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Root and Root Canal Morphology of Permanent Maxillary Premolars in a selected sample of Egyptian Population: An Anatomical and Anthropological Study

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Abstract

Background: Dental root and canal morphology vary significantly across populations, impacting endodontic therapy and anthropological studies. Understanding these variations is crucial for clinical success and population classification. This study assessed root and canal morphology in maxillary premolars (maxillary first premolars and maxillary second premolars) in an Egyptian population using cone-beam computed tomography (CBCT).

Methods: A total of 243 CBCT scans (121 maxillary first premolars and 122 maxillary second premolars) were analyzed. Root morphology was categorized by the number of roots (one or two), and canal configurations were classified using Vertucci's classification (Types I-VIII). Statistical analysis, using chi-square evaluated variations.

Results: Maxillary first premolars predominantly had two roots (72.72%), while maxillary second premolars mostly had one root (65.50%). The most common canal configuration in maxillary first premolars was Type IV (84.2%), and in maxillary second premolars, it was type I (79.87%). Other configurations included type II (8.13% in first premolars, 6.7% in second premolars) and type IV (13.4% in second premolars). Significant variations were observed ($p = 0.0001$).

Conclusion: This study highlights significant variability in root and canal morphology of maxillary premolars in an Egyptian population. Maxillary first premolars commonly have two roots with type IV canals, while maxillary second premolars typically have one root with type I canals. These findings emphasize the importance of CBCT for accurate diagnosis and tailored treatment approaches in endodontics and anthropology.

1 Introduction

Dental morphological characteristics exhibit considerable variation across populations, playing a significant role in both anthropological and forensic studies. Root and root canal morphology, in particular, provide valuable insights into population-specific traits and have direct implications for clinical dentistry.[1] The study of root morphology involves the examination of radicular structures, which aids in characterizing populations based on their unique dental features.

In endodontics, a thorough understanding of root canal anatomy is critical, as variations in canal configuration can significantly influence treatment outcomes. Failure to account for such anatomical diversity can lead to procedural complications, including missed canals, incomplete debridement, and ultimately, treatment failure. [2,3]

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Dental characteristics are significantly influenced by genetics in both the internal and exterior anatomy of root canals; this contributes to population-specific dental traits. While environmental factors may modulate these variations, their impact is generally considered minimal. Population-specific studies on root and root canal designs are crucial for anthropological study and clinical practice due to their minimal impact. Lack of understanding of the architecture of the root and canals sometimes causes problems during endodontic procedures, such as trouble finding the equipment needed to irrigate and fill canals. [4-6]

Root canal treatment RCT is a principal step for repairing and safeguarding severely damaged or diseased teeth. The process consists of three main milestones: obturation root canal shaping, which includes chemo-mechanical trimming and biomechanical preparation and access cavity preparation Contaminated pulp tissue, including the nerve and blood supply, must be eliminated. Efficient germ removal, especially in the apical region, is requisite to the long-term sustainability of RCT. This is achieved by thorough chemo-mechanical trimming and precise instrumentation. Among the main objectives of RCT is to ensure that a consistent filling is put in by cleaning and shaping the root canal to a predefined diameter. However, the intricate and diverse shape of the root canal system, especially in the apical region, makes it more challenging to eliminate organic material and reduce the microbial burden. [7-9]

By looking at these anatomical traits, the research aims to increase our understanding of dental characteristics in this group; the findings will enhance results of therapy and give a deeper recognition of the oral architecture of specific populations. Examining the root and root canal structure of permanent maxillary premolars in a population sample from Egypt is another goal of this research; additionally, the current analysis will yield valuable data for anthropological research and endodontic clinical procedures.

2 Materials and Methods

2.1 Ethical Approval

Under permission number REC-D 11153-5, the research ethics committee of the MSA University Faculty of Dentistry granted ethical approval for the current investigation.

2.2 Sample size calculation

Sample size was measured Based on the findings of a prior study, El-Messiry H 2021 in which the prevalence of type III root morphology was (19.6%) by employing a 95% confidence interval, a 5% margin of error, and applying finite population correction, the minimal accepted sample size (n) comprised a total of (243) cases divided into 121 maxillary first premolar and 122 maxillary second premolar. Sample size was determined using EPI INFO version 7.2.5.0. [10]

2.3 Samples selection

Following the application of our inclusion and exclusion criteria, a final sample of 243 scans of the maxillary premolar area belonging to individuals of Egyptian origin was chosen and analyzed out of 400 scans that were taken from the database kept at the Endodontic department, MSA University. Patients who were at least twenty years old were included in the scans.

For the scans to be accurately detected and interpreted, they had to meet high-quality standards and possess a specific voxel resolution of 0.4mm. The lack of patient records status and information like name, sex, or age was an exclusion criterion.

The CBCT scans of Egyptian patients that were available and had been previously taken during the years 2022–2024 as part of their dental examination, diagnosis, or treatment planning were used in the present study. This was done to prevent the patients from receiving unnecessary radiation doses for the study.

2.4 Image evaluation

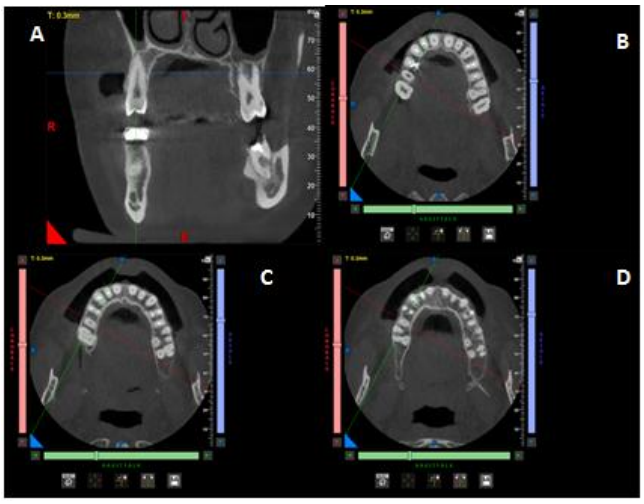

Figure 1: CBCT images showing Type I root canal in premolars A) CBCT coronal view, B) CBCT coronal cross sectional view, C) CBCT middle cross sectional view, D) CBCT apical cross sectional view

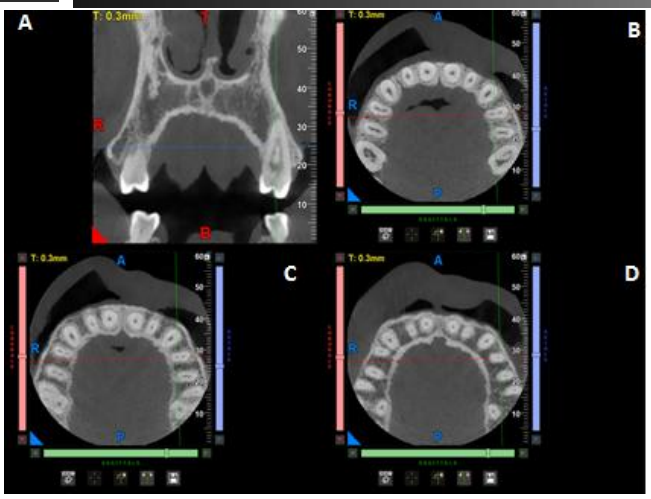

Figure 2: CBCT images showing Type II root canal in premolars A) CBCT coronal view, B) CBCT coronal cross sectional view, C) CBCT middle cross sectional view, D) CBCT apical cross sectional view

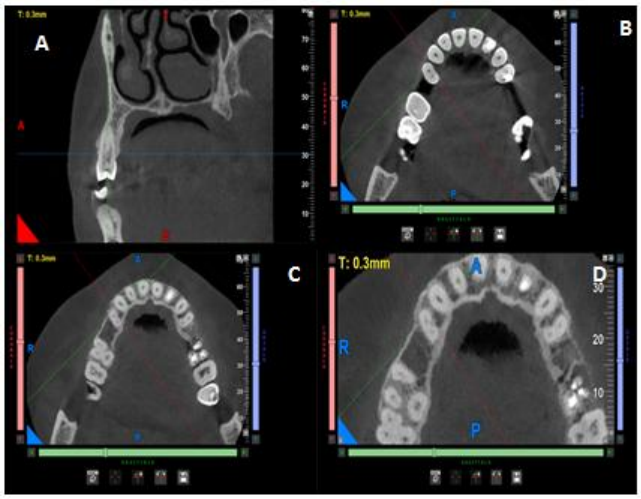

Figure 3: CBCT images showing Type IV root canal in premolars A) CBCT coronal view, B) CBCT coronal cross sectional view, C) CBCT middle cross sectional view, D) CBCT apical cross sectional view

According to EL-Hadidy O [11], all measurements were carried out independently by two endodontists who evaluated all the images (with different experiences). Each investigator carried out the measurements twice across two distinct sessions, with a two-week gap between the attempts. A collaborative session involving all investigators was held to reach agreement on accurate anatomical determination.

2.6 Classification of samples

The measurements of teeth were recorded and measured as follows:

1) Number of roots

Number of roots was classified as either: [12]

- One root
- Two roots

2) The anatomical configuration of canals based on Vertucci classification. [13, 14]

Type I: One canal extending from coronal pulp to the apical end.

Type II: Two unconnected canals depart from the coronal pulp which join together forming one canal before apical end.

Type III: One canal originates from the coronal pulp, divides into two within the root, and reunites till apical end.

Type IV: Two independent canals run from the pulp chamber to the apex.

Type V: A single canal emerges from the pulp chamber, splits into two different canals, with two different apical foramina.

Type VI: Two different canals exit the pulp chamber, unite midway, and then divide again into two different canals with two different apical foramina.

Type VII: One canal emerges from the pulp chamber, divides, reunites along its path, and eventually divides into two before the apical end.

Type VIII: Three canals emerge from the pulp chamber and extend separately till the apical end. **(Fig. 4)**

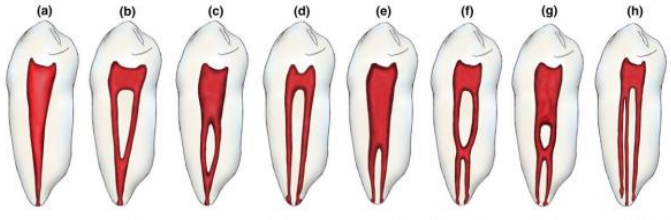

Figure 4. Diagrammatic illustration of Vertucci's classification for root canal morphology (a) Type I (1-1), (b) Type II (2-1) , (c) Type III (1-2-1), (d) Type IV(2-2) ,(e) Type V (1-2), (f) Type VI (2-1-2), (g) Type VII (1-2-1-2), (h) Type VIII(3-3) [12]

2.7 Statistical Analysis

Statistical analysis was performed using SPSS 20®, Graph Pad Prism®, and Microsoft Excel 2016. Data were presented as frequencies and percentages. Comparisons between groups were conducted using the Chi-square test to determine statistical significance. All analyses were performed with a significance level set at $p < 0.05$.

3 Results

3.1 Roots number

The distribution of root numbers for maxillary first premolar and maxillary second premolar teeth according to the Vertucci root canal classification were presented in **Table 1** and **(Fig. 5)** In maxillary first premolar teeth (121 total teeth) were distributed as 88 teeth (72.72%) have 2 roots and 33 teeth (27.27%) have 1 root. The chi-square test was performed to compare between then and shows a statistically significant difference with a p-value of 0.0001. In maxillary second

premolar teeth (122 total teeth) were distributed as 42 teeth (34.40%) have 2 roots and 80 teeth (65.50%) have 1 root. The chi-square test also was used to compare between them and shows a statistically significant difference with a p-value of 0.0001.

Table 1. Roots number distribution among maxillary first premolars and maxillary second premolars according to Vertucci root canal classification:

Tooth	Total N	2 roots		1 root		Chi square	P value
		N	%	N	%		
Max 1st premolar	121	88	72.72%	33	27.27%	48.807	0.00001*
Max 2nd premolar	122	42	34.40%	80	65.50%	23.35	0.00001*

*Significant difference as $P \leq 0.05$.

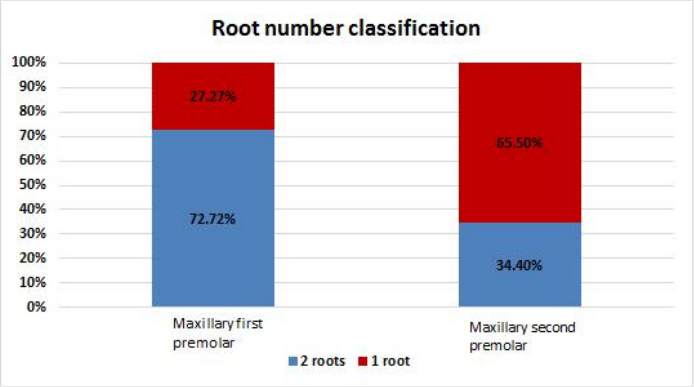

Figure 5. Stacked bar chart representing roots number distribution among maxillary first premolar and maxillary second premolars.

3.2 Root canals number

The distribution of root canal types for maxillary first premolar and maxillary second premolar teeth according to the Vertucci root canal classification were detailed in **table 2** and illustrated in **figure 6**. In maxillary first premolar teeth (209 totals) were distributed as type I: 16 teeth (7.65%), type II: 17 teeth (8.13%) and type IV: 176 teeth (84.2%) with a statistically significant difference between them, as indicated by a p-value of 0.0001. In maxillary second premolar teeth (164 totals) were distributed as type I 131 teeth (79.87%), type II 11 teeth (6.7%), and type IV: 22 teeth (13.4%) with significant difference between them as P=0.0001.

Table 2. Root canals number distribution among maxillary 1st premolar and maxillary 2nd premolar according to Vertucci root canal classification:

	Total N	Type I		Type II		Type IV		P value
		N	%	N	%	N	%	
Max 1st premolar	209	16	7.65	17	8.13	176	84.2	0.0001*
Max 2nd premolar	164	131	79.87	11	6.7	22	13.4	0.0001*

*Significant difference as $P \leq 0.05$.

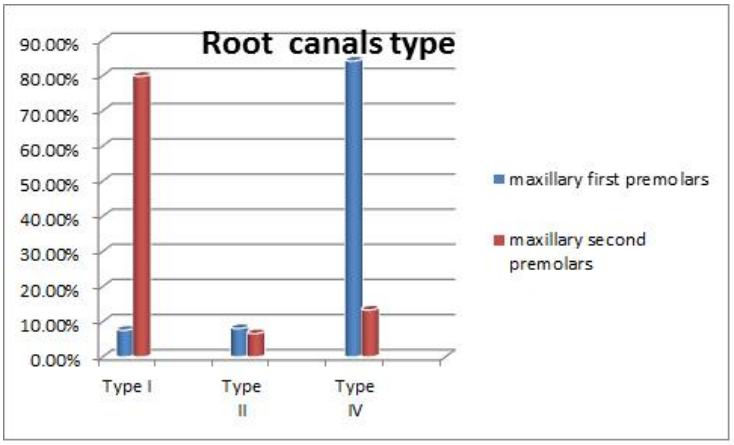

Figure 6. Bar chart representing root canals number distribution among maxillary first premolars and maxillary second premolars according to Vertucci root canal classification.

4 Discussion

In endodontic treatment, it is crucial to fully eliminate infected root dentin and necrotic tissues. However, accomplishing this in clinical settings is a major difficulty due to the intricate and diverse morphologies of root canals. Studies indicate that the occurrence of overlooked root canals varies between 12% and 23%. Furthermore, lesions around the root apex are detected in 83–98% of these overlooked canals, with a relative risk ranging from 3.13 to 6.25. A comprehensive knowledge of root anatomy specific to different racial groups is essential for developing and executing successful dental treatment approaches. [15]

Several publications on tooth anatomy have explored the relationship between root structure and sex. These studies concluded that there is no significant difference was observed in the number of roots and types of root canals between the teeth of males and females in Spanish [16], Turkish [17], and Nepalese [18] populations.

In the present study, cone-beam computed tomography (CBCT) was utilized to assess root and root canal morphology of permanent maxillary premolars in a group of the Egyptian population due to its ability to provide high-resolution, cross-sectional images of the tooth and surrounding structures. This advanced imaging modality enables clinicians to accurately identify the number, shape, and configuration of root canals. CBCT is particularly advantageous in cases involving complex

anatomical variations, such as curved, fused, or accessory canals, which are frequently undetected using conventional imaging techniques. [19]

In current study there was a variation in root distribution between first and second premolars in the maxilla. Most of the first premolars in the maxilla (72.72%) exhibited two roots, and 27.27% exhibited a single root. The significant difference (p = 0.0001) confirms two-rooted first premolars to represent a common anatomical feature in such a selected sample of the Egyptian population.

This observation aligns with previous studies conducted in other populations. For instance, Al Zubaidi *et al.* [20] reported that 58.6% of maxillary first premolars in their study had two roots, while 39.8% had one root and 1.6% had three roots. Similarly, Mirah *et al.* [(21)] found that 82.6% of maxillary first premolars in a Saudi subpopulation had two roots, with 16.3% having one root and 0.97% having three roots. These consistent findings across different populations suggest that maxillary first premolars with two roots are a common anatomical feature, particularly in Middle Eastern populations.

Comparative analysis with studies in other populations reveals both similar and contrasting root and canal structures. European and Asian studies have documented a relatively lesser proportion of two-rooted first premolars, and therefore, possibly, genetic and environmental factors in shaping dental structures. The number of roots in maxillary first premolars within a selected Korean population was 71.5% of maxillary first premolars had 1 root.[22] Moreover, maxillary first premolars were mainly single-rooted (64.9%) in the Japanese populatio. [23]

Second premolars, in contrast, exhibited a predominantly single-rooted form (65.50%) with 34.40% exhibiting two roots. The chi-square analysis exhibited a significant difference (p = 0.0001), in agreement with the fact that root variation in the terms of root numbers are specific between two types of premolars.

This observation conforms to trends worldwide, with a less complex root form in premolars in comparison with first premolars. Jung YH *et al.* found that 97.6% of maxillary second premolars had 1 root. [22] Maxillary second premolars were predominantly single-rooted (97.8%) in the Japanese population. [23] But Mirah et al. found that maxillary second premolars with 2 roots were 9 in number, while only 3 second premolars were found with a single root. [21]

The root canal distribution according to Vertucci's system again mirrors premolar root form complexity in the maxilla. In first premolars, type IV (84.2%) represented most frequent configuration, with type II (8.13%) and type I (7.65%) following in sequence. All such observations agree with studies reporting type IV to represent the most common configuration in first premolars in the maxilla.

Similarly, in maxillary second premolars, type I (79.87%) continued to predominate, with type II (6.7%) and type IV (13.4%) following in sequence. Notably, type IV configuration percentages in premolars outnumbered first premolars, and therefore, even in premolars with fewer general root structures, inner canal structures can have significant variation. Differences between types in both premolars, as seen, were significant (p = 0.0001), and in consonance with the imperative for careful anatomical examination in root canals in endodontic therapy.

Al-Zubaidi SM *et al.* [20] found that for maxillary first premolars, type IV was the most frequent, accounting for 57.8% of the sample (n = 289), followed by type II (32.8%, n = 164). For maxillary second premolars, type I was the main occurrence. 302 (60.4%), followed by type II (16.4%, n = 82).

Jung YH *et al.* found that the most common canal configuration in maxillary first premolars was Vertucci type IV (42.6%), whereas type I predominated in second premolars (76.5%). [22]

Observations exhibited a striking variation in root and root configuration between first and second premolars, and an awareness of such Anatomical variation is important for both endodontic therapy and anthropologic classification.

5 Conclusion

This study highlights the complexity of maxillary first premolars compared to second premolars and align with Middle Eastern population trends, contrasting with Asian and European studies where single-rooted first premolars are more common. The high prevalence of intricate canal configurations emphasizes the need for precise radiographic assessment in endodontic treatment to avoid procedural errors. These results provide valuable clinical and anthropological insights, aiding in improved treatment planning and population-specific dental trait analysis, reinforcing the importance of understanding anatomical variations for successful endodontic outcomes.

Authors' Contributions

Samah Mohamed Kamel (SM Kamel) conceived the study concept and was primarily responsible for manuscript writing. **Hinar Hani Al Moghazy** (HH Al Moghazy) and **Mohamed Ahmed Kamal Nada** contributed to manuscript drafting, data analysis, and interpretation of results. **Karam Loui Aziz, Mariam**

Ahmed El Shazly, Mohamed Aysar Mohamed and Sherif Saeed Mohamed Fayed participated in data collection and analysis. All authors reviewed and approved the final manuscript.

Conflict of interest

The authors declare that they hold no competing interests.

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