Saudi Dental Journal (2019) 31, 322–329

King Saud University

Saudi Dental Journal

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ORIGINAL ARTICLE

Golden proportion evaluation in maxillary anterior teeth amongst Saudi population in Riyadh

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Received 10 January 2019; revised 26 February 2019; accepted 4 March 2019
Available online 13 March 2019

KEYWORDS

Anterior teeth;
Esthetics;
Golden proportion;
Gold standard

Abstract *Introduction:* In achieving pleasing dental aesthetics, the maxillary anterior teeth are essential. Numerous methods are used to measure their dimensions, including the golden proportion between their perceived widths and the width-to-height ratios, referred to as the golden proportion and is considered as a gold standard for esthetic evaluation.

The objective of this study was to evaluate the existence of the golden proportion between the width of the maxillary anterior teeth of Saudi males and females.

Methods: This clinical observational study included a total of 61 participants that met the inclusion criteria having 36 females and 25 males, all Saudi nationals, presented to Princess Nourah bint Abdulrahman University (PNU), College of dentistry, clinics. Dental casts of the maxillary arches for each participant were made after taking digital impressions in addition to taking photographs. The dimensions and the perceived width of the anterior teeth viewed from the front were measured using a digital caliper. SPSS was used to analyze the data.

Results: There were significant differences between the subject's width-to-height ratios and the golden proportion of 0.80 where (p-value < 0.05). Thus, indicating that no golden ratio was observed except in case of tooth number 12 in male subjects where mean value was (0.83) with a standard deviation of (0.09) and the p-value of ($p = 0.144$) > 0.05.

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Peer review under responsibility of King Saud University.

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https://doi.org/10.1016/j.sdentj.2019.03.001
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Conclusions: From the perceived widths of maxillary anterior teeth, the golden proportion was not found to exist. No gold standard was detected for the width-to-height proportions of maxillary incisors. Therefore, in addition to anterior teeth measurements, specific population characteristics and perception of an agreeable smile should be considered for evaluating esthetics.

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1. Introduction

The constant increase in esthetic demands in dentistry has led to progress in the development of several types of guidelines in order to achieve optimal aesthetic results. Advanced dental materials and techniques are introduced to maximize an attractive outcome. The morphologic features of the maxillary anterior teeth are essential not only for dental esthetics, but also for facial esthetics (Hasanreisoglu et al., 2005). In the majority of people, facial appearance is a significant concern, and it plays a vital role in a person's self-image, self-esteem and quality of life (Dos Santos et al., 2017). Numerous factors are related to dental esthetics, such as the color, the shape of the teeth and the shape of the dental arch. These factors are influenced by individual preferences, cultural factors, and sociodemographic factors. The viewer's perception of a visual experience could be perceived attractive by one individual, while it could be entirely different for another. Therefore, several esthetic guidelines were developed to achieve optimal esthetics. Golden proportion is one of the most essential and valuable guidelines, which is a constant ratio of 1.618:1 (Stephen, 2007). It is widely observed in nature and is pleasing to the human eyes.

The introduction of the golden proportion in dentistry proposed approximating the apparent dimensions of maxillary anterior teeth when viewed from the front (Levin, 1978). Several studies assessed the gold, golden proportion in their population. A study done in India revealed that the golden percentage was somewhat inconstant in terms of relative tooth width (George and Bhat, 2010). Another study in Malaysia compared the golden proportion of 0.618 with the perceived width ratio of lateral to central incisor and canine to lateral incisor and revealed the statistically significant difference for the width to height ratio of central incisors compared to the golden standard of 80% (Al-Marzok et al., 2013). In Saudi Arabia, only one study compared the dimensions of the maxillary anterior teeth concerning their width and high ratio and resulted with no significant difference between the central incisors and canines amongst males and females (Al-Sehaibany, 2011).

Due to the limited number of studies assessing the gold proportion in Saudi Arabian population, this study targeted to investigate the golden proportion further digitally and find out the differences between width and height of maxillary anterior teeth for the Saudi population in Riyadh.

2. Materials & method

2.1. Participants selection

The sample size for this study consisted of 61 Saudi nationals, 36 females and 25 males, from 18 to 28 years of age. This research was carried out at the dental clinics of the college of dentistry, Princess Nourah Bint Abdulrahman University. The consent and ethical clearances for the study were obtained from the institutional ethical committee PNU, and all the Participants signed the consent form in the beginning.

2.2. Inclusion criteria

Participants were clinically checked at PNU's dental clinic by the examiners and selected according to the following inclusion criteria:

1. Natural anterior teeth
2. No history of orthodontic treatment
3. No missing maxillary teeth
4. No tooth wear.
5. No spacing or crowding
6. Normal gingival or periodontal conditions.

2.3. Digital data collection

All Participants were photographed from a frontal view with a maximum smile using a Digital Camera (Canon 60D- Japan). Also, the impressions were taken digitally using the Cerec- Sirona intraoral camera. A digital caliper was used to calculate the actual sizes of the teeth (see Fig. 1). While recording data each tooth was coded with a numeric symbol (w = width, h = height). FDI tooth numbering system was used which referred to its order within right and left quadrant of the maxillary arch for example; Left central incisor height was denoted by (11 h), and width was denoted by (11 w) whereas Right central incisor width was denoted by (21 w) respectively.

Fig 1 Mannesman Digital Vernier Caliper.

2.4. Golden proportion measurement

The golden proportion for each subject; photograph and impression; was assessed by following the definition of Levin in 1978, which states that the ratio between the width of the lateral incisor and that of the central incisor should be 1:1.618 while the optimal ratio between the width of lateral incisor and that of the canine is 1:0.618 when viewed from front.

The measurements were performed as follows; the widths of the teeth were measured at the mesiodistal contact points of teeth, and the height of the teeth was measured from the zenith of the tooth to the incisal edge (see Fig. 2). Each measurement was made thrice by the same examiner, and the constant values were used for the accuracy and calibration of results.

All clinical & dimension measurements were undertaken initially by the principal investigator. This examiner was calibrated against two other examiners. The calibration was performed as follows; the principal investigator carried out the clinical evaluation and golden proportion measurements for the first five patients followed by two other examiners who investigated the same sample under similar conditions. The recorded data by both examiners was cross-tabulated for validity, and an agreement of 98% was confirmed. Since there was no doubt about the level of agreement, kappa statistics were not required.

2.5. Data analysis

Digital analysis of the photographs and impression was performed using Keynote software. It determined the apparent and actual anterior tooth dimensions for the calculation of the GP (Golden proportion) and W/H (width to height) ratios.

3. Results

3.1. Participants demographics

The data for a total of 61 participants included in the study was grouped according to the gender for comparison between 25 males and 36 females. The participants aged between 18 and 28 years with an average of 22.34 years and a standard deviation of (2.55). SPSS version 17.0, IBM 9 was used to analyze the collected data.

3.2. Maxillary anterior teeth measurements

3.2.1. Width and height calculations

Table 1 shows the measurements of participants' maxillary anterior teeth (width & Height) of central incisors, lateral incisors, and canines for both quadrants (right and left) with standard deviation. Where mean of right central incisor width, for example, is 8.5246 mm compared to 8.5649 mm for the left, with a standard deviation of (0.61). The maximum value of the right central incisor width was 10.41 mm, and the minimum value was 7.44 mm compared to the maximum value of left central incisor width 10.00 mm and a minimum value of 7.06 mm.

3.2.2. Width to height ratio calculations

Table 2 shows the width to height ratio for each tooth calculated by dividing the width of the tooth by the height. In order to assess the incidence of golden proportion a one-sample *t*-test was used to compare the width to height ratios of all teeth with the proportion of 80% (0.80). At a significance level of (α = 0.05) for testing the mean ratio of width to height for

Fig. 2 Measuring the Golden Proportion.

Table 1 Descriptive statistics about measurements of participant's teeth.

Measurements of tooth	Symbol	N	Minimum	Maximum	Mean	Std. Deviation
Right central incisor height	11 h	61	7.65	11.82	9.7282	0.91150
Right central incisor width	11 w	61	7.44	10.41	8.5246	0.56110
Right lateral incisor height	12 h	61	4.71	10.00	7.8092	1.00053
Right lateral incisor width	12 w	61	5.41	7.79	6.6556	0.50108
Right Canine height	13 h	61	6.83	11.42	8.8780	0.97262
Right Canine width	13 w	61	6.25	9.84	7.7861	0.66395
Left central incisor height	21 h	61	7.25	12.47	9.6643	1.01569
Left central incisor width	21 w	61	7.06	10.00	8.5649	0.60795
Left lateral incisor height	22 h	61	5.52	9.87	7.9036	0.87906
Left lateral incisor width	22 w	61	5.09	9.60	6.7228	0.68177
Left Canine height	23 h	61	6.70	11.52	8.9815	0.91830
Left Canine width	23 w	61	6.53	8.91	7.7116	0.54863

Table 2 Mean values (SD) of the width-to-height ratio of maxillary central and lateral incisors and canines and their comparison with the golden proportion (0.80).

Tooth	W/H	All Subjects		Female		Male	
		Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Right central incisor	11	0.88 (0.70)	< 0.001	0.90 (0.07)	< 0.001	0.86 (0.07)	< 0.001
Right lateral incisor	12	0.86 (0.11)	< 0.001	0.89 (0.11)	< 0.001	**0.83 (0.09)**	**0.144**
Right canine	13	0.88 (0.10)	< 0.001	0.90 (0.11)	< 0.001	0.86 (0.10)	0.009
Left central incisor	21	0.89 (0.09)	< 0.001	0.90 (0.09)	< 0.001	0.88 (0.09)	< 0.001
Left lateral incisor	22	0.86 (0.11)	< 0.001	0.86 (0.11)	0.001	0.85 (0.11)	0.028
Left canine	23	0.87 (0.09)	< 0.001	0.88 (0.08)	< 0.001	0.85 (0.08)	0.008

each tooth whether it equals the golden proportion (0.80) or not.

Results in Table 2 showed that there were significant differences between the samples W/H ratios and the golden proportion of 0.80 where (p-value < 0.05). Thus, indicating that no golden proportion was observed except in case of tooth 12 in male subjects where mean value was (0.83) with a standard deviation of (0.09) and a p-value of ($p = 0.144$) > 0.05. In other words, the mean width to height ratio for the right lateral incisor of male patients involved in research was found close to the golden proportion of 0.80.

3.2.3. Width comparison for adjacent teeth

Tables 3 and 4 Calculated width ratios for maxillary lateral to central incisors and lateral incisor to canine were and compared them to the golden proportion of 0.618, 1.618 respectively. As the prevalence of golden proportion requires specified width ratios between lateral incisor to central incisor of (1:1.618), and between lateral incisor to the visible canine from the frontal view (1:0.618).

It is clear from Table 3 that width ratios of lateral to central incisor for right quadrant is (0.78) and for left quadrant is (0.96) which was at a significance level of ($\alpha = 0.05$) for testing the mean ratios of the width with the golden proportion of (0.618). One-sample *t*-test showed significant differences ($p < 0.05$) between the mean ratios of widths of maxillary anterior teeth compared with the ideal golden proportion (0.618). These findings indicate that the golden proportion was not found amongst the research participants.

Furthermore, it is clear from Table 4 that width ratios of lateral incisor to the canine ratio for the right side is (1.72) and for the left side is (1.75) taking into consideration that half width of canine is considered for calculations. Hence, a one-sample *t*-test showed significant differences ($P < 0.05$) comparing the mean widths ratios of lateral incisor to canine with the ideal golden proportion (1.618). This reports for the participants recorded comparative widths, the golden proportion did not exist.

3.2.4. Width to height ratio comparison for adjacent teeth

Moreover, for more confirmation, width to height ratios of lateral incisor to central incisor, and canine to lateral incisor were calculated to check whether there are significant differences between the mean values and the golden proportion (0.618) at a significance level ($\alpha = 0.05$). Results in Table 5 showed that significant differences exist between mean W/H ratios of lateral to central incisor and canine to lateral incisor and none of the four mean W/H ratios equals the golden proportion (0.618).

3.2.5. Checking the effect of demographical variables

Results in Table 6 clarify; Whether demographical variables such as gender can cause significant differences in W/H ratios between participants at a significance level of ($\alpha = 0.05$), to test these, two independent T-test was done. Before performing the test, two assumptions were checked; data in each group (male, female) is approximately normally distributed using Kolmogorov – Smirnov test at ($\alpha = 0.05$), and the results of

Table 3 Width ratios for maxillary lateral to central incisors and their comparison with the golden proportion (1.618).

Width ratio	Ratio	All Subjects		Female		Male	
		Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Right lateral incisor to central incisor	12w/11w	0.78 (0.53)	< 0.001	0.78 (0.06)	< 0.001	0.78 (0.04)	< 0.001
Left lateral incisor to central incisor	22w/21w	0.96 (0.11)	< 0.001	0.96 (0.10)	< 0.001	0.97 (0.12)	< 0.001

Table 4 Width ratios for maxillary lateral incisor to canine and their comparison with the golden proportion (0.618).

Width ratio	Ratio	All Subjects		Female		Male	
		Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Right lateral incisor to canine	12w/13w	1.72 (0.14)	< 0.001	1.73 (0.16)	< 0.001	1.69 (0.12)	0.004
Left lateral incisor to canine	22w/23w	1.75 (0.16)	< 0.001	1.76 (0.18)	< 0.001	1.73 (0.13)	< 0.001

Table 5 Width to height ratios for maxillary lateral to central incisors and canine to lateral incisor and their comparison with the golden proportion (0.618).

Width to Height ratio	Ratio	All Subjects		Female		Male	
		Mean (SD)	p-value	Mean (SD)	p-value	Mean (SD)	p-value
Right lateral incisor to central incisor	12/11	0.98(0.12)	< 0.001	0.99 (0.13)	< 0.001	0.96 (0.08)	< 0.001
Right canine to lateral incisor	13/12	0.52 (0.06)	< 0.001	0.51 (0.06)	< 0.001	0.52 (0.06)	< 0.001
Left lateral incisor to central incisor	22/21	0.96(0.11)	< 0.001	0.96 (0.10)	< 0.001	0.97 (0.12)	< 0.001
Left canine to lateral incisor	23/22	0.51(0.06)	< 0.001	0.51 (0.06)	< 0.001	0.50 (0.05)	< 0.001

Table 6 Two independent T-test for equality of means of width to height ratios according to gender.

Variable	Levene's Test for Equality of Variances		T-test for Equality of Means		
	F	p-value	T	p-value	Mean difference
W/H ratio for tooth 11	0.474	0.494	1.995	0.051	0.037
W/H ratio for tooth 12	0.035	0.852	2.203	**0.032**	**0.060**
W/H ratio for tooth 13	0.019	0.891	1.780	0.080	0.048
W/H ratio for tooth 21	0.303	0.584	1.047	0.299	0.025
W/H ratio for tooth 22	0.320	0.574	0.472	0.639	0.013
W/H ratio for tooth 23	0.549	0.462	1.259	0.213	0.028

Levene's test for variance homogeneity showed that all p-values are higher than the significance level 0.05 and hence variances of two groups within each variable is homogenous.

Now, results in Table 6 showed that there is a significant difference in mean values of W/H ratio for tooth 12 between males and females with a mean difference of (0.06) and ($p = 0.032$) < 0.05. This result is compatible with the result in Table 2 which showed that males had a mean width to height ratio for the right lateral incisor close to the golden proportion of 0.80, while females had not.

3.2.5.1. Comparing width to height ratios for anterior right and left quadrants. Comparing right to the left mean of width to height ratios for lateral incisor to central incisor, and canine to lateral incisor as shown in Figs. 4–5.

Fig. 3 compared mean scores of Width to height ratio for central incisors where mean W/H ratio for left central incisor is higher than right one with a difference of (0.01) regardless the gender and age of patients.

Furthermore, Fig. 4 showed both W/H ratio for left lateral incisor and right lateral incisor in sample patients who had approximately the same mean W/H ratio of (0.86) regardless the gender and age variables.

Finally, Fig. 5 showed that the mean W/H ratio for half right canine is more significant than half left canine with a difference of (0.01) regardless of the gender and age variables.

4. Discussion

Now a day dental esthetics is a primary consideration for all patients, to achieve an excellent esthetics number of authors provided guidelines. The most important guidelines for esthetics are the golden proportion value. The optimal width-to-height proportion of maxillary central incisor varies between 66% and 85% (Wolfart et al., 2006; Wolfart et al., 2005), which indicate that the size and form of the maxillary anterior teeth are essential for both dental and facial esthetics (Hasanreisoglu et al., 2005).

The golden proportion (1.618: 1.0) describes the ratio between the dimensions of a larger and a smaller length. Many previous pieces of research have used this mathematical proportions in dentistry like, Levin, 1978 identified the golden proportion between the width of central incisor, lateral incisor and the canine (Levin, 1978). The golden proportion is founded to be a reliable predictor for determining the width of the maxillary central incisors. (George and Bhat, 2010). In 1993, Preston presented that 17% of his study samples had a golden proportion between the width of the maxillary central and lateral incisors (Preston, 1993).

On the other hand, other authors found that the golden proportion did not exist between the widths of the maxillary anterior teeth. (Gillen et al., 1994; Rosenstiel et al., 2000; Ward, 2001).

In this study, relative proportions of central and lateral incisors and canines' dimensions were recorded according to the golden proportion of 1.618 and no relationship was found. So the results of the current study concurred with previous studies, that golden proportion did not exist in the study sample of Saudi population similar to the results of a study carried out by Wolfart et al., 2006, who reported a width-to-length proportion of 82% (Parnia et al., 2010).

The mean width to height ratio for the right lateral incisor of male patients involved in research is close to the golden proportion of 0.80. A Significant difference between the mean ratios of widths of maxillary anterior teeth compared with the ideal golden proportion for lateral to central incisor and between lateral incisor to canine was observed. Similarly, significant differences between mean W/H ratios of lateral to central incisor and canine to lateral incisor and the golden proportion existed. Also, a significant difference in the mean values of the W/H ratio for tooth number12 between males and females was seen. These findings were also reported by Parnia et al. (2010) who showed that considering the width

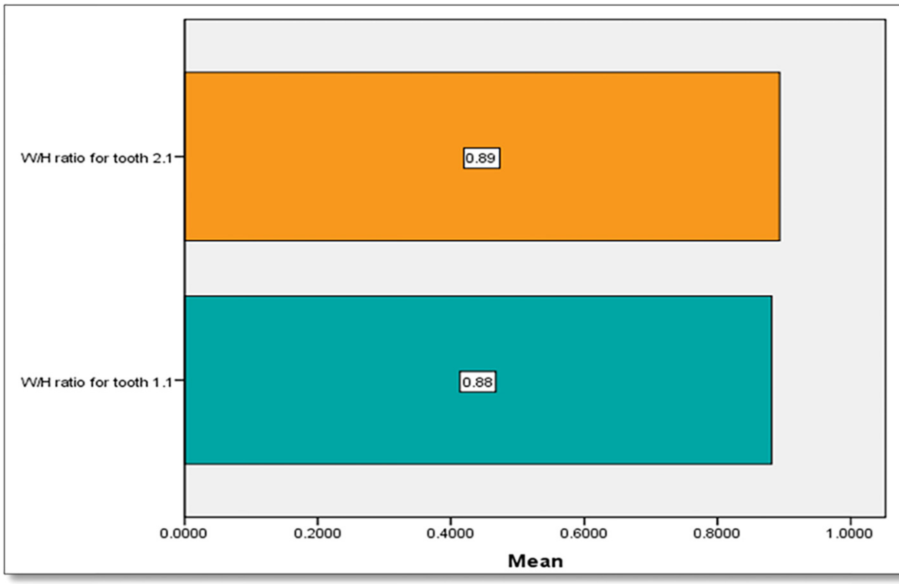

Fig. 3 Comparison between mean scores of Width to height ratio for central incisors.

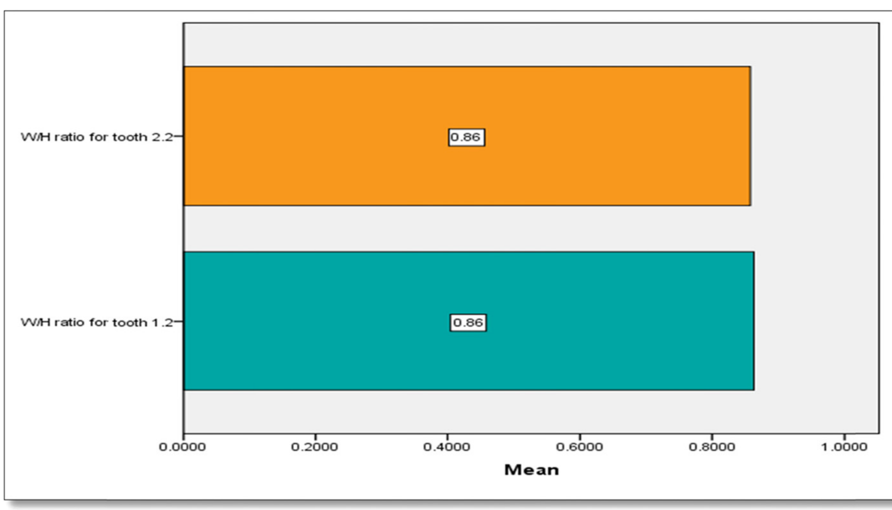

Fig. 4 Comparison between mean scores of Width to height ratio for lateral incisors.

to width ratios and the width to height ratios of maxillary anterior teeth showed no golden proportions were found.

Excluding the gender difference effects amongst the participants, the current study found, the mean width to height ratio for the right lateral incisor of male patients involved in this research closer to the golden proportion of 0.80 similar to the study done by Rana (2014). Wolfart et al. (2006), also showed that there were no differences in the objective measurements between genders (Wolfart et al., 2006)

The variation of views among the current studies and previous studies could be explained due to the lack of the standardization of the protocol used to evaluate the gold proportion. Besides, the differences in racial characteristics might influence such variation (Hasanreisoglu et al., 2005).

In general, this study agrees with other studies estimate that no gold standard exists in nature. The optimal width-to-height ratio of upper central incisors is the dominating aesthetic factor and should be considered in restoring upper maxillary teeth.

Within the limitations of the study, it was observed that the participants' selected in the current study was random and not based on obvious esthetics. Although, the sample size selected for the current study was comparable with previous studies, however, increase in the sample size is recommended to obtain definitive conclusions Accordingly, for future study it is highly recommended considering more specific samples having "The Agreeable Smile" criteria in order to increase the possibility of matching the golden proportion standards and leading the results to be significant. Also, Rosenstiel, Ward & Rashid, rec-

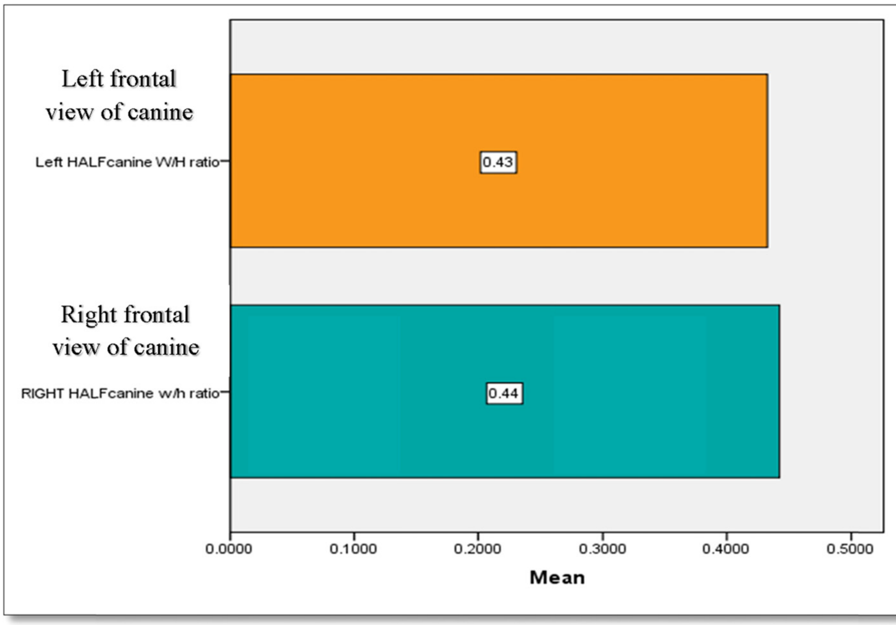

Fig. 5 Comparison between mean scores of width to height ratio for canines.

ommended using a ratio of 70% instead of 80% (Rosenstiel et al., 2000). Many studies reported that to produce a satisfactory appearance instead of concentrating on a single ratio, such as the golden proportion, other ratios reflecting harmony among tooth lengths should be considered. (Mahshid et al., 2004; Rosenstiel et al., 2000; Shirinzad and Ahmady, 2004).

5. Conclusion

In both genders the golden proportion was not found to exist between the perceived widths of maxillary anterior teeth. No gold standard was detected for the width-to-height ratios of maxillary incisors except for male participants where mean width to height ratio for the right lateral incisor was found close to the golden proportion of 0.80. Therefore, in addition to the golden proportion measurement, specific population characteristics and perception of an "agreeable smile" should be considered in future studies in order to evaluate esthetics.

Conflict of interest

None of the authors that were a part of the study in any capacity have any shape, size or form of conflict of interest to declare.

Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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