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PERIODONTAL PARAMETERS AND SHAPES OF MAXILLARY CANINES IN A MIDDLE EAST POPULATION – A PRELIMINARY REPORT

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ABSTRACT

BACKGROUND: The periodontium biotype shows considerable variation among individuals, and these differences are often linked to tooth crown morphology. The size, form, and shade of the maxillary canines significantly influence smile esthetics, with sexual dimorphism frequently observed. This study aimed to evaluate the crown forms of maxillary canines and their corresponding gingival characteristics in healthy Middle East Asian adults.

MATERIALS AND METHODS: Sixty systemically healthy males and females aged 21–35 years from the middle eastern population were examined. Clinical parameters recorded included crown width (CW), crown length (CL), mesiodistal width (MDW), contact surface length (CS), interproximal papilla height (Ph), and gingival angle (GA). Based on crown morphology, teeth were categorized as trapezoidal, pentagonal, or square (incisor-shaped) groups, which were compared for differences in these parameters.

RESULTS: Significant differences were observed among crown shape groups for gingival angle ($P < 0.05$). In addition, correlations were found between crown morphology and parameters such as MDW/CL ratio.

CONCLUSION: Maxillary canine crown shape is significantly associated with variations in gingival angle and MDW/CL ratio. These findings may provide valuable guidelines for esthetic planning in restorative and prosthodontic procedures involving maxillary canines.

INTRODUCTION

The morphology of teeth and surrounding periodontal structures is intrinsically interconnected. Gingival architecture is generally categorized into two primary biotypes: thick-flat and thin-scalloped. The thin-scalloped biotype is typically associated with narrow cervical tooth contours, smaller contact areas, and interproximal contacts positioned closer to the incisal edge, along with longer interproximal papillae. In contrast, the thick-flat biotype presents broader cervical contours, wider contact areas located near the gingival margin, and shorter interproximal papillae [1,2].

Tooth and gingival morphology are influenced by multiple factors, including race, geographic region, gender, and dietary habits [3]. Understanding the average tooth and gingival shapes in specific populations is crucial for precise prosthodontic planning. Previous studies have demonstrated that these characteristics vary significantly both within and between racial groups [4-6].

Comprehensive knowledge of dental and gingival anatomy is fundamental for successful prosthetic rehabilitation. Restorative interventions must ensure biological compatibility and seamless aesthetic integration with surrounding soft tissues. Smile esthetics are determined by tooth shape, size, color, alignment, and symmetry, together with gingival contour, regularity, and papillary form [1,2,6]. Among anterior teeth, the maxillary anterior segment plays a pivotal role in facial esthetics by supporting the upper lip, enhancing facial harmony, and contributing to essential functions such as food incision, speech, and mandibular guidance during eccentric movements [7].

Accordingly, a thorough understanding of anterior tooth and gingival morphology is critical for achieving restorative outcomes that are both esthetically pleasing and functionally effective. The objectives of restorative dentistry extend beyond recreating crown morphology and esthetics to preserving or enhancing periodontal and temporomandibular joint health. This framework supports more precise clinical decision-making in esthetic prosthodontics, with particular emphasis on the influence of periodontal context on restorative success.

In contemporary implant dentistry, the morphology of maxillary anterior teeth is equally vital in achieving optimal esthetic outcomes. When planning implant-supported prostheses in the esthetic zone, crown shape becomes a decisive factor. To date, numerous studies have evaluated the association between central incisor morphology and periodontal parameters, including a recent study by the present authors[8]. However, there is little or no literature addressing maxillary canines, despite their integral role in smile esthetics and functional harmony [1,2]. Analyses focusing specifically on human canine morphology and attractiveness are rare. Most investigations emphasize maxillary incisors, soft tissues, or central incisors alone [3–7]. Others only discuss canines in the context of their role as substitutes for lateral incisors [9–13]. Moreover, common mathematical proportions such as the golden proportion or golden percentage are rarely applicable to canines [14].

The general outline of the maxillary canine crown is typically described as pentagonal or trapezoidal[15]. The labial surface is convex in all directions, with the curvature being more pronounced mesiodistally. Understanding the influence of canine morphology on dental esthetics is essential in patient-centered treatment planning. For instance, the most esthetically favorable canine substitution occurs when the edge width is approximately 62.5% of the central incisor crown width, with the edge height positioned about 0.5 mm gingival to the incisal edge of the central incisor. Variations in the collocation of edge width and height directly affect the esthetic outcome of canine substitution. [16]Moreover, differences in esthetic preferences among observer groups underscore the importance of individualized and patient-specific approaches.

The present clinical study aimed to define and quantify the morphological characteristics of maxillary canines. Based on established measurement parameters, crowns were classified into three distinct forms: trapezoidal, square (incisor-like), and pentagonal. These categories represent the most commonly encountered morphological variants of maxillary canines.

MATERIALS AND METHODS

Following ethical clearance from the Institutional Review Board (IRRB- 02 – 22122024), 60 Middle Eastern dental patients (both male and female), aged 21–35 years, were recruited from the outpatient department of the ISNC Dental Clinic, Jeddah, Saudi Arabia. All participants were informed in detail about the nature and purpose of the study, and written informed consent was obtained prior to any clinical procedures.

Eligibility criteria:.Participants were required to be in good systemic health, have completed skeletal growth, and possess both permanent maxillary canines. Exclusion criteria included:

- presence of destructive periodontal disease;
- current pregnancy or lactation;
- use of medications affecting gingival thickness (e.g., cyclosporine A, calcium channel blockers, phenytoin);
- extensive restorations or prosthetic replacement of maxillary central incisors;
- carious lesions on interproximal surfaces or at the cementoenamel junction;
- history of dental trauma altering incisor morphology;
- previous orthodontic treatment;
- evident craniofacial asymmetry;
- history of periodontal surgery involving the anterior maxilla;
- incisal wear (abrasion, attrition, or erosion) extending into dentin;
- incomplete passive eruption.

Data collection: For each participant, demographic data (age and gender) were recorded. Standardized intraoral photographs were captured using a cheek retractor and mouth prop to ensure reproducibility. A millimeter-calibrated ruler was positioned immediately below the incisal edges of the maxillary central incisors to enable precise measurement and morphological assessment.

Measurements

Quantitative assessments of tooth morphology were performed using image analysis software (ImageJ, National Institutes of Health, USA). The software's built-in calibration tool was applied to convert pixel values into millimeters, ensuring measurement accuracy (Images 1–3). All measurements were independently carried out by three calibrated examiners, and standardized values were assigned for each parameter assessed.

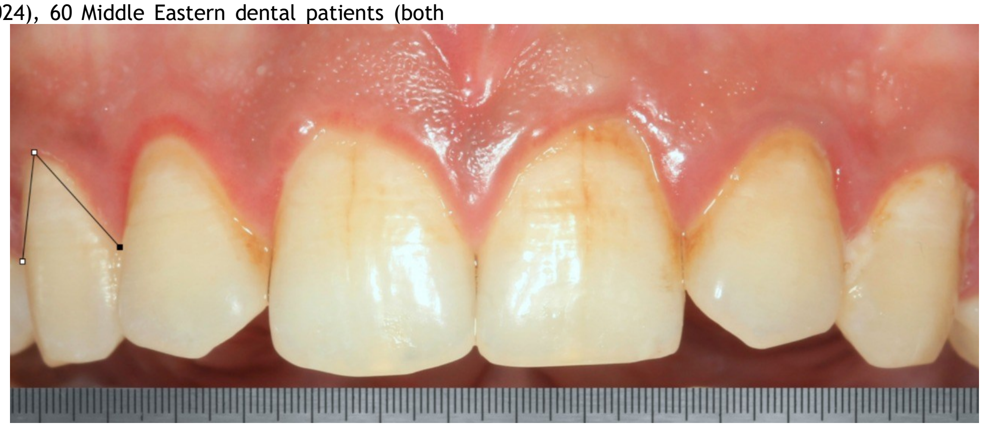

IMAGE 1: GINGIVAL ANGLE (GA) MEASUREMENT

IMAGE 2: CROWN LENGTH (CL) MEASUREMENT

IMAGE 3: INTERPROXIMAL PAPILLA HEIGHT(PH) MEASUREMENT

The following parameters were evaluated:

- **Crown Width (CW):** The mesiodistal width of the crown was measured at the junction between the middle and cervical thirds of the crown length. This point was determined by dividing the crown into three equal parts: incisal, middle, and cervical thirds.
- **Crown Length (CL):** Defined as the longest apicocoronal dimension of the crown, measured parallel to the tooth's long axis—from the incisal edge to the gingival zenith.
- **Crown Width-to-Length Ratio (CW/CL):** Calculated by dividing CW by CL. This ratio reflects the relative narrowness of the apical third of the clinical crown.
- **Mesiodistal Width(MDW)** The greatest horizontal distance between the mesial and distal interproximal contact points on the labial aspect of the tooth.
- **Interdental Papilla Height (PH):** The vertical distance (parallel to the long axis of the tooth) from the highest point of the interdental papilla to a reference line connecting the gingival zeniths of the adjacent teeth on the distal side.
- **Gingival Angle (GA):** The angle formed at the marginal gingiva, calculated by intersecting two lines: one extending from the most apical point of the facial gingival margin along the tooth's long axis, and the other connecting the most apical points of the mesial and distal interproximal contact areas.
- **Contact Surface Length (CS):** Measured along the mesial surfaces of the maxillary central incisors, from the most apical extent of the contact area to its most incisal point.

RESULTS:

Table 1: Cluster Analysis Of Frequency To Determine Canine Shapes

CL/CW	FREQUENCY	SHAPE
0.46-0.67	35	TRAPEZOIDAL
0.68-0.85	50	PENTAGONAL
0.86-1.04	35	SQUARE(like incisor)
	120	

Data Analysis and Tooth Shape Classification Crown width-to-length (CW/CL) ratios were calculated for all maxillary canines. To categorize tooth morphology, the k-means clustering algorithm—an unsupervised machine learning method for partitioning data into groups—was applied. Prior to clustering, a validity test was conducted to determine the optimal number of clusters, which was set at three.

Based on CW/CL ratios of the 120 maxillary canines examined in this cohort of young Middle Eastern adults, three distinct morphological groups were identified:

- **Trapezoidal shape:** CW/CL ratio 0.46–0.67 (n = 35)
- **Pentagonal shape:** CW/CL ratio 0.68–0.85 (n = 50)
- **Square(incisor like) shape:** CW/CL ratio 0.86–1.04 (n = 35)

This classification highlights the variation in canine crown morphology within the studied population and provides a standardized framework for morphological assessment, with potential implications for esthetic dental treatment planning.

Table 2: Descriptive Features Of The Given Variables:

Statistics										
		CROWN WIDTH(CW)	CROWN LENGTH(CL)	CW/ CL ratio	MESIO-DISTAL WIDTH (MDW)	INTERDENTAL PAPILLA HEIGHT(PH)	GINGIVAL ANGLE(GA)	CONTACT SURFACE(CS)	MDW/CL	(CS)/(CL)
N	Valid	120	120	120	120	120	120	120	120	120
	Missing	0	0	0	0	0	0	0	0	0
Mean		2.89	3.8733	0.7699	2.775	1.1292	73.5008	1.1116	0.7356	0.2982
Std. Error of Mean		0.06349	0.08968	0.0141	0.07111	0.03325	0.92667	0.03733	0.01557	0.01093
Median		2.8	3.6	0.7871	2.6	1.2	78	1	0.7429	0.2936
Mode		3	3	.93[a]	3	1.2	78.00[a]	1	1	0.33
Std. Deviation		0.69553	0.98234	0.15448	0.77895	0.36424	10.15116	0.40889	0.17056	0.11974
Variance		0.484	0.965	0.024	0.607	0.133	103.046	0.167	0.029	0.014
Skewness		1.556	0.466	-0.228	0.895	-0.681	-0.567	0.225	-0.51	0.818
Std. Error of Skewness		0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221	0.221
Kurtosis		3.093	-0.834	-0.847	2.853	0.408	-0.42	-0.232	1.645	1.545
Std. Error of Kurtosis		0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438	0.438
Range		3.3	3.6	0.59	5.2	1.9	44	1.8	1.04	0.62
Minimum		1.9	2.3	0.46	0	0	50	0.2	0	0.06
Maximum		5.2	5.9	1.04	5.2	1.9	94	2	1.04	0.68
a. Multiple modes exist. The smallest value is shown										

Descriptive Statistics A total of 120 maxillary canines were analyzed. The mean values and standard deviations (SD) of the measured parameters were as follows:

- **Crown width (CW):** 2.89 ± 0.70 mm
- **Crown length (CL):** 3.87 ± 0.98 mm
- **Crown width-to-length ratio (CW/CL):** 0.77 ± 0.15
- **Mesiodistal width (MDW):** 2.78 ± 0.78 mm
- **Interdental papilla height (PH):** 1.13 ± 0.36 mm
- **Gingival angle (GA):** 73.50° ± 10.15°
- **Contact surface length (CS):** 1.11 ± 0.41 mm
- **Mesiodistal width-to-crown length ratio (MDW/CL):** 0.74 ± 0.17
- **Contact surface-to-crown length ratio (CS/CL):** 0.30 ± 0.12

These findings establish baseline morphological characteristics of maxillary canines in a young Middle Eastern adult population and provide a reference framework for esthetic and periodontal considerations in prosthodontic treatment planning.

Table 3: Descriptive Features Of The Given Variables Based On Shapes

Descriptives									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
INTERDENTAL PAPILLA HEIGHT(PH)	trapezoidal	35	1.1371	0.36549	0.06178	1.0116	1.2627	0	1.8
	pentagonal	50	1.066	0.40839	0.05775	0.9499	1.1821	0.2	1.9
	square	35	1.2114	0.27841	0.04706	1.1158	1.3071	0.5	1.7
	Total	120	1.1292	0.36424	0.03325	1.0633	1.195	0	1.9
GINGIVAL ANGLE(GA)	trapezoidal	35	68.7543	10.35395	1.75014	65.1976	72.311	50	80
	pentagonal	50	72.418	10.46172	1.47951	69.4448	75.3912	52	94
	square	35	79.7943	5.48034	0.92635	77.9117	81.6768	65	88
	Total	120	73.5008	10.15116	0.92667	71.6659	75.3357	50	94
MDW/CL	trapezoidal	35	0.782	0.15413	0.02605	0.7291	0.835	0.46	1
	pentagonal	50	0.7253	0.17815	0.02519	0.6746	0.7759	0	1.04
	square	35	0.7041	0.17008	0.02875	0.6457	0.7625	0.46	1.04
	Total	120	0.7356	0.17056	0.01557	0.7048	0.7665	0	1.04
(CS)/(CL)	trapezoidal	35	0.3164	0.11621	0.01964	0.2765	0.3563	0.13	0.57
	pentagonal	50	0.2854	0.11207	0.01585	0.2536	0.3173	0.06	0.68
	square	35	0.2983	0.13414	0.02267	0.2522	0.3444	0.12	0.68
	Total	120	0.2982	0.11974	0.01093	0.2766	0.3199	0.06	0.68

Table 3 illustrates the mean values and standard deviations of gingival variables across different maxillary incisor shapes.

Table 4: Anova Test Results

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
INTERDENTAL PAPILLA HEIGHT(PH)	Between Groups	0.439	2	0.219	1.672	0.192
	Within Groups	15.349	117	0.131		
	Total	15.788	119			
GINGIVAL ANGLE(GA)	Between Groups	2233.43	2	1116.715	13.028	0
	Within Groups	10029.04	117	85.718		
	Total	12262.47	119			
MDW/CL	Between Groups	0.115	2	0.058	2.018	0.137
	Within Groups	3.346	117	0.029		
	Total	3.462	119			
(CS)/(CL)	Between Groups	0.02	2	0.01	0.686	0.506
	Within Groups	1.686	117	0.014		
	Total	1.706	119			

Comparative Analysis

One-way Analysis of Variance (ANOVA) revealed statistically significant differences among the various tooth shape groups with respect to

- **Gingival Angle (GA):** $P < 0.001$

Table 5: Games -Howell Post Hoc Analysis

Multiple Comparisons							
Dependent Variable: GINGIVAL ANGLE(GA)							
						95% Confidence Interval	
	(I) Shape	(J) Shape	Mean Difference (I-J)	Std. Error	Sig.	Lower Bound	Upper Bound
Games-Howell	Trapezoidal	pentagonal	-3.66371	2.29171	0.253	-9.1452	1.8178
		square	-11.04000*	1.98018	0	-15.8183	-6.2617
	pentagonal	Trapezoidal	3.66371	2.29171	0.253	-1.8178	9.1452
		square	-7.37629*	1.74559	0	-11.5472	-3.2053
	square	Trapezoidal	11.04000*	1.98018	0	6.2617	15.8183
		pentagonal	7.37629*	1.74559	0	3.2053	11.5472

*. The mean difference is significant at the 0.05 level.

Games-Howell post hoc analysis revealed statistically significant differences between various incisor shapes as follows:

- **Gingival Angle (GA):** Significant differences noted between **square** and **ovoid** ($P < 0.05$), and **taper** and **square** ($P < 0.05$).
  Table 6:

Correlations							
		CW/ CL ratio	INTERDENTAL PAPILLA HEIGHT(PH)	GINGIVAL ANGLE(GA)	CONTACT SURFACE(CS)	MDW/CL	(CS)/(CL)
CW/ CL ratio	Pearson Correlation	1	-0.003	.461**	0.029	-.190*	-0.088
	Sig. (2-tailed)		0.975	0	0.756	0.038	0.342
	N	120	120	120	120	120	120
INTERDENTAL PAPILLA HEIGHT(PH)	Pearson Correlation	-0.003	1	0.004	.612**	-0.137	-0.165
	Sig. (2-tailed)	0.975		0.969	0	0.137	0.072
	N	120	120	120	120	120	120
GINGIVAL ANGLE(GA)	Pearson Correlation	.461**	0.004	1	-0.034	0.019	0.026
	Sig. (2-tailed)	0	0.969		0.713	0.833	0.782
	N	120	120	120	120	120	120
CONTACT SURFACE(CS)	Pearson Correlation	0.029	.612**	-0.034	1	-0.06	-.188*
	Sig. (2-tailed)	0.756	0	0.713		0.517	0.039
	N	120	120	120	120	120	120
MDW/CL	Pearson Correlation	-.190*	-0.137	0.019	-0.06	1	.185*
	Sig. (2-tailed)	0.038	0.137	0.833	0.517		0.043
	N	120	120	120	120	120	120
(CS)/(CL)	Pearson Correlation	-0.088	-0.165	0.026	-.188*	.185*	1
	Sig. (2-tailed)	0.342	0.072	0.782	0.039	0.043	
	N	120	120	120	120	120	120
**. Correlation is significant at the 0.01 level (2-tailed).							
*. Correlation is significant at the 0.05 level (2-tailed).							

Correlation analysis of variables influencing canine shapes revealed several significant associations:

- **CW/CL ratios** showed significant correlation with **gingival angle**(*P*< 0.01) and MDW/CL(P<0.05)
- **CS** showedsignificant correlation with **interdental papilla height(P<0.01) and CS/CL ratios (P<0.05)**
- Additionally**CS/CL ratios**showed significant correlation with **MDW/CL ratios**(P<0.05)

DISCUSSION

Understanding the morphology of teeth and gingival tissues is essential for achieving optimal esthetic and functional outcomes in clinical practice. Comprehensive knowledge of intraoral structures—including the gingiva, mucosa, natural teeth, and overall dentition—is fundamental to successful prosthetic rehabilitation. The present study evaluated the shape and dimensions of the clinical crown of the maxillary canines, along with associated gingival characteristics, in young Middle Eastern adults, with the aim of establishingreference values to guide restorative planning.

Previous research has demonstrated that tooth dimensions vary significantly across different ethnic groups [17- 23]. However, the maxillary canines are among the most consistently shaped teeth, with only minor variations reported. In this study, three distinct morphological variants of canines were identified through cluster analysis of CW/CL ratios. Cluster analysis has been widely applied in clinical research as an objective method for categorizing complex datasets into meaningful subgroups. Although primarily considered a descriptive and exploratory technique, its findings should ideally be validated in independent populations [28].

One of the primary objectives of this study was to confirm the existence of three distinct maxillary canine shapes and quantify their relative prevalence. Because tooth size and morphology are known to differ across ethnic groups[24], the study sample was deliberately restricted to individuals of Middle Eastern descent to ensure population homogeneity and enhance the reliability of the results.

Several studies have classified anterior tooth morphology using the crown width-to-length (CW/CL) ratio, recognizing it as a reliable parameter for characterizing tooth shape [24-26]. In contrast, another investigation reported that the width-to-length ratio of the clinical crown exhibited minimal variation with respect to gender and stature, although males generally presented with longer and wider anterior teeth than females[27]. Collectively, these findings suggest that the CW/CL ratio is a stable and consistent reference for evaluating anterior tooth form in clinical practice.

Most available evidence on canine morphology has focused primarily on sexual dimorphism in maxillary and mandibular canines[29.30]. To the best of our knowledge, the present study is among the first to categorize three distinct maxillary canine shapes—**trapezoidal, pentagonal, and square (incisor-like)**—within a Middle Eastern population.

Our study observed that square crowns exhibited statistically significant differences in gingival angle compared with trapezoidal and pentagonal crowns, indicating that broader crown forms are associated with wider gingival angles. In contrast, no significant differences were found in interdental papilla height or contact surface areas among the different crown shapes.

Consistent with previous studies [31-36], these findings reinforce the association between periodontal tissue morphology and clinical crown shape in the maxillary anterior region. Earlier research has highlighted the crown width-to-length (CW/CL) ratio as a reliable parameter for distinguishing periodontal biotypes [33,37-39]. In alignment with this evidence, we applied the CW/CL ratio to classify tooth shape and subsequently analyzed corresponding gingival characteristics.

ANOVA analysis in this study revealed a significant association between the CW/CL ratio and gingival angle, with square-shaped canine crowns showing statistically significant differences compared with both trapezoidal and pentagonal crowns. This suggests that trapezoidal crowns, typically narrower, are more often associated with pronounced gingival scalloping, whereas square crowns are linked to flatter gingival architecture.

In the overall analysis, canine crown shape demonstrated significant correlations with both gingival angle and the MDW/CL ratio. These findings are consistent with previous literature indicating that anterior crown morphology is closely related to gingival contour. Weisgold et al[40,41] further emphasized that long, tapering teeth are more prone to gingival recession, whereas square teeth are generally accompanied by a wider gingival zone, which is more resistant to recession.

The position of the most apical point of the contact area is a critical factor in restorative treatment within the esthetic zone. However, the literature offers limited and inconsistent criteria for defining truly tapered or square teeth. Gobatto et al. (2012)[[26] addressed this by comparing the contact surface-to-crown length (CS/CL) ratio across various tooth shapes, thereby reducing subjectivity in classification. They reported that teeth with a CS less than 43% of the CL are triangular/tapered, while those with a CS greater than 57% of the CL are square.

In the present study, no significant associations were observed between periodontal parameters and the three tooth shape categories. Nonetheless, tapered teeth generally demonstrated smaller contact surfaces compared with square forms, a finding that is in line with Gobatto et al [42]. Their work further demonstrated that greater gingival angle (GA) corresponds with increased crown width (CW) and higher CS/CL ratios—indicating that broader crowns yield larger contact surfaces.

These findings carry important clinical implications for periodontal and restorative procedures such as crown lengthening, placement of full-coverage restorations at or apical to the gingival margin, and dental implant therapy. A thorough understanding of tooth shape prior to surgical or restorative intervention is critical for achieving optimal esthetic results. For instance, in ovoid teeth, the interdental papilla often does not completely occupy the embrasure space. Consequently, replacing a single ovoid shaped tooth while leaving the contralateral tooth unaltered may produce suboptimal esthetics, including black triangles or asymmetry in crown form. Anticipating such limitations and discussing them with patients during treatment planning—taking into account both tooth and gingival morphology—is essential for achieving predictable esthetic outcomes.

Ahmad[42] defined the gingival zenith (GZ) as the most apical point of the free gingival margin, located relative to the long axis of the tooth. In the maxillary central incisors and canines, the GZ is positioned slightly distal to the long axis, whereas in the lateral incisors it is located along the tooth's midline. Similarly, Rufenacht[43] described the gingival zenith position (GZP) as distally displaced in central incisors and canines, while coinciding with the vertical bisected midline (VBM) in lateral incisors.

From an esthetic standpoint, the reshaping of canines plays a critical role in successful canine substitution therapy. In such cases, the morphology of the maxillary central incisor is typically used as the reference standard for canine recontouring to ensure optimal harmony within the anterior dentition.

Several previous studies have reported that factors such as shade, gingival height, symmetry, crown width, crown height, and cusp tip morphology of the substituted canine can significantly influence esthetic treatment outcomes[45-49]. In particular, the canine edge height has been shown to play a key role in establishing an optimal smile arc[50] and in determining the position of the gingival margin[51,52].

CONCLUSION

This study characterized the clinical crown morphology of maxillary canines in a Middle Eastern adult population, identifying three distinct shapes—trapezoidal, pentagonal, and square—with pentagonal crowns being the most prevalent. Crown shape was significantly associated with key gingival parameters, including gingival angle, interdental papilla height, mesiodistal width-to-crown length ratio, and contact surface-to-crown length ratio. These correlations provide a robust reference framework for esthetic and periodontal treatment planning, facilitating more predictable outcomes in anterior restorative procedures, canine substitution, and prosthetic rehabilitation. Future research in larger and ethnically diverse populations is warranted to validate these findings and further refine clinical guidelines for individualized treatment planning.

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