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The intercuspal and interorifice distances of maxillary molars: A cone-beam computed tomography study

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Abstract

Objective: Proper and conservative endodontic access cavity preparation is a crucial step in performing a successful root canal treatment that ensures a long-term prognosis. This study aimed to evaluate the intercuspal and interorifice length of maxillary first and second molars using cone beam computed tomography (CBCT).

Methods: The CBCT scans of 400 mature and intact maxillary first and second molars (16, 17, 26, and 27) were evaluated. The measured variables included the distances between the buccal cusps (intercuspal distance) and buccal orifices (interorifice distance), the interorifice/intercuspal ratio, and the angle at the intersection of interorifice and intercuspal lines. The variables were compared between different teeth and between male and female patients.

Results: The interorifice and intercuspal distances were significantly greater in males compared to females (P<0.05), except for the intercuspal distance in the left maxillary second molar (P=0.056). There was a statistically significant difference concerning the angle formed between the interorifice and intercuspal lines among tooth numbers 26 and 27 (P=0.044). The interorifice/intercuspal ratio was significantly different between the maxillary first and second molars on the right (P=0.006) and left sides (P<0.001).

Conclusions: The angle formed between the intercuspal and interorifice distances and the interorifice/ intercuspal ratio was greater in the maxillary first molars compared to the second molars. Moreover, males generally had larger internal and external anatomical features than females. Hence, when preparing a conservative access cavity in maxillary molars, clinicians are advised to consider both the external tooth anatomy and the patient's gender as important factors.

Keywords: Access cavity preparation, Cone-beam computed tomography, Conservative treatment, Endodontics, Maxillary molar, Root canal therapy

Introduction

Successful endodontic treatment depends on appropriate endodontic access cavity preparation, sufficient instrumentation, thorough irrigation, and three-dimensional obturation. Gaining thorough knowledge of root canal morphology and its possible variations is essential for a clinician to perform a successful root canal treatment (RCT). Conventional access cavity preparation has been proven to negatively impact the fracture resistance of endodontically treated teeth (1, 2). Therefore, it is essential to preserve maximum tooth structure during access cavity preparation.

Various methods have been employed for evaluating root canal anatomy, including staining and clearing, 2-dimensional radiographic imaging, sectioning procedures, cone beam computed tomography (CBCT), and micro-computed tomography (micro-CT) (3). CBCT provides accurate and high-resolution images for quantitative and qualitative measurements of the dental structure. CBCT images are displayed in three

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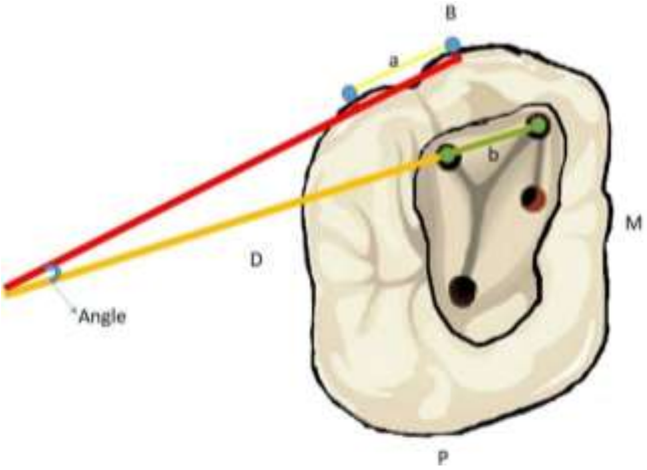

Figure 1. Meassuring the mesiobuccal and distobuccal intercuspal (a) and interorifice (b) distances, interorifice/ intercuspal ratio (b/a), and the angle at the intersection of interorifice and intercuspal lines (M: Mesial, D: Distal, P Palatal, and B: Buccal)

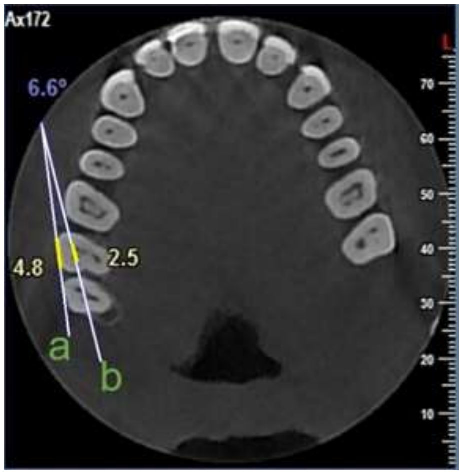

Figure 2. The CBCT axial view of a right maxillary second molar representing the mesiobuccal and distobuccal intercuspal (a) and interorifice (b) distances and the angle at the intersection of interorifice and intercuspal lines

different planes and reduce the superimposition of surrounding structures (4).

Several studies have reported that the interorifice distance is a suitable diagnostic indicator for determining root canal configuration in mandibular and maxillary molars (5, 6). This parameter can also help in detecting the presence and configuration of the second mesiobuccal (MB2) canal in the maxillary first molars (7) and predicting the position of the distobuccal canal in the maxillary second molars (8).

The diagnostic value of distances between different crown landmarks has been evaluated in the literature. Miyazaki et al. (9) reported a sexual dimorphism in the intercuspal distance in maxillary premolars. It is well-known that there is a relationship between the pulp chamber and the external morphology of the tooth regardless of gender, type of tooth, or arch (10). Aydın (11) reported that maxillary molars with wider palatal cusp have a higher possibility of having two palatal canals.

The knowledge about tooth anatomy can guide clinicians to locate the canals and prepare more conservative access cavities. The current study aimed to evaluate several morphologic parameters including the mesiobuccal and distobuccal interorifice and intercuspal distances, the interorifice/ intercuspal ratio, and the angle at the intersection of interorifice and intercuspal lines using CBCT images in maxillary first and second molars.

Materials and methods

Sample selection

The protocol of this cross-sectional study was approved by the Institutional Review Board for Ethics Approval, Inonu University, Turkey (2018/23-24). CBCT images of permanent maxillary first and second molars were retrieved from the archives of a private Oral and Maxillofacial Radiology Center. CBCT images were obtained from patients referred to this center from January 2018 to January 2023.

The required minimum sample size was calculated as 88, at 95% confidence level (α=0.05) and 90% power (β=0.10) when the effect size was considered as 0.35. To increase the accuracy of the study, the sample size was increased and a total of 100 CBCT scans were selected.

The inclusion criteria were intact maxillary first and second molars with complete root formation. Samples with root canal anomalies and the images in which the canal orifices were not visible at the cementoenamel junction (CEJ) level were excluded.

Image acquisition and measurements

CBCT images were acquired using a CBCT scanner (NewTom 5G, Verona, Italy) at 110 kV and a maximum of 20.0 mA. Images with FOV = 18×16, 15×12 , 12×8, or 8×8 cm were used. The voxel sizes of the images were 0.3, 0.25, or 0.2 mm. The scans were obtained by an experienced radiologist and according to the manufacturer's recommended protocol.

The scans were adjusted on the axial view at which the mesiobuccal and distobuccal cusps were most prominent. To detect the mesiobuccal and distobuccal orifices, the CEJ level was selected in all samples in the axial slices. For measuring the anatomic variables, a straight line was drawn from the most prominent point of the mesiobuccal and distobuccal cusps (a). A second line was drawn between the mesiobuccal and distobuccal canal orifices (b) (Figure 1). The ratio of the two determined lines (b/a) was measured for each tooth. Additionally, the angle at the intersection of intercuspal and interorifice lines was measured (Figure 1). Figure 2 represents the measurements of morphologic parameters for a maxillary second molar in a CBCT scan.

Image evaluatıon

The CBCT images were analyzed with the built-in NNT software (New Tom, Verona, Italy). The contrast and brightness of the images were adjusted to ensure optimal visualization. Two endodontists (L.A and H.O) evaluated the images together twice with an interval of 2 weeks between evaluations. When disagreements occurred, an oral and maxillofacial radiologist (N.D.) was consulted to perform a third evaluation and reach a final consensus. All images from 400 maxillary molar teeth were evaluated.

Statıstıcal analysis

All parameters were measured three times, and the average value was recorded. Data analysis was conducted using SPSS 21.0 software (IBM Inc., New York, USA).

The Kolmogorov-Smirnov test was used to evaluate the normal distribution of the data. Since the interorifice distance values were distributed normally, an independent samples t-test was employed to compare interorifice distances between male and female patients. Intercuspal distance values did not display a normal distribution and therefore non-parametric Mann-Whitney U test was used to compare this variable between male and female patients. Comparison of interorifice and intercuspal distances between different teeth was p; performed by one-way analysis of variance and Friedman test, respectively. The interorifice/ intercuspal ratio and the angle at the intersection of interorifice and intercuspal lines were compared between the contralateral and ipsilateral first and second molars using paired samples t-test and Wilcoxon signed rank test, respectively. The significance level was set at $P<0.05$.

Results

A total of 100 CBCT scans were evaluated. The images pertained to 56 female and 44 male patients. Patients had an average age of 24.2 years with an age range of 18-43 years. In each CBCT scan, the right and left first and second maxillary molars were assessed, resulting in a total of 400 evaluated teeth.

Tables 1 and 2 indicate the interorifice and intercuspal distances in the sample, respectively. The mean interorifice distance of teeth 16, 17, 26, and 27 were 2.42 ± 0.4, 2.46 ± 0.5, 2.46 ± 0.3, and 2.28 ± 0.4 mm, respectively (P=0.61; Table 1). The mean intercuspal distance of teeth 16, 17, 26, and 27 were 4.56 ± 0.49, 4.5 ± 0.48, 4.7 ± 0.42, and 4.64 ± 0.46, respectively (P=0.67; Table 2).

When the intercuspal and interorifice distance values were compared between genders, all values were significantly greater in male patients compared to females (P<0.05; Tables 1 and 2). The only exception was the mean intercuspal distance recorded for tooth umber 27, which was insignificantly greater in male patients compared to females (4.73 ± 0.49 mm versus 4.55 ± 0.44, P = 0.056; Table 2)

Table 3 shows the angles formed by the intercuspal and interorifice lines drawn in the transverse plane on the buccal side of maxillary molars. The average angles for tooth numbers 16, 17, 26, and 27 were 8.72 ± 4.97, 8.17 ± 4.07, 9.2 ± 5.53, and 7.97 ± 4.04, respectively (Table 3). According to the Wilcoxon signed ranks test, the average angle at the intersection of the interorifice and intercuspal lines was significantly greater in the left maxillary first molar than the ipsilateral second molar (P=0.044; Table 3).

Table 1. The mean and standard deviation (SD) of interorifice distances (mm) in right and left maxillary molars based on patients' gender

(Tooth number)	Tooth	Male (n = 44)		Female (n = 56)		Total	P-value
		Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)	Mean ± SD	
16	Right maxillary first molar	2.51 ± 0.4	2.5 (1.8-3.4)	2.33 ± 0.41	2.4 (1.5-3.4)	2.42 ± 0.4	0.028*
17	Right maxillary second molar	2.45 ± 0.53	2.35 (1.5-3.7)	2.08 ± 0.47	2.1 (1.2-3.6)	2.46 ± 0.5	<0.001*
26	Left maxillary first molar	2.56 ± 0.33	2.5 (1.9-3.3)	2.36 ± 0.4	2.35 (1.5-3.3)	2.46 ± 0.3	0.008*
27	Left maxillary second molar	2.49 ± 0.47	2.4 (1.5-3.6)	2.08 ± 0.48	2.1 (1.3-3.4)	2.28 ± 0.4	<0.001*
	P-value	0.9		0.23		0.61	

*indicates a significant difference between genders at $P<0.05$.
Min: Minimum, Max: Maximum

Table 2. The mean and standard deviation (SD) of intercuspal distances (mm) based on patients' gender

(Tooth number)	Tooth	Male (n = 44)		Female (n = 56)		Total	P-value
		Mean±SD	Median (Min-Max)	Mean±SD	Median (Min-Max)	Mean±SD	
16	Right maxillary first molar	4.69 ± 0.48	4.8 (3.5-5.7)	4.44 ± 0.5	4.35 (3.3 - 5.9)	4.56 ± 0.49	0.005*
17	Right maxillary second molar	4.64 ± 0.52	4.75 (3.5-5.9)	4.36 ± 0.45	4.3 (3.2 - 5.3)	4.5 ± 0.48	0.005*
26	Left maxillary first molar	4.69 ± 0.4	4.8 (4-5.5)	4.51 ± 0.45	4.5 (3.3 - 5.6)	4.7 ± 0.42	0.038**
27	Left maxillary second molar	4.73 ± 0.49	4.8 (3.6-5.9)	4.55 ± 0.44	4.5 (3.7 - 5.5)	4.64 ± 0.46	0.056
	P-value	0.95		0.68		0.67	

*indicates a significant difference between genders at P<0.05.
Min: Minimum, Max: Maximum

Table 4 shows the interorifice/ intercuspal distance ratios in the sample. The average ratio for teeth number 16, 17, 26, and 27 was 0.53 ± 0.09, 0.5 ± 0.11, 0.54 ± 0.08, and 0.49 ± 0.1, respectively (Table 4). The interorifice/ intercuspal ratio in tooth number 16 was significantly greater than in tooth number 17 (P=0.006; Table 4). Moreover, the interorifice/ intercuspal ratio of tooth number 26 was significantly higher than that of tooth number 27 (P<0.001; Table 4).

Discussion

Three-dimensional analysis of crown and canal morphology is integral to a thorough knowledge of root canal treatment. Intercuspal distances are particularly useful in interpreting dental structures because cusp tips are the sites of initial mineralization and positional variations in cusps often reflect developmental changes (12). This study evaluated the relationship between the anatomy of the crown and root canal orifices in permanent maxillary first and second molars. CBCT has been proven to be a reliable, efficient, noninvasive, and consistent tool in detecting internal anatomic variations. Therefore, several studies have used CBCT for measuring interorifice distance in molars (5, 6).

The findings of this study suggest that the mean interorifice and intercuspal distances were comparable among the maxillary first and second molars. Moreover, male patients almost always represented larger intercuspal and interorifice distances.

The maxillary second molar closely resembles the maxillary first molar. However, compared to the first molar, its mesiobuccal canal orifice is located more on the buccal and mesial sides and the distobuccal orifice approaches the midpoint between the mesiobuccal and palatal orifices (13).

Although the distobuccal canal in the maxillary second molar is located more palatal than the first molar and the resulting angle should be greater, our findings did not confirm this assumption. Indeed, the angle formed between the interorifice and intercuspal lines was greater in the first maxillary molars than the second maxillary molars on both the right and left sides, although the difference was only significant on the left side.

One of the major challenges in preparing an access cavity, especially in multirooted teeth, is the removal of unnecessary tooth structure to determine the orifice position. Currently, minimally invasive practice is adopted in the dental field given the technological advancement in applied sciences, magnification, and imaging techniques. In the present study, it was observed that the interorifice/intercuspal ratio was 0.53 ± 0.09 and 0.54 ± 0.08 for the right and left maxillary first molars, respectively. These values were found to be 0.50 ± 0.11 and 0.49 ± 0.1 for the right and left second

Table 3. Comparison of the angle formed between the intercuspal and interorifice lines on the buccal side among the ipsilateral and contralateral maxillary molars

Tooth number	Tooth	Mean ± SD	Median (Min-Max)	P-value
16	Right maxillary first molar	8.72 ± 4.97	6.9 (3.4 - 36.5)	0.192
17	Right maxillary second molar	8.17 ± 4.07	6.8 (3.2 - 22.7)	
16	Right maxillary first molar	8.72 ± 4.97	6.9 (3.4 - 36.5)	0.962
26	Left maxillary first molar	9.2 ± 5.53	7.4 (3.4 - 35)	
17	Right maxillary second molar	8.17 ± 4.07	6.8 (3.2 - 22.7)	0.521
27	Left maxillary second molar	7.97 ± 4.04	6.75 (3 - 24.8)	
26	Left maxillary first molar	9.2 ± 5.53	7.4 (3.4 - 35)	0.044*
27	Left maxillary second molar	7.97 ± 4.04	6.75 (3 - 24.8)	

*indicates a significant difference between groups at P<0.05
SD: Standard deviation, Min: Minimum, Max: Maximum

Table 4. Comparison of the interorifice to intercuspal ratio on the buccal side among the ipsilateral and contralateral maxilary first and second molars

Tooth number	Tooth	Mean ± SD	Median (Min-Max)	P value
16	Right maxillary first molar	0.53 ± 0.09	0.52 (0.31 - 0.86)	0.006*
17	Right maxillary second molar	0.50 ± 0.11	0.48 (0.23 - 0.75)	
16	Right maxillary first molar	0.53 ± 0.09	0.52 (0.31 - 0.86)	0.805
26	Left maxillary first molar	0.54 ± 0.08	0.53 (0.31 - 0.74)	
17	Right maxillary second molar	0.50 ± 0.11	0.48 (0.23 - 0.75)	0.489
27	Left maxillary second molar	0.49 ± 0.1	0.49 (0.28 - 0.7)	
26	Left maxillary first molar	0.54 ± 0.08	0.53 (0.31 - 0.74)	<0.001*
27	Left maxillary second molar	0.49 ± 0.1	0.49 (0.28 - 0.7)	

*indicates a significant difference between groups at $P<0.05$.
SD: Standard deviation, Min: Minimum, Max: Maximum

molars, respectively. This ratio can be of diagnostic value and guide the clinician in preparing an ideal access cavity with minimum dentin removal. In the present study, the ratio of the interorifice/intercuspal lines was significantly greater in the first molars compared to the second molars on both the right and left sides.

The intercuspal and interorifice distances of the maxillary first molars were significantly greater in males compared to female patients except for the intercuspal distance in the left maxillary second molar. Other studies reported similar findings (14-16). Kanazawa et al. (14) found that male patients exhibited significantly greater intercuspal distance values. Leung et al. (16) found that Southern Chinese females had smaller mesiodistal tooth dimensions than males. In some studies, sexual dimorphism of tooth dimensions has been suggested as a complementary tool for sex estimation in forensic investigations (17, 18). On the contrary, Sekikawa et al. (19) evaluated the morphology of maxillary molars and found no significant difference between male and female genders. In another study, Harris et al. (20) observed that although American white males represented larger maxillary molar sizes, the intercuspal difference between genders was insignificant. The differences between the results of these studies could be attributed to the variations in race and sample size calculation.

The current study had some shortcomings. The formation of secondary dentin around the pulp chamber could occur due to age and also in response to heavy masticatory forces. Moreover, cuspal attrition could affect the intercuspal distance. However, these factors were not considered or evaluated in the current study. Further studies are recommended with larger sample sizes to evaluate the relationship between the external and internal tooth anatomy of maxillary and mandibular molars.

Conclusions

Based on the findings of the current study, the following statements are concluded:

1- Generally, male patients had significantly greater internal and external anatomical features than women.

2- The interorifice and intercuspal distances were comparable between the maxillary first and second molars.

3- The angle formed between the intercuspal and interorifice distances and the interorifice/intercuspal ratio was greater in the maxillary first molars compared to the second molars.

4- When preparing a conservative access cavity in maxillary molars, clinicians are advised to consider both the external tooth anatomy and the patient's gender as important factors.

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Conflict of interest

There are no conflicts of interest.

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