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Odontometry and Crown Morphology of Maxillary and Mandibular Premolars in a Sample of Egyptian Population

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Aim: This work was to study the odontometry and crown morphology of maxillary and mandibular premolars regarding to number of cusps, groove pattern and mesio-distal crown width and bucco-lingual crown thickness in a sample of Egyptian population.
Materials and methods: 228 dental study casts were used to determine the occlusal morphology of maxillary and mandibular premolars. Number of cusps and groove pattern were determined. Mesio-distal crown width and bucco-lingual crown thickness of each individual tooth were measured using a digital caliper.
Result: Regarding cusps' number and groove pattern of maxillary premolars, maxillary first and second premolars showed prevalence of 2-cusp type with 97.4% and 96.5% respectively. As for the mandibular first premolar, showed prevalence of 2-cusp type with 98.2% and the mandibular second premolar showed prevalence of the 3-cusp type with 54.4 %. As for the groove pattern, both maxillary premolars showed straight shaped groove pattern with 100%. While mandibular first premolar showed prevalence of no groove pattern with 65.8% and mandibular second premolar Y groove shaped pattern with 57.9%. The mean mesio-distal crown width of maxillary first premolar was significantly higher than that of second premolar, while the mean bucco-lingual crown thickness of second premolar was significantly higher that of first premolar. Mandibular first premolar showed significantly lower mesio-distal as well as bucco-lingual crown measurements than that of second premolar.
Conclusion: The morphological characteristics of maxillary and mandibular premolars in a sample of Egyptian population were consistent with those of other studies performed on different populations using similar methodology.

Keywords: Cusp number; Groove pattern; Odontometry; Premolars

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Introduction

Morphological variations that occur in human teeth are considered as a matter of interest to anthropologists, clinicians , and forensic dentists. [1]

Tooth crown morphology varies among the major races of humankind. The study of odontometry and dental morphological characteristics is crucial as it provides information on phylogenetic relationships within species, as well as variations and diversity within populations. Furthermore, understanding variations in dental morphology for each individual tooth helps in performing dental treatments such as orthodontic, endodontic, and restorative procedures[2–4]

Studying the external tooth morphology has been the domain of many morphological and morphometric studies in different populations. Many studies showed different methods to study dental morphology among different races [5]

Premolars are divided into two types: bicuspid and tricuspid premolars. They differ in the number of cusps and occlusal groove patterns. Occlusal groove has three different patterns; Y shaped pattern which is associated mainly with the three cusps type, while the straight, U shape and H shape patterns are associated with the two cusps type [6,7]

The possibility of having different patterns and variable measurements of maxillary and mandibular premolars is very common and should be considered a racial characteristic in Egyptian population when compared to other populations.

This study aimed to investigate the odontometry and crown morphology of premolars in a sample of Egyptian population regarding cusps' number, groove pattern, mesio-distal (MD) and bucco-lingual (BL) dimensions of the crown.

Material and Methods

A total of 228 casts (114 upper and 114 lower) were used in this study (one side was used from each cast). Cast were collected from the department of fixed prosthodontics, Ain Shams and Future University in Egypt to examine the crown morphology and to measure the MD and BL dimensions of the premolars. All procedures adhered to the guidelines set forth by the Research Ethics Committee on Living Creatures in Egypt, including the National Committee of Bioethics and the Future University Institutional Review Board (FUE.REC (37)/10-2024).

Inclusion criteria[4]

- Well aligned maxillary and mandibular premolars without any crowding or rotation in the premolar area
- Presence of maxillary and mandibular premolars with clear anatomic details of the crown.
- Egyptian patients

Exclusion criteria[8]

- Teeth with restorations.
- Fractured teeth.
- Teeth with heavy attrition.

Assessment of Occlusal morphology

Cusps' number and groove pattern

Examination of maxillary and mandibular first and second premolars was done on the dental study casts. A cusp was identified as a pronounced elevation on the occlusal surface of the premolar and ending in a conical, or a flat surface [9]. Then the occlusal pattern of each premolar was classified according to the standards of characterization of the morphological variants of permanent teeth – Arizona State University- Dento-anthropological [10] into:

Maxillary first and second premolars:

- Presence of two cusps.
- Presence of three cusps.

Mandibular first and second premolars:

- Presence of two cusps.
- Presence of three cusps.
- Presence of four cusps.

Then, Groove pattern was determined after marking the grooves using a pencil and

premolars were then further classified as follows:

Maxillary premolars:

- Straight shaped groove.
- Y-shaped groove.

Mandibular premolars

- Straight shaped groove.
- Y-shaped groove.
- U-shaped groove.
- H-shaped groove
- No groove.

Measurement of MD and BL crown dimensions

The MD and BL crown dimensions of each tooth were measured by a single examiner using a digital caliper[11]. For MD crown width measurements, the examiner held the cast vertically and placed the caliper's blades on the premolars' contact points [8,12][Fig. (1 A)]. BL crown thickness values were obtained from the midpoint on the buccal surface to the midpoint on the lingual surface of the crowns [13]with the blade's proximal sides parallel to the long axis of the tooth in both measurements [Fig. (1 B)][14]. Each premolar was measured three times, and the mean value was used. Different recording sheets were used each time to ensure no access to previous measurements [15].

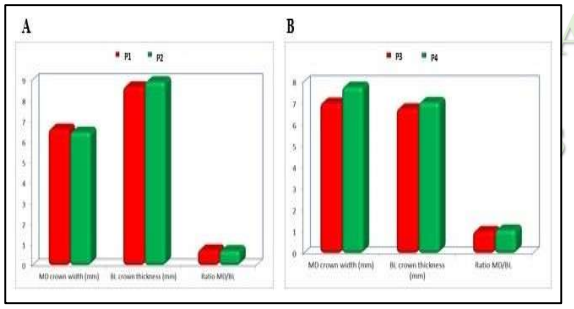

Fig. 1: A Photograph showing: MD crown width measurement [12] (A),and BL crown thickness measurement using a digital caliper[14] (B).

Statistical analysis

The recorded data were analyzed using the Statistical Package for the Social Sciences, version 20.0 (SPSS Inc., Chicago, Illinois, USA). Quantitative data were presented as mean ± standard deviation (SD), while qualitative data were expressed as frequency and percentage. The following statistical tests were applied:

- Independent-samples t-test: Used to compare means between two groups.
- Chi-square (χ^2) test: Used to compare proportions between qualitative parameters.
- Pearson's correlation coefficient (r): Used to assess the degree of association between two sets of variables which were the MD and BL dimensions.

A confidence interval of 95% and a margin of error of 5% were employed. Therefore, the interpretation of p-values was as follows:

- P-value < 0.05 was considered significant.
- P-value < 0.001 was considered highly significant.
- P-value > 0.05 was considered insignificant.

Result

Cusps' number of Maxillary (P1 & P2) and Mandibular Premolars (P3 & P4):

Regarding cusps' number of P1 and P2 frequent cuspal pattern for P1 was the 2-cusps variety 97.4%, compared to 3-cusp form 2.6%. As for P2, the predominating cusps' number was the 2-cusp type with 96.5% where the 3-cusp type was 3.5 %. [Table (1) and Fig. (2, 4A & 4B)].

Regarding cusps' number of P3 and P4, frequent cuspal pattern for P3 was the 2-cusp variety (98.2%), compared to 3-cusp form (1.8%). As for P4, the predominating cusps' number was the 3-cusp type with 54.4% where the 2-cusp type was 45.6 % [Table (1) and Fig. (2) & Fig. (4 C-I)]. There was a statistically significance difference between P3 and P4 regarding cusps' number.

Table 1: Showing distribution of cusps' number of maxillary and mandibular premolars.

Cusps' number of Premolars	Maxillary *(n=228)*		Mandibular *(n=228)*	
	No.	%	No.	%
First premolar	N=114		N=114	
2 cusps	111	97.4	112	98.2
3 cusps	3	2.6	2	1.8
4 cusps	0	0.0	0	0.0
Second premolar	N=114		N=114	
2 cusps	110	96.5	52	45.6
3 cusps	4	3.5	62	54.4
4 cusps	0	0.0	0	0.0
Chi-square test	0.130		75.616	
p-value	0.719		<0.001**	

x^2-Chi-square test
p-value>0.05 NS; *p-value <0.05 S; **p-value <0.001 HS

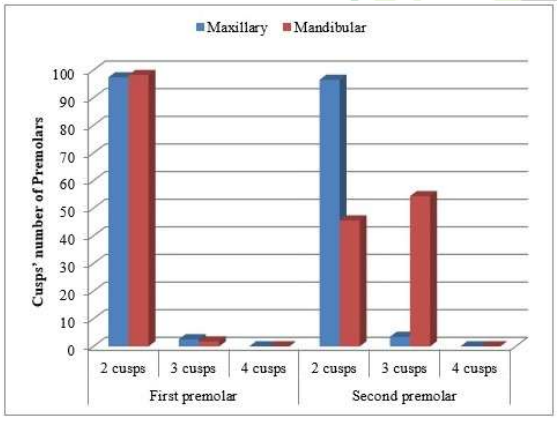

Fig. (2): Bar chart showing the distribution of cusps' number of maxillary and mandibular premolars.

Groove pattern of Maxillary (P1 & P2) and Mandibular Premolars (P3 & P4):

The predominant groove pattern in both P1 and P2 was the "straight shaped" pattern (100%) [Table (2) and Fig. (3, 4A & 4B)]. The predominant groove pattern in P3 was the "no groove" pattern (65.8%) followed by "U-shaped" pattern (14.9%) then "straight shaped" pattern (12.3%). While P4 showed "Y-shaped" pattern (57.9%) followed by "H-shaped" pattern (21.1%) and "U-shaped" pattern (11.4%) [Table (2) and Fig. (3) & Fig. (4 C-I)]. There was a statistically significant difference between P3 and P4 regarding cusps' number and groove pattern.

Table (2): Showing distribution of groove patterns of maxillary and mandibular premolars.

Groove pattern of Premolars	Maxillary *(n=228)*		Mandibular *(n=228)*	
	No.	%	No.	%
First premolar	N=114		N=114	
Straight shape	114	100	14	12.3
Y shaped	0	0.0	4	3.5
U shaped	0	0.0	17	14.9
H shaped	0	0.0	4	3.5
No groove	0	0.0	75	65.8
Second premolar	N=114		N=114	
Straight shape	114	100	11	9.6
Y shaped	0	0.0	66	57.9
U shaped	0	0.0	13	11.4
H shaped	0	0.0	24	21.1
No groove	0	0.0	0	0.0
Chi-square test	0.000		145.093	
p-value	1.000		<0.001**	

x^2-Chi-square test
p-value>0.05 NS; *p-value <0.05 S; **p-value <0.001 HS.

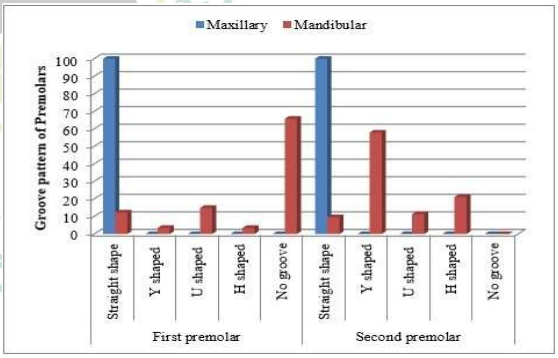

Fig. (3): Bar chart showing the distribution of groove patterns of maxillary and mandibular premolars.

MD and BL Crown Dimensions

MD and BL crown dimensions of Maxillary Premolars (P1 & P2)

Regarding the MD crown width, P1 (6.634 mm) showed higher mean value than P2 (6.485 mm). Regarding the BL crown thickness, P2 (8.933 mm) showed higher mean value than P1 (8.685 mm). MD/BL ratio was 0.765 mm in P1 and 0.727 mm in P2. Descriptive statistics (means and standard deviations) for P1 and P2 were presented in [**Table (3A)** and **Fig. (5A)].** There was a statistically significant difference between P1 and P2 regarding MD crown width (mm), BL crown thickness (mm) and Ratio MD/BL (mm).

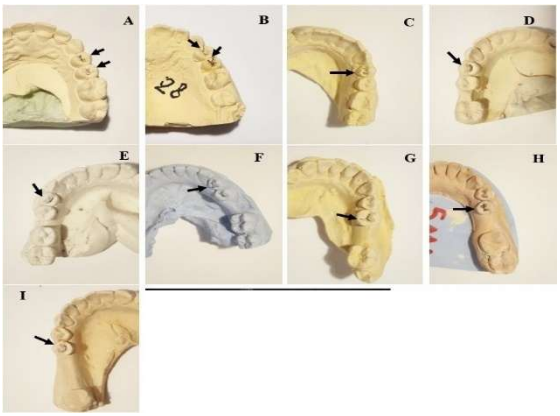

Fig. (4): A photograph of a study cast showing cusps' number and groove pattern: (A): P1 and P2 with 2-cusps (arrows) and a "straight shaped" groove. (B): P1 and P2 with 3-cusps (extra mesial cusp) (arrows) and "straight shaped" groove. (C): P3 with 2-cusps and "no groove" (arrow). (D) P3 with 2-cusps and "U-shaped" groove (arrow). (E): P3 with 2-cusps and "straight shaped" groove (arrow). (F): P3 with 3-cusps and "Y-shaped" groove (arrow). (G): P4 with 3-cusps and "Y-shaped" groove (arrow). (H): P4 with 2-cusps and "H-shaped" groove (arrow). (I): P4 with 2- cusps and "U-shaped" groove (arrow).

MD and BL crown dimensions of Mandibular Premolars (P3 & P4)

Regarding the MD crown width, P4 (7.779 mm) showed higher mean value than P3 (7.033 mm). Regarding the BL crown thickness, the mean for P3 was 6.764 mm while that of P4 was 7.059 mm. MD/BL ratio was 1.045 mm in P3 and 1.107 in P4. Descriptive statistics (means and standard deviations) for P3 and P4 were presented in [Table (3B) and Fig. (5B)]. There was a statistically significant difference between P3 and P4 regarding MD crown width (mm), BL crown thickness (mm) and MD/BL ratio (mm).

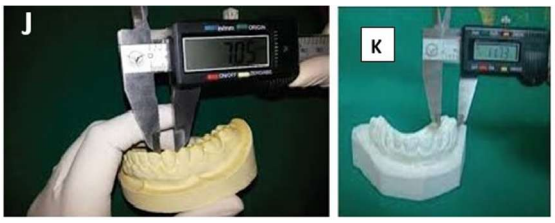

Fig. (5): Bar chart comparing: (A): P1 and P2, and (B): P3 and P4 regarding MD crown width (mm), BL crown thickness (mm) and ratio between MD/BL (mm).

Table (3): Comparison between P1, P2 (A) and P3, P4 (B) regarding MD crown width (mm), BL crown thickness (mm) and MD/BL ratio (mm).

(A)				
Tooth	**P1*(n=114)***	**P2 *(n=114)***	**t-test**	**p-value**
MD crown width (mm)	6.634±0.689	6.485±0.429	2.142	0.047*
BL crown thickness (mm)	8.685±0.539	8.933±0.532	3.496	0.006*
MD/BL Ratio (mm)	0.765±0.079	0.727±0.043	4.511	<0.001**
(B)				
Tooth	**P3 *(n=114)***	**P4 *(n=114)***	**t-test**	**p-value**
MD crown width (mm)	7.033±0.504	7.779±0.527	10.923	<0.001**
BL crown thickness (mm)	6.764±0.439	7.059±0.537	4.541	<0.001**
MD/BL Ratio (mm)	1.045±0.092	1.107±0.102	4.819	0.003*

t-Independent Sample t-test;
p-value <0.05 S; **p-value <0.001 *HS

As for the correlation between P1 and P2, regarding BL and MD dimensions, r for P1 was 0.442 and for P2 0.853 with a significant positive correlation between BL and MD variables. [Table 4, Fig. (6A & B)]. As for the correlation between P3 and P4 regarding BL and MD dimensions, P3 was 0.167, and P4 was 0.191 with a significant positive correlation between BL and MD variables in P4 and a non-significant correlation in P3.Table 4, Fig. (6C& D)].

Table (4): Correlation between BL and MD in P1, P2, and P3, P4 among the study sample.

BL correlation with MD		**Maxillary Premolars**		**Mandibular Premolars**	
		P1	**P2**	**P3**	**P4**
	r	0.442	0.853	0.167	0.191
	p-value	<0.001**	<0.001**	0.075	0.041*

r-Pearson Correlation Coefficient
p-value >0.05 NS; *p-value <0.05 S; **p-value <0.001 HS

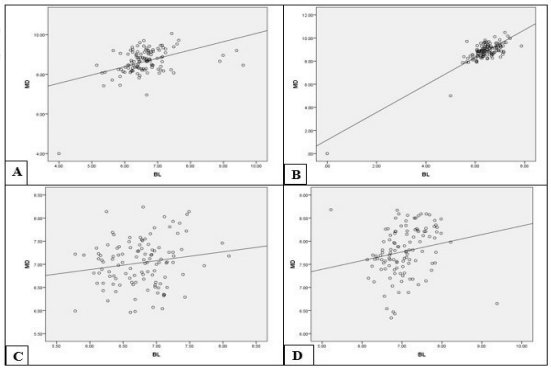

Fig. (6): Scatter plot between BL and MD in P1 (A), P2 (B), P3 (C) and P4 (D) among study sample.

Discussion

Among various populations, dentitions exhibit varying degrees of expression, frequency, and tooth variation [16]. The accumulation of data of dental morphological traits across different populations has heightened anthropologists' interest in these traits and their mode of inheritance. Tooth crown morphology exhibits variations among the major human races[3]

Knowledge about these common variations occurring in tooth morphology help in the performance of different dental treatments such as in conservative dentistry. This aids in creating accurate restoration of tooth morphology and function [17] and ensures correct tooth spacing, esthetics, phonation, mastication which can be affected as a result of tooth loss [18]. Moreover, it might as well be used in anthropological research for the identification of a population [19]

Occlusal surface morphology of posterior teeth has been a matter of interest for many dental anthropologists [20] Variations in cusps' number, size, and groove pattern have been examined in teeth of different populations [21]

The exact etiology for the extra cusp formation is unknown but many theories have been postulated to explain this trait. Over activity of the dental lamina was thought to be the reason; However, it is now believed that paired box (Pax) and muscle segment homeobox (MSX) genes were responsible for these variations [22] These extra cusps are typically small and develop late [23]

The present study revealed that the cusps' number of P1 in a sample of Egyptian population was 2- cusps variety (97.4%), compared to 3-cusp form (2.6%). As for P2, the predominating cusps' number was the 2-cusp type with (96.5%) where the 3-cusp type was (3.5 %). The current results coincide with Scott et al., (2018) [24] who stated that the mesial accessory cusp of maxillary premolars have lowest frequencies in African, Asian and European populations and was about (2%). While in Neanderthals, researchers revealed highest frequency in P1 than in P2[25] Nayak et al., (2013)[19], found an unusual presentation of P1 and P3 with three-cusps pattern and a Y-shaped groove pattern. The premolars revealed one buccal cusp and two lingual cusps; mesiolingual and distolingual which were separated by a groove that extended on the lingual surface as a lingual developmental groove. The authors concluded that the variations in P1 and P3 regarding crown morphology were few, which supports the current results. However, Bansal et al., (2016)[26] found that P2 was represented with four cusps; Buccal, Palatal and two accessory cusps; mesiobuccal accessory cusp and distobuccal accessory cusp and this may be due to the diversity that might happen among populations. The researcher explained that the term "accessory" is used to describe these cusps as lobe-like structures present buccally rather than occlusally.

As for the mandibular premolars, P3 showed the 2-cusp variety with a percentage of 98.2, compared to 3-cusp form (1.8%). As for P4 the predominating cusps' number was the 3-cusp type with (54.4%) where the 2-cusp type was (45.6 %). The predominant groove pattern in P3 was "no groove" pattern (65.8%) followed by "U-shaped" pattern (14.9%). While P4 showed "Y-shaped" pattern (57.9%) followed by "H-shaped" pattern (21.1%) and "U-shaped" pattern (11.4%). Scheid and Weiss, (2012) [27] agreed with the present results, as they stated that the most common cusp configuration for P3 was the two cusp type with "no groove" pattern. Also, Bath-Balogh and Fehrenbach (2011)[28] has reported that the frequency of P4 with 2 cusps was represented by (45%) and 3 cusps (55%). The current results also coincide with similar studies that were conducted in India and China [29,30]. [1] Nagaveni et al., (2015) stated in case report that a four cusp type P4 and this was considered a case of molarization of P4,

being similar to a lower second molar with two buccal and two lingual cusps. In another agreement with the present study, Ahmed et al., (2016) [6] have also revealed that P4 had 2- cusp type with (37.5%) and the 3-cusp type have been found (62.4%) which supports the current study. However, regarding the configuration of occlusal groove pattern, U-shaped pattern represented the most common pattern (54%) followed by the H-shaped pattern (46%). The present results were also not coinciding with Sunil and Gopakumar (2012) [29], who have found that P4 had frequent cuspal pattern 2-cusp variety (52.8%), compared to 3-cusp form (44.4%). The predominant groove patterns were the U-shaped pattern (45.27%) in 2-cusp variety and Y pattern in 3-cusp (45.27%). The researchers explained that the heavy physique and complexity of crown forms associated with the Western population might be the reason for this difference in the results in addition to the prevalence of certain traits among different populations.

For maxillary teeth to occlude properly with mandibular teeth there have to be definite proportionality of tooth size [31] MD and BL crown dimensions were measured in this study because of its importance in clinical dentistry as well as other sciences such as anthropology and anatomy. In orthodontics, the diagnosis and treatment of malocclusions require accurate knowledge of tooth measurements as the stable occlusion is reliable on the correct intercuspation of the teeth[32] Study casts were used in the present work for measurement of crown MD and BL dimensions of P1, P2, P3 and P4. The accuracy of plaster casts made from alginate impressions as a representation of actual tooth size according to Hunter and Priest, (1960)[33] who concluded that measurements done on dental casts are reliable. Furthermore, Anderson, *(2005)*[34] used both techniques (direct and indirect) in his odontometric study and he demonstrated that there were no statistically significant differences between the two methods. A digital caliper was used for measurement of crown MD and BL dimensions because of its accuracy. It eliminates measurement transfer and calculations errors [33]

The present study on a sample of Egyptian population revealed that the mean MD crown width of P1 was 6.634 mm while that of P2 was 6.485 mm. As for the BL crown thickness, the mean for P1 was 8.685 mm while that of P2 was 8.933 mm. The current results were found in agreement with Nelson and Ash, (2010)[35] who stated that P1 and P2 showed a MD crown width of 7.0mm. As for the BL crown, thickness for both P1 and P2 was 9.0 mm. Both of Scheid and Weiss, (2012)[27] and Nagas et al., (2018)[36] stated that P1 showed a MD crown width of 7.1mm while P2 was 6.6mm. Regarding the BL crown thickness, P1 was 9.2mm and P2 was 9.0 mm.

As for the MD crown width of mandibular premolars, the mean for P3 was 7.03 mm while that of P4 was 7.77 mm. The BL crown thickness, the mean for P3 was 6.76 mm while that of P4 was 7.05 mm. The present results were also matching with Nelson and Ash, (2010) [35] who stated that P3 and P4 showed a MD crown width of 7.0 mm. As for the BL crown thickness for both P3 was 7.5 mm and P4 was 8.0 mm. Scheid and Weiss, (2012)[27] stated that P3 showed a MD crown width of 7.0 mm while P4 was 7.1 mm and in the BL crown thickness, P3 was 7.7mm and P4 was 8.2 mm. On the other hand, according to Nagaş et al., (2018)[36] the BL crown thickness of P3 was 7.5 mm while that of P4 was 8 mm.

Based on these previous studies, dental morphological characteristics and odontometry are crucial in anthropological research. They provide insights into phylogenetic relationships between species and variations within populations [37]. Understanding common variations in dental anatomy and morphology for each tooth can also aid in dental treatments. Hence, the findings of this anatomical study are

applicable to both anthropological research and clinical dental sciences[29]

Conclusions

- P1 and P2 showed prevalence of 2-cusp type. As for P3 showed prevalence of 2-cusp type, while P4 showed prevalence of the 3-cusp type. Regarding the groove pattern, all P1 and P2 showed straight shaped groove pattern while P3 showed prevalence of no groove pattern and P4 showed prevalence of Y-shaped groove pattern.
- The mean MD crown width of P1 was significantly higher than that of P2 while the mean BL crown thickness of P2 was significantly higher that of P1. P3 showed significantly lower MD as well as BL crown measurements than that of P4.

Recommendations

- Similar studies should be conducted to examine other teeth groups in the Egyptian population.
- Further studies concerning right, left, female, and male differences should be done on human subjects.
- Studies should be conducted continuously on the dentition of Egyptian population to document evolutionary changes that occur among generations and relate this to different environmental factors.

Declarations

Ethical Approval

The study design was approved by the Research Ethics Committee at Faculty of Oral and Dental Medicine, Future University in Egypt (FUE.REC (37)/10-2024) in accordance with the ethical standards of the national research committee.

Data availability

The datasets used during the current study, available from the corresponding author on reasonable request.

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Competing interest statement

The authors declare no conflict of interest

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