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FACIAL TEETH DIMENSIONS AND CROWN ROOT RATIO IN EGYPTIAN POPULATION: CROSS-SECTIONAL CBCT ANALYSIS

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ABSTRACT

Objective: Beauty with health is the motto of today's world. This has made the focus of Dentistry nowadays, not only on preventing and curing diseases, but rather on meeting the demands for better esthetics. The Aim of this cross-sectional study was to establish reference data for facial dimensions of and the R/C ratios for the maxillary anterior dentition with complete root formation in the Egyptian population by using CBCT. **Subjects and methods:** 600 CBCT scans 300 males and 300 females were collected between (2020–2024) from the archive of the radiology department in faculty of dentistry, The British University in Egypt and examined with two Oral Radiology specialists. **Results:** The average root length of maxillary central incisors was 14.2 mm in males and 14 mm in females, while the lateral incisors measured 12.2 mm in males and 12.1 mm in females. For maxillary canines, the root length was 13.2 mm in males and 14 mm in females. The mean R/C ratios for maxillary anterior teeth ranged from 1.4 to 1.9 in both males and females. **Conclusions:** Males not only have broader anterior dentition but also slightly taller crowns than females. Interestingly, the maxillary central incisors exhibited the highest AI dimension in men, whereas the maxillary canines were the longest in women.

KEYWORDS: Facial Teeth Dimensions ,Crown Root Ratio , CBCT

INTRODUCTION

Beauty with health is the motto of today's world. This has made the focus of dentistry nowadays, not only on preventing and curing diseases, but rather on meeting the demands for better esthetics [(1)]. Esthetics dentistry has become one of the most lucrative, progressive, and challenging areas of this field. Recent technologies are being incorporated & advanced research is being applied in the field of esthetic dentistry. This has made dentistry evolve from a curative to a creative science [(2)].

When planning treatment for cases of compromised esthetic, it is of extreme importance in today's times to consider the principles of smile design for a comprehensive and holistic approach to patient care [(3)]. An attractive smile enhances how the individual's personality is perceived and influences its acceptance in society. The tenets of smile design necessitate a cohesive blend of facial aesthetics and dental elements, particularly focusing on the dimensions, shape, alignment of the teeth and their relationship to the alveolar bone and gingival tissues [(4)].

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Another factor for achieving a healthy and balanced result of dental treatment is acknowledging the interrelationship between the esthetic and the functional outcome through the assessment of crown\root ratio (R\C ratios) [5]. Knowledge the R\C ratios of normal dentition that have been identified objectively (using radiographs) acts as a reference for the prognosis of many dental procedures, for instance I the creation of dental prosthesis, either fixed dental prosthesis (FDPs) or removable partial dentures (RPDs), facilitating tooth motion for orthodontic treatments, and addressing skeletal discrepancies during orthognathic procedures [6, 7].

Thus far, the majority of information regarding normal dentition has been obtained by periapical or panoramic radiography. Panoramic radiographs can be readily obtained in dental clinics with little mistakes and provide acceptable repeatability under modest radiation exposure[8,9]. Several previous studies have indicated that measurements of the maxillary central incisors on panoramic radiographs exhibit the lowest reliability when compared to other tooth types [10, 11]. Additionally, identifying the cement-enamel junction on periapical radiographs taken with the paralleling technique can be influenced by angular variations between the tooth and the film [12] . Despite the high radiation doses and relatively high cost of cone-beam computed tomography (CBCT), it has become widely accepted in dentistry due to its ability to produce distortion-free slice images of single roots. These images are excellent for measuring tooth dimensions as well as crown and root lengths [13] . Kim et al. [14] found that while CBCT-based measurements showed a broader range of agreement limits for root lengths than for crown lengths, they could serve as reliable references for assessing incisor, canine, and premolar root length in 60 patients from Korea with malocclusion. However, due to the limited size in that study, the results cannot be applied to the all populations.

There is no previously published study that assessed the absolute or relative values of teeth dimensions of natural permanent dentition in the Egyptian population. Hence, the aim of this cross-sectional study was to generate reference data for facial dimensions and the root\crown (R\C) ratios of the maxillary anterior dentition with complete root formation in the Egyptian population using CBCT. Specifically, the study aimed to identify significant differences in CBCT measurements based on demographic factors such as sex and age.

SUBJECTS AND METHODS

Sample size: 600 CBCT scans 300 males and 300 females were collected between (2020–2024) from the archive of the radiology department, the study used a retrospective, exploratory, non-interventional approach on a cross-sectional population sample that had reported to the Outpatient CBCT unit for different dental purposes (Diagnosis, dental implants, restorative treatment, oral surgeries) in faculty of dentistry of The British University in Egypt(Ethical committee acceptance approval number 25-08) and examined with two Oral Radiology specialists

Inclusion criteria: Medically free Egyptian females and males with an age range of 20 –50 years were included in the study

Exclusion criteria: The CBCT scans for individuals with any evident radiographic abnormality suggestive of systemic disease predisposing to osteoporosis were excluded. The maxillary anterior teeth intended for measurements with a large pathological lesion, bone asymmetry, deformity, surgical defect healing, fracture, reconstruction, were also excluded from the study.

The crown heights and root lengths of maxillary anterior teeth were measured in millimeters (mm) and calibrated. The crown height (Crh) was defined as a perpendicular line extending from a specific point (m) to a reference line on the incisal and occlusal surface (i), with point ‘m’ representing the midpoint of a tangent line that linked the distal and proximal bone (Figures 1, 2).

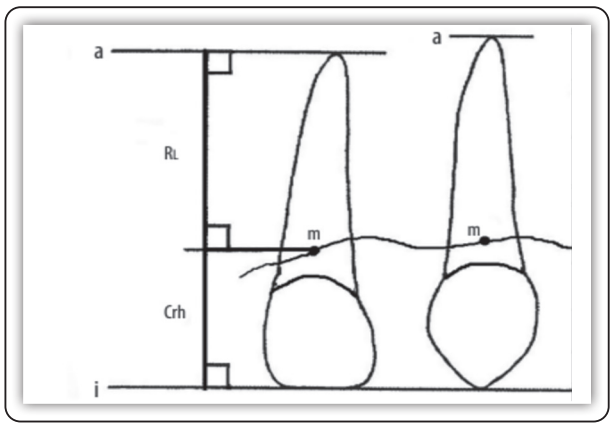

FIG (1) Method of Radiograph to measure root length and crown height in the assessment of the root\crown (R\C) ratio. a – apical level, i – incisal\occlusal reference line, RL – root length, Crh – crown height, m – the midpoint of the line connecting the mesial and distal proximal bone. Root length in mm = measured perpendicular from point m to point a. Crown height in mm = measured perpendicular from point m to i.

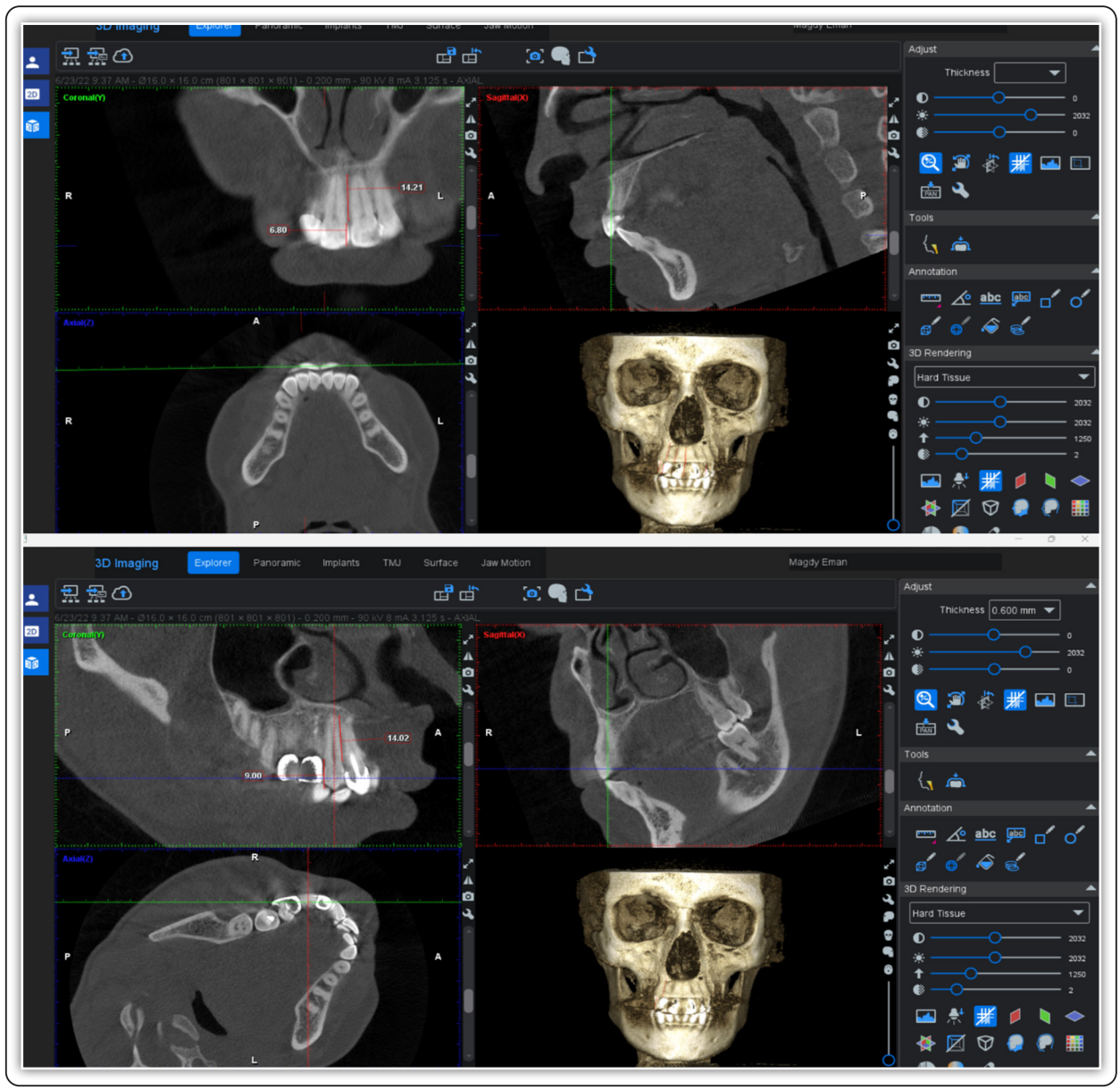

FIG (2) Crop of CBCT Measurements for Crown Root Ratio

For measuring root length (RL), the perpendicular distance between (m) and the apical reference line (a) was considered.

Crown dimensions (width, height) was measured on the multiplanar view on Planmeca Romexis® software, the orientation of the view on the three planes was recorrected to view the facial aspects of the anterior maxillary crowns each tooth separately.

A CBCT acquisition was obtained with Planmeca® Viso G7 machine (Planmeca Oy, Helsinki, Fin land). The acquisition parameters were as follow: field of view 30 x 30 cm, voxel size 200 μm, tube voltage 100 kV, and current 50 mA.

Image analysis:

All photos were analyzed using Planmeca Romexis® software (Version 6.3, Planmeca Oy, Asentajankatu 6, FIN-00880 Helsinki, Finland). Images were observed on a Dell monitor (22'' Full HD 1920 × 1080 display) in a dimly lit environment. On the multiplanar (MPR) screen, coronal, axial, and sagittal views were reoriented to provide linear distance measurements between the bizygomatic processes on axial pictures, representing the maximum distance between the most prominent sites on the right and left zygomatic arches [15] (**Figure 1**).

Intra-examiner repeatability was evaluated by re-assessing the radiographs by the same examiner after a two-week interval. To ensure repeatability by one examiner (inter-examiner reliability), another examiner must be trained to do the same measures. The intra-class correlation coefficient (ICC) was computed, resulting in established agreement.

Descriptive Analysis of Crown and Root Dimensions

Crown Dimensions

The crown dimensions exhibit noticeable variations between males and females. Males generally have larger crown dimensions across all upper anterior teeth compared to females. The difference is most apparent in the upper right lateral incisor and the upper right canine, where the measurements show a clear distinction. The upper right and left central incisors display relatively minor differences, indicating that some teeth are more affected by size variations than others.

The distribution of crown dimensions in males presents a slightly higher degree of variation compared to females, as indicated by the spread of values. In some cases, the differences between the two sexes are subtle, while in others, the distinctions are more prominent. The variations in crown dimensions reflect patterns of sexual dimorphism, with males typically exhibiting larger teeth.

Root Dimensions

The root dimensions, while also larger in males, show a more uniform pattern compared to crown dimensions. The differences between male and female root measurements are less pronounced. While the measurements indicate that males generally have longer roots, the variations are minimal across most teeth. The differences observed are more noticeable in the canines and lateral incisors, whereas central incisors exhibit closer values between the sexes.

The distribution of root lengths suggests a more consistent pattern in both males and females, with fewer extreme variations. Unlike crown dimensions, where differences are more evident, root dimensions appear to follow a more uniform structure across individuals.

TABLE (1). Comparison of crown and root dimensions between male and female subjects for various upper anterior teeth. The table presents the mean, standard deviation, minimum, and maximum values for each dimension. A two-sample t-test was conducted to compare measurements between sexes, with the corresponding p-values indicating statistical significance.

	Mean Male	Mean Female	Std Male	Std Female	Min Male	Min Female	Max Male	Max Female	p-value
Upper Right Canine Crown	10.18	9.64	0.335989	0.474225	9.5	9	10.5	10.5	0.01
Upper Right Canine Root	14.28	13.98	0.388158	0.355278	13.5	13.5	14.7	14.5	0.09
Upper Right Lateral Incisor Crown	8.21	7.24	0.172884	0.150555	7.9	7	8.5	7.5	1.1
Upper Right Lateral Incisor Root	12.32	12.17	0.220101	0.163639	12	12	12.7	12.5	0.1
Upper Right Central Incisor Crown	7.07	7.05	0.067495	0.108012	7	6.8	7.2	7.2	0.6
Upper Right Central Incisor Root	14.11	14.05	0.465355	0.383695	13	13	14.6	14.3	0.8
Upper Left Central Incisor Crown	7.21	7.17	0.128668	0.125167	7	7	7.4	7.4	0.5
Upper Left Central Incisor Root	14.37	13.94	0.585093	0.392145	12.9	13.2	14.9	14.4	0.07
Upper Left Lateral Incisor Crown	8.13	7.23	0.194651	0.11595	7.8	7.1	8.4	7.5	1.1
Upper Left Lateral Incisor Root	12.02	12.05	0.214994	0.184089	11.8	11.7	12.5	12.3	0.7
Upper Left Canine Crown	10.51	9.85	0.398469	0.516935	10	9.1	11	10.7	0.01
Upper Left Canine ‘Root	14.05	14.03	0.365908	0.36833	13.5	13.5	14.7	14.6	0.9

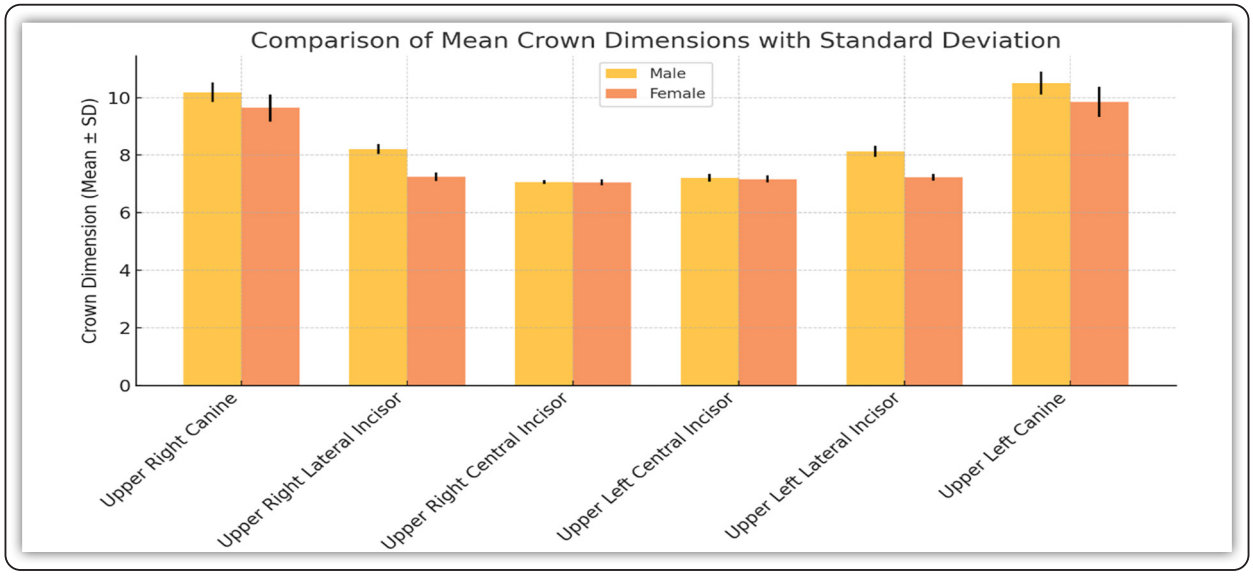

FIG (3) Bar chart comparing the mean crown dimensions of different upper anterior teeth between males and females.

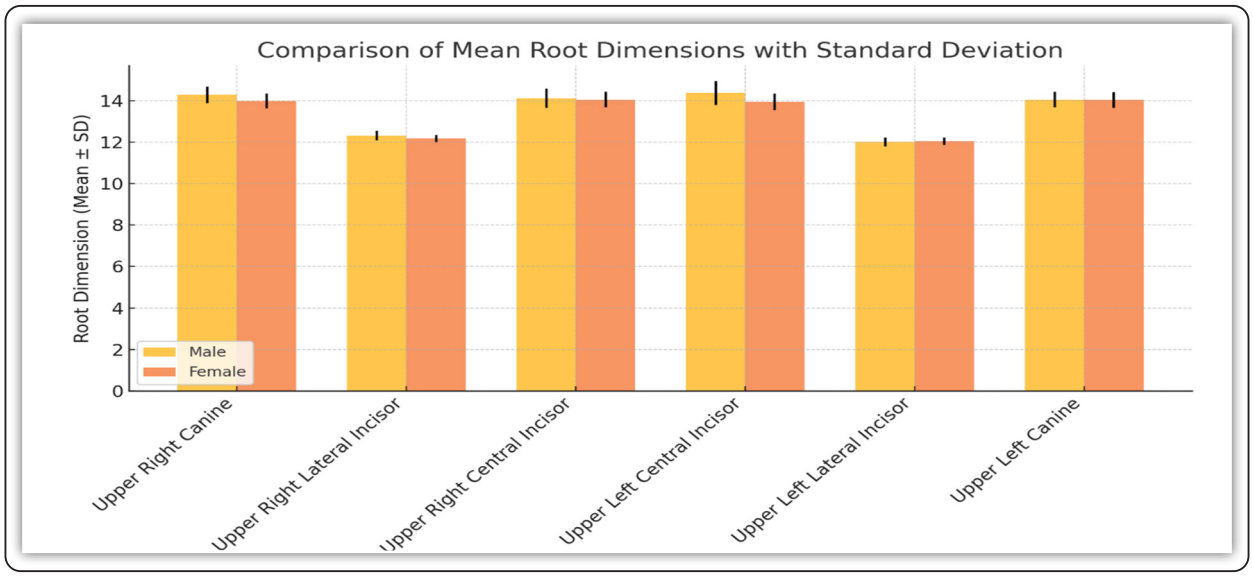

FIG (4) Bar chart comparing the mean root dimensions of different upper anterior teeth between males and females.

Right vs. Left Tooth Comparison

A paired t-test analysis was conducted to compare crown and root dimensions between the right and left sides of the same individuals. The results indicate significant differences in some teeth while others show close symmetry.

For crown dimensions, a statistically significant difference was observed between the upper right and left canines in both males ($p = 0.006$) and females ($p = 0.004$). This suggests that one side may consistently have a slightly larger crown dimension than the other. Similarly, the upper right and left central incisors showed a significant difference in both males ($p = 0.0005$) and females ($p = 0.0009$), indicating a measurable asymmetry in these teeth.

In contrast, the upper right and left lateral incisors did not exhibit significant differences in crown dimensions in females ($p = 0.7577$), though a moderate difference was seen in males ($p = 0.1206$). This suggests that lateral incisors maintain a higher level of symmetry compared to other tooth types.

For root dimensions, the results were more varied. The upper right and left lateral incisors showed a significant difference in both males ($p = 0.0066$) and females ($p = 0.0086$), suggesting a potential developmental or functional factor influencing their asymmetry. However, the upper right and left canines and central incisors did not show strong asymmetry in root dimensions, with p-values above 0.1 in most cases. This indicates that, while some teeth exhibit clear differences in size between the right and left sides, root dimensions generally remain more consistent than crown dimensions.

TABLE (2) Paired t-test results comparing crown and root dimensions between the right and left sides of the upper anterior teeth in male and female individuals. Significant difference ($p < 0.05$)

		p-value Crown Male	p-value Crown Female	p-value Root Male	p-value Root Female
Upper Right Canine	Upper Left Canine	0.01	0.004	0.1	0.7
Upper Right Lateral Incisor	Upper Left Lateral Incisor	0.1	0.7	0.01	0.01
Upper Right Central Incisor	Upper Left Central Incisor	<0.001	<0.001	<0.001	0.4

Bilateral Symmetry in Crown and Root Dimensions

The correlation analysis assessing bilateral symmetry between left and right tooth dimensions reveals strong associations in both males and females, particularly in the central incisors. The Pearson correlation coefficients for the upper right and left central incisor crowns were 0.806 in males and 0.781 in females, indicating strong symmetry in crown dimensions. Similarly, root dimensions for the central incisors showed an even higher correlation in males (0.960) compared to females (0.406), suggesting greater consistency in root length symmetry in males.

For the lateral incisors, the correlation coefficients were slightly lower but still statistically significant in females (0.751) compared to males (0.683) for crown dimensions. Root correlations, however, were more variable, with a moderate correlation in females (0.793) but a weaker association in males (0.225), indicating some differences in the development of lateral incisor roots between sexes.

The upper canines exhibited notable bilateral symmetry, with females showing a strong correlation (0.938) for crown dimensions, while males had a moderate correlation (0.690). Root dimensions for the upper canines, however, were less strongly correlated in both sexes, with males showing a correlation of 0.368 and females 0.353, suggesting slightly greater variation in root development compared to crowns.

Crown Dimensions

Mesiodistal (MD) Dimensions

Males generally exhibit larger mesiodistal crown dimensions compared to females. The upper right canine in males has the highest mean MD value (7.22 mm), while the smallest MD measurement is observed in the upper right lateral incisor (5.16 mm). In females, the upper left and right canines show the largest MD values (6.70 mm), whereas the upper right and left lateral incisors exhibit the smallest values (4.60 mm). The differences in MD dimensions suggest that males tend to have broader teeth, which is consistent with known sexual dimorphism in dental anatomy.

Incisogingival (IA) Dimensions

The incisogingival measurements follow a similar trend, with males generally showing higher values than females. The upper right central incisor exhibits the highest IA mean in males (7.58 mm), whereas the smallest IA measurement is seen in the upper left lateral incisor (4.12 mm). In females, the largest IA dimension is recorded for the upper right central incisor (6.33 mm), while the smallest is observed in the upper right and left lateral incisors (4.67 mm). These results suggest that males not only have broader teeth but also slightly taller crown dimensions.

Variation and Symmetry

Both males and females exhibit relatively consistent measurements between the right and left sides, indicating symmetry in dental development. However, minor differences are observed, particularly in the lateral incisors, where slight variation in MD and IA values between sides may indicate individual variation or asymmetry in tooth morphology.

TABLE (3) Descriptive statistics (mean, standard deviation, minimum, and maximum) for mesiodistal (MD) and incisocervical (IA) crown dimensions in males and females.

		Upper Right Canine MD	Upper Right Canine IA	Upper Right Lateral Incisor MD	Upper Right Lateral Incisor IA	Upper Right Central Incisor MD	Upper Right Central Incisor IA	Upper Left Central Incisor MD	Upper Left Central Incisor IA	Upper Left Lateral Incisor MD	Upper Left Lateral Incisor IA	Upper Left Canine MD	Upper Left Canine IA
Max	Female	6.7	6.6	4.7	4.8	6.1	6.5	6.1	6.3	4.7	4.7	6.8	6.6
Max	Male	7.9	7.72	5.98	4.13	6.95	7.75	6.94	7.73	5.94	4.12	6.9	7.73
Mean	Female	6.63	6.47	4.6	4.7	6.1	6.33	6.1	6.23	4.6	4.67	6.7	6.53
Mean	Male	7.22	7.05	5.16	4.12	6.52	7.58	6.58	7.54	5.29	4.12	6.83	7.06
Min	Female	6.5	6.3	4.5	4.6	6.1	6.2	6.1	6.1	4.5	4.6	6.6	6.4
Min	Male	6.8	6.69	4.7	4.11	6.1	7.4	6.3	7.3	4.96	4.11	6.8	6.7
Std	Female	0.12	0.15	0.1	0.1	0	0.15	0	0.12	0.1	0.06	0.1	0.12
Std	Male	0.59	0.58	0.71	0.01	0.43	0.18	0.33	0.22	0.56	0.01	0.06	0.58

TABLE (4) Comparative statistics of mesiodistal (MD) and Inciso Cervical (IA) crown dimensions between males and females.

MD					
	Mean Male	Mean Female	p-value	Std Dev Male	Std Dev Female
Upper Right Canine	7.22	6.63	0.224	0.59	0.12
Upper Right Lateral Incisor	5.16	4.6	0.305	0.71	0.1
Upper Right Central Incisor	6.52	6.1	0.232	0.43	0
Upper Left Central Incisor	6.58	6.1	0.126	0.33	0
Upper Left Lateral Incisor	5.29	4.6	0.164	0.56	0.1
Upper Left Canine	6.83	6.7	0.134	0.06	0.1
IA					
	Mean Male	Mean Female	Std Male	Std Female	p-value
Upper Right Canine	7.05	6.47	0.58	0.15	0.216
Upper Right Lateral Incisor	4.12	4.7	0.01	0.1	0.009
Upper Right Central Incisor	7.58	6.33	0.18	0.15	0.001
Upper Left Central Incisor	7.54	6.23	0.22	0.12	0.003
Upper Left Lateral Incisor	4.12	4.67	0.01	0.06	0.003
Upper Left Canine	7.06	6.53	0.58	0.12	0.258

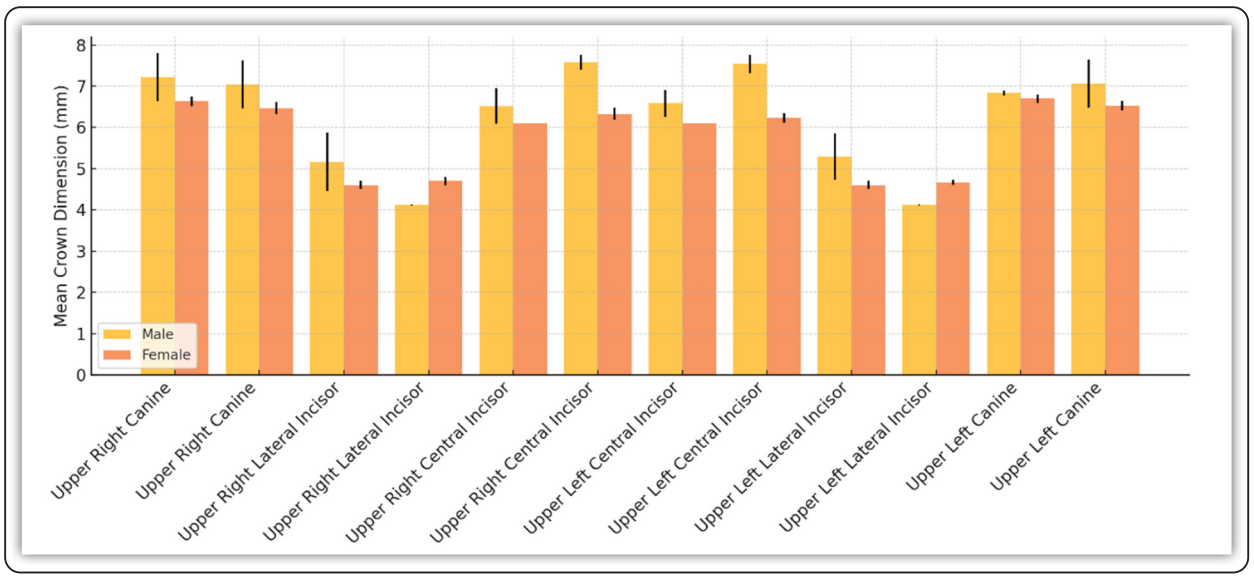

FIG (5) Bar chart comparing the mean crown dimensions (mesiodistal and incisocervical between males and females across different upper anterior teeth.

DISCUSSION

Understanding the facial dimensions and crown-to-root (C\R) ratios of anterior dentition serves as a key reference for the outcome of many dental procedures [16, 17, 18] . The degrees of expression, frequency and variation of teeth in dentitions differ across populations [19] . The final form of a tooth is determined by the sum of its genetic factors and long-term environmental influences. While several studies have analyzing tooth characteristics within specific nations [20], detailed investigations into of the facial crown dimensions of anterior teeth and their (C\R) ratios remain limited. Therefore it is essential to compile and analyze data within individual nations. This study aimed to conduct a comprehensive examination of these aspects within the Egyptian population.

Brezniak et al. [21] highlighted that angular discrepancies between the tooth and the film can significantly affect the accuracy of locating the labial and palatal CEJ points on periapical radiographs to determine the anatomical (R\C) ratios. Other studies utilizing panoramic radiographs have focused only on the clinical R\C ratio, as the CEJ is often difficult to identify accurately on these images [22]. Additionally, panoramic radiographs are susceptible to vertical magnification and patient positioning errors, even under optimal conditions [23]. To overcome these limitations, the present study employed CBCT to measure the anatomical root\ crown (R\C) ratios of anterior dentition. CBCT offers distortion-free slice images of individual roots, enabling more precise evaluation of crown and root lengths, as well as R\C ratios [21, 23].

Previous studies have reported lengths of anterior teeth roots in different countries using CBCT imaging. In Brazil, the average root length of both maxillary central incisors was found to be 12 mm [24]. Research conducted on a Korean population indicated that the average root length of maxillary central incisors measured 12.3 mm in men and 11.75 mm in women, while maxillary canines averaged 15.83 mm in men and 15.23 mm in women [25] . A study from China reported that the maxillary central incisors had a root length of 13.3 mm, the lateral incisors measured 13.4 mm, and the canines reached 16.6 mm [26] .

In the present study, our findings revealed that the average root length of maxillary central incisors was 14.2 mm in men and 14 mm in women, while the lateral incisors measured 12.2 mm in men and 12.1 mm in women. For maxillary canines, the root length was 13.2 mm in men and 14 mm in women. However, despite this difference, the root-to-crown (R\C) ratios between females and males did not show statistically significant variation [25, 27] . Direct comparison of root lengths between Egyptian participants and those of other nationalities is not feasible based on existing literature, as previous studies have used varying measurement protocols, resulting in discrepancies in the reported values.

Gender-based differences in anterior tooth dimensions have been observed across various racial groups, with male subjects generally having wider anterior teeth than females [28-32] . Gillen et al. [28] reported that in both Black and White populations, men tend to have maxillary anterior teeth that are broader and longer than those of women. Similarly, research by Sterrett et al. [29] indicated that in a White population, the average clinical crown width and length of maxillary anterior teeth were significantly greater in males than in females. Owens et al. [30] also assessed the width of maxillary central incisors in multiple racial groups and consistently found that men had broader central incisors than women. These results coincide with the current study where we also found that men generally displayed larger mesiodistal (MD) crown dimensions compared to women.

The crown width-to-height ratio is considered to be the most stable reference, as it exhibited minimal variation between sexes or different dentition [31]. It has been suggested that for optimal esthetics, the maxillary central incisors should have a width-to-height ratio of approximately 80% [32, 33] . In the present study, however, the recorded ratios exceeded this ideal proportion in both men and women. Ratios ranging from 86% to 125% were observed in this study, in contrast to the 76% to 86% range commonly reported in dental literature [32-34] . These findings are consistent with a prior Turkish study that recorded ratios between 72% and 124% [31] . This suggests that the maxillary anterior teeth of both the Egyptian and Turkish groups examined tend to have a more square-like shape, likely due to either shorter crown heights or greater widths compared to other populations.

These findings hold significant value in clinical dentistry, as they can contribute to improving dental treatments and achieving successful outcomes. However, the study has certain limitations. It primarily focuses on the facial dimensions and root-to-crown (R\C) ratios of the anterior dentition within the Egyptian population. Further research is necessary to examine the entire dentition in greater detail and on a larger scale. Another limitation is the challenge of directly comparing the results with previous studies due to variations in assessment methods. Despite these limitations, the study remains valuable for assessing both congenital and acquired dental anomalies, facilitating comparisons with other nationalities, and serving as a diagnostic reference. In both academic and clinical contexts, the findings should enhance awareness of sex-based differences as well as variations among dental arches and individuals.

CONCLUSIONS

Despite the inherent limitations in accuracy when assessing R\C ratios using CBCT data, we were able to determine the average R\C ratios and facial dimensions for the maxillary anterior dentition in the Egyptian population. The mean R\C ratios for the maxillary anterior teeth ranged from 1.4 to 1.9 in both males and females. The maxillary central incisors exhibited the longest incisogingival dimension in men, whereas the maxillary canines were the longest in women. Interestingly, males not only have broader anterior dentition than females but also slightly taller crowns.

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