</tr>
<tr>
<td>Absent</td>
<td>285(29.9)</td>
<td>345(36.2)</td>
<td>630(66)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fused MB1, MB2 (Figure 8 shape)

<table>
<thead>
<tr>
<th>Number of roots</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21(2.2)</td>
<td>60(6.3)</td>
<td>81(8.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>57(6)</td>
<td>57(6)</td>
<td>114(11.9)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>459(48.1)</td>
<td>252(26.4)</td>
<td>711(74.5)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>36(3.8)</td>
<td>12(1.3)</td>
<td>48(5.1)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Gender

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>318(33.3)</td>
<td>225(26.7)</td>
<td>489(51.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>171(17.9)</td>
<td>210(22.0)</td>
<td>465(48.7)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ X^2 = 108.127, p <0.001 \]
\[ X^2 = 105.127, p <0.001 \]
In a clinical situation, the number of root canals and where they are located are more significant considerations to endodontists than the root number. Previous root canal morphology investigations using CBCT scans have shown similar incidences\(^1,2,3,8,20\). Three canals were the most frequent finding, followed by four canals. The presence of fused canals in the form of C-shapes was also found in this study, as previously reported in an Iraqi sub-population\(^9\).

This study found more variety in the root canal numbers in upper second molars, as reported by earlier research\(^1,2,17,22\). Among these diversities, it is possible to see fused MB1 and MB2 root canals at the orifice of the mesiobuccal root to form a shape like figure 8, which can be subdivided into one canal configuration described by Vertucci's classification. The prevalence of fused MB canals was about 9.1%, primarily found in the rhomboidal form of the crown.

Regarding gender, more frequency of heart-shaped crowns was found in females than males, while the rhomboidal crown was predominant in males, with a statistically significant correlation\((p=0.0001)\).

The one-rooted and two-rooted upper second molars were more frequently found in females; conversely, the upper second molar with three or four roots was more frequent in males, with a statistically significant relation\((p=0.001)\).

In the current study, a significant relation to gender was found regarding the incidence of an MB2 canal, the shape of the crown, and the number of roots in the upper second molars. These results concur with earlier studies\(^7,19,23\). However, Zeng et al.\(^24\) reported that gender had only a small and non-significant impact on the incidence of the MB2 canal. Together, these results support the idea that geographic location may have an impact on the frequency of the MB2 canal in maxillary molars.

Regarding the effect of age, it was previously found that the patient's age is an essential factor to consider in the preoperative evaluation of canal morphology for endodontic treatment\(^17,23,25\), likely due to an increase in the level of calcification. However, Olczak et al.\(^11\) and Ghobashy et al.\(^27\) concluded that the patient's age was not associated with the number of MB root canals in the maxillary molars. The present study results indicate that the presence of MB2 is associated with the age of the patient.

Regarding the symmetry of bilateral homonymous teeth, the earlier studies ranged from 59% to 83% of the maxillary molars\(^13,24,25\), while the current study revealed bilateral symmetry in 73.68% of the root canal anatomy.

In summary, the relationship between crown shape and root canal morphology in the maxillary second molar is a crucial factor that dental professionals must take into account when treating these complex teeth. These variations can influence the placement and angulation of cusps and grooves, which, in turn, affect the course of the root canals.

Although it was clearly demonstrated previously that CBCT systems are a valuable tool for analyzing root canal morphology, CBCT cannot be routinely used in all cases during endodontic treatment. It is important to note that CBCT still uses ionizing radiation and is not risk-free. Therefore, every endodontic case should be judged individually using adequate magnification and illumination tools using conventional radiographs. CBCT should be considered only when further radiographic details are required for diagnosis and treatment planning.

### Conclusion

Despite this study's limitations, the findings showed that the rhomboid form of the maxillary second molar crown is more prevalent, with a greater tendency to have three and four roots and the presence of the two mesiobuccal canals. Meanwhile, the heart-shaped crown has a greater tendency to have fewer roots than one mesiobuccal canal. Understanding the interplay between crown anatomy and root canal configuration is essential for successful endodontic procedures and for ensuring long-term health of patients' teeth.

### References