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Original Article

Evaluation of Maxillary First Molar Teeth's Mesiobuccal Root and Root Canal Morphology using two classification systems amongst a Turkish population: A Cone-beam Computed Tomography study

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CLINICAL SIGNIFICANCE

Clinicians must possess knowledge regarding the prevalence and nature of additional canals in the mesiobuccal roots of maxillary first molars across varying populations. Failure to address this issue can lead to treatment failure and unsatisfactory outcomes for patients.

ABSTRACT

Objectives: This research aimed to analyze and compare the morphology of the mesiobuccal (MB) root and its canals in maxillary first molars (M1Ms) using Vertucci (1984) and Ahmed et al. (2017) classification systems.

Materials and Methods: 250 cone beam computed tomography (CBCT) images of 500 M1M teeth were evaluated for MB root and canal configurations. The images were analyzed from sagittal, axial and coronal perspectives. Canal number and morphology were documented according to Vertucci's method as well as a more recent classification system.

Results: The majority of MB roots had Type I morphology according to the Vertucci classification (right: 38.4%; left: 43.2%), and according to the new root canal morphology classification system, the most common code detected was ^{3}16 MB^{1} in the right side (37.6%), ^{3}26 MB^{1} for the left side (41.2%). Subsequently, Type IV (right: 24.4%; left: 26.0%) and Type V (right: 16.4%; left: 14.4%) were the next most frequently identified morphologies according to the Vertucci classification, whereas according to Ahmed's classification ^{3}16 MB^{2} (24.4%), ^{3}26 MB^{2} (25.2%), ^{3}16 MB$^{1-2}$ (16.4%), and ^{3}26 MB$^{1-2}$ (14.0%) were the most common.

Conclusion: It is vital for dentists to locate and treat all parts of a tooth, especially the MB2 canals in M1Ms, to prevent endodontic treatment failure due to microbial contamination and infection. For clinicians seeking clarity in root and canal morphology, the new classification system offers a more precise and user-friendly approach than the traditional Vertucci classification.

1. Introduction

The development of teeth is a series of complex biological processes governed by epithelial-mesenchymal interactions. Disruption of these interactions during the developmental process can alter the normal course of odontogenesis and lead to developmental anomalies and variations.[1] Depending on the developmental stage of the tooth, several variations may occur in the number, size, and/or shape of roots/canals. Studies have shown that these variations can differ significantly among populations, within populations, and even within the same individual.[2] Achieving success in endodontic procedures hinges on the effective cleaning, shaping, and filling of the root canal system. A profound understanding of root canal morphology is vital to ensure the right treatment approach. Thus, radiographic evaluation is indispensable in diagnosing and strategizing treatments for root canals.[3]

Various systems are available to classify root canals and accessory canal morphologies.[4,5] Weine, et al. [6] utilized cross-sectional and radiographic methods to initially divide root canal configurations within a single root into three types, and later, one more type was added. Vertucci, et al. [5] used the clearing technique to identify internal root canal anatomy and proposed a more complex classification, with a total of eight configurations. Despite these efforts to systematically define variations in canal configurations, variations in root canal morphology have been observed in different populations.[2,7] Versiani, et al. [4] using micro-CT technology, described 37 types of root canal configurations within a single root. With the increasing range of anatomical variations and the more apparent shortcomings of the existing systems, Ahmed et al.[8] proposed a more comprehensive system for the classification of the root, root canal, and accessory canal morphologies. Recent scholarly investigations have consistently highlighted that the system developed by Ahmed et al. not only possesses broader applicability but also excels in accuracy.[9-11]

Traditional methods used to analyze the root canal morphology (such as sectioning, canal staining, and clearing technique) are generally invasive and require special preparation.[12] Although periapical radiography is one of the most important diagnostic tools in endodontic treatment, it may fail to provide accurate information regarding variations due to superimpositions.[13] Cone-beam computed tomography (CBCT) allows a three-dimensional view of root canals from different angles in a 360-degree axis, enabling a more precise analysis of the root canal anatomy.[14] Additionally, it provides a high-quality image with lower radiation exposure compared to traditional CT scans. Micro-computed tomography (micro-CT) is another diagnostic tool that provides more detailed information about root and canal morphology compared to CBCT, but it is expensive, time-consuming, and not currently suitable for clinical use.[15] This CBCT study aims to comparatively evaluate the morphology of the mesiobuccal (MB) root and root canals of maxillary first molars (FDI tooth #16 and 26) using two classification systems (Vertucci, et al. [5] and Ahmed, et al. [8]).

For clinicians, an in-depth understanding of diverse root and root canal structures is paramount. Recognizing and managing these variations correctly during root canal treatments is essential to enhance treatment outcomes. This research was conducted to investigate the root anatomy and canal patterns of M1Ms using CBCT scans to evaluate the reliability and accuracy of different systems for both educational and clinical practice. Moreover, the study aimed to discern if these patterns demonstrated variations based on age or sex.

2. Materials and Methods

2.1. Data collection

In this cross-sectional retrospective study, a total of 250 CBCT images (125 females, 125 males) taken between January 2022 and June 2023 for various diagnostic reasons were used to evaluate the MB root and root canal configurations of permanent M1Ms. Ethical approval for the study was obtained from the Ethics Committee of the Faculty of Dentistry, Necmettin Erbakan University, for non-drug and non-medical device research. All revisions were conducted in accordance with the principles outlined in the Helsinki Declaration.

Using the G-power 3.1.9.4 software program, the sample size was calculated to be at least 188 individuals at a 95% confidence level, α=0.05, power (1-β)=0.95 according to the differences between two independent proportions.[16]

Samples were selected according to the following criteria:

- CBCT images of sufficient diagnostic quality
- Patients with bilateral M1Ms aged 16-70 years
- Teeth with intact or minor caries lesions/restoration and complete root development.

Images of teeth with root canal treatment, post-core restorations, crowns, resorptive defects, internal calcifications, or fractures in the maxillary posterior region were excluded from the study.

2.2. Cone-beam computed tomography

CBCT data were obtained from a CBCT machine (J Morita MFG. Corp., 3D Accuitomo 170, Kyoto, Japan) with exposure parameters of 90 kVp and 5 mA for 17.5 seconds scanning time, and a voxel resolution of 0.250 mm with a field of view of 10x10 cm. The examinations were performed using the i-Dixel One Data Viewer imaging software (J Morita MFG Corp., Kyoto, Japan) on a 27-inch color Ultra Sharp LED TFT display (Dell, Dell Inc. Round Rock, TX, USA) with a resolution of 2560 x 1440 and 3.7 MP. To obtain appropriate visualization, contrast and brightness of the images were adjusted using image processing tools. The root number and MB root canal morphology of maxillary first molars were determined using different planes (coronal, axial, and sagittal).

2.3. Calibration

Calibration for this study was performed twice, one week apart, by an oral and maxillofacial radiologist with six years expertise (SU). The expert was instructed to evaluate 50 CBCT scans. These scans were analysed from axial, sagittal and coronal perspectives and the root canal morphology was reported according to the classifications established by Vertucci and Ahmed. Intracorrelation coefficiant (ICC) values were calculated for intraobserver agreement. The kappa values were 0.86 and 0.80 for Vertucci and Ahmed et al. classifications.

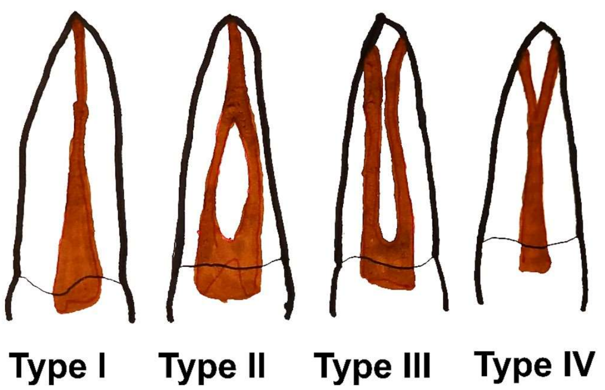

Fig 1. Weine's classification for root canal morphology

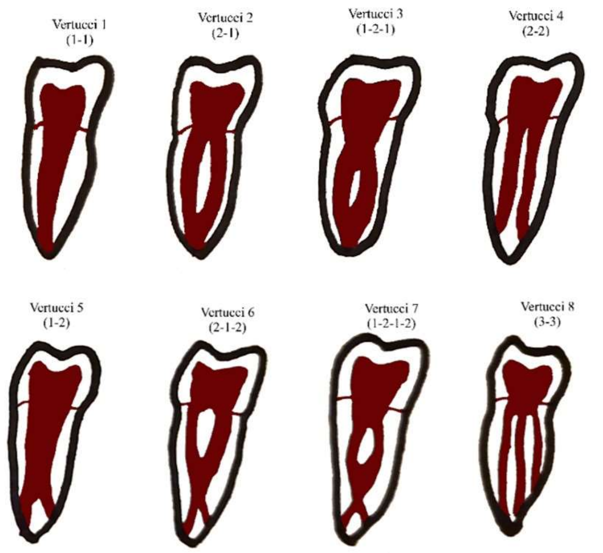

Fig 2. Vertucci's classification for root canal morphology

2.4. Root canal analysis

The obtained images were grouped according to the patient's age (10–20, 21–30, 31–40, 41–50, over 51 years) and gender (female and male). The MB root canal morphology of the permanent maxillary first molars was evaluated separately according to the classification systems of Vertucci, et al. [5] (Fig. 1) and Ahmed, et al. [8] (Fig. 2-5). In the presence of anomalies, 6-category classification of Zhang, et al. [17] for root fusion and 3-category classification of Fan, et al. [18] for C-shaped canals were used.

2.4. Statistical Analysis

SPSS version 26 (IBM Corp., Armonk, NY, USA) software was used for data entry and statistical analysis. Descriptive statistics such as frequency, mean, and standard deviation were calculated. The chi-square test was used for data analysis, and the significance level set at 0.05 ($p<0.05$).

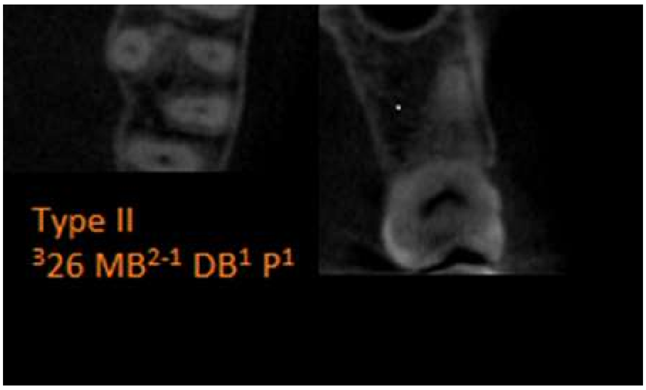

Fig 3. CBCT images demonstrating root canal morphological variations of three-rooted maxillary molar tooth using the two systems [above – Vertucci classification; below – new system (Ahmed et al. 2017)]; 26: Maxillary left first molar, MB: Mesiobuccal, DB: Distobuccal, P: Palatal.

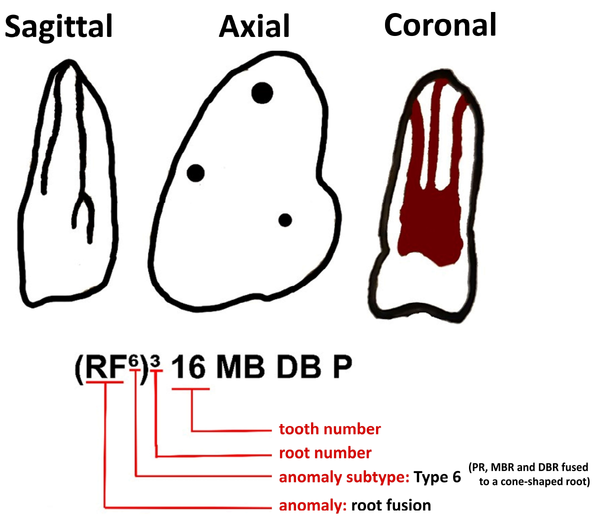

Fig 4. Coding of root canal morphology of maxillary molar tooth with root fusion (RF) according to the Ahmed et al. classification

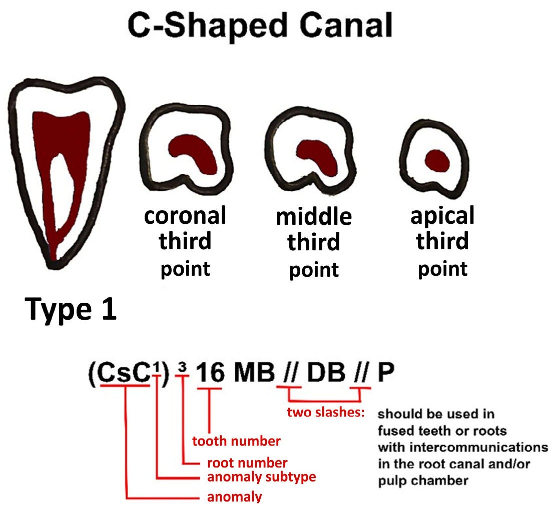

Fig 5. Ahmed et al. classification in C-shaped canals(CsC)

3. Results

The distribution of all evaluated CBCT images according to age groups and sex is shown in Fig. 6. A total of 500 MB roots of permanent M1Ms were examined in 250 CBCT images. The largest age group among the participants was 21-30 years old (n=75). There was no statistically significant difference in the sex distribution among the age groups ($p=0.685$). According to Vertucci, et al. [5] and the new classification systems [8], Table 1 shows the distribution of the number of roots and MB root morphologies of permanent M1Ms according to age and sex.

Most of the maxillary first molars had three roots (right side: 99.2%; left side: 96.4%) (Table 2). There was no statistically significant difference in the number of roots based on sex and age groups ($p>0.05$) (Table 2).

The majority of MB roots had Type I morphology according to the Vertucci classification [5] (right side: 38.4%; left side: 43.2%), and according to the new root canal morphology classification system, the most common code detected was ^{3}16 MB^{1} in the right side (37.6%), ^{3}26 MB^{1} for the left side (41.2%). Subsequently, Type IV (right 24.4%; left 26.0%) and Type V (16.4%; left 14.4%) were the next most frequently identified morphologies according to the Vertucci classification, whereas according to Ahmed's classification ^{3}16 MB^{2} (24.4%), ^{3}26 MB^{2} (25.2%), ^{3}16 MB$^{1-2}$ (16.4%), and ^{3}26 MB$^{1-2}$ (14.0%) were the most common. Three teeth (1.2% for both right and left sides) were encountered that were not specified in the Vertucci classification and were coded as "other". In Ahmed's classification, four teeth each (0.4% for both right and left sides) showed root fusion bilaterally, one tooth on the right side (0.4%), and two teeth on the left side (0.8%) exhibited C canal anomalies. In maxillary molars with no anomalies in the MB roots, the least common morphologies (0.4%) were ^{3}16 MB^{3} and ^{1}16 MB$^{1-2-1-2}$ for the right side, and ^{3}26 MB$^{2-1-2-3-2}$ and ^{3}26 MB^{1-2-3} for the left side. According to both Vertucci and Ahmed's classifications, there was no statistically significant difference in root morphologies based on sex and age ($p>0.05$) (Table 2). 16 $(RF^{7})^{4}$ MB1^{1} MB2^{1} (0.4%), 16 $(CsC^{1})^{4}$M//D//P (0.4%), 26 $(RF^{6})^{3}$MB^{1} (0.4%), 26 $(RF^{7})^{4}$ MB1^{1} MB2^{1} (1.2%), 26 $(CsC^{1})^{4}$M//D//P (0.8%) were also detected in the MB roots of M1Ms according to the new classification (Table 2).

Table 1: Ahmed et al. codes summary allocated for tooth type

Type of tooth	Classification
Single-rooted	$^{1}TN^{O-C-F}$
Double-rooted	$^{1}TN\ R1^{O-C-F}R2^{O-C-F}$
Multirooted	$^{1}TN\ R1^{O-C-F}R2^{O-C-F}Rn^{O-C-F}$

TN, tooth number; R, root; O, orifice; C, canal; F, foramen

4. Discussion

Adverse endodontic treatment outcomes may be observed due to missed root anatomy and the presence of untreated canals.[19] Achieving the goals of endodontic treatment, namely thorough cleaning, shaping and obturation of the entire root canal system are required for a favorable endodontic outcome.[20] The treatment of M1Ms is no exception, and it is well-known that the mesiobuccal root of this tooth type may frequently present with additional canals and complex internal morphology.[3,21]

Over the years, numerous methods have been used to study root canal morphology by means of both *in vitro* and *in vivo* study designs.[22-24] In the past, *ex vivo* studies often required the employment of destructive methods for the evaluation of root and canal morphology using extracted teeth, such as tooth sectioning in combination with radiography or clearing & staining.[22,23] These older methods already found a high prevalence of additional canals (> 90%) in the mesiobuccal root of maxillary first molars.[7] More recently, non-destructive imaging methods such as CBCT for clinical studies [21,25] and micro-CT for laboratory studies [26] have become increasingly common methods for the evaluation of dental morphology.[27] CBCT has been proven to be both highly accurate and reliable when used for the study of root and canal morphology.[28] CBCT has been reported to be equal or superior to

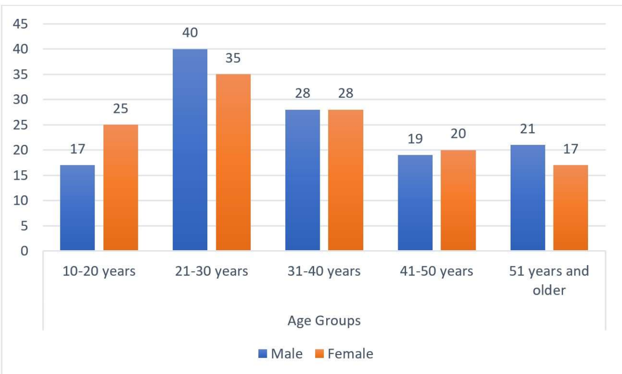

Fig 6. Distribution of age groups according to gender

Table 2. Root numbers and morphologies of the upper first molars and their mesiobuccal canals by age and sex

Variables	Total	Gender			Age Groups					p value
		Male	Female	p value	10-20 years	21-30 years	31-40 years	41-50 years	51 years and older	
Right Root Number										
One	1 (0.4%)	0 (0.0%)	1 (100.0%)		0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	
Three	244 (97.6%)	121 (49.6%)	123 (50.4%)	0.367	40 (16.4%)	74 (30.3%)	54 (22.1%)	39 (16.0%)	37 (15.2%)	0.707
Four	5 (2.0%)	4 (80.0%)	1 (20.0%)		2 (40.0%)	1 (20.0%)	1 (20.0%)	0 (0.0%)	1 (20.0%)	
Left Root Number										
One	3 (1.2%)	1 (33.3%)	2 (66.7%)		0 (0.0%)	1 (33.3%)	1 (33.3%)	1 (33.3%)	0 (0.0%)	
Two	3 (1.2%)	2 (66.7%)	1 (33.7%)		0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (100.0%)	0 (0.0%)	
Three	239 (95.6%)	117 (49.0%)	122 (51.0%)	0.069	40 (16.7%)	72 (30.1%)	55 (23.0%)	35 (14.6%)	37 (15.5%)	0.078
Four	5 (2.0%)	5 (100.0%)	0 (0.0%)		2 (40.0%)	2 (40.0%)	0 (0.0%)	0 (0.0%)	1 (20.0%)	
Right Vertucci Classification										
Type I	96 (38.4%)	43 (44.8%)	53 (55.2%)		18 (18.75%)	22 (22.9%)	20 (20.8%)	20 (20.8%)	16 (16.7%)	
Type II	15 (6.0%)	12 (80.0%)	3 (20.0%)		1 (6.7%)	3 (20.0%)	3 (20.0%)	4 (26.7%)	4 (26.7%)	
Type III	10 (4.0%)	5 (50.0%)	5 (50.0%)		3 (30.0%)	3 (30.0%)	1 (10.0%)	0 (0.0%)	3 (30.0%)	
Type IV	61 (24.4%)	35 (57.4%)	26 (42.6%)		11 (18.0%)	23 (37.7%)	13 (21.3%)	7 (11.5%)	7 (11.5%)	
Type V	41 (16.4%)	16 (39.0%)	25 (61.0%)	0.06	6 (14.6%)	17 (41.5%)	10 (24.4%)	3 (7.3%)	5 (12.2%)	0.601
Type VI	17 (6.8%)	10 (58.8%)	7 (41.2%)		2 (11.8%)	4 (23.5%)	6 (35.3%)	3 (17.6%)	2 (11.8%)	
Type VII	6 (2.4%)	1 (16.7%)	5 (83.3%)		0 (0.0%)	1 (16.7%)	2 (33.3%)	2 (33.3%)	1 (16.7%)	
Type VIII	1 (0.4%)	1 (100.0%)	0 (0.0%)		0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Other	3 (1.2%)	2 (66.7%)	1 (33.3%)		1 (33.3%)	1 (33.3%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	
Left Vertucci Classification										
Type I	108 (43.2%)	48 (44.4%)	60 (55.6%)		18 (16.7%)	27 (25.0%)	21 (19.4%)	24 (22,2%)	18 (16.7%)	
Type II	10 (4.0%)	4 (40.0%)	6 (60.0%)		2 (20.0%)	2 (20.0%)	3 (30.0%)	1 (10.0%)	2 (20.0%)	
Type III	3 (1.2%)	1 (33.3%)	2 (66.7%)		2 (66.7%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Type IV	65 (26.0%)	39 (60.0%)	26 (40.0%)		8 (12.3%)	28 (43.1%)	15 (23.1%)	8 (12.3%)	6 (9.2%)	
Type V	36 (14.4%)	17 (47.2%)	19 (52.8%)	0.314	4 (11.1%)	12 (33.3%)	10 (27.8%)	3 (8.3%)	7 (19.4%)	0.294
Type VI	18 (7.2%)	10 (55.6%)	8 (44.4%)		4 (22.2%)	4 (22.2%)	5 (27.8%)	2 (11.1%)	3 (16.7%)	
Type VII	6 (2.4%)	5 (83.3%)	1 (16.7%)		2 (33.3%)	1 (16.7%)	1 (16.7%)	0 (0.0%)	2 (33.3%)	
Type VIII	1 (0.4%)	0 (0.0%)	1 (100.0%)		0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	
Other	3 (1.2%)	1 (33.3%)	2 (66.7%)		2 (66.7%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	0 (0.0%)	
Right Ahmed et al. Classification										
^{3}16 MB^{1}	94 (37.6%)	41 (43.6%)	53 (56.4%)		17 (18.1%)	22 (23.4%)	20 (21.3%)	20 (21.3%)	15 (16.0%)	
^{3}16 MB$^{2-1}$	15 (6.0%)	12 (80.0%)	3 (20.0%)		1 (6.7%)	3 (20.0%)	3 (20.0%)	4 (26.7%)	4 (26.7%)	
^{3}16 MB^{1-2-1}	10 (4.0%)	5 (50.0%)	5 (50.0%)		3 (30.0%)	3 (30.0%)	1 (10.0%)	0 (0.0%)	3 (30.0%)	
^{3}16 MB^{2}	61 (24.4%)	35 (57.4%)	26 (42.6%)		11 (18.0%)	23 (37.7%)	13 (21.3%)	7 (11.5%)	7 (11.5%)	
^{3}16 MB$^{1-2}$	41 (16.4%)	16 (39.0%)	25 (61.0%)		6 (14.6%)	17 (41.5%)	10 (24.4%)	3 (7.3%)	5 (12.2%)	
^{3}16 MB^{2-1-2}	17 (6.8%)	10 (58.8%)	7 (41.2%)		2 (11.8%)	4 (23.5%)	6 (35.3%)	3 (17.6%)	2 (11.8%)	
^{3}16 MB$^{1-2-1-2}$	5 (2.0%)	1 (20.0%)	4 (80.0%)	0.052	0 (0.0%)	1 (20.0%)	1 (20.0%)	2 (40.0%)	1 (16.7%)	0.621
^{3}16 MB^{3}	1 (0.4%)	1 (100.0%)	0 (0.0%)		0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
16 (RF^{7})^{4} MB$_{1}^{1}$ MB$_{2}^{1}$	4 (0.4%)	3 (75.0%)	1 (25.0%)		1 (25.0%)	1 (25.0%)	1 (25.0%)	0 (0.0%)	1 (25.0%)	
^{1}16 MB$^{1-2-1-2}$	1 (0.4%)	0 (0.0%)	1 (100.0%)		0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0 (0.0%)	
16 (CsC^{1})^{4}M//D//P	1 (0.4%)	1 (100.0%)	0 (0.0%)		1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Left Ahmed et al. Classification										
^{3}26 MB^{1}	103 (41.2%)	45 (43.7%)	58 (56.3%)		17 (16.5%)	25 (24.3%)	20 (19.4%)	23 (22,3%)	18 (17.5%)	
^{3}26 MB$^{2-1}$	11 (4.4%)	4 (36.4%)	7 (63.6%)		2 (18.2%)	2 (18.2%)	3 (27.3%)	2 (18.2%)	2 (18.2%)	
^{3}26 MB^{1-2-1}	3 (1.2%)	1 (33.3%)	2 (66.7%)		2 (66.7%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
^{3}26 MB^{2}	63 (25.2%)	37 (58.7%)	26 (41.3%)		8 (12.7%)	27 (42.9%)	15 (23.8%)	8 (12.7%)	5 (7.9%)	
^{3}26 MB$^{1-2}$	35 (14.0%)	17 (48.6%)	18 (51.4%)		4 (11.4%)	12 (34.3%)	10 (28.6%)	2 (5.7%)	7 (20.0%)	
^{3}26 MB^{2-1-2}	18 (7.2%)	10 (55.6%)	8 (44.4%)		4 (22.2%)	4 (22.2%)	5 (27.8%)	2 (11.1%)	3 (16.7%)	
^{3}26 MB$^{1-2-1-2}$	6 (2.4%)	5 (83.3%)	1 (16.7%)		2 (33.3%)	1 (16.7%)	1 (16.7%)	0 (0.0%)	2 (33.3%)	
^{3}26 MB$^{2-1-2-3-2}$	1 (0.4%)	0 (0.0%)	1 (100.0%)	0.167	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (100.0%)	0 (0.0%)	0.385
^{3}26 MB^{1-2-3}	1 (0.4%)	0 (0.0%)	1 (100.0%)		1 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
26 (RF^{6})^{3}MB^{1}	1 (0.4%)	0 (0.0%)	1 (100.0%)		1 (25.0%)	1 (25.0%)	1 (25.0%)	0 (0.0%)	1 (25.0%)	
26 (RF^{7})^{4} MB$_{1}^{1}$ MB$_{2}^{-1}$	3 (1.2%)	3 (100.0%)	0 (0.0%)		1 (33.3%)	1 (33.3%)	0 (0.0%)	0 (0.0%)	1 (33.3%)	
^{1}26 MB^{1}	3 (1.2%)	1 (33.3%)	2 (66.7%)		0 (0.0%)	1 (33.3%)	1 (33.3%)	1 (33.3%)	0 (0.0%)	
26 (CsC^{1})^{4}M//D//P	2 (0.8%)	2 (100.0%)	0 (0.0%)		1 (50.0%)	1 (50.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	

MB: Mesiobuccal; RF: Root fusion; CsC: C-shaped canal phosphor plate radiography [30] and not significantly different from micro-CT [31] for the determination of dental morphology.[32,33]

The presence of additional canals in the MB root of M1Ms has been well established by numerous studies.[7,21,26,28] The reported prevalence of additional anatomy/canals in these teeth using CBCT may however vary significantly, and has been reported to range from as low as 48% (in a Venezuelan population) to as high as 97.6 (in a Belgian population) in a worldwide CBCT study.[28] While some authors are in agreement with these findings, for example, Fernandes et al. [21] reported a high prevalence of MB2 canals (87% and 92% for left and right maxillary first molars respectively) using CBCT. Others, Silva, et al. [34], have found a much lower prevalence of MB2 canals ranging from 34 to 42% using the same methodology. This variation in the prevalence of MB2s between studies may be related to several factors, including: racial and/or ethnic differences, environmental factors, human genetics and ethnic considerations.[10,35] Furthermore, differing CBCT machines and software used by different investigators may additionally have played a role in the varied findings.[21]

The present study found no significant differences between the canal morphology of the MB root of M1Ms and the variables of sex or age. This is supported by the findings of other studies.[21,36] Other authors have found significant associations between the prevalence of MB2 canals and sex.[7,37] In several investigations, age has also been associated with the prevalence of MB2 canals in maxillary first molars, with increasing age showing a reduced prevalence of this feature.[7,37] One explanation for this finding may be the structural changes to dental tissues over time, such as the continued deposition of secondary dentin causing alteration to the pulp space and canal structure.[38] Despite this finding, it should be noted that MB2 canals and/or additional anatomy in the MB root may be observed at any age.[21] Furthermore, a high level of bilateral symmetry regarding MB2 prevalence (88-97%) has been reported in the literature.[21,36,37]

The classification systems of both Vertucci and Ahmed et al. were employed in the present study.[8,23] The well-known Vertucci classification has been used for the study of root canal morphology for several decades.[23] Advantages of the Vertucci classification system include its familiarity, simplicity and ease of use. However the system demonstrates several notable drawbacks, such as an inability to describe root number, report highly complex canal structures and dental anomalies.[8] These drawbacks are supported by the findings of the present study as well as previous studies [24,26,39], which have reported that some teeth cannot be adequately described using the Vertucci system and were simply noted as “other” or not classified.

The Ahmed et al.[8] system was recently introduced aiming to overcome some of the shortcomings of the well known Vertucci classification system and has the advantage of simultaneously providing an accurate description of both the root and canal structures found in any tooth type using a single code. This system can additionally describe complex canal configurations, anatomical variations and dental anomalies.[40] Whilst this is a notable advantage of the newer system, only a low number of dental anomalies, such as root fusion and C-shaped canals were observed in the present study. The system of Ahmed, et al. [8] could however report these complex morphologies. Although the new classification system has proven to be highly descriptive and accurate, it has the limitation that it generates a larger number of unique codes/categories compared to previous classifications, which complicates it. [24] This finding is supported by the results of the present study.

Several limitations in this study warrant attention. Given that the research was carried out in just one location, a larger sample size would have been more appropriate. Moreover, this retrospective study utilized scans with varying voxel sizes and fields, potentially influencing the outcomes. To get a more accurate gauge of this distribution in the Turkish population, multi-center studies with expanded sample sizes would be beneficial. Furthermore, the CBCT used in this study offers a lower spatial resolution compared to micro- and nano-CT, which might have affected the results.

The new classification system can be an essential tool for both undergraduate and graduate students to gain an in-depth understanding of root and canal morphology. Utilized in pre-clinical courses, this system can enhance the theoretical knowledge of students and also contribute to the improvement of their practical skills in clinical applications. Hence, the integration of this technology into the curriculum should be recognized and supported as part of innovative pedagogical approaches in dental education. Such integration can enable students to grasp complex topics like root and canal morphology more effectively, thereby enhancing the quality of education in the field of dentistry.

5. Conclusion

In conclusion, the presence of additional anatomy in the MB root of M1Ms carries important clinical significance in endodontics. Failure to locate and treat all anatomy present in a given tooth, especially MB2 canals in maxillary first molars, may result in endodontic treatment failure due to persistent microbial contamination and infection. Clinicians should therefore be aware of both the presence and prevalence of additional canals in the MB roots of M1Ms in different populations. For clinicians seeking clarity in root and canal morphology, the new classification system offers a more precise and user-friendly approach than the traditional Vertucci classification. This advancement ensures more accurate diagnosis and treatment planning, ultimately enhancing patient outcomes.

References

1. Shrestha A, Marla V, Shrestha S, Maharjan IK. Developmental anomalies affecting the morphology of teeth–a review. *Rev Bras Odontol*. 2015;12(1):68-78.
2. Hatipoğlu FP, Mağat G, Hatipoğlu Ö, Taha N, Alfirjani S, Abidin IZ, et al. Assessment of the prevalence of middle mesial canal in mandibular first molar: a multinational cross-sectional study with meta-analysis. *J Endod*. 2023;49(5):549-558.
3. Costa F, Pacheco-Yanes J, Siqueira Jr J, Oliveira A, Gazzaneo I, Amorim C, et al. Association between missed canals and apical periodontitis. *Int Endod J*. 2019;52(4):400-406.
4. Versiani MA, Ordinola-Zapata R. Root canal anatomy: implications in biofilm disinfection. In: Chávez de Paz LE, Sedgley CM, Kishen A, eds. *Root canal anatomy: implications in biofilm disinfection*. Springer; 2015.
5. Vertucci F, Seelig A, Gillis R. Root canal morphology of the human maxillary second premolar. *Oral Surg Oral Med Oral Pathol*. 1974;38(3):456-464.
6. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. *J Endod*. 2012;38(10):1305-1308.
7. Sert S, Bayirli GS. Evaluation of the root canal configurations of the mandibular and maxillary permanent teeth by gender in the Turkish population. *J Endod*. 2004;30(6):391-398.
8. Ahmed H, Versiani M, De-Deus G, Dummer P. A new system for classifying root and root canal morphology. *Int Endod J*. 2017;50(8):761-770.
9. Karobari MI, Iqbal A, Syed J, Batul R, Adil AH, Khawaji SA, et al. Evaluation of root and canal morphology of mandibular premolar amongst Saudi subpopulation using the new system of classification: a CBCT study. *BMC Oral Health*. 2023;23(1):1-11.

10. Karobari MI, Noorani TY, Halim MS, Ahmed HMA. Root and canal morphology of the anterior permanent dentition in Malaysian population using two classification systems: a CBCT clinical study. *Aust Endod J.* 2021;47(2):202-216.
11. Karobari MI, Parveen A, Mirza MB, Makandar SD, Nik Abdul Ghani NR, Noorani TY, et al. Root and root canal morphology classification systems. *Int J Dent*. 2021;2021:1-6.
12. Habib AA, Kalaji MN. Root canal configurations of the first and second mandibular premolars in the population of north Syria. J Taibah Univ Medical Sci. 2015;10(4):391-395.
13. Cotton TP, Geisler TM, Holden DT, Schwartz SA, Schindler WG. Endodontic applications of cone-beam volumetric tomography. *J Endod*. 2007;33(9):1121-1132.
14. Patel S, Kanagasingam S, Mannocci F. Cone beam computed tomography (CBCT) in endodontics. *Dent Update*. 2010;37(6):373-379.
15. Somma F, Leoni D, Plotino G, Grande N, Plasschaert A. Root canal morphology of the mesiobuccal root of maxillary first molars: a micro-computed tomographic analysis. *Int Endod J.* 2009;42(2):165-174.
16. Alhujhuj RR, Jouhar R, Ahmed MA, Almujhim AA, Albutayh MT, Adanir N. Evaluation of Root Canal Configuration of Maxillary and Mandibular First Molar by CBCT: A Retrospective Cross-Sectional Study. *Diagnostics*. 2022;12(9):2121.
17. Zhang Q, Chen H, Fan B, Fan W, Gutmann JL. Root and root canal morphology in maxillary second molar with fused root from a native Chinese population. *J Endod*. 2014;40(6):871-875.
18. Fan W, Fan B, Gutmann JL, Cheung GS. Identification of C-shaped canal in mandibular second molars. Part I: radiographic and anatomical features revealed by intraradicular contrast medium. *J Endod*. 2007;33(7):806-810.
19. Tredoux S, Warren N, Buchanan GD. Root and canal configurations of mandibular first molars in a South African subpopulation. *J Oral Sci*. 2021;63(3):252-256.
20. Awawdeh L, Al-Qudah A. Root form and canal morphology of mandibular premolars in a Jordanian population. *Int Endod J.* 2008;41(3):240-248.
21. Fernandes NA, Herbst D, Postma TC, Bunn BK. The prevalence of second canals in the mesiobuccal root of maxillary molars: A cone beam computed tomography study. *Aust Endod J.* 2019;45(1):46-50.
22. Weine FS, Healey HJ, Gerstein H, Evanson L. Canal configuration in the mesiobuccal root of the maxillary first molar and its endodontic significance. *Oral Surg Oral Med Oral Pathol*. 1969;28(3):419-425.
23. Vertucci FJ. Root canal anatomy of the human permanent teeth. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 1984;58(5):589-599.
24. Buchanan GD, Gamieldien MY, Fabris-Rotelli I, Van Schoor A, Uys A. Root and canal morphology of maxillary second molars in a Black South African subpopulation using cone-beam computed tomography and two classifications. *Aust Endod J.* 2022.
25. Buchanan GD, Gamieldien MY, Fabris-Rotelli I, van Schoor A, Uys A. A study of mandibular premolar root and canal morphology in a Black South African population using cone-beam computed tomography and two classification systems. *J Oral Sci*. 2022;64(4):300-306.
26. Camargo Dos Santos B, Pedano MS, Giraldi CK, Machado De Oliveira JC, Barbosa Lima IC, Lambrechts P. Mesiobuccal root canal morphology of maxillary first molars in a brazilian sub-population-a micro-ct study. *Eur Endod J.* 2020;5(2):105-111.
27. Hatipoğlu FP, Mağat G, Hatipoğlu Ö, Al-Khatib H, Elatrash AS, Abidin IZ, et al. Assessment of the Prevalence of Radix Entomolaris and Distolingual Canal in Mandibular First Molars in 15 Countries: A Multinational Cross-sectional Study with Meta-analysis. *J Endod*. 2023; [ahead of print].
28. Martins JN, Alkhawas M-BA, Altaki Z, Bellardini G, Berti L, Boveda C, et al. Worldwide analyses of maxillary first molar second mesiobuccal prevalence: a multicenter cone-beam computed tomographic study. *J Endod*. 2018;44(11):1641-1649. e1641.
29. Neelakantan P, Subbarao C, Subbarao CV. Comparative evaluation of modified canal staining and clearing technique, cone-beam computed tomography, peripheral quantitative computed tomography, spiral computed tomography, and plain and contrast medium–enhanced digital radiography in studying root canal morphology. *J Endod*. 2010;36(9):1547-1551.
30. Matherne RP, Angelopoulos C, Kulild JC, Tira D. Use of cone-beam computed tomography to identify root canal systems in vitro. *J Endod*. 2008;34(1):87-89.
31. Domark JD, Hatton JF, Benison RP, Hildebolt CF. An ex vivo comparison of digital radiography and cone-beam and micro computed tomography in the detection of the number of canals in the mesiobuccal roots of maxillary molars. *J Endod*. 2013;39(7):901-905.
32. Karobari MI, Arshad S, Noorani TY, Ahmed N, Basheer SN, Peeran SW, et al. Root and root canal configuration characterization using microcomputed tomography: a systematic review. *J Clin Med*. 2022;11(9):2287.
33. Karobari MI, Assiry AA, Lin GSS, Almubarak H, Alqahtani SA, Tasleem R, et al. Roots and root canals characterization of permanent mandibular premolars analyzed using the cone beam and micro computed tomography—a systematic review and metanalysis. *J Clin Med*. 2023;12(6):2183.
34. Silva EJNL, Nejaim Y, Silva AI, Haiter-Neto F, Zaia AA, Cohenca N. 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.
35. Buchanan GD, Gamieldien MY, Tredoux S, Vally ZI. Root and canal configurations of maxillary premolars in a South African subpopulation using cone beam computed tomography and two classification systems. *J Oral Sci*. 2020;62(1):93-97.
36. Ghobashy AM, Nagy MM, Bayoumi AA. Evaluation of root and canal morphology of maxillary permanent molars in an Egyptian population by cone-beam computed tomography. *J Endod*. 2017;43(7):1089-1092.
37. Kim Y, Lee S-J, 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.
38. Carvalho TS, Lussi A. Age-related morphological, histological and functional changes in teeth. *J Oral Rehabil*. 2017;44(4):291-298.
39. Buchanan GD, Gamieldien MY, Fabris-Rotelli I, van Schoor A, Uys A. Root and canal morphology of the permanent anterior dentition in a Black South African population using cone-beam computed tomography and two classification systems. *J Oral Sci*. 2022;64(3):218-223.
40. Ahmed H, Ibrahim N, Mohamad N, Nambiar P, Muhammad R, Yusoff M, et al. Application of a new system for classifying root and canal anatomy in studies involving micro-computed tomography and cone beam computed tomography: Explanation and elaboration. *Int Endod J.* 2021;54(7):1056-1082.2013;24(5):605.

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