**ORIGINAL ARTICLE**

# Evaluation of Root Canal Morphology of the Maxillary Permanent First Molar among Iraqi Population: A Cone Beam Computed Tomography Study (Retrospective Study)

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## Abstract

**Purpose:** Endodontic success mainly depends on the complete root canal system debridement, both mechanically and chemically. The maxillary first molar possesses one of the most complex root canal anatomy. The purpose of this study was to map the maxillary first molar's root canal anatomy and its variations. Cone Beam Computed Tomography (CBCT) was used to determine the prevalence of the Second Mesiobuccal Canal (MB2) and its possible relation to the gender of the patient in the Iraqi population.

**Materials and Methods:** Images from documented archives of CBCT scans for 415 patients who had maxillofacial diagnosis or root canal treatment were used in this study. Totally 656 maxillary first molars (336 females and 320) males) were included. The root canal configuration, frequency of MB2, and its two-sided symmetry were observed. The (chi-square test) was used to calculate the gender correlation. The P-value of less than 0.05 (p<0.05) was considered significant.

**Results:** In 61.1% of the cases, the MB2 canal was discovered with high bilateral symmetry (73.6%). Genders did not show any statistically significant differences.

**Conclusion:** The existence of MB2 canal in the maxillary first molars is high and approximately more than half of the cases. No relation was found between the existence of the MB2 canal and the gender of the patient. CBCT is a clinically efficient method for the diagnosis and improvement of root canal therapy.

**Keywords:** Maxillary First Molars; Root Canal Morphology; Cone Beam Computed Tomography; Second Mesiobuccal Canal.

# 1. Introduction

Despite the advances in implant technology, endodontic therapy is frequently used to treat irreversible pulpal and periapical diseases so that natural teeth can be preserved. Successful endodontic outcomes mainly depend on complete mechanical and chemical cleaning and disinfection, followed by a hermetically sealed root canal system. Therefore, in order to provide proper treatment, the clinician should have a good knowledge of canal anatomy and any possible variations [1]. However, the complex structure of root canals possesses clinical issues and difficulties, jeopardizing the fundamental purpose of root canal therapy. The highest rate of endodontic failure among all teeth is in the maxillary permanent molars due to the complex root canal structure and variant architecture of their mesiobuccal roots [2]. Incapability to locate, clean, or obturate an MB2 canal is the most frequent cause of technical shortcomings in maxillary molars, which can lead to an unfavorable prognosis due to lingering intracanal infection [3, 4]. As a result, variances in root canal systems and race-specific characteristics should be noted [5]. In the literature, the root canal system's internal structure has been detected by many methods, such as tooth clearing and dye injection [6], conventional radiography [7], scanning electron microscopy [8], micro-CT [9], or CBCT [10].

As a non-intrusive method, CBCT can offer three-dimensional images of the dento-alveolar area to the dentist. Nowadays, CBCT has become widely used for diagnosis and morphological analysis in endodontics [11, 12]. CBCT was utilized in several previous studies to identify the morphology and prevalence of the MB2 canal of permanent maxillary molars in people of different ethnicities [11, 13-16]. However, few studies evaluated the MB2 canal and provided information about this canal's symmetry between contralateral molars in the Iraqi population using CBCT. Therefore, this study was designed to determine the roots number, canal configuration, incidence, and bilateral symmetry of the MB2 canal in the maxillary first molars of the sub-Iraqi population at various ages and genders. In addition, to describe the apparent differences and similarities, using related research with similar methods.

# 2. Materials and Methods

The CBCT scans of 415 patients who presented to Al-Ghadeer Specialized Dental Center in Baghdad between January 2019 and February 2020, for diagnosis or root canal treatment were included in this study. These scans were taken by CBCT machine (Planmeca Promax 3D, Finland); an experienced radiologist assessed the appropriateness of data gathering, reconstruction, and other image quality test parameters. Computer software (Romaxis version 5 software) was used to assess the reproducibility of objective measures.

Two observers analyzed the images simultaneously: an experienced oral radiologist and an endodontist. Among the age group between 18 and 65 years, any CBCT image with at least one completely formed permanent maxillary first molar was included. Teeth with open apices, fracture, resorption, calcifications, or previous endodontic treatment, posts, or crown restorations were excluded. Only 399 patients met the inclusion requirements.

## 2.1. Method of Observation

Data was created and the patients were categorized based on their gender, quantity of roots, and number of canals per root, presence or absence of MB2 in each scan with their configuration in accordance with Vertucci's categorization. Vertucci has classified root canal configuration of human permanent teeth into eight types (Figure 1). type I: A single canal extends from the pulp chamber to the apex. Type II: two separate canals leave the pulp chamber and join short of the apex to form one canal. Type III: One canal leaves the pulp chamber, divides into two within the root, and then merges to exit as one canal. Type IV: Two separate and distinct canals extend from the pulp chamber to the apex. type V: One canal leaves the pulp chamber and divides short of the apex into two separate and distinct canals with separate apical foramina. Type VI: Two separate canals leave the pulp chamber, merge within the body of the root, and re-divide short of the apex to exit as two distinct canals. Type VII: One canal leaves the pulp chamber, divides, and then rejoins within the body of the root, and finally re-divides into two distinct canals short of the apex. Type VIII: Three separate canals extend from the pulp

chamber to the apex.). Each CBCT scan was examined on different axes: first, the sagittal and coronal sections, which were positioned parallel to the root's long axis, and then the axial or horizontal sections that were perpendicular to the long axis of the root (Figure 2).
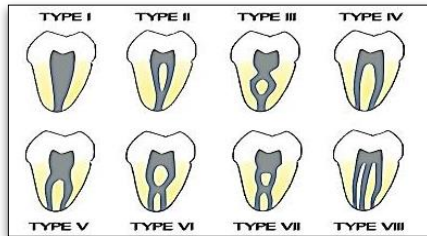


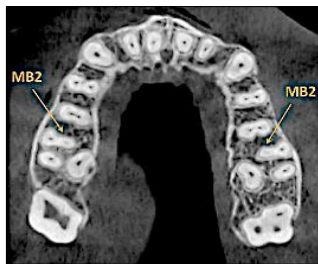**Figure 1.** The schematic diagram represents Vertucci's classification of MB2 root canal morphology



**Figure 2.** Axial section showing the bilateral symmetry of MB2 canal in left and right (maxillary first molars) (arrows)

## 2.2. Statistical Analysis

The conducted data were analyzed with (SPSS software, version 23, IBM Corp; Armonk, NY). The most significant result was the correlation of (MB2) root canals in maxillary first molars to gender by the (chi-square test). P-values <0.05 were considered statistically significant. The Kendal tau correlation coefficient was used to examine the type distributions of the canal on both sides (left and right).

## 3. Results

As mentioned before only 399 of the 415 patients were included in the study. Eight hundred thirty pictures from CBCT scans were examined. Only 656 maxillary first molars (336 females and 320 males) matched the previously stated inclusion standards.

## 3.1. Roots Number and Morphology

About 647 of all the examined maxillary first molars had: three separate roots (98.6%), three teeth (0.5%) had one root, five teeth (0.8%) had two roots (all of them had a buccal and palatal root), and only one tooth had four roots (0.02%).

## 3.2. The Canals Number in Each Root

Distobuccal and palatal roots had a single canal when three distinct roots were present, in all of the examined teeth, while for the MB roots, 39% had a single canal, 61.1% had two canals, and only one tooth (0.2%) had three canals. In the other molars with one root (only three teeth), one had a single canal, and the other two had three canals, two buccally and one palatally. Molars with two roots (five teeth) one had a single canal per each root. The other four teeth had a single canal palatally and two canals buccally. Only one tooth had four roots with a single canal per each root.

## 3.3. Root Canal Anatomy of Mesiobuccal Root Considered by Vertucci's Classification

When MB2 was present, the mesiobuccal (MB) root of the maxillary first molars' root canal configuration was (38.7% type I), (34.3% type II), (4.6% type III) (19.5% type IV), (0.8% type V), (0.6% type VI), (0.9% type VII), and (0.3% type VIII) (Figure 3).
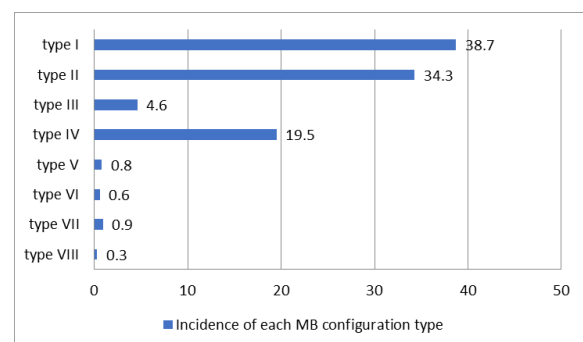


**Figure 3.** The MB root canal configuration of the maxillary first molar

## 3.4. Symmetry in the Bilateral Corresponding Teeth Roots Number and Morphology

Of 258 patients that had bilateral homonym maxillary first molar teeth, 190 (73.6%) had perfect

symmetry concerning the absence or presence of MB2 canal in homonym teeth, and about 68 patients (26.4%) showed asymmetry between the homonym teeth on the opposite side (Figure 2).

### 3.5. Incidence of MB2 in Different Genders

Regarding the presence of MB2 in different genders, Pearson chi-square tests were performed; no statistically significant difference was found between males and females, as illustrated in Table 1.

**Table 1.** Incidence of MB2 in different genders

|        | MB2/Yes | MB2/No | Total | Sig. |
|--------|---------|--------|-------|------|
| **Male** | 123(38.4%) | 197(61.6%) | 320 | 0.785 |
| **Female** | 132(39.3%) | 204(60.7%) | 336 | |

## 4. Discussion

The knowledge of root number and canal configuration has a significant influence on endodontic treatment's success rate [17]. This study has two-purposes. First, to offer a novel explanation based on unbiased findings from the current investigations and data from the scientific papers defined the effect of sex on this anatomical trait in the Iraqi people. The second purpose is to permit an interpretation of the detected differences and similarities, based on related papers that employed comparable methods (CBCT imaging) to generate an evidence-based background that might be important from a therapeutic or anthropological standpoint.

Many methods were used in previous studies to evaluate canal morphology, such as staining and tooth clearing, magnification with loops, and conventional radiographs [18, 19]. CBCT has recently made it possible to provide in vivo nondestructive 3D images of both the root and canal system's external and internal morphology. This method produces low radiation, higher resolution, and accuracy. It can be revealed as a reliable way for discovering the MB2 canal [20-23]. The importance of CBCT for the research and evaluation of root canals and diagnosis of fractures, and external and internal root resorption have been highlighted by many studies [2-4].

In the present study, three separated roots were the most frequently observed root morphology of the maxillary first molar: (98.6%) palatal, distobuccal, and mesiobuccal root. The mesial roots' majorities have two canals (61.1%). Considering Vertucci's categorization [24], it shows a variety of types other than just type I (which constituted only 38.7% of cases).

This study affords a complete report on the root canal morphology of maxillary first molars in Iraqi people by using CBCT, previous studies on different samples of the Iraqi population were performed [19, 22, 25]. Previously reported studies showed a different percentage of MB2 canal incidence among other ethnic groups of Iraqi population [22-25].

MB2 canals were found in 61.1% of the population sample in the current study, other researchers concerning the prevalence of MB2 canals among different Iraqi populations reported a higher prevalence rate of MB2 (81.78%) [22] or a lower percentage (53.7%) [25] (Figure 4). The technique, racial variances, and/or sample size changes may all have an impact on these variations in the MB2 canal prevalence rate.
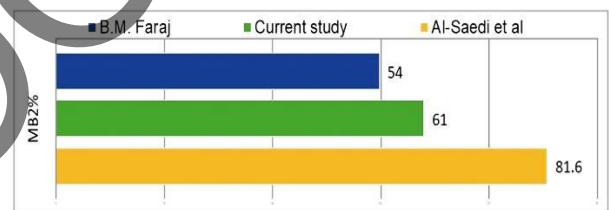


**Figure 4.** Bar chart demonstrating the prevalence of MB2 in different ethnic groups of the Iraqi population. CBCT was used in these studies

Many studies utilizing CBCT reported similar variations in the frequency of MB2 canals, A total prevalence rate of 92% was reported by Hiebert *et al.* [26]. Zhang *et al.* discovered MB2 canals in 85.4% of their study sample [27], utilizing CBCT, 86.6% of the 149 maxillary first molar in the Naseri *et al.*'s study sample demonstrated the presence of an MB2 canal [28], whereas a similar prevalence rate was noted in the Shetty *et al.*'s study (86.36%) in an Indian population [29].

Coelho *et al.* [30], found MB2 in 75.91% of their sample, while In a population of South Africans, Fernandes *et al.* reported MB2 prevalence rates of 92% and 87% on the right and left sides, respectively [1], whereas Estrela *et al.* reported MB2 prevalence in 76% of the Brazilian population under evaluation [31]. The MB2 canal prevalence was evaluated by CBCT in a global survey, and the results showed that the ratio varied

from 48.0% in Venezuela to 97.6% in Belgium, with an average rate of 73.8% [23].

On the other hand, certain investigations have documented lesser rates of prevalence for MB2 canal, including the study conducted by Su *et al.* (45.9%) [32]. Additionally, Tanvi *et al.* who studied an Indian community found a prevalence rate of 55.7% [33], while Zand *et al.*'s study of Iranian participants found a prevalence rate of 55.1% [34]. Lastly, a study by Al-Shehri *et al.* found that 330 maxillary first molars of Saudi patients had a 64.9% prevalence rate of MB2 canal [35].

These discrepancies in the prevalence rate of the MB2 canal could potentially be attributed to changes in sample size, racial disparities, and/or variations in the methodology applied.

In this study when MB2 was present; Type II was the most prevalent, accounting for (34.3%) of cases, whereas type IV accounted for 19.5% followed by type III (4.6%), the other categories were less common. Al-Saedi et al who studied the prevalence of MB2 in a different Iraqi ethical group in the most southern region of the country reported a similar prevalence of MB2 morphology but with a higher percentage than reported in the current study; type II (44.58%), followed by type IV (31.30%) [22].

The results of this investigation align with a previous study conducted on patients from Saudi Arabia, which found that Vertucci's type II was the most common kind (47%), followed by type I (29.4%), and types III and IV (11.8% each). No additional types were seen in this study [36]. In a study conducted by Khademi *et al.*, 389 maxillary first molars were assessed in a sample of the Iranian population. The presence of MB2 was observed in 70.2% of the sample; the most prevalent canal type was type II, accounting for 53.1% of cases, followed by type I, which accounted for 29.8% [37]. Naseri *et al.* conducted an assessment of an Iranian population and found that type VI was the predominant canal type (35.6%), followed by type II (32.9%) [28]. In a study done by Ghobashi *et al.* in an Egyptian population, it was discovered that the most prevalent canal type, as classified by Vertucci, was type II (45.6%), followed by type IV (27.27%) and type I (25.45%) [14].

The comparison between these studies is difficult; the dissimilar results are related to the difference in the patient demographic of each region, race, sample size,

the sensitivity of observers' reading, CBCT, software variances, and parameter settings could also be the cause for the dissimilar MB2 prevalence rates seen in other studies.

Our findings didn't display a significant association between the incidence of MB2 and patient gender. These findings coincide with other studies in the literature [1, 15, 38]. A similar correlation between sex and MB2 incidence in another sample of the Iraqi population was reported [22]. Mordanov *et al.* did a study involving Russian patients and reported that there was no significant association between sex and the prevalence of the MB2 canal [39]. Furthermore, Fernandes *et al.* found no statistically significant correlation between gender, and the occurrence of the MB2 canal [1]. Das *et al.* utilized an endodontic microscope to observe and analyze the prevalence rate of MB2 canal. Their findings revealed no significant difference in this rate based on sex [40]. Falcão *et al.* likewise found no significant variations in the presence of the MB2 canal based on gender [41].

Meanwhile, Martins *et al.* discovered that there was no significant difference in the occurrence rate of the MB2 canal between males and females [23]. In contrast, Zhang *et al.* observed a significant correlation between both gender and age with the presence of the MB2 canal [42].

On the other hand, a significant relation was reported between the prevalence rate of MB2 canal and sex by Faraj *et al.* who did a study involving a sample of patients in the northern region of Iraq [25], the rationality of these findings was affected by the use of various CBCT machines, voxel sizes, fields of views, and software programmers. These factors could account for the discrepancies in the reported ratios, along with differences in the racial composition of the study samples.

Regarding the bilateral symmetrical occurrence of MB2, in this study, we found high symmetry concerning the absence or presence of the (MB2) canal in homonym teeth on the opposite side. Of 258 patients with bilateral homonym maxillary first molar teeth, 190 (73.6%) had perfect symmetry, the impact of these findings has great importance on clinical practice, the dentist should be attentive to the possible occurrence of MB2 on the opposing side in a patient with a known MB2 in one of his maxillary first molars. This result is similar to that of

Zheng Q *et al.* [42], who reported a symmetrical distribution of additional canals in the (MB) root of maxillary molar teeth (71.11 %) and concluded that the occurrence of the other canal in the MB root is usually bilateral and does not differ by patient sex.

Even though root canal treatment is still the treatment of choice for the majority of teeth with a predictable success rate, the failure of treatment in maxillary molar teeth may be due to a lack of understanding regarding the genuine existence of MB2 canals and difficulties in detecting them. Unidentified and hence untreated MB2 canals serve as a source of ongoing microbial infection, resulting in the failure of endodontic therapy and the subsequent development of apical periodontitis [1].

## 4.1. Limitations of This Study

The subjective nature of investigational studies can be influenced by the researchers' perspectives. Additionally, the sample size was determined based on available information from databases at that period of time, as recent statistics on the Iraqi population were not accessible.

## 5. Conclusion

Despite the limitations of this CBCT investigation, it was found that the prevalence of the (MB2) canal in the maxillary first molars of the Iraqi population is considerable, accounting for more than half of all cases (61.1%). It was also shown that the chances of these canals being present in bilateral symmetry were very high (73.6%). There is no link between the occurrence of MB2 canal and the gender of the patient. CBCT is a clinically effective method for diagnosing and interpreting root canal anatomy, which can help to enhance the overall root canal treatment outcome.

## Acknowledgments

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