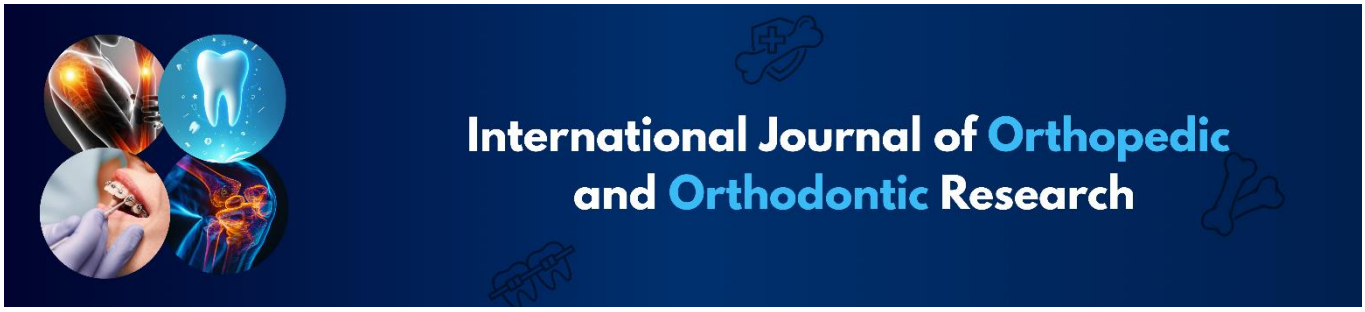

Bilateral Symmetry of Second Mesiobuccal Canal Configuration and Its Relationship to Inter-Orifice Distance in Maxillary First Molars: A CBCT Study

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Abstract

Background: The second mesiobuccal (MB2) canal in the maxillary first molar is the most commonly missed endodontic canal, and recent evidence suggests the use of CBCT-based bilateral symmetry for prediction of its anatomy. There are no data on the Iraqi populations, and no study has investigated whether configuration symmetry is associated with inter-orifice distance symmetry.

Objective: This study aimed at investigating the bilateral symmetry of the MB2 presence and configuration, and its association with the inter-orifice distance symmetry, in the Iraqi population.

Methods: A retrospective CBCT study was conducted on 40 subjects (80 maxillary first molars; 20 females, 20 males), classified as either MB2 absent, Fused, or Separate. The bilateral symmetry was assessed using Cohen's Kappa and McNemar's tests. The absolute difference of inter-orifice distance between the configuration-similar and dissimilar pairs was measured and the correlation between the right and left sides was calculated.

Results: MB2 was present in 87.5% of molars (92.5% right, 82.5% left). Concordance of presence was moderate (κ = 0.55, 90.0% agreement) while concordance of configuration was moderate (κ = 0.45, 72.7% agreement, n = 33). The absolute difference of intra-patient distance measurements between concordant and discordant pairs was not significantly different (0.49 ± 0.43 mm vs 0.49 ± 0.39 mm; P = 0.935), while there was no correlation between right–left distances (r = 0.15, P = 0.409).

Conclusion: Moderate bilateral concordance of MB2 presence and configuration in this Iraqi-Iranian population was seen to be lower than what had been reported elsewhere and was without any inter-orifice distance symmetry. Bilateral anatomy can help in clinical suspicions but cannot substitute for independent examination of each individual tooth.

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Keywords: cone-beam computed tomography, bilateral symmetry, second mesiobuccal canal, maxillary first molar, inter-orifice distance

1. Introduction

MB2 (mesiobuccal) canal of maxillary first molars continues to be the endodontic canal most often missed, and its continuous presence as a reservoir of microorganisms is well-established as one of the reasons for treatment failures[1,2]. Mesiobuccal root is a highly complicated root from an anatomical point of view, which features different shapes of canal orifices, splitting and fusing throughout the length of the canals, as well as frequent fusion of MB2 with MB1 at apical levels [3,4]. Cone-beam computed tomography (CBCT) is now the gold standard for *in vivo* assessment of this anatomical entity, providing three-dimensional visualisation of the pulp chamber floor without the superimposition associated with periapical radiographs [5]. The prevalence

rate of MB2 differs widely among populations from 48% to 97.6%, which may be due to the difference in voxel size and examiner standards and also to the real prevalence difference in the populations [6]. There have been some studies using CBCT on different populations to establish the prevalence and configuration of the same [7,8].

As CBCT increasingly becomes able to capture the contralateral side of the arch within a single capture, clinicians are increasingly able to refer to the contralateral tooth when formulating a treatment plan. There is now an emerging interest in whether the contralateral tooth provides any clinical predictability. CBCT-based study indicated high bilateral concordance rate for MB2 occurrence and morphology in homologous first molars (91.9%), but the bilateral concordance decreased significantly for non-homologous (either adjacent or contralateral) teeth [9]. CBCT-based study also demonstrated bilateral symmetry for MB2 (κ=0.78) [10,11]. There is an earlier CBCT data from Taiwan that had mentioned bilateral symmetry and occurrence of MB2 along with inter-orifice dimensions, but the approach used was different [12]. However, all of the existing bilaterally symmetric data were collected on non-Middle Eastern populations, and no study has attempted to investigate whether bilateral similarity in terms of categorical configuration of apical structure (either fused or separate) correlates with contralateral similarity in quantitative anatomy, i.e. whether contralateral pairs that are similar in terms of their configuration are also similar in terms of their inter-orifice distance. The second research question becomes important since inter-orifice distance is one of the rare quantifiable landmarks that can be used to characterize teeth at pulp chamber floor before assessing full root length.

This study therefore had two aims: the first one was to estimate the prevalence, apical configuration, and bilateral (contralateral) concordance of the MB2 canal in maxillary first molars of middle east population, a population not investigated for this characteristic before; and the second goal was to find out whether contralateral similarity in apical configuration correlates with contralateral similarity in inter-orifice distance.

2. Materials and Methods

2.1. Ethics and sample size

The present study was conducted according to the rules described in the Declaration of Helsinki (updated version of 2000)[13], and the study received approval from the Research Ethics Committee (Number of approval ECD-202517). Reviews further emphasize that research-ethics committee approval should precede clinical research and that participants must provide consent [14,15,16]. The written consent for the use of anonymized imaging data in future research was gained from all patients at the time of CBCT acquisition.

This is a retrospective, observational radiographic study performed on CBCT scans of an existing database limited to patients for whom both the right and the left maxillary first molars were included in the volume of the image. Thus, 40 patients and 80 maxillary first molars were selected and formed 40 pairs of contralateral teeth. The images were obtained using a J. Morita CBCT system (J. Morita Corp., Kyoto, Japan) at 100 kVp, 7.1 mA, voxel size 0.125 mm, FOV – small (80×80 mm). Inclusion criteria include: maxillary first molars with developed roots, absence of metallic restorations and endodontic materials which may induce scattering artefacts and absence of periapical pathology and root resorption. If one molar out of the pair of teeth did not fulfill inclusion criteria, then the patient was not included in the sample.

2.2. Image Analysis and Classification

CBCT images were analyzed using One Volume Viewer (J. Morita Corp., Kyoto, Japan), with examination of the images in axial, sagittal, and coronal planes. An MB2 canal was sought from the floor of the pulp chamber to the apex of the tooth. Molars were divided into three groups: Group A (MB2 absent) – only one MB1 canal found; Group B (Fused) – MB2 canal found at the orifice but fused with MB1 at some level in the root; Group C (Separate) – MB2 canal found and ending in a separate apical foramen. In MB2-positive teeth, the canal morphology was additionally classified by Vertucci's classification (Types II, III, IV, V, and VI).

Classification of right and left molars in each patient was done independently, with examiner blind to the classification of contralateral molars, to avoid biased classification caused by assumption of bilateral symmetry. Classification was done by a single examiner (M.S.) who was calibrated for the classification and measurement procedure using CBCT images.

2.3. Morphometric Measurement

The inter-orifice distance between the MB1 and MB2 orifices was determined for all MB2-positive molars using the software's linear measurement tool as the distance (mm) between the centers of the MB1 and MB2 orifice openings as defined in the pulp chamber floor. All measurements were taken in the axial plane in the level where the orifice openings were most clearly visible. Each CBCT image set was first oriented to the long axis of the tooth prior to taking any measurement.

The absolute difference in the inter-orifice distance within a subject with bilaterally MB2-positive molars (Distance_right − Distance_left) was the main measurement used in configuration-distance symmetry analysis.

2.4. Statistical Analysis

IBM SPSS Statistics (Version 26.0; IBM Corp., Armonk, NY, USA) was used for statistical analysis. Frequencies and percentages were used to report the prevalence of MB2 as well as the distribution of apical configurations and Vertucci subtypes between the sides. Cohen's Kappa test[17], including 95% confidence intervals, was employed to evaluate bilateral concordance of MB2 prevalence among all 40 pairs using the criteria of MB2 presence or absence on the right and left sides. For patients with MB2-positive molars bilaterally, a second Cohen's Kappa test was performed to assess agreement between apical configurations (fused vs. separate) [18]. The Kappa values were evaluated based on the Landis and Koch classification (slight, fair, moderate, substantial, and almost perfect agreement). McNemar's test was used to test for any left–right directional asymmetry of MB2 prevalence or configuration data [19].

For the configuration-distance relationship, the patients were categorized into two groups: concordant configuration (both fused or both separate) and discordant configuration (one fused and one separate). The absolute difference of inter-orifice distance in intra-patient comparison was analyzed among the groups using the independent samples t-test while testing for normal distribution using the Shapiro-Wilk test[20]

and employing the Mann Whitney-U test in cases of non-normal distribution. To serve as a secondary validation measure, the correlation between the inter-orifice distance on the right and left side was estimated among the groups using Pearson's correlation coefficient (Spearman's rho when applicable)[21].

Intra-observer agreement was evaluated using re-examination of a randomly selected subset of the same teeth after 2–4 weeks' interval, using Cohen's Kappa for canal classification and ICC for inter-orifice distance. $P < 0.05$ was taken as statistically significant.

3. Results

Out of the total 40 participants (80 maxillary first molars; 20 females, 20 males; mean age 30.4 ± 4.2 years; range 25-48) studied, the MB2 canal was present in 70 out of 80 teeth (87.5%), in line with the previously described single tooth assessment of this patient group. Prevalence in each side was 92.5% (37/40) for right first molars and 82.5% (33/40) for left first molars.

3.1. Bilateral Concordance Regarding Mb2 Presence

Bilateral MB2 presence was detected in 33 subjects, and bilateral absence of the MB2 was observed in 3 subjects, accounting for an agreement in 36 out of 40 subjects (90.0%). Only four subjects were found discordant in terms of MB2 presence, with its occurrence on the right and absence on the left. The bilateral agreement was moderate (Cohen's kappa = 0.55). McNemar test did not show any statistically significant directional asymmetry ($P = 0.125$); however, only the right-sided pattern of discordance should be noted for further confirmation.

3.2. Bilateral Concordance Regarding Apical Configuration

Of the 33 subjects with bilateral MB2, the apical configuration (fused/separate) was concordant in 24 (72.7%) subjects and discordant in 9 (27.3%), with the concordance of moderate strength (Cohen's kappa = 0.45). The McNemar test revealed lack of directional asymmetry ($P = 1.000$). Vertucci classification coincided precisely bilaterally in 24/33 cases (72.7%).

3.3. Relationship Between Configuration and Distance

The mean absolute difference in inter-orifice distance among concordant configuration patients was almost identical to the mean absolute difference in distance among discordant configuration patients (both 0.49 mm ± 0.43 mm and 0.49 mm ± 0.39 mm, respectively, $n = 24$ and $n = 9$). Since the value of distances' differences in the concordant group failed the normality test (Shapiro-Wilk $P = 0.011$), the main statistical test for comparison was non-parametric Mann-Whitney U test that revealed no significant difference ($U = 105.5$, $P = 0.935$); parametric t-test confirmed this finding ($t = -0.02$, $df = 31$, $P = 0.983$, mean difference 0.003 mm, 95% CI -0.332 to 0.339, Cohen's $d = 0.01$).

Symmetry of inter-orifice distance. Among the 33 bilateral MB2 positive individuals, there was no significant difference between the right and left distance (right side 2.30 ± 0.49 mm, left side 2.23 ± 0.49 mm, paired t-test $P = 0.510$). But there was no significant correlation between the right and left distance of the same individual (Pearson $r = 0.15$, $P = 0.409$, Spearman $\rho = 0.16$, $P = 363$).

Table 1: Bilateral concordance of MB2 canal presence (n = 40 patients) and bilateral concordance of apical configuration among bilaterally MB2-positive patients (n = 33)

	Left MB2 present	Left MB2 absent	Total
Right MB2 present	33	4	37
Right MB2 absent	0	3	3
Total	33	7	40
	Left Fused	Left Separate	Total
Right Fused	10	4	14
Right Separate	5	14	19
Total	15	18	33

MB2 canal presence: Cohen's $\kappa = 0.55$ (moderate agreement); McNemar's exact $P = 0.125$ concordance of apical configuration: Cohen's $\kappa = 0.45$ (moderate agreement); McNemar's exact $P = 1.000$

Table 2: Inter-orifice distance symmetry by configuration concordance status

Group	n	Mean absolute intra-patient distance difference (mm)	Test	P-value
Concordant configuration	24	0.49 ± 0.43	Mann–Whitney U (primary)	0.935
Discordant configuration	9	0.49 ± 0.39	Independent t-test (supportive)	0.983

Cohen's $d = 0.01$; mean difference = 0.003 mm (95% CI −0.332 to 0.339)

4. Discussion

As far as we know, this is the first study that examined the prevalence, the configuration, and the concordance between both sides of the MB2 canals in the Iraqi population using CBCT technology. In general, the prevalence of the MB2 canals in the current study population was 87.5%, which was within the broad range previously reported in other CBCT studies (48%-97.6%) [6]. Nevertheless, the prevalence of MB2 canals on both sides was more different than it should be expected if there was no laterality effect (92.5% vs 82.5%). All four patients who had discordance between the presence of MB2 canals on both sides were characterized by the presence of the MB2 canals only on the right side, and not on the left.

Bilateral concordance for presence of MB2 was moderate ($\kappa = 0.55$, 90% raw agreement), and concordance for apical configuration in those patients with MB2 on both sides was also moderate ($\kappa = 0.45$, 72.7% agreement). These numbers are lower than concordance found in two recent bilateral-symmetry CBCT studies: 91.9% homologous agreement found by[9]. and $\kappa = 0.78$ found by [10], even despite methodological similarities. Considering that the comparison cohorts in both studies included substantially larger number of patients (99 and 146 respectively) compared to this study (40 patients), the reduced Kappa values in this study can be at least partly attributed to statistical instability rather than

true difference in the population characteristics, although anatomical differences in the population cannot be excluded either. It is known from literature concerning the relationship between chamber floor anatomy and canals' orifices that existing associations between the presence of MB2 and bilateral symmetry remained descriptive and inconsistently quantified for different populations [5,12]. The most interesting result of this investigation is connected with the association between configuration concordance and the underlying quantitative anatomy.

In contrast to the hypothesis that contralateral pairs characterized by similar apical configuration (both being fused or separated) should demonstrate more similarity in terms of inter-orifice distance, the absolute intra-patient distance difference was almost the same in the case of concordance (0.49 ± 0.43 mm) and discordance (0.49 ± 0.39 mm), with an effect size equal to 0.01. Moreover, the right- and left-side inter-orifice distances did not correlate within individuals ($r = 0.15$, $P = 0.409$), although the difference between means of these parameters on group level was not statistically significant ($P = 0.510$ for paired sample t-test). Thus, the absence of correlation despite the symmetry on the group level suggests that the inter-orifice distance is a locally controlled variable.

The result of this study is consistent with our previous finding which states that the inter-orifice distance itself does not provide information about whether MB2 will be fused or separate from the single tooth perspective, and this study goes one step further; the inter-orifice distance does not provide information on configuration neither at a single tooth nor bilateral perspectives. Together, these results support that predictors for MB2 configuration should include multiple parameters including pulp chamber floor pattern (K-, Y- and I- type) [5], mesio-distal width of pulp chamber and root canal curvature, in addition to inter-orifice distance, not just linear measurement.

Clinically, the moderate concordance of presence of MB2 between right and left maxillary first molars seen in this study provides a more cautious result than those of previous studies [9,10]: The finding of MB2 on the other side may raise suspicion clinically, but since there is 90% overall agreement of presence of MB2, almost 1 in 10 patients would show presence discordance in this population, while the concordance rate of configuration is even lower. Examination of the presence of MB2 must be done independently [2].

5. Conclusion

MB2 was common in the present Iraqi cohort (87.5%), similar to the large range that has been previously noted among various populations. Concordance regarding the presence of MB2 ($\kappa = 0.55$) and its apical configuration ($\kappa = 0.45$) was moderate, compared to substantial to almost perfect agreement in recent bilateral symmetry studies of other populations, thus suggesting that the contralateral side can be used but should not replace the independent examination of each maxillary first molar. Inter-orifice distances between two MB2s on the right and left sides were not symmetrical, and no correlation between the right and left inter-orifice distances was observed in the same patients, suggesting that this quantitative measure is locally controlled rather than being controlled by one bilateral development pattern. In addition to our previous finding that the inter-orifice distance alone is not predictive of the configuration of MB2, these findings suggest that an accurate prediction of MB2 configuration based on one parameter alone will probably be impossible, and therefore models of multi-parameter or population-specific configuration should be investigated.

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