ORIGINAL STUDY

Anthropometric Parameters of Pristine Maxillary Anterior Teeth and Facial Index in Correlation With Recurring Esthetic Dental Proportion by Three Dimensional Digital Software

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Abstract

Purpose: This study was conducted to evaluate the clinical crown dimensions of pristine maxillary anterior teeth and assess their correlation with facial indices, assess the recurring esthetic dental (RED) correlation to actual dimensions in a subset of the Egyptian population, and explore any sex-based differences. Patients and methods: A total of 20 normal Egyptian patients (10 males, 10 females). The various parameters were analyzed intra-oral and facial using the MEDIT software: maxillary anteriors width and length, facial length (NA-GN) and width (ZY-ZY). The results were statistically analyzed. Results: Regarding inter-zygomatic distance, there was no significant difference for females and males. The correlation between facial index and teeth parameters in both genders were not statistically significant. RED proportion is applicable among the Egyptian population. Conclusion: There is a correlation between teeth dimensions and facial proportions, which varies by sex. RED is applicable in dental treatment planning, but individual variations based on gender and ethnic background should be considered for optimal aesthetic outcomes.

Keywords: 3D face scanning, Aesthetic dentistry, Dental symmetry, Facial index, Recurring esthetic dental (RED) proportion

1. Introduction

Smile is a key aspect of facial appearance, since it conveys person's emotions and is essential for social interactions. 'Smile designing' involves a blend of artistic and scientific principles aimed at creating an aesthetically pleasing smile, although perceptions of beauty can vary across different cultures and ethnicities, affecting these standards [1,2]. Dental impression and facial contour are important in smile restoration. Traditional methods often uncomfortable and difficult for certain patients, have led to a preference for optical impressions using intraoral scans [3], digital face scanners like BELLUS 3D to capture precise facial dimensions [4].

Achieving an aesthetically pleasing result also requires understanding the scientific relationship between teeth and facial dimensions. Recurring esthetic dental (RED) proportion is a common technique that is used for figuring out how wide anterior teeth are in relation to each other [2].

This study analyses the clinical crown dimensions and symmetry of pristine maxillary anterior teeth, assesses the RED in a subset of the Egyptian population. In addition, exploring potential relationships between teeth dimensions and facial measurements, as well as any variations based on sex [5].

2. Patients and methods

There were 20 adult patients in this cross-sectional study, divided into two groups: 10 females in group I and 10 males in group II.

Data collection was done by the principal investigator using the medit intraoral scanner and bellus 3D face scanner. The procedure was conducted in

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the clinic of the Fixed Prosthodontic Department in Dental Educational Hospital of Nahda University in Bani-Suef, Egypt, after obtaining approval from the Research Ethics Committee of the Faculty of Dental Medicine for Girls, Al-Azhar University (Code of approval: P-BI-21-02). Informed consent was obtained from all participants.

Patients of the same age group (20e35) met the inclusion criteria: free systemic disease (GI, D.M, gastric influx), psychologically free, free of any obvious facial asymmetry, free of facial trauma or surgeries, normal Class 1 occlusion (normal overjet and overbite), free from any tooth wear disorder, intermediate gingival biotype (periodontally healthy without any previous orthodontic treatment), and maxillary anterior teeth free from restoration. The study excluded patients with a history of anterior maxillary or mandibular surgery, anterior sextant restorations, pregnant or lactating women, patients taking medications known to increase the risk of gingival hyperplasia, those who had previously received orthodontic treatment, those with facial asymmetry and clefts, and smokers.

A face scanner (Bellus 3D) was used to measure the proportions of the face following manufacturer's instructions [6]. The bizygomatic width (zyezy), which is measured from the left zygion to the right zygion, was defined as the maximum facial width, whereas the morphological face height (N-Gn) was defined as the distance between the nasal base between eyebrows (nasion) and the lowest point of the chin in the mid-sagittal plane (Gn: Gnathion) [7] All measurements were conducted using digital three dimensional (3D) face scanning software (BELLUS 3D), which provides the patient's face a 3D model [8]. The facial form (facial index) were determined using the formula: FI = FW/FH × 100 [9]. Thus proportionate the correlation between facial height and facial width.

2.1. Assessment of pristine maxillary anterior teeth dimensions

The dimensions of the pristine maxillary anterior teeth: the width and length of the central incisors, lateral incisors, and canines on both the right and left segments, as well as the inter-canine distance, were measured for each case (Fig. 1). These measurements were obtained using scans taken with the MEDIT i700 intraoral scanner (Fig. 2).

A systematic scanning strategy was followed, starting with the occlusal side from the posterior left to right areas in a zigzag motion, then moving to the palatal/lingual and buccal sides (Fig. 3). If any tissues were missed, the scanner was reactivated to capture them.

Fig. 1. Showing: width and length of the central incisors, lateral incisors, and canines on both the right and left segments.

Fig. 2. Showing: Medit i-700 intraoral scanner.

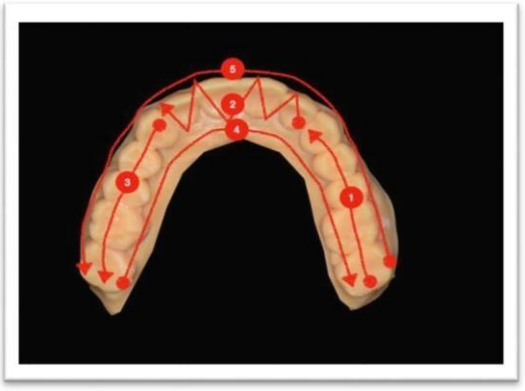

Fig. 3. Showing: Scan strategy [3].

The measurement of the inter-canine distance was made between the cusp tips of the right and left canines [10] (Fig. 4). All measurements of face and teeth were collected, tabulated, and statistically analyzed to assess the interrelation between teeth parameters and face index in both genders. Also to assess the presence of sexes variation.

2.2. Assessment of interrelation between teeth parameters and face index

2.2.1. Correlating the results with RED proportion

For each case, the central incisor widths (CIW), lateral incisor width (LIW), and canine were

Fig. 4. Showing: inter-canine distance measurement.

calculated and compared with the ideal width determined by the RED equation, which varies based on facial type according to Marten Saller scale [11]. The RED equation determines the ideal CIW using the formula: CIW = ICW/2 (1 + RED + RED²) [12] multiplying the CIW by the RED proportion yields the LIW, while multiplying the LIW by the RED proportion yields canine width (up to the cusp tip) [13]. The RED proportion is adjusted according to the facial index, with taller faces requiring a smaller RED proportion. Specifically, a 62 % RED proportion is recommended for extra tall faces, 70 % for normal faces, and 80 % for very short faces [12]. To correlate the actual and calculated canine width, the measured width was divided by 2, according to the RED proportion, which suggests that the frontal view width of each maxillary tooth decreases by a specific percentage as one goes posteriorly [14]. The RED equation calculates the canine width only up to the cusp tip, as it evaluates a 3D smile in a 2D manner [12].

2.3. Sample size calculation

To detect the relationship between the anthropometric parameters of pristine maxillary anterior teeth and facial index and their correlation with RED proportion, a minimum total sample size of 20 samples will be sufficient to detect the effect size of 1.6, with a power (1-b = 0.90) at a significance probability level of *P* less than or equal to 0.05, according to a previous study by Jeseok Oh *et al*. [15].

3. Results

3.1. Assessment of facial index

The mean inter-zygomatic distance was 104.52 ± 2.26 mm for females and 109.74 ± 6.82 mm for males, there was no statistically significant difference ($P > 0.05$). The mean nasion-gnathian distance was 119.34 ± 9.78 mm for females and 120.19 ± 6.70 mm for males, also without significant difference ($P > 0.05$). The mean facial index was 88.37 ± 6.88 % for females, classifying them as mesoprosopic, and 91.37 ± 4.18 % for males, classifying them as leptoprosopic, showing that there was no significant difference between the two groups ($P > 0.05$) (Table 1).

3.2. Assessment of Pristine maxillary anterior teeth dimensions

Regarding the central tooth, females had the highest symmetry percentage with 95.84 ± 1.37 % for width and 96.17 ± 2.07 % for length, but there were no statistically significant differences between males and females ($P > 0.05$). In the lateral tooth, females again showed the highest symmetry with 96.79 ± 2.82 % for width and 96.32 ± 2.69 % for length, though no significant differences were observed between the genders ($P > 0.05$). Similarly, for the canine tooth, females achieved the highest symmetry at 97.04 ± 1.66 % for width and 95.45 ± 2.66 % for length, but no statistically significant differences were found between males and females ($P > 0.05$) (Table 2).

Table 1. Mean ± SD of Inter-Zygomatic distance, Nasion- Gnathian distance, and facial index for female and male groups.

Variable	Females	Males	*P* value*
Inter-Zygomatic distance (Width)	104.89 ± 2.97	109.74 ± 6.82	0.054 (NS)
Nasion-Gnathian distance (Length)	119.34 ± 9.78	120.19 ± 6.70	0.825 (NS)
Facial index (W/L)	88.37 ± 6.88 (g)	91.37 ± 4.18 (h)	0.254 (NS)

**P*-value from Independent T-test.
NS, Nonsignificant at *P* greater than 0.05; S, Statistically significant at *P* less than or equal to 0.05; g, Face classification type is Mesoprosopic; h, Face classification type is Leptoprosopic.

Table 2. Mean ± SD of symmetry (%) between left and right measurements for male and female groups at three different teeth (central, lateral, and canine).

	Females	Males	*P* value*
Central			
Width	95.84 ± 1.37	95.45 ± 3.36	0.740 (NS)
Length	96.17 ± 2.07	95.57 ± 4.62	0.713 (NS)
Lateral			
Width	96.79 ± 2.82	95.46 ± 3.34	0.348 (NS)
Length	96.32 ± 2.69	95.51 ± 3.63	0.575 (NS)
Canine			
Width	97.04 ± 1.66	95.68 ± 2.63	0.182 (NS)
Length	95.45 ± 2.66	93.76 ± 7.12	0.492 (NS)

**P* value from Independent T-test.
NS, Nonsignificant at *P* greater than 0.05; S, Statistically significant at *P* less than or equal to 0.05.

3.3. Correlation between teeth parameters and face index

In the female group, the results of Pearson correlation showed a weak to moderate positive correlation between teeth parameters and facial index, though these correlations were not statistically significant 00201128062484 Similarly, in the male group, a weak to moderate positive correlation was observed between teeth parameters and facial index, but the correlations were also not statistically significant ($P > 0.05$) (Table 3 and Fig. 5).

3.4. Correlating the results with RED proportion

For CIW, females achieved the highest matching percentage between actual dimensions and calculated RED at 94.49 ± 3.29 %, compared with 91.75 ± 4.17 % for males, but the difference between the groups was not statistically significant ($P > 0.05$). In LIW, females had the highest matching percentage at 86.91 ± 6.25 %, compared with 85.54 ± 6.21 % for males, with no statistically significant differences between the genders ($P > 0.05$). For CW, males achieved the highest matching percentage at 93.17 ± 3.82 %, compared with 89.87 ± 8.07 % for females, though the difference was not statistically significant ($P > 0.05$) (Table 4 and Fig. 6).

Table 3. Correlation between teeth parameters (W/L%) and face index in the male and female.

	r	*P*-value	Correlation type
Females			
Facial index vs. Central W/L %	0.292	0.413 (NS)	Moderate positive
Facial index vs. Lateral W/L %	0.054	0.882 (NS)	Weak positive
Facial index vs. Canine W/L %	0.286	0.423 (NS)	Moderate positive
Males			
Facial index vs. Central W/L %	0.215	0.551 (NS)	Weak positive
Facial index vs. Lateral W/L %	0.468	0.172 (NS)	Moderate positive
Facial index vs. Canine W/L %	0.237	0.510 (NS)	Weak positive

r = Pearson Correlation value, NS = Nonsignificant. Non-significant at *P* greater than 0.05, S = Statistically significant at *P* less than or equal to 0.05.

4. Discussion

In the practice of modern dentistry, esthetics has become increasingly important and strongly linked with a natural harmonious appearance [15]. In this study Medit i-700 intraoral scanner was used to measure the teeth dimensions as in a previous study. It can capture up to 70 FPS (FRAMES PER SECOND), faster than the previous model, high image resolution for better quality, more durable tip [16].

The current study found a statistically significant difference in FW between males (125 mm) and females (111 mm), and that's similar to Young *et al.* [17], FH in males (135 mm) and (133) in females, similar to Jeremi'c *et al.* [18]. The mean value of the facial index was found to be significant ($P < 0.001$)

Table 4. Percentage of matching between the actual dimensions results and calculating RED in male and female groups.

	Females	Males	*P*-value
CIW	94.49 ± 3.29	91.75 ± 4.17	0.121 (NS)
LIW	86.91 ± 6.25	85.54 ± 6.21	0.628 (NS)
CW	89.87 ± 8.07	93.17 ± 3.82	0.079 (NS)

**P*-value from Independent T-test.
NS, Nonsignificant at *P* greater than 0.05; S, Statistically significant at *P* less than or equal to 0.05.

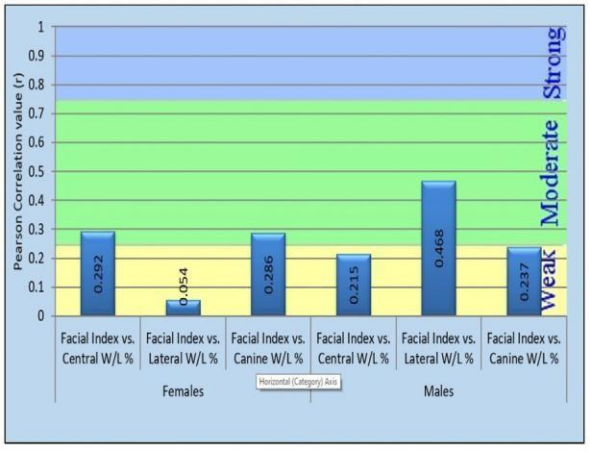

Fig. 5. Bar chart represents the Correlation value (r) between teeth parameters (W/L %) and face index in the male and female groups.

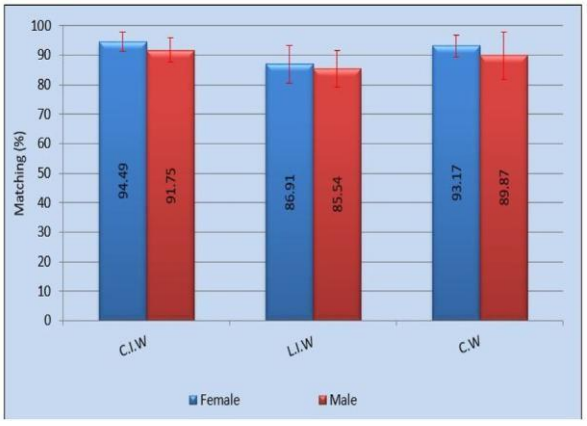

Fig. 6. Bar chart represents the percentage of matching between the actual dimensions results and calculating RED in male and female groups.

(91.37 ± 4.18 %) in males (88.37 ± 6.88 %) for females, in line to the results obtained by the study of Shetti *et al*. [19].

In addition, for assessment of the dimensions by medit software, sections were created vertically and horizontally across each tooth. This was performed to detect the most depressed DGJ and incisal edge precisely. This ensures accurate measurement of the distance between them [20].

In this study the maximum length for each maxillary anterior tooth was determined by measuring the distance from the lowest point at DGJ till the incisal edge, the max width was measured as the distance between contact areas mesio-distally and inter canine distance was measured from one cusp tip to the contralateral cusp tip according to previous studies [13,20,21].

On the other hand, the present study's findings showed that the mean MCI tooth width-to-height ratio was 0.88 mm, which was consistent with the other studies [22e24].

Moreover, greater differences were found when comparing the present results with other previous studies [22,25]. As the height of the extracted teeth is differ than the height measured on retained and that could be explained by the stability and level of the gingiva.

On the other hand, in this study the interrelation between tooth dimensions and sex was assessed; there were no statistically significant differences between males and females either in width or length ($P < 0.05$). The results recognized higher value regarding (length and width) in males compared with females, that was matching the findings of Magne *et al*. [22] length and width dimensions for central, lateral, canine in males (9.6 mm, 8.2 mm), (8.0 mm, 6.7 mm), (9.6 mm, 7.7 mm) respectively when compared with female dimensions (9.2 mm, 8.1 mm), (7.5 mm, 6.5 mm), (8.7 mm, 7.6 mm) that was in accordance with the findings of Orozco-Varo *et al*. [25].

Moreover, several studies note that different results depend on the sample of the chosen populations: Pakistani populations tend to show lower measurements [26], and Chinese populations often exhibit a larger W/L ratio [27]. Gender differences are noted, with men generally having larger width and length measurements than women, Ethnicity plays a role, as Caucasian populations generally have higher W, L, and W/L ratios compared with Asian populations, though there is still considerable variability within ethnic groups [5].

Regarding the teeth symmetry in this study, it has been found that the female symmetry percentages were high, with Central incisors showing (95.84 ± 1.37 %) symmetry in width and (96.17 ± 2.07 %) in length, Lateral incisors showing 96.79 ± 2.82 % symmetry in width and 96.32 ± 2.69 % in length, Canines showing (97.04 ± 1.66 % symmetry in width and 95.45 ± 2.66 % in length. No statistically significant differences were discovered between males and females regarding teeth width or length, as indicated by a ($P > 0.05$). The findings are consistent with Wang *et al*.'s meta-analysis and systematic review [28].

Furthermore, the interrelation between the teeth parameters and face dimensions was evaluated in this study, concerning sexual variation. In females the mean facial index was (88.37 %) and the mean W/L was (88.71 %) for central incisor, (87.51 %) for lateral, and (87.04 %) for canine, while in males the MFI was (91.37 %) and the mean W/L was (84.84 %) for central incisor, (83.60 %) for lateral, and (81.49 %) for canine. So, the results revealed that a Face shape impact: Narrow faces (Eyryprosopic) had significantly lower teeth parameters compared with wider faces (Leptoprosopic or Hyperleptoprosopic). These results were in agreement with the previous study of Kostic *et al*. [29] which has concluded that both sexes teeth and face dimensions positively correlate, although this relationship is variable and depends on the sample's ethnicity [5].

Moreover, the correlation between the actual (measured) and calculated teeth dimensions by RED equation was assessed, in the present study The RED equation is used to calculate tooth width, and its accuracy depends on face type [12]. In this study, Leptoprosopic (narrow face) was the most common in males, Mesoprosopic (average face) was the most common in females. So, the RED proportion (62 %) was used for males while (70 %) was used for females to calculate central incisor width according to RED formula: $CIW = ICW/2\ (1 + RED + RED^2)$.

Besides, the results of the current study showed that the matching percentages in the Egyptian population when the actual teeth dimensions were compared with ideal constant RED (70 %) was (94.49 %) in central, (86.91 %) in lateral, and (89.87 %) in canine. Those results for females, while in males the matching percentage was (91.75 %) in central, (85.54 %) in lateral, and (93.17 %) in canine.

The present study revealed that there were no statistically significant differences between actual dimensions and calculated RED dimensions, so RED proportion could be applied successfully as a guide reference for esthetically pleasing smiles among the Egyptian population. Also, these results showed that the matching percentage for incisors were higher in females, while for canine was higher in males and there were no significant differences

between males and females. The results of the present study are not consistent with other studies concluded that RED proportion did not provide constant results due to difference in ethnicity among different populations [30].

4.1. Conclusion

There is a correlation between teeth dimensions and facial proportions, which varies by gender. The females show the highest anterior teeth symmetry percentage than males.

The RED proportion is applicable in dental treatment planning, but individual variations based on gender and ethnic background should be considered for optimal aesthetic outcomes.

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Biographic data

The procedure was conducted in the clinic of the Fixed Prosthodontic Department in Dental Educational Hospital of Nahda University in Bani-Suef, Egypt.

Ethical approval

Research Ethics Committee of the Faculty of Dental Medicine for Girls, Al-Azhar University (Code of approval: P-BI-21-02). Informed consent was obtained from all participants.

Conflicts of interest

There are no conflicts of interest.

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