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EVALUATION OF ROOT AND CANAL MORPHOLOGY OF MAXILLARY FIRST MOLAR AMONGST UPPER EGYPT SUBPOPULATION USING A NEW SYSTEM OF CLASSIFICATION (A CBCT RETROSPECTIVE STUDY)

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ABSTRACT

Aim of the study: To evaluation of root and root canal morphology in permanent maxillary first molar in the Upper Egypt subpopulation with a new classification system via CBCT.

Material and methods: The present study includes 1500 maxillary first molars CBCT images, were examined and classified according to Ahmed et al classification.

Results: a total of 1,500 CBCT scans with an age range spanning from 14 to 72 years. The mean age of participants was 36.8 years and the sample comprised 631 males (42.1%) and 869 females (57.9%), showing a slight predominance of female participants. For the coding classifications, the most prevalent code was "^{3}M MB$^{1\text{-}1\text{-}1}$ P^{1} DB^{1}" with 446 participants (29.7%), followed by "^{3}M MB$^{2\text{-}2\text{-}2}$ P^{1} DB^{1}" with 418 participants (27.9%) .Among males (n=631), the most common code was "^{3}M MB$^{1\text{-}1\text{-}1}$ P^{1} DB^{1}" in 164 participants (26%) among females (n=869), the code "^{3}M MB$^{2\text{-}2\text{-}2}$ P^{1} DB^{1}" was more prevalent (295, or 33.9%). Regarding calcified roots, the majority of participants (861, 57.4%) had no calcified roots (0), while 550 participants (36.7%) had one calcified root, and only 89 participants (5.9%) had two calcified roots

Conclusion: Combining CBCT imaging with this new classification allows for more detailed description and precise information about root canal configuration which enhances pre-evaluation of the root canal morphology and will have positive impact on the outcome of endodontic therapy

KEYWORDS: Root Canal Configuration, Upper Egypt Sub-population, Cone Beam Computed Tomography (CBCT), Maxillary First Molars.

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INTRODUCTION

Many factors affect the achievement of a successful endodontic treatment as determining the location of all the root canals, being one of the most important factors which enables the practitioner to completely debride, disinfect and ultimately seal the root canal in three dimensions. To do so it is crucial for the endodontist to be fully acquainted not only with the normal anatomy of the root but also deviation of norm and complexities in the root canal configuration to enhance prognosis. Missed or improper management of the root canal systems may yield negative results or even total failure of the entire root canal procedure. [1]

First permanent molars in the maxillary arch are one of the earliest teeth to erupt and often develop infection at a young age; which makes this particular tooth liable to pulp infections and periapical involvement may need endodontic treatment. this necessitates the well knowledge of their morphology. [2] The external and internal morphology for this tooth particularly has been extensively studied due to its clinical significance in endodontic treatment. Understanding the variations in root and 3-dimensional (3D) architecture of the root canal system is crucial to establish successful endodontic therapy, as these variations can affect treatment outcomes and prognosis. [3] Hence, a great deal of research has been performed on root canals in the maxillary first molar specifically mesio-buccal root canal system, a wide variety of researchers have studied the anatomy of this complicated and ever-changing canal. [4, 5]

Many systems have been suggested to classify root and canal morphology, aiming to provide a standardized framework for clinicians and researchers. One such system is the Vertucci classification, which categorizes root canal configurations into eight types based on the number and pattern of canals. [2] The Vertucci classification has been widely used, nonetheless it has limitations, especially in comprehending the full complexity of root canal anatomy as it only provides information about one root at a time not the whole tooth. [6, 7]

To address these limitations, in 2017, **Ahmed et al** [8] constructed a new classification system to explicitly describe root and canal morphology based on cone-beam computed tomography (CBCT) imaging. A system which offers a detailed framework to describe the complex variations observed in root and canal morphology, facilitating accurate diagnosis and help formulate the ultimate treatment planning positively impacting the prognosis of a case.

For many years numerous methods have been employed to analyze morphology of root and canal which varied from primitive methods as examination under microscope, with or without root canal dying/ sectioning or clearing technique, and conventional radiographic technique up to more advanced technologies as micro-computed tomography (Micro CT) a 3D imaging method, digital radiography, and spiral computed tomography. [9] Cone-beam computed tomography (CBCT) has emerged strongly as a more meticulous and greatly appreciated tool for studying root canal morphology. CBCT has been advocated as it offers higher resolution, three-dimensional imaging capabilities, and reduced radiation exposure. These advantages make CBCT particularly well-suited for studying the intricate details of root canal anatomy. [5]

Previous research examining root and canal morphology among different populations has reported a high prevalence of variations, including additional roots, canals, and complex canal configurations. [10] However, there is a deficiency of data specifically focusing on the Upper Egypt subpopulation using modern imaging techniques such as CBCT.

By employing CBCT imaging and a new system of classification, the authors attempt to fill this gap within the literature by providing a comprehensive analysis of root and canal morphology within the

Upper Egypt subpopulation. This subpopulation presents a unique demographic with distinct genetic and environmental factors that may influence root and canal morphology. Hence, investigating the root and canal anatomy of the upper first molar in this subpopulation could provide valuable insights into the variability of dental morphology. Furthermore, insights gained from this study may enhance and refine treatment protocols and the development of tailored approaches to address the unique anatomical challenges encountered in diverse population groups.

The purpose of the current study is to evaluate the root and canal morphology of the maxillary first molar among the Upper Egypt subpopulation using the **Ahmed et al** [8] classification system. By applying this novel classification system to CBCT images, we seek to elucidate the prevalence and distribution of various root and canal configurations in this specific population.

MATERIAL AND METHODS:

Ethical consideration:

Ethical approval was obtained for this retrospective study from the research ethics Committee at Faculty of Dentistry, Minia University, with an Ethical Approval No. (108/ 943). A general consent was already available for previous cases seeking variable dental treatments which included the use of these CBCT scans for research and examination -retrospective studies- without disclosing personal data. The sample size was calculated at 95% confidence interval, prevalence of canal configuration based on the study of **Karobari et al** [11] and determined to be 1500 CBCT scans.

Study settings, sample selection and CBCT scan parameters:

All participants for the study were sourced from Department of Oral and Maxillofacial radiology, Faculty of Dentistry, Minia University, Egypt. A total of 1500 CBCT scans which were administrated for diagnostic purposes between (2022- 2024) were retrospectively studied. Clear undistorted images of maxillary first molars teeth with mature root apex were included. While presence of previous root canal-treatment, root fractures, root resorption were excluded from the study. All CBCT images were obtained and analyzed using the Planmeca ProMax 3D Classic (Planmeca Oy, Helsinki, Finland) under the following specifications (Standardized kilo voltage = 90 kvp and 6.3 mA). scanner system, scanning of 8×8 cm images with a voxel size of 0.2 mm. All examination sessions were performed using a colorful LCD computer screen and appropriate background illumination.

Data collection and calibration:

The Oral and Maxillofacial Radiology Department provided the CBCT images, which were obtained for clinical diagnosis unrelated to this investigation. Regarding data records; personal data was blocked to preserve the identity of the patient as to adhere to ethical obligations. On the other hand, age and gender were recorded for each scan.

The calibration procedure was implemented by an expert endodontist and two radiologists with ten years of experience at interpreting CBCT images. The root and root canal configuration were recorded following through evaluation of CBCT scans in axial, sagittal, and coronal views, and a single code according to the predetermined classification was assigned to each tooth. Following sufficient due process, of debate and discussion on disagreements, an amiable conclusion was recorded. The root canal morphology was recorded with a single code with the new **Ahmed et al** classification.

The classification code was as the following example (^{3} M MB^{1-2-1} P^{1} DB^{1}); the abbreviation (M); represented the tooth a code for either right or left first maxillary permanent molar instead of the tooth number (TN) as the side (right and left) was not included into the comparison. The superscript number to the right (3) represents the number of roots for the tooth for all scanned cases 3 roots were found. As for the abbreviation to the left (MB, P, DB) denoted the Mesiobuccal, Palatal, Distobuccal roots respectively. (MB); represents the Mesiobuccal root while the superscripted numbers represent the canals at the coronal followed by the middle followed by the apical levels (1-2-1) indicates one root canal coronally, 2 canals in the middle of the root, 1 root canal in the apical third. (P) abbreviation denote the palatal root while the superscripted numbers represent the canals and was given number (1) as all the canals within the palatal root was a single canal at all levels. (DB) abbreviation denote the distobuccal root while the superscripted numbers represent the canals and was given number (1) as all the canals within the distobuccal root was a single canal at all levels.

For Each case the age, gender, classification code and presence of calcified canal was recorded in to an excel sheet and sent for statistical analysis.

STATISTICAL ANALYSIS

Statistical analyses were executed using (SPSS) version of the software (SPSS Inc, Chicago, IL). Regarding descriptive statistics; mean frequency and standard deviation, were implement, followed by comparison of root canal morphology in maxillary first molar and calcification in correlation with patient's age and gender via the Chi-square test followed by one way ANOVA test the significance level was set ($p \leq 0.05$).

RESULT

The demographic data reveals that the study included a total of 1500 participants with an age range spanning from 14 to 72 years. The mean age of participants was 36.8 years with a standard deviation of 11.6 years, indicating moderate variability in the age distribution. The standard deviation suggests that approximately 68% of participants fell within the age range of 25.2 to 48.4 years (± 1 SD from the mean). Regarding gender distribution, the sample comprised 631 males (42.1%) and 869 females (57.9%), showing a slight predominance of female participants. This gender imbalance, with females representing approximately 16% more of the sample than males, should be considered when interpreting gender-specific findings as it may affect the generalizability of results across genders. **Tab. (1)**

Table 1: Descriptive statistics of demographic data

		Descriptive statistics N=1500
Age	*Range*	(14-72)
	Mean ± SD	36.8±11.6
Sex	*Male*	631(42.1%)
	Female	869(57.9%)

Regarding data on calcified roots and coding classifications among the 1,500 CBCT scans. The majority of participants (861, 57.4%) had no calcified roots (0), while 550 participants (36.7%) had one calcified root, and only 89 participants (5.9%) had two calcified roots. This distribution indicates that calcification was absent in over half the sample, with double calcification being relatively rare. For the coding classifications, the most prevalent code was "^{3}M MB$^{1\text{-}1\text{-}1}$ P^{1} DB^{1}" with 446 participants (29.7%), followed by "^{3}M MB$^{1\text{-}2\text{-}2}$ P^{1} DB^{1}" with 418 participants (27.9%). The codes "^{3}M MB$^{1\text{-}1\text{-}2}$ P^{1} DB^{1}" and "^{3}M MB$^{1\text{-}2\text{-}2}$ P^{1} DB^{1}" were found in 252 (16.8%) and 240 (16.0%) participants respectively. Less common were the codes "^{3}M MB$^{2\text{-}2\text{-}2}$ P^{1} DB^{1}" (114 participants, 7.6%) and "^{3}M MB$^{2\text{-}2\text{-}1}$ P^{1} DB^{1}" (30 participants, 2.0%). Notably, two code categories ("^{3}M MB$^{1\text{-}2\text{-}1}$ P^{1} DB^{1}" and "^{3}M MB$^{2\text{-}1\text{-}1}$ P^{1} DB^{1}") had zero occurrences in the sample, suggesting these morphological variants may be extremely rare or nonexistent in the studied population. **Tab. (2), Fig (1)**

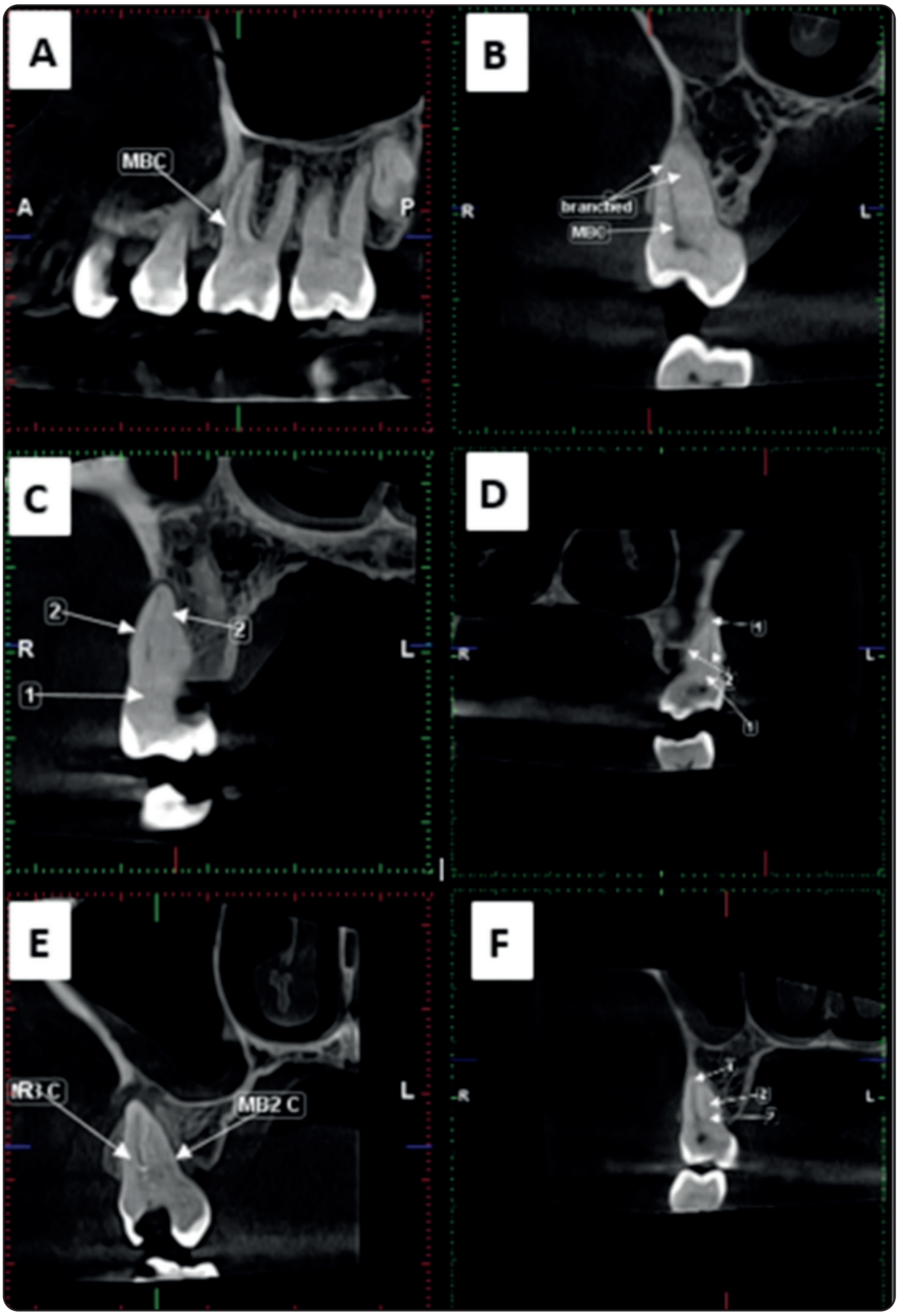

Fig. (1) CBCT showing; A) Sagittal CBCT view for maxillary first molar showing MB root with one canal and DB root with one canal which represent classification code (3M MB1-1-1 P1 DB1) , B) Coronal CBCT view showing MB2 canal branched from MB1 canal at the apical one third which represent code (3M MB1-1-2 P1 DB1) , C) Coronal CBCT view showing one MB canal branched into two MB all through the middle and apical two thirds which represent classification code (3M MB1-2-2 P1 DB1), D) Coronal CBCT view showing one MB canal branched into two canals at the middle third then united again at apical third which represent classification code (3 M MB1-2-1 P1 DB1), E) Coronal CBCT view showing mb2 canal separated from mb1 canal all through the root which represent classification code (3M MB2-2-2 P1 DB1), F) Coronal CBCT view showing two MB canals united together at apical one third which represent classification code (3M MB2-2-1 P1 DB1).

TABLE (2) Descriptive statistics of calcified roots and prevalence of classification codes

		Descriptive statistics N=1500
Number of calcified roots	*0*	861(57.4%)
	1	550(36.7%)
	2	89(5.9%)
Code	$^3M\ MB^{1\text{-}1\text{-}1}\ P^1\ DB^1$	446(29.7%)
	$^3M\ MB^{1\text{-}2\text{-}1}\ P^1\ DB^1$	0(0%)
	$^3M\ MB^{1\text{-}1\text{-}2}\ P^1\ DB^1$	0(0%)
	$^3M\ MB^{1\text{-}2\text{-}2}\ P^1\ DB^1$	252(16.8%)
	$^3M\ MB^{2\text{-}2\text{-}2}\ P^1\ DB^1$	418(27.9%)
	$^3M\ MB^{2\text{-}2\text{-}1}\ P^1\ DB^1$	240(16%)
	$^3M\ MB^{2\text{-}1\text{-}1}\ P^1\ DB^1$	114(7.6%)
	$^3M\ MB^{2\text{-}1\text{-}2}\ P^1\ D^B1$	30(2%)

The comparative analysis of the distribution of coding classifications between male and female participants, revealing statistically significant differences between sexes (p<0.001). Among males (n=631), the most common code was "^{3}M MB$^{1\text{-}1\text{-}1}$ P^1 DB^1" in 164 participants (26%), followed closely by"^{3}M MB$^{1\text{-}2\text{-}2}$ P^1 DB^1" occurring in 147 participants (23.3%) and " ^{3} M MB$^{2\text{-}2\text{-}2}$ P^1 DB^1" in 123 participants (19.5%). In contrast, among females (n=869), the code "^{3}M MB$^{2\text{-}2\text{-}2}$ P^1 DB^1" was more prevalent (295, or 33.9%) and " ^{3} M MB$^{1\text{-}1\text{-}1}$ P^1 DB^1" was the second most common (282, or 32.5%) followed by "^{3}M MB$^{1\text{-}2\text{-}2}$ P^1 DB^1" was found in significantly fewer participants (130, or 15%), while Notable differences include the higher prevalence of code "^{3}M MB$^{2\text{-}1\text{-}1}$P^1 DB^1" in males (11.1%) in comparison to females (5.1%), and code "^{3}M MB$^{2\text{-}1\text{-}2}$ P^1 DB^1" being rare in both groups but more common in females (2.9%) than males (0.8%). The highly significant p-value (p<0.001) confirms that these gender-based differences in code distribution are not due to chance, suggesting potential anatomical or physiological differences between sexes that influence these morphological classifications. **Tab. (3)**

The relationship between participant age and the number of calcified root canals, revealing a statistically significant association (p<0.001). Participants with no calcified root canals had mean age (28.1 ± 8.8 years), followed by those with one calcified root canals mean age (36.0 ± 12.3 years), while those with two calcified root canals mean age (39.6 ± 9.9 years). The superscript notations (a, b, c) indicate statistically significant differences between specific groups in post-hoc comparisons. Indicating that with increase of age the number of calcified root canals. **Tab. (4)**

TABLE (3) Comparison of classification code between different gender

		Gender		P value
		Male	**Female**	
		N=631	**N=869**	
Classification	$^3M\ MB^{1\text{-}1\text{-}1}\ P^1\ DB^1$	164(26%)	282(32.5%)	***<0.001****
	$^3M\ MB^{1\text{-}2\text{-}1}\ P^1\ DB^1$	0(0%)	0(0%)	
	$^3M\ MB^{1\text{-}1\text{-}2}\ P^1\ DB^1$	0(0%)	0(0%)	
	$^3M\ MB^{1\text{-}2\text{-}2}\ P^1\ DB^1$	122(19.3%)	130(15%)	
	$^3M\ MB^{2\text{-}2\text{-}2}\ P^1\ DB^1$	123(19.5%)	295(33.9%)	
	$^3M\ MB^{2\text{-}2\text{-}1}\ P^1\ DB^1$	147(23.3%)	93(10.7%)	
	$^3M\ MB^{2\text{-}1\text{-}1}\ P^1\ DB^1$	70(11.1%)	44(5.1%)	
	$^3M\ MB^{2\text{-}1\text{-}2}\ P^1\ {}^DB1$	5(0.8%)	25(2.9%)	

Chi square test ****: Significant level at P value < 0.05***

TABLE (4) Comparison of Age and number of calcified root canals

		Number of calcified root canals			P value
		0	1	2	
Age	Mean ± SD	28.1±8.8 ^{a}	36±12.3 ^{b}	39.6±9.9 ^{c}	***<0.001****

One Way ANOVA test with post hoc analysis
Superscripts with different small letters refer to significant difference between each two groups
****: Significant level at P value < 0.05***

Comparative analysis of age distribution across different coding classifications, showing statistically significant differences with a p value (<0.001). The mean age varies considerably among the different codes, with "^{3}M MB^{2-1-1} P^{1} DB^{1}" having the highest mean age at 41.9 ± 3.7 years, followed by "^{3}M MB^{2-2-2} P^{1} DB^{1}" at 38.6 ± 10.9 years. The code "^{3}M MB^{1-2-2} P^{1} DB^{1}" is associated with the youngest population, with a mean age of 32.0 ± 13.9 years. The remaining codes show intermediate values: "^{3}M MB^{1-1-1} P^{1} DB^{1}" (37.1 ± 9.9 years), "^{3}M MB^{2-1-2} P^{1} DB^{1}" (36.8 ± 7.1 years), and "^{3}M MB^{2-2-1} P^{1} DB^{1}" (35.7 ± 14.0 years). Notably, the standard deviations indicate varying degrees of age dispersion within each code group. The codes "^{3}M MB^{2-2-1} P^{1} DB^{1}" and "^{3}M MB^{1-2-2} P^{1} DB^{1}" show the largest standard deviations (14.0 and 13.9 years respectively), suggesting greater age heterogeneity within these groups. In contrast, "^{3}M MB^{2-1-1} P^{1} DB^{1}" shows the least age variability (SD = 3.7 years), indicating a more age-homogeneous group. The highly significant p-value confirms that the observed age differences among these morphological classifications are not due to chance and likely reflect meaningful biological or developmental patterns. **Tab. (5)**

TABLE (5) Comparison of Age between different classification codes.

	Age	P value
^{3} M MB^{1-1-1} P^{1} DB^{1}	37.1±9.9	**<0.001***
^{3} M MB^{1-2-2} P^{1} DB^{1}	32±13.9	
^{3} M MB^{2-2-2} P^{1} DB^{1}	38.6±10.9	
^{3} M MB^{2-2-1} P^{1} DB^{1}	35.7±14	
^{3} M MB^{2-1-1} P^{1} DB^{1}	41.9±3.7	
^{3} M MB^{2-1-2} P^{1} DB^{1}	36.8±7.1	

One Way ANOVA test with post hoc analysis
****: Significant level at P value < 0.05***

A detailed matrix of pairwise comparisons between different codes regarding participant age, revealing which specific code pairs differ significantly from each other. The code "^{3}M MB^{1-2-2} P^{1} DB^{1}" (associated with the youngest mean age) differs significantly from all other codes, with all comparisons yielding significant p-values (p<0.001 in most cases, p=0.026 when compared with "^{3}M MB^{2-1-2} P^{1} DB^{1}"). Similarly, the code "^{3}M MB^{2-1-1} P^{1} DB^{1}" (associated with the oldest mean age) also differs significantly from most other codes, with p-values ranging from p<0.001 to p=0.029. Interestingly, several pairwise comparisons reveal no statistically significant differences: "^{3}M MB^{1-1-1} P^{1} DB^{1}" compared with "^{3}M MB^{2-2-2} P^{1} DB^{1}" (p=0.053), "^{3}M MB^{2-2-1} P^{1} DB^{1}" (p=0.124), and "^{3}M MB^{2-1-2} P^{1} DB^{1}" (p=0.887); "^{3}M MB^{2-2-2} P^{1} DB^{1}" compared with "^{3}M MB^{2-1-2} P^{1} DB^{1}" (p=0.402); and "^{3}M MB^{2-2-1} P^{1} DB^{1}" compared with "^{3}M MB^{2-1-2} P^{1} DB^{1}" (p=0.618). These non-significant comparisons suggest that certain morphological variants share similar age distributions despite their structural differences. The pattern of significant and non-significant differences creates distinct age-related clusters among these morphological classifications, potentially reflecting developmental sequences or age-related morphological changes that merit further investigation. **Tab. (6)**

TABLE (6) Pairwise comparison between Age and each two Classes

Multiple Comparisons		P value
^{3}M MB^{1-1-1} P^{1} DB^{1}	^{3}M MB^{1-2-2} P^{1} DB^{1}	<0.001*
	^{3}M MB^{2-2-2} P^{1} DB^{1}	0.053
	^{3}M MB^{2-2-1} P^{1} DB^{1}	0.124
	^{3}M MB^{2-1-1} P^{1} DB^{1}	<0.001*
	^{3}M MB^{2-1-2} P^{1} DB^{1}	0.887
^{3}M MB^{1-2-2} P^{1} DB^{1}	^{3}M MB^{2-2-2} P^{1} DB^{1}	<0.001*
	^{3}M MB^{2-2-1} P^{1} DB^{1}	<0.001*
	^{3}M MB^{2-1-1} P^{1} DB^{1}	<0.001*
	^{3}M MB^{2-1-2} P^{1} DB^{1}	0.026*
^{3}M MB^{2-2-2} P^{1} DB^{1}	^{3}M MB^{2-2-1} P^{1} DB^{1}	0.002*
	^{3}M MB^{2-1-1} P^{1} DB^{1}	0.006*
	^{3}M MB^{2-1-2} P^{1} DB^{1}	0.402
^{3}M MB^{2-2-1} P^{1} DB^{1}	^{3}M MB^{2-1-1} P^{1} DB^{1}	<0.001*
	^{3}M MB^{2-1-2} P^{1} DB^{1}	0.618
^{3}M MB^{2-1-1} P^{1} DB^{1}	^{3}M MB^{2-1-2} P^{1} DB^{1}	0.029*

One Way ANOVA test with post hoc analysis

****: Significant level at P value < 0.05***

DISCUSSION

Diagnostic imaging is of utmost importance in decision making and planning for treatment. Successful endodontic treatment depends substantially on locating all root canals and adequately cleaning, debriding, shaping, and finally providing a fluid tight seal. The CBCT images has become a greatly appreciated and valuable tool for diagnosis, as well as help enhancing endodontic procedures. [12, 13] Endodontic failure mainly is due to missed canals, insufficient disinfection, and inadequate obturation. Consequently, meticulous clinical and radiographic analysis is required for a positive outcome of root canal therapy. [14]

The CBCT imaging has enhanced endodontic treatment prognosis. [15] Providing a 3D image along with reduced radiation exposure and superior image quality are few of the major benefits gained from CBCT compared to more conventional imaging techniques. [16] It has long been used as a reliable tool to elucidate the morphology of roots and configuration of the root canals. Further; it exceptionally assesses postoperative complications and mishaps of the procedure like separated instruments, over extended obturation, radicular perforations and root fractures improving the overall prognosis of an endodontic cases [17]

Great variation in the literature regarding the root and canal morphology of teeth has been reported and demonstrated; permanent maxillary first molar is no exception. [18] The number of roots, root canals, and their shape varies greatly. Age, gender and ethnicity are factors that affect these variations [19]

Classification systems are required to describe the root canal configuration subsequently avoiding procedural errors. The first classification for root canals was configurated by **Weine et al** in 1969. [20, 21] This classification described the single root from the root canal orifice down to the apical foramen of the root into four types. While **Vertucci et al** in 1974 constructed a different classification followed by many other classifications. [22]

Previous classification systems failed to describe both root and root canal configuration collectively and due to the extreme variations within the morphology of human teeth; many root canals of the teeth remained unclassified. [18, 23] **Ahmed et al** [8] introduced a new system of classification which provided a more precise and accurate description and provided inclusive data about the root numbers, canals, and accessory canals. It was more successful in describing the complex anatomy of teeth regardless of any variation from norm. [24, 25, 26] Thus; this present study aims to classify the maxillary first permanent molar using this new classification system in the Upper Egypt subpopulation via CBCT. The maxillary first molar regarded as one of the most difficult teeth to treat specially Mesiobuccal canal due to its varying configuration. [27]

A total of 1500 CBCT scans of first maxillary molars included in the study which were classified according to the new classification system. According to the authors' knowledge, there has been no other study conducted within the Upper Egypt subpopulation where this new classification system was used to classify the maxillary first permanent molars via CBCT.

The results revealed that 100% of the examined CBCT scans showed 3 roots for the maxillary first permanent molar (MB, P and DB) roots; this was consistent with a similar study for Burmese and Thai populations. [28] However, previous studies showed a higher prevalence of buccal root fusion as in Ugandan population. [29] The difference in the results may be attributed to the difference in the studied population. [30] Furthermore, this comes in accordance with **Alavi et al** [31] who found that typically, maxillary first permanent molars most likely have three roots and (3 to 4) root canals, with the extra canal in the MB root. Moreover, it comes in agreement with **Tandon et al** [32] and **Martins et al** [33] who demonstrated a (79.4%) three-root configuration which was the most prevalent.

Regarding the current study (100%) of all distal and palatal roots showed presence of only one canal which comes in accordance with **Ghobashy et al[34], El Taher et al[35] and Naseri et al[36]** whom all found that it was most likely to find one canal in either palatal or distal roots.

According to the present study approximately (70 %) of all Mesiobuccal root showed two root canals which varied between; 27.9% (^{3}M MB^{2-2-2} P^{1} DB^{1}) two canals from the orifice to apical foramen, 16.8% (^{3}M MB^{1-2-2} P^{1} DB^{1})one orifice which splits into two canals at the middle third down to the apex, 16% (^{3}M MB^{2-2-1} P^{1} DB^{1}) two canals from the orifice till the apical third where the two canals join in the apical third, 7.6 % (^{3}M MB^{2-1-1} P^{1} DB^{1}) two canals that join to form one canal in the middle third down to the apex, and 2% (^{3}M MB^{2-1-2} P^{1} DB^{1}) two canals in the coronal third join in the middle third then split once more through the apical third ending in two apical foramen. This indicates that in this specific sub population two separate Mesiobuccal canals are more prevalent which comes in agreement with the results of a study conducted by **Vertucci** [6] and studies that evaluated the Egyptian population, [28] Burmese population, [28] and Chinese population. [37] all whom found that regarding canal configurations, in the maxillary first molar MB root showed type IV Vertucci which ranged between (28.6% - 30 %). On the other hand, 29.7 % of all cases showed one canal all through the Mesiobuccal root with the configuration (^{3}MMB^{1-1-1} P^{1} DB^{1}) which are the same results as reposted by **Rwenyonyi et al.** [29] who showed in their study that Type I Vertucci had the highest percentage of occurrence.

The differences within the prevalence of a certain configuration of Mesiobuccal canal may be attributed to the different population of each study this asserted the fact that different morphologic configurations are affected by ethnicity, and race.[38] The site where a canal splits or merges especially if it is located at the middle or the apical third is a major challenge during root canal treatment. Knowing in advance the specific location where a canal splits into two or more canals is of utmost importance as stated by **Martins et al** [38] The outcome of a root canal treated tooth is directly correlated to the thorough cleaning and shaping of all root canal irregularities. Thus, giving adequate importance to both, the roots and their canal systems, is imperative for long-term success of endodontic treatment.

Regarding age and gender; comparative analysis of age distribution across different coding classifications, showing statistically significant differences at p value of (<0.001). The mean age varies considerably among the different classification codes. Likewise comparative analysis of the distribution of coding classifications between male and female participants, revealing statistically significant differences between sexes (p<0.001).

The most prevalent configuration for male case was (^{3} M MB$^{1\text{-}1\text{-}1}$ P^{1} DB^{1}) with a (26 %) incidence and for females was (^{3} M MB$^{2\text{-}2\text{-}2}$ P^{1} DB^{1}) with a (33.9 %) incidence. The highly significant assured that these gender-based differences in code distribution are not due to chance, suggesting potential anatomical or physiological differences between age and sex that influence these morphological classifications. Many previous studies have demonstrated that age and gender influence the configuration and morphology of the pulp space. [39, 40, 41, 42] While our results disagree with **Naseri etal** [36] who found no significant difference regarding the canal configurations in relation to gender and age; variation in the population and sample size.

Regarding calcified roots, the majority of participants (861, 57.4%) had no calcified roots (0), while 550 participants (36.7%) had one calcified root, and only 89 participants (5.9%) had two calcified roots. This distribution indicates that calcification was absent in over half the sample, with double calcification being relatively rare. Meanwhile; as the mean age increased the number of calcified root canals increased. **Onn et al** [43] showed that age is a detrimental factor on the incidence of canal calcification. As the patient becomes older, pulp space shrinks, primarily due to the natural continuous narrowing of the pulp space by tertiary and reparative dentine deposition and calcification of the root canal system.

Many studies have correlated the high frequency of mishaps during the root canal treatment to presence of calcified root canals. Severely calcified teeth are liable to perforation especially during initially locating the root canal opening. Generally, the calcification process develops from the crown down in the apical direction thus, once calcification of the root canal orifice has been eliminated and the enlarging instruments have found their way in to the original root canal preparation becomes easier. However, when root canal system is completely calcified root canal systems, finding the orifice is particularly difficult. [44, 45, 46]

Detailed imaging of root canal system, presence of root canal splitting and the level at which the splitting happens and the presence of calcification are all important information that should be acknowledged before endodontic treatment; this not only allows for better decision making and preparation for the treatment but also decreases risks of developing complications during the procedure and overall enhances the prognosis.

CONCLUSION

Combining CBCT imaging with this new classification allows for more detailed description and precise information about root canal configuration which enhances pre-evaluation of the root canal morphology and will have positive impact on the outcome of endodontic therapy.

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