Original Article

Efficacy of gender on the width-length ratio of maxillary anterior teeth in an Egyptian population and establishment of a guideline for esthetical accepted ratio of teeth dimensions to gingival display

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Abstract

Aim: The present study aims to correlate between gender and width-length ratio of maxillary anterior teeth in a sample of Egyptian population and to obtain an optimal esthetical accepted ratio of teeth dimensions to gingival display. **Materials and Method:** Stone casts were poured from irreversible hydrocolloid impressions of 100 adult Egyptian participants. These casts were used to measure the maximum mesiodistal width, maximum crown length and the width/length ratio for each maxillary anterior tooth. In addition, two frontal photographs were taken for each participant and the visible anterior teeth width, length and width/length ratio were measured. Finally, a sample with gummy smile was selected and the gingival display of the original image was digitally manipulated to create a series of five images with different gingival displays, then these images were subjected to assessment by 50 dentists and 50 laypersons using a numerical rating scale. **Results:** There was statistically significant difference between female and male group for all teeth width values and W/L ratio of lateral incisor and canine**.** There was no significant difference between dentists and laypersons perception except for the smile with -4 mm gingival display**. Conclusion:** Gender affects actual teeth width values as well as actual and apparent W/L ratios of lateral incisor and canine. Laypersons considered 0mm and -2mm gingival display the most attractive situation, on the other hand dentists considered 0 mm gingival display the most attractive one, while all participants agreed that 4mm gingival display is the least attractive one.

Keywords: width-length ratio, teeth dimensions, gingival display, dental esthetics, smile.

1. Introduction

Obtaining an esthetic smile is considered a multifactorial goal that has to be achieved by applying essential features. Attractive smile is influenced by many factors as tooth color, position, shape, arrangement, orientation of the teeth, especially of the maxillary anterior teeth, and visibility of teeth, all these factors can be labeled as white esthetic factors. In addition, there are pink esthetic factors that play an important role as upper lip position, and amount of gingival display. Although any factor could be considered separately, these factors act esthetically as one unit in a symmetric and harmonious manner. [1]

Several guidelines have been presented with respect to smile design in order to achieve excellent aesthetics. One of the most important guidelines is golden standard value. This standard, states that the optimal width-to-length ratio of maxillary central incisor ranges between 66% and 85% (recently 78%).[2] Another guideline is the golden proportion that was first applied in dentistry by Lombardi who stated that the width of central incisor-to-lateral incisor width and the width of lateral incisor-to-canine width is 1.6:1 when the patient is seen from the front.[3] One more guideline considered as part of the smile design is the amount of gingival display. Excessive gingival display (gummy smile) can render a smile as extreme and unattractive. Yet, the amount of gingival display considered attractive differs between many studies, additionally it may vary by sex and population. Many studies evaluated the width-length (W/L) ratio in maxillary anterior teeth, the golden proportion, the Recurring Esthetic Dental (RED) proportion and the degree of gingival display in order to reach an attractive smile design. [4] Although these studies have important results, we still have no standard rule that could be connected to each patient in order to achieve an attractive smile. Consequently, this study aims to investigate the correlation between gender and width-Length ratio of maxillary anterior teeth in a sample of Egyptian population and obtaining an optimal esthetical accepted ratio of teeth dimensions to gingival display.

2. Materials and Methods

Ethical approval for the study was obtained from the Faculty of Dentistry Research Ethics Committee, Cairo University. The sample used in this study consisted of 100 healthy participants (table 1), chosen from a population of Egyptian origin that met the following criteria:

- Participants age 20-30 years old.
- Complete intact maxillary and mandibular anterior teeth.
- Healthy periodontium.
- Normal dentofacial appearance (no facial or dental anomalies).
- No spacing or crowding in anterior maxillary teeth.

The 100 participants were equal in strata size (50 males and 50 females) to allow studying efficacy of gender on the width-length ratio of maxillary anterior teeth. Egyptian participants from the outpatient clinic in the Faculty of Dentistry Cairo University and October Six University who satisfied the above criteria were included in the study. Informed consent was obtained from all the participants who were included in this study.

Maxillary impression for each participant was made with irreversible hydrocolloid material (alginate Cavex CA37) using metal perforated stock tray with suitable size for patient arch. Manufacturer-recommended amounts of powder and tap water (18–22°C) and hand mixing was applied according to manufacturer's instructions using rubber bowl and wide-bladed plastic spatula. The mixed alginate was rubbed onto the labial and incisal surfaces of anterior teeth with a gloved finger to fill the incisal grooves, allowing accurate reproduction of the tooth anatomy.

Upon removal of the impression from the mouth, impression was inspected for defects under good lighting. The impressions that were not suitable for the study were discarded and repeated. Then the impression was rinsed under gently running cool tap water to remove any saliva or blood, dipped in disinfectant [CIDEX OPA (ortho-phthaladehyde) solution], waiting for one minute and again washed in running tap water, then dried until the shine just disappears and covered with damp gauze and left in a zip-lock plastic bag. The impression was taken to the laboratory and poured with type IV dental stone (Kromotypo Type 4, LASCOD Spa) within 10 minutes. The manufacturer-recommended powder/liquid ratios were used and the stone mixed using a vacuum mixer (VPM2, Whipmix) for pouring. All the anatomic landmarks were poured and then a base was done. The casts were retrieved between one and three hours of pouring. Sample numbers were scribed with a straight laboratory handpiece and tungsten carbide rose head bur on the palatal surface of the cast.

Two frontal photographs for anterior teeth were taken for each participant, the first one is a spontaneous smile view and the second one is a close up retracted view involving the lower third of the face with teeth on maximum intercuspation.

A specially designed head stabilizer device, mounted on a stand, was used to standardize the photographic conditions (**Hasanreisoglu U et al. 2005**) (Fig. 1). Each subject was seated in a chair with the head upright, and with the occlusal plane of the maxillary teeth parallel to the floor. The stabilizer was adjusted to the subject by fitting the earpieces into the external auditory canals. In addition, a nasal relater attached to

the system was placed on the bridge of the nose. A constant camera settings and lightening conditions were applied for all photographic procedures (digital SLR camera: Nikon D7100, 105 mm macro-lens, dual flash: Nikon wireless remote speedlight SB-R200, F stop: 20, shutter speed: 100, iso:400, 1:5 magnification). The lens was positioned at a fixed distance of 52 cm from the subject and parallel to the true perpendicular of the face in natural head position, and the camera was supported by tripod and raised to the level of the patient's lower facial third. Then, the patient was asked to smile by saying a joke. Twenty photographs were taken during smiling. Out of these, photograph representing the subject's most wide smile was chosen and considered to be his/her spontaneous smile. Cheek retractor was then applied and participant was asked to bite on his/her teeth, and a retracted photographic view was taken with the same settings and conditions as mentioned before.

After collection of all casts, measurements were taken to record the lengths and widths of all included teeth using a digital caliper (Digit-Cal STAINLESS HARDENED) with a precision of 0.01 mm. The measurements were all recorded in millimeters by a single calibrated operator. The clinical crowns of the maxillary anterior teeth were measured, the maximum mesio-distal width (perpendicular to the longitudinal axis of the tooth) (Fig. 2), and the maximum crown length (parallel to the longitudinal axis of the tooth and between the most apical point of the gingival margin, gingival zenith, and the most incisal point of the crown) were recorded for each tooth, and the scores were arranged separately in two tables according to gender type. Another two tables were made for measuring width/length ratio for each maxillary anterior tooth according to gender type.

The images of the participants (close up retracted view) were uploaded and imported to Adobe Photoshop CC 2015.5(Adobe Systems, Inc.). Using the rectangular marquee tool in the information palette, the maximum visible width and length (a pixel-based measurement) for each maxillary anterior tooth were recorded in millimeters (Fig. 3). Taking into account the magnification of the camera in the working field.

Results were recorded in two tables according to gender type, another two tables were made for measuring apparent width/length ratio for each maxillary anterior tooth according to gender type. After the results of the visible width/length ratio were collected and statistical analysis was made, a sample with gummy smile was selected whom visible width/length ratio of maxillary anterior teeth was nearly the same as mean value of W/L in the present study. The gingival display of the original image was digitally manipulated using adobe photoshop CC 2015.5 to create a series of five images with different gingival displays, ranging from 4 mm of gingival display to 4mm of tooth covering by the upper lip. The nose and chin were removed from the image to eliminate any confounding factors (Fig. 4).

The images were printed as glossy photographs (4 inches * 6 inches), and presented, in no set sequence, to each rater. A numerical rating scale (NRS) was used, where 0 was the rating for least attractive, and 10 was the rating for most attractive. The NRS has been shown to be an easy instrument to interpret, reliable, and useful. [5] The images were subjected to assessment by fifty dentists and fifty laypersons. Participant dentists were master or doctorate degree students at Cairo university and participant laypersons were college students from five educational faculties (medicine, science, engineering, arts and media).

Statistical analysis:

Data presented as frequency (n), mean, standard deviation (SD) and 95% Confidence interval (95% CI) when appropriate. Coefficient of variation was used to determine the difference between apparent and actual tooth dimensions. Independent t-test was used to compare between Male and Female population. Kruskal Wallis test used to compare between different Display followed by Mann Whitney U test for pairwise comparison. Mann Whitney test used to compare between lay person and dentist for different display. The significance level was set at P ≤ 0.05. Statistical analysis was performed with IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics Version 25 for Windows.

3.Results

A total of 100 subjects, equally divided into fifty females and fifty males, were included in this study. When the mean width, length and W/L ratio values were compared between female and male group, there was statistically significant difference for all teeth width values and W/L ratio of lateral incisor and canine (table 2). All teeth width values and W/L ratio of lateral incisor and canine were higher in male group than that

of female group figure (5), Whereas there was no statistically significant difference for all apparent teeth dimensions. However, there was statistically significant difference for apparent W/L ratio of lateral incisor and canine (table 3). It was found that apparent W/L ratio for lateral incisor was higher in male group, while apparent W/L ratio for canine was higher in female group figure (6).

A total of 100 participants, 50 dentists and 50 laypersons, participated in evaluation of the most pleasing Amount of gingival display on spontaneous smile. When comparing smile ratings within each rater group, the ratings of the smile images were significantly different (P<0.001). Regarding dentists evaluation, the highest rating was for the smile with 0 mm gingival display by median score 9, followed by -2 mm gingival display by median score 8, followed by both 2 mm and -4 mm gingival display by median score 5 and the lowest rating was for the smile with 4 mm gingival display by median score 3. However, there was no statistically significant difference between 0

mm and -2 mm gingival display and also between 2 mm and -4 mm gingival display, while for laypersons, the highest rating was for both 0 mm and -2 mm gingival display by median score 8, followed by -4 mm gingival display by median score 6, followed by 2 mm gingival display by median score 4 and the lowest rating was for the smile with 4 mm gingival display by median score 3. there was no statistically significant difference between 0 mm and -2 mm gingival display.

Comparing the ratings of each smile between dentists and lay persons, the results showed that ratings have no significant difference in both groups except for the smile with -4 mm gingival display was significant different. figure (7) shows aesthetic score for different display for dentist and layperson group.
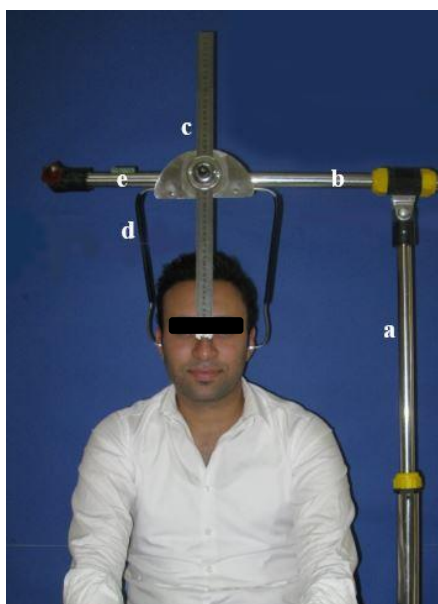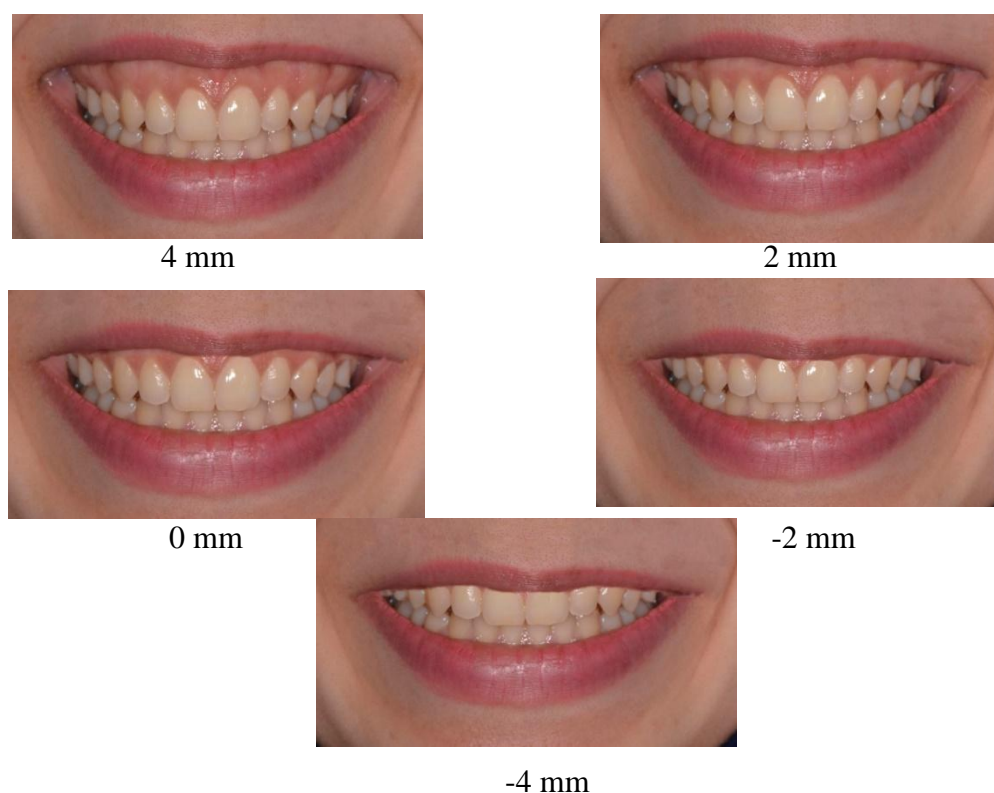

Figure 1: Specially designed head stabilizer device a: vertical stand, b: horizontal bar, c: nasal relater, d: lateral bar ending with earpiece, e: balance indicator.

Figure 2: the maximum mesio-distal width measurement of upper right central incisor.
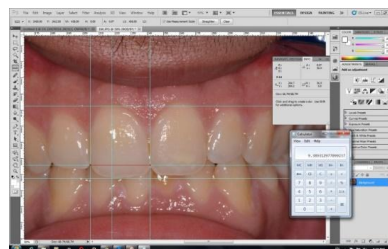
Figure 3: the maximum visible width measurement for upper right central Incisor

4 mm

2 mm

0 mm

-2 mm

-4 mm

Figure 4: gingival display was increased or decreased by moving the upper lip. The smile was altered by 2 mm increments. The gingival margin between the maxillary central incisors was used as a reference point.

Confidence level	Strata size	Total sample size
80	30	60
90	50	100
95	71	142

Table 1: sample size calculation, a total sample size of 100 will be satisfactory to obtain confidence coefficient 90% and 10% margin of error.

Actual	Gender				p-value
	Female		Male		
	Mean	SD	Mean	SD	
Width Canine	7.48	0.60	7.84	0.43	≤0.001*
Width Lateral	6.61	0.66	6.77	0.41	0.035 *
Width Central	8.69	0.47	8.87	0.60	0.015*
Length Canine	9.34	1.22	9.53	0.89	0.214 NS
Length Lateral	8.61	0.98	8.52	0.63	0.412 NS
Length Central	10.14	0.83	10.37	1.04	0.087 NS
W/L Canine	0.81	0.08	0.83	0.06	0.047*
W/L Lateral	0.77	0.06	0.80	0.05	0.001*
W/L Central	0.86	0.05	0.86	0.06	0.767 NS

Table 2: values for mean, standard deviation (SD) and p-value in relation to Actual tooth width, length, and W/L ratio for both female and male group.
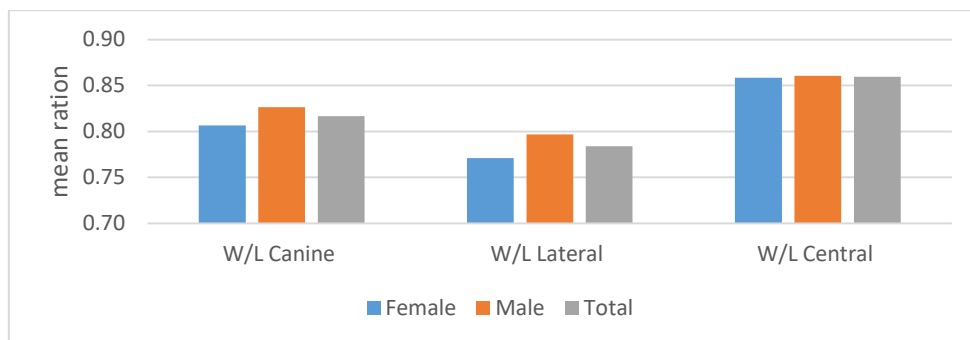
Figure 5: Bar chart showing actual W/L ratio data for female and male.

Apparent	Gender				p-value
	Female		**Male**		
	Mean	**SD**	**Mean**	**SD**	
Width Canine	5.11	0.63	4.99	0.95	0.289 NS
Width Lateral	5.95	0.52	5.99	0.48	0.580 NS
Width Central	8.68	0.48	8.83	0.75	0.094 NS
Length Canine	8.91	1.23	9.03	0.90	0.417 NS
Length Lateral	8.62	0.92	8.37	0.92	0.055 NS
Length Central	10.25	0.77	10.24	0.93	0.887 NS
W/L Canine	0.58	0.11	0.55	0.08	0.01*
W/L Lateral	0.70	0.08	0.72	0.06	0.038*
W/L Central	0.85	0.06	0.87	0.07	0.088 NS

Table 3: values for mean, standard deviation (SD) and p-value in relation to Apparent tooth width, length, and W/L ratio for both female and male group.
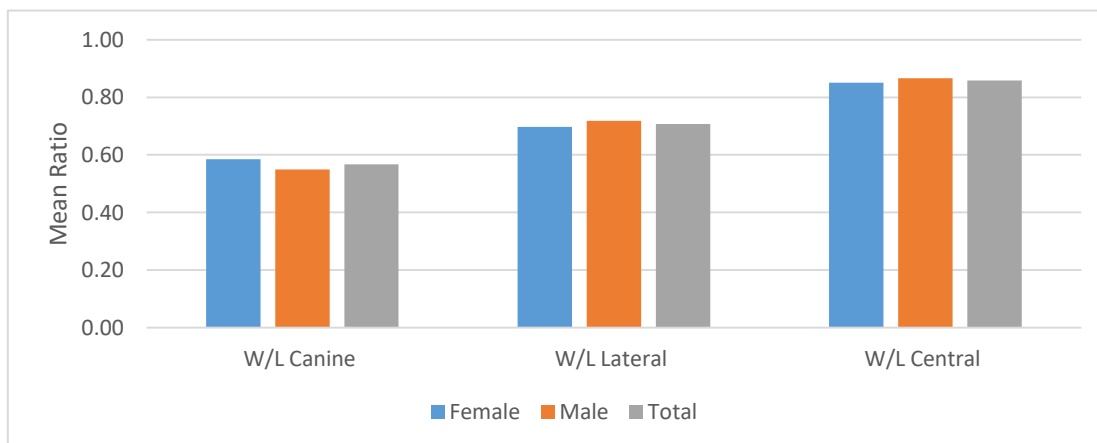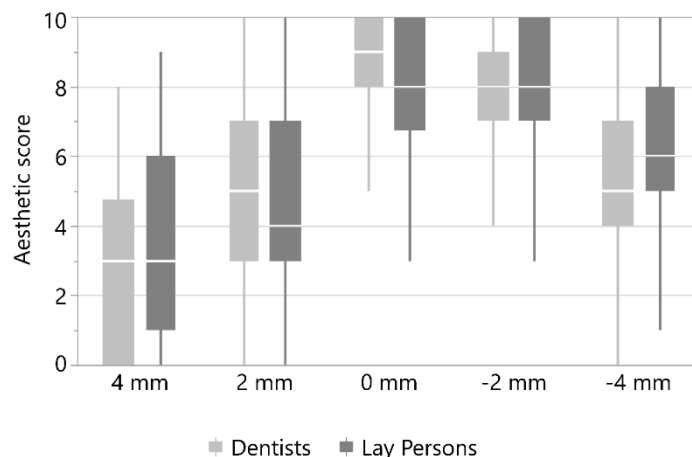

Figure 6: Bar chart showing apparent W/L ratio data for female and male.

Figure 7: Box and plot showing Aesthetic score for different display for Dentist and layperson

Discussion

Width/length ratios of maxillary anterior teeth are considered specifically to be the most stable reference, since they have least variation among races and between genders. However, some studies have shown differences in the widths, lengths, and width/length (W/L) ratios of maxillary anterior teeth. [6] Authors have proposed different ratios. Brisman proposed that the optimal width/length ratio of the maxillary central incisor should be 75%, while others like Sterret, suggested ratios up to 85%. [7] Therefore, in this study we measured the width/length ratio for each maxillary anterior tooth in a sample of Egyptian population. Previous studies have confirmed the presence of sexual dimorphism within the human dentition and examples of ethnic differences and geographic variability in tooth size have been documented. [8] These findings suggested the need for evaluation of tooth dimensions and proportions in different populations as it may help to specify certain aesthetic modifications to the treatment for that particular population. With no surprise, these parameters had been studied in various populations. [7, 9, 10] Until recently, no data for tooth dimensions and proportions in an Egyptian population was available. For this reason, in the current study we investigated tooth dimensions and the existence of sexual dimorphism in a sample of Egyptian population.

A youthful smile is defined as full display of maxillary incisor crowns, with 1–2 mm of gingival margin. However, the amount of gingival display considered attractive differs among various studies. [11] Excessive gingival display, that can render a smile as unpleasant, has many treatment modalities depending on its cause. [12] One of these modalities is esthetic crown lengthening that can be used in case of altered anterior teeth width/length ratios. Therefore, in the current study we aimed at establishment of a guideline for esthetical accepted ratio of teeth dimensions to gum exposure.

Either the gingival zenith or the cementoenamel junction CEJ can be used as apical reference for tooth length measurements. Measurements based on the CEJ have more precision when measured on extracted teeth as level of marginal gingiva may vary because of various conditions such as inflammation, while the CEJ is a fixed point. However, the present study used the gingival zenith point, on participant with healthy periodontium, as the apical landmark for the tooth length measurement because of its clinical relevance. A specially designed head stabilizer device was used to allow fixation of head on the desired position with no excess motion, and to standardize the photographic conditions. This technique following the method used by other authors. Hasanreisoglu et al. 2005, [10] used a specially designed stabilizer device resembling a face bow, whereas Jain et al. 2015, [13] used a customized cephalostat.

The results of current study indicate that anterior teeth dimensions vary by gender. There was statistically significant difference between females and males regarding all anterior teeth widths, where canines were in the range of 0.4 mm wider in males, while central and lateral incisors were in the range of 0.2 mm wider in males. These results are in agreement with many other authors who confirmed gender variations in the dimensions of the anterior teeth, with men exhibiting wider anterior teeth than women. [9, 13]

The results in the present study for W/L ratio of anterior teeth in a sample of Egyptian population were 86% for the CI, 78% for the LI and 82% for the C. These results were in agreement with Sterrett et al. 1999, [7] and Orozco-Varo et al. 2015, except for W/L of canine was of lesser value (79%) than this study. The present results were also similar to Zlataric et al. 2007, [14] (in a Caucasian population) except for W/L ratio of CI was of lesser value (83%), and also similar to Zagar 2011, [15] (in a Caucasian population) except for W/L ratio of LI was of greater value (82%). The present results were in contrast with Hasanreisoglu et al. 2005, [10] who revealed greater W/L for all anterior teeth indicating wider teeth appearance in a Turkish population. The present results were also in contrast with Magne et al. 2003, [16] (white subjects) and Tsukiyama et al. 2012, [17] (Asian subjects) who revealed lesser W/L ratio for all anterior teeth and this may be attributed to different methodology by measuring anatomical and not clinical tooth dimensions.

The present study aimed to evaluate the most pleasing gingival display on spontaneous smile as perceived by dentist and layperson groups. All participants agreed that when the upper lip covered the upper incisors by 4 mm, it created an unattractive smile, which has been shown in a previous study conducted by Zawawi et al. 2013, who evaluated the influence of education on the esthetic perceptions of female University students of the effect of lip position and gingival display on smiling. A study by Hunt et al. 2002, [4] was akin to the present result, who found that 0 mm of gingival display was the most attractive, which is in agreement with the dentist perception in our study, and that 3 mm of gingival display had the lowest score for attractiveness.

In another study, Geron and Atalia 2005, [18] found that lip coverage of the upper incisors between 0–2 mm was found to be the most pleasing esthetically, which is in agreement with the layperson perception in our study. The present study was in contrast with Zawawi et al. 2013, [19] regarding the most pleasing gingival display, where they found that 2 mm of gingival display is the most attractive smile. The present study found that there was no difference between lay people and dentists in their perceptions of gummy smile, and this is in agreement with Kokich et al. 1999, who compared the perceptions of dental professionals and lay people. Both groups agreed that 3 mm of gingival display resulted in an unattractive smile. Another study conducted by Kokich et al. 2006, showed that 4 mm of gingival display was rated by dentists as unattractive. In the present study there was no significant difference between dentist and layperson perception in the amount of gingival display upon smiling except for the -4 mm gingival display photo. A study by Jornung and Fardal 2007, found that dentists are more precise at assessing gingival display, compared to lay people. In contrast, another study by Barros et al. 2012, stated that no differences were found in the esthetic perception of orthodontists versus laypersons in assessing photos of spontaneous smiles.

The results of this study could be helpful for management of patients with excessive gingival display. The gingival display can be considered, in conjunction with tooth width-to-length ratios of the anterior teeth, by the esthetic dentist, orthodontist, and periodontist, in determining appropriate treatment. [19]

Conclusion

The results and conclusions of this study are applicable to the Egyptian population, Within the limitations of the present study, the following conclusions were drawn:

1. Gender affects actual teeth width values as well as actual and apparent W/L ratios of lateral incisor and canine.
2. The actual W/L ratio for central incisor is the same in both genders, while lateral incisor and canine W/L ratios are higher in males.

3. The apparent W/L ratio for central incisor is nearly the same in both genders, while for lateral incisor, it's higher in males and for canine, it's higher in females.

4. Laypersons considered 0 mm and -2 mm gingival display the most attractive situation, on the other hand dentists considered 0 mm gingival display the most attractive one, while all participants agreed that 4mm gingival display is the least attractive one.

Clinical recommendation:

The results of this study can be used as an aiding esthetic tool for diagnosis and treatment of anterior esthetic rehabilitation cases. Furthermore, tooth dimensions guidelines can be provided for each gender separately.

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