Scientific Research Publishing

Biometric Assessment of Maxillary Anterior Tooth Dimensions in a Hong Kong SAR Population

Ho Yin Chan, Brian J. Millar

Faculty of Dentistry, Oral & Craniofacial Sciences, King's College London, London, UK
Email: brian.millar@kcl.ac.uk

Abstract

Objectives: To study the biometric dimensions of upper front teeth in a Hong Kong SAR population including gender differences and compare this with the often recommended use of the Golden Proportion when selecting tooth proportions. **Methods**: A sample of dental casts was obtained from 100 patients: 50 females and 50 males with an age range from 18 to 35 years. The sample was selected based on the criteria of intact maxillary anterior dental arches, free from imbrications and crowding, no restorations or replaced teeth in the upper front teeth. The width and length of the 600 upper anterior teeth included in the casts were measured, together with the combined upper anterior tooth width for each cast. Analysis of width/height ratio, sexual dimorphism, and golden proportions was statistically analyzed. The data was analysed by SPSS using one-sample t-test, two-sample t-test, and paired t-test. **Results**: Most measurements had a normal distribution. Paired sample t-test revealed that the average length of male maxillary incisors is significantly higher than female maxillary incisors, while there is no obvious difference in maxillary incisor width. The mean width/length ratio of maxillary incisors ranges from 0.78 to 0.87. The mean values of maxillary apparent tooth width prove that the golden proportion (GP) ratio 1.618 was absent in the current sample. The current study data shows that the mean values of tooth width and length differed from some other populations. **Conclusions**: Based on the findings of this research, there is no statistically significant difference in the maxillary anterior tooth dimensions for the right and left sides of the arch. Length and width dimensions of the central incisor (CI) were greater than those of lateral incisor (LI) and Canine (C) for both genders, suggesting CI to be the dominant anterior tooth. Some gender differences in tooth dimensions, with males tend to have longer tooth dimensions than females, the average width/length ratio of the female is higher than male,

which confirms that the male tends to have longer teeth. The result shows the absence of golden proportion (GP) ratios suggesting that the Golden Proportion guideline was not applicable for the Hong Kong SAR population for either gender.

1. Introduction

A pleasing dental smile is psychologically significant to patients and they associate it with the success of the dental treatment [1] and dental aesthetics is becoming one of the primary reasons for patients to seek dental treatment [2]. Nowadays clinicians are increasingly faced with redesigning the teeth in the smile zone, often referred to smile design, where the width and length of the upper anterior teeth in particular are changed. The guidelines used in reshaping these teeth to produce a harmonius and attractive result may be based on historical data from one population that is less ideal for other racial groups. There is also a perception of gender differences in teeth. While the relative dimensions of anterior teeth are one of the most important objective criteria within the aesthetic checklist because of their clinical relevance however, aesthetically pleasing objectives may vary with different ethnicities.

In many dental anatomy textbooks and journals, the teeth dimensions presented were derived from direct measurements of the skulls [3] [4]. Those measurements determined the distance from the cementoenamel junction (CEJ) to the incisal tip, without consideration of gingiva, and hence it is not the true clinical crown height that applies in chair-side usage. Moreover, they lacked specific information about the skull including age, gender, racial group as well as the overall sample size.

The individual tooth proportion (ITP) referring to individual tooth width and length and intra-arch proportion (IAP) referring to tooth-to-tooth ratio from a direct frontal view (Figure 1) of maxillary anterior teeth also have been considered as a key factor for aesthetic dentistry and a harmonious tooth arrangement [5].
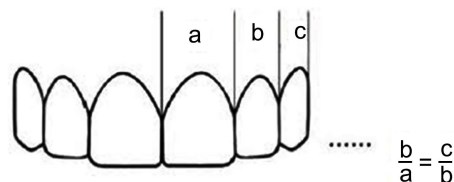

$$\frac{b}{a} = \frac{c}{b}$$

Figure 1. IAP, The proportion of the width of maxillary front teeth from the direct frontal view. If b = 0.1618a and c = 0.1618b then this also conforms to the golden proportion.

A frequently quoted IAP relationship is the golden proportion (GP) but this remains a controversial topics in aesthetic dentistry since Levin and Lombardi published the original work [6] [7]. The concept of GP was based on a theory that in nature there is a relationship which exists between beauty and mathematics. Such beauty ratio is around 1.618:1. That means it will reach a visual harmony when the size of the smaller section is almost 62% of that of the larger one. Applying this ratio to aesthetic teeth dimension (Figure 1), the upper central incisor (CI) would be in golden proportion to the lateral incisor (LI) if the ration of CI:LI is 1.618:1.0. Levin also designed a grid with straight line defining the spaces in golden proportion and recommended that such a grid can be used to evaluate and develop well-proportioned teeth [6].

Preston[7] discredited the concept of Golden Proportion and suggested that it may exist in nature but is not that common in natural dentitions, with an occurrence of only around 17%. He measured 58 computer-generated images of dental casts with software and evaluated the frequency of the golden proportion (taking the range of 0.61 - 0.63) in the ratios of the maxillary lateral incisors to central incisors, and canine to lateral incisors [7]. He concluded that GP in natural teeth was uncommon and the average perceived maxillary lateral-to-central incisor ratio was around 0.66 and the mean perceived maxillary canine-to-lateral incisor ratio was around 0.84. Recent studies also suggest a lack of evidence to support the existence of the GP in natural dentitions and conclude that GP does not exist or is not aesthetically pleasing to dental profession or layman [8] [9] [10].

However the GP continues to be frequently cited world-wide as an aesthetic guideline in maxillary anterior teeth restoration [11] [12] [13] [14] which causes confusion for the dental team. Although GP is suggested in many literature and textbook as a useful guideline for achieving harmony proportion and aesthetics, no consensus is made on when and how we should apply this golden proportion concept on handling aesthetic cases. One factor contributing to this could be ethnic variation: it is possible that GP exists in some racial groups and not others, explaining why some clinicians recommend it while other studies disprove it.

Tooth size varies between different ethnic groups [15] [16] [17] [18]. Gender variation in tooth size has been noted in many ethnical groups, with teeth of men being typically wider and longer than those of females [19] [20] [21]. While some races reveal there is no sexual dimorphism [22]. This may explain why GP applies in some groups and not others while there is a lack of data on tooth dimensions in the Hong Kong SAR population.

The aim of the current study was to investigate a Hong Kong SAR population (18 - 35 years of age) to determine:

- The width and length of maxillary anterior teeth.
- The presence of sexual dimorphism.
- The width/length ratios of maxillary anterior teeth.
- To determine if there is a statistically strong correlation between the Golden

Proportion Ratio and teeth width & length dimension is applicable to this population.

2. Materials and Methods

This analysis of study casts was designed to provide data on anterior teeth from a Hong Kong SAR population and was approved and conducted according to the requirements of the Research Ethics Committee of King's College London (MRS-18/19-10999) and was performed in accordance with the Declaration of Helsinki.

Subject Recruitment Criteria:

The selection criteria for the study:

- People of Chinese/Far East origin, 18 - 35 years of age.
- Intact and sound upper and lower anterior dental arches without imbrications or crowding.
- There should be no restoration or prostheses.
- Absence of abnormal or pathological tooth wear or interproximal reduction having been carried out on the anterior teeth for orthodontic purposes.

The exclusion criteria included:

- Current or stabilized periodontal disease including gingival recession.
- Anterior spacing or diastema.
- Allergic to alginate impression material or impression tray adhesive.
- Severe gag reflex for taking maxillary impressions.
- Unclear gender or racial data, or damaged models.

There are 100 patients included in this study, with 50 males and 50 females. Study models were taken from their maxillary arches. Only local southern Chinese Hong Kong patients are selected.

After explanation and obtaining consent, alginate impressions were taken from the upper arch, covering all the maxillary front teeth with extension up to at least the first molar. High definition alginate impression material was used with stock impression trays. Impressions were rinsed, disinfected, wrapped in damp gauze, identified by the patient's hospital number and cast in dental gypsum within 30 mins after being removed from the mouth. After 24 hours air dry in room temperature, the stone casts were trimmed and returned for measurement.

The tooth length (lowest point on the incisal edge to the most cervical point of the labial surface of the clinical crown in mm perpendicular to the occlusal plane) and width (greatest mesiodistal, labial surface dimension in mm at the level of the contact point parallel to the occlusal plane) of the six maxillary front teeth included in each set of casts were measured using precision calipers (Figure 2). In order to have a consistent measurement value, each measurement was repeated, at least 3 times. To prevent operator fatigue, measurement was limited to 10 casts at a time. After two weeks, one sample in every ten casts was randomly selected to repeat the measurement to test the error of the method. Some studies have used photographs to analyse GP but this study used study casts to obtain accurate dimensional measurements.
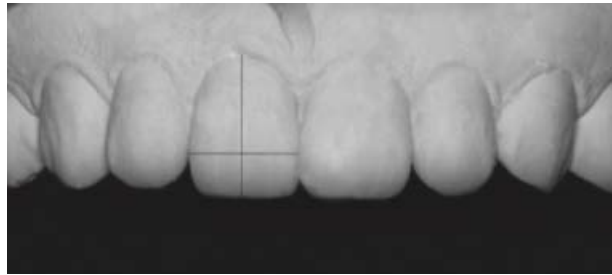
Figure 2. Study cast displaying tooth length and width measurements carried out.

Upper anterior arch length (from the distal contact of one canine, across the labial surfaces of the anterior teeth to the distal contact of the contralateral canine) was measured (mm) using dental floss and a flexible ruler.

Each maxillary stone model was put on a piece of blank paper and the apparent width of the anterior teeth, as seen from a frontal view, was marked, to create a Levin's grid for that specific case. The width of each element of the grids was measured (mm), using a divider and a ruler as in previous studies [23] [24].

The data collected was analyzed with SPSS v25 software. The range, mean, standard deviation of width and length of the teeth was calculated according to the gender. The paired sample t-test were performed to compare male and female mean value of tooth dimensions. Also, independent sample t-tests were performed to determine if there is any gender differences in the width, length, and width/length ratio in related to tooth type. The level of statistical significance was set at $p < 0.05$.

3. Results

There were one hundred pairs of study casts investigated this study, including 50 females and 50 males.

3.1. Tooth Width, Length and Width/Length Ratio

Table 1 and Table 2 show the mean value of the direct measurement according to gender. For all tooth types, the male teeth are recorded as having grater width and length with a statistically significant gender difference in length measurements($p < 0.05$). The length of the male incisor is significantly greater than the incisors of the female. However for the width there is no such significant difference($p > 0.05$).

Comparing contralateral teeth (e.g. 22 vs 12) there was no statistically significant differences in width and length for all tooth types, regardless of gender. The width/length ratio data obtained were shown in Table 3. The width/length ratios of females are statistically higher ($p < 0.05$) than the width/length ratios of males in all tooth type. The inter-tooth ratios comparing each tooth with the adjacent tooth are summarised in Table 4. There were no significant gender differences in tooth ratio.

Table 1. The mean (mm) standard deviation (SD) range (R) and 95% confidence interval (95% CI) of the widths and lengths of upper anterior tooth types according to size and gender.

	Upper Anterior Teeth					
	13		12		11	
	Width	Length	Width	Length	Width	Length
Male	7.35 (0.18)	9.07 (0.19)	6.23 (0.16)	8.10 (0.20)	7.99 (0.18)	9.62 (0.18)
Range	5.00	7.5	4.00	5.00	4.50	5.9
95% CI	7.00 - 7.71	8.70 - 9.45	5.91 - 6.55	7.71 - 8.49	7.64 - 8.35	9.25 - 9.99
Female	7.2 (0.18)	8.19 (0.23)	6.18 (0.17)	7.27 (0.18)	7.60 (0.16)	8.70 (0.18)
Range	5.1	8	4.50	5.30	4.50	6.00
95% CI	6.84 - 7.57	7.73 - 8.66	5.83 - 6.53	6.90 - 7.63	7.28 - 7.92	8.33 - 9.07
	23		22		21	
Male	7.38 (0.19)	9.06 (0.22)	6.31 (0.16)	8.27 (0.20)	7.94 (0.18)	9.77 (0.18)
Range	4.2	6.5	4.50	5.00	4.90	5.00
95% CI	7.04 - 7.71	8.62 - 9.51	5.99 - 6.62	7.83 - 8.67	7.58 - 8.29	9.40 - 10.12
Female	7.03 (0.19)	8.18 (0.21)	6.04 (0.18)	7.24 (0.17)	7.50 (0.17)	8.74 (0.17)
Range	5.2	8.00	4.6	5.50	4.5	5.30
95% CI	6.65 - 7.41	7.76 - 8.61	5.69 - 6.39	6.90 - 7.60	7.15 - 7.85	8.40 - 9.08

Table 2. The mean (mm) s.d, range and 95% CI of the widths and lengths of upper anterior tooth types according to gender.

	Upper Anterior Tooth Groups					
	Central Incisor		Lateral Incisor		Canine	
Gender	Width	Length	Width	Length	Width	Length
Male	7.96	9.69	6.27	8.19	7.37	9.07
Range	5.1 - 10.10	6.1 - 12.0	6.05 - 6.49	5.1 - 11.0	5.0 - 10.0	5.0 - 12.5
95% CI	7.72 - 8.21	9.44 - 9.95	4.0 - 8.5	7.91 - 8.46	7.12 - 7.6	8.78 - 9.36
Female	7.55	8.72	6.11	7.26	7.12	8.25
Range	5.1 - 9.6	6.0 - 12.0	4.0 - 8.6	5.0 - 10.5	4.9 - 10.1	5.0 - 13.0
95% CI	7.32 - 7.78	8.48 - 8.97	5.86 - 6.35	7.01 - 7.50	6.86 - 7.37	7.95 - 8.55

Table 3. Mean width/length ratios (s.d), range and 95% CI of tooth types according to gender (Pooled). (UCI-upper central incisor, ULI-upper lateral incisor, UC-Upper canine).

	Upper Anterior Tooth Groups		
Gender	UCI	ULI	UC
Male - Mean (SD)	0.82 (0.010)	0.78 (0.012)	0.82 (0.011)
Range	0.56 - 1.11	0.53 - 1.17	0.5 - 1.14
95% CI	0.80 - 0.84	0.75 - 0.80	0.80 - 0.84
Female - Mean (SD)	0.87 (0.11)	0.86 (0.012)	0.87 (0.012)
Range	0.61 - 1.14	0.48 - 1.12	0.6 - 1.3
95% CI	0.85 - 0.89	0.83 - 0.87	0.85 - 0.90

Table 4. Inter tooth width/width and length/length ratios (s.d), R, and 95% CI according to gender.

Tooth Type						
	UCI/ULI		ULI/UC		ULI/UC	
Gender	Width	Length	Width	Length	Width	Length
Male	1.28 (0.015)	1.20 (0.013)	1.09 (0.012)	1.08 (0.014)	0.91 (0.013)	0.85 (0.009)
Range	0.85 - 1.75	0.91 - 1.55	0.80 - 1.44	0.78 - 1.45	0.6 - 1.27	0.63 - 1.09
95% CI	1.25 - 1.31	1.17 - 1.22	1.06 - 1.11	1.05 - 1.11	0.88 - 0.94	0.84 - 0.87
Female	1.26 (0.016)	1.21 (0.123)	1.07 (0.013)	1.07 (0.013)	0.89 (0.012)	0.86 (0.013)
Range	0.98 - 1.75	0.85 - 1.59	0.75 - 1.59	0.76 - 1.42	0.64 - 1.36	0.51 - 1.2
95% CI	1.22 - 1.29	1.19 - 1.24	1.05 - 1.10	1.05 - 1.10	0.86 - 0.92	0.84 - 0.89

3.2. Canine-Canine Arch Perimeter

The mean value of the canine-canine arch perimeter obtained by using flexible tape is 53.2 mm (SD-3.99 mm; 95% CI: 52.4 - 54.0). The mean sum of the individual mesiodistal width of all the upper anterior teeth by measurement is 42.4 mm (SD-6.72; 95% CI: 41.0 - 43.7). There was a statistically significant difference between the mean flexible tape measurement and the mean sum of mesiodistal width of all upper anterior teeth.

3.3. Golden Proportion Estimation

The mean apparent width ratio is obtained by finding the mean of the apparent width of each tooth type as related to the apparent widths of the lateral incisor of the same side as shown in Table 5. All these mean values indicate that the golden proportion (GP) was absent in the current sample.

For Central Incisor/Lateral Incisor ratio, only 5.5% of females and males had a GP ratio in the range 1.6 - 1.7. The Fisher Exact test did not show the gender to be statistically significant ($p > 0.05$). For Canine/ Lateral Incisor, only 4% of the female and 4.5% of males have a ratio in the range 0.6 - 0.7. The Fisher Exact test did not show the gender to be statistically significant ($p > 0.05$).

4. Discussion

The Hong Kong SAR population is an admixture of people from locals and immigrants from southern China. Despite careful planning and designs of the study, the current research suffered from some limitation. These include the relatively limited sample size, only recruiting attenders to the teaching dental hospital. The lack of precision in measuring the teeth was found to be small. However the true length of the tooth is debatable. Either the CEJ or the gingival zenith can be used as the apical landmark for the tooth length measurement. The measurement based on the CEJ is more precise than the marginal gingivae because the gingival level might be affected by inflammation and periodontal condition while CEJ is a fixed point. The current study used the gingival zenith as an apical reference point because of clinical relevance.

Table 5. Mean apparent width ratios relative to the upper lateral incisor according to gender.

	Ideal Portion	Mean	95% CI		Coefficient of Variation
Male			Lower	Upper	
UCI/ULI	1.618	1.389	1.328	1.450	0.094
ULI/ULI	1.000	1	1	1	1
UC/ULI	0.618	0.898	0.859	0.936	0.038
Female					
UCI/ULI	1.618	1.376	1.329	1.422	0.054
ULI/ULI	1.000	1	1	1	0
UC/ULI	0.618	0.884	0.848	0.920	0.033

The rank order of the teeth (from largest to smallest) according to both the width and length was: Upper central incisor > upper canine > upper lateral incisors. The same results were obtained from other studies [22]-[29].

It is a common thought to assume that the right and left teeth are similar in dimension but Marvoskoufis [30], measured 140 central incisors and reported that 86% - 90% did not have the same dimension or form of maxillary central incisors. Another similar study did not identify [31] any significant differences after measuring 658 incisors. Regrettably, no overall conclusion could be made, as many publications neglect to mention the method of measurement, the racial origins of their subjects and the sample size. Two teeth can be different in the outline form but having the same dimension on measurement. This is because the measurements can be made on different reference points and reference points may follow different curvatures.

In the present study, no statistically significant differences can be found on measuring the width and length of contralateral maxillary anterior teeth, regardless of gender. This finding is helpful when considering the symmetry of upper anterior teeth during orthodontic and prosthodontic treatment.

Sexual dimorphism has been found and reported for most of the studies [22] [32], most of them tend to show that teeth of men are larger than those of women. This result is applicable to all the teeth in different ethnic groups, but it was found that canines of both maxilla and mandible show the largest degree of sexual dimorphism. Lavelle [26] had measured dental casts of 40 male and 40 female subjects. A mean difference of 0.3 mm in the maxillary central incisors, with a mesiodistal diameter of 8.40 mm & 8.1 mm for male and female respectively. Moorees and his co-workers[27] found a difference of 0.38 mm with a sample from 87 male and 87 female subjects (8.78 and 8.40 mm mesio-distal width to male and female respectively) and found that this difference happened in the whole range of values, from 7.9 - 10.1 mm for male and from 7.1 - 9.8 mm for female subjects.

In the current study, the male teeth were larger than the equivalent female

teeth with the mean length of maxillary anterior of the male was found to be significantly ($p < 0.05$) higher than those of female, while there was no significant difference in widths of all tooth type. The mean difference is around 1mm which could be relevant during treatment planning.

It is suggested that the width/length ratio would be a useful guide on the restoration and replacement of upper anterior teeth, with such ratio define the relative shape and forms of the teeth. In the present study, the width/length ratio of female in all tooth type is higher than those of male, due to the previous finding that the length value of upper anterior teeth is significantly higher in male compared to female. This data indicates that in the population in the present study, the male upper anterior teeth are longer than slender on average comparing to female. According to the data of the present study, the width/length ratio of central incisor and canine is around 80% in both groups of male and female. Various papers have a conclusion that is the maxillary front teeth should have a width/height ratio of around 80% to result a satisfactory and pleasing appearance [25].

Arch perimeter estimates using a flexible ruler (measuring tape) were consistently greater (>5 mm) than the sum of the widths of individual teeth in the arch, excluding any arches including imbrications and diastema. The observed difference may be related, at least in part, to the convexity of the teeth included in an arch and tooth alignment, whereby the nature of the proximal contact between teeth resulted in an increase in the arch perimeter estimate, relative to the sum of the mesiodistal widths as measured at right angles to the labial surfaces of the teeth. This finding suggests that if arch perimeter estimates are to be used clinically, the method used should be stipulated, or at least two estimates provided one using a flexible ruler and the other based on the sum of the mesiodistal dimensions of the relevant teeth. In this way, a measure of the range of possible arch perimeter estimates may be recorded and communicated as appropriate.

The mean arch perimeter estimates recorded in the present study using a flexible rule were similar to those reported in previous studies using similar techniques [33] [34] [35].

The mean values of the width and length of the canine, lateral incisor and central incisors obtained in the current study were comparable with data reported by Sanjay *et al.* 2014 [36] and Beyuo & Wilson [23] and Shetti *et al.* [24] where similar measurement methods were used in different populations. Between-group differences were evaluated for statistical significance by the independent sample t-test ($p < 0.05$). Comparing the data from the present study to the data reported by Beyuo & Wilson [23] the mean values of width and length of all tooth type from the current study were significantly lower than values obtained from a Zimbabwean population, except the length of male central and lateral incisors.

Comparing the present study to the work by Sah *et al.* [21], the female means values of width and length of all tooth type were statistically significantly lower ($p < 0.05$) in the present study. The width of the lateral incisor and canine of the

male were significantly lower (p < 0.05).

In the present study, the width/length ratio of female upper lateral incisors and the female upper canine did not show a statistically significant difference to data reported by Beyuo & Wilson [23] while the mean values of the width/length ratio of other tooth types were significantly lower(p < 0.05).

The theory of golden proportion in dentistry seems controversial. It was first proposed by the Pythagoreans and had been previously identified by the ancient Egyptians as the golden number 1.618. Lombardi [36] was the first one in dentistry to nominate the use of the golden proportion. Levin pointed out that the width of the maxillary lateral incisor is in the golden proportion to the width of the central incisor and also the width of the maxillary canine to the lateral incisor when viewing from the front.

Since this theory was proposed, many studies tried to assess the existence of GP in the population [3] [37]. Recent studies on specific racial groups in India [38] [39] [40], Zimbabwe [23], Saudi Arabia [41], Malaysia [42] and China [43] have all agreed that GP has a very low incidence and should not be relied on.

Application of GP gives the results of abnormally constricted arch with a narrow canine when viewing from the front. There is a study produced computerized artificial frontal smile images to be ranked by the dentist, the GP ratios images were shown to be the least pleasing in appearance [8].

In the present study GP ratios could only be determined in a few samples and so cannot be recommended as a guide. In measuring the central incisor/lateral incisor ratio and canine/lateral incisor ration, there is only 5.5% and 4% of the measurement closed to the GP ration 1.618 respectively.

Shillingburg and his co-workers suggested that the golden proportion to be around 0.6. [12]. The golden proportion was not found to exist although the range was wide (0.55 - 0.64). The absence of GP ratio was the norm and therefore the GP ratio could not be recommended as a guide in developing an aesthetically pleasing anterior dentition.

Due to objective judgement and the variety in our nature, pure mathematic formula cannot be applied in aesthetic dentistry. Individual variation and individualised aesthetic judgement should be born in mind. Although we should follow some fundamental dental asethetic guidelines during our treatment planning, we should be reminded that aesthetics may vary greatly from person to person. It is important for us to consider the "big picture" dentofacial aesthetic of each individual and the wide variety of natural teeth proportions when restoring or replacing the maxillary anterior teeth. In addition, the patient's objective judgment of beauty and individual cultural characteristics must be respected.

While research had been done to evaluate the tooth size dimension and width/length proportion in the past most was carried out in Western Caucasian populations [32] [4] [44]. Therefore, although the maxillary tooth width/length ratio has been seen as one of critical and valuable factor for getting a satisfactory

aesthetic outcome in the maxillary aesthetic region this was based on the Western Caucasian research data. The present paper shows variations do exist between different ethnic populations and therefore dentists and laboratory technician should take the ethnic group variation into account during the prosthetic or restoration treatment in the maxillary aesthetic region.

5. Conclusions

According to the findings of this research, there was no significant statistical difference in maxillary front tooth dimensions between the right and the left sides of the maxillary arch.

The only gender difference was males tending to have larger teeth and longer teeth than females, resulting in the average width/length ratio of the female higher than male.

The Golden Proportion ratio was not applicable for the Hong Kong SAR population for either gender. While general rules can be a guide in smile design, individual factors should be taken into account and the often advised of Golden Proportion cannot be recommended.

There was no external funding for this study.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Davis, L., Ashworth, P. and Spriggs, L. (1998) Psychological Effects of Aesthetic Dental Treatment. *Journal of Dentistry*, **26**, 547-554. https://doi.org/10.1016/S0300-5712(97)00031-6

[2] Larsson, P., John, M., Nilner, K. and List, T. (2013) Normative Values for the Oro-Facial Esthetic Scale in Sweden. *Journal of Oral Rehabilitation*, **41**, 148-154. https://doi.org/10.1111/joor.12121

[3] Gillen, R.J., Schwartz, R.S., Hilton, T.J. and Evans, D.B. (1994) An Analysis of Selected Normative Tooth Proportions. *International Journal of Prosthodontics*, **7**, 410-417.

[4] Sterrett, J., Oliver, T., Robinson, F., Fortson, W., Knaak, B. and Russell, C. (1999) Width/Length Ratios of Normal Clinical Crowns of the Maxillary Anterior Dentition in Man. *Journal of Clinical Periodontology*, **26**, 153-157. https://doi.org/10.1034/j.1600-051X.1999.260304.x

[5] Ward, D.H. (2001) Proportional Smile Design Using Recurring Esthetic Dental (Red) Proportion. *Dentistry Clinical North America*, **45**, 143-154. https://doi.org/10.1016/S0011-8532(22)00473-6

[6] Levin, E. (1978) Dental Esthetics and the Golden Proportion. *The Journal of Prosthetic Dentistry*, **40**, 244-252. https://doi.org/10.1016/0022-3913(78)90028-8

[7] Preston, J. (1993) The Golden Proportion Revisited. *Journal of Esthetic and Restorative Dentistry*, **5**, 247-251. https://doi.org/10.1111/j.1708-8240.1993.tb00788.x

[8] Rosenstiel, S., Ward, D. and Rashid, R. (2000) Dentists' Preferences of Anterior

Tooth Proportion—A Web-Based Study. *Journal of Prosthodontics*, **9**, 123-136. https://doi.org/10.1053/jopr.2000.19987

[9] Mahshid, M., Khoshvaghti, A., Varshosaz, M. and Vallaei, N. (2004) Evaluation of "Golden Proportion" in Individuals with an Esthetic Smile. *Journal of Esthetic and Restorative Dentistry*, **16**, 185-192. https://doi.org/10.1111/j.1708-8240.2004.tb00032.x

[10] Basting, R., Trindade, R. and Flório, F. (2006) Comparative Study of Smile Analysis by Subjective and Computerized Methods. *Operative Dentistry*, **31**, 652-659. https://doi.org/10.2341/06-24

[11] Rufenacht, C.R. (2000) Principles of Esthetic Integration. Quintessence, Chicago, 160-165.

[12] Shillingburg, H.T., Hobo, S., Whitsett, L.D., Jacobi, R. and Brackett, S.E. (1997) Fundamentals of Fixed Prosthodontics. 3rd Edition, Quintessence, Chicago, 422-423.

[13] Goldstein, R.E. (1998) Esthetics in Dentistry. 2nd Edition, BC Decker, Hamilton, 189-191.

[14] Marcushamer, E., Tsukiyama, T., Griffin, T.J., Arguello, E., Gallucci, G.O. and Magne, P. (2011) Anatomic Crown Width/Length Ratios of Unworn Maxillary Teeth in Asian Subjects. *International Journal of Periodontics & Restorative Dentistry*, **31**, 495-503.

[15] Bishara, S., Jakobsen, J., Abdallah, E. and Fernandez Garcia, A. (1989) Comparisons of Mesiodistal and Bnccolingnal Crown Dimensions of the Permanent Teeth in Three Populations from Egypt, Mexico, and the United States. *American Journal of Orthodontics and Dentofacial Orthopedics*, **96**, 416-422. https://doi.org/10.1016/0889-5406(89)90326-0

[16] Keene, H. (1979) Mesiodistal Crown Diameters of Permanent Teeth in Male American Negroes. *American Journal of Orthodontics*, **76**, 95-99. https://doi.org/10.1016/0002-9416(79)90303-8

[17] Mack, P. (1981) Maxillary Arch and Central Incisor Dimensions in a Nigerian and British Population Sample. *Journal of Dentistry*, **9**, 67-70. https://doi.org/10.1016/0300-5712(81)90037-3

[18] Otuyemi, O. and Noar, J. (1996) A Comparison of Crown Size Dimensions of the Permanent Teeth in a Nigerian and a British Population. *The European Journal of Orthodontics*, **18**, 623-628. https://doi.org/10.1093/ejo/18.6.623

[19] Orozco-Varo, A., Arroyo-Cruz, G., Martínez-de-Fuentes, R. and Jiménez-Castellanos, E. (2015) Biometric Analysis of the Clinical Crown and the Width/Length Ratio in the Maxillary Anterior Region. *The Journal of Prosthetic Dentistry*, **113**, 565-570.e2. https://doi.org/10.1016/j.prosdent.2014.11.006

[20] Calcada, D., *et al.* (2014) Anthropometric Analysis of Anterior Maxillary Teeth with Digital Photography—A Study in a Portuguese Sample. *International Journal of Esthetic Dentistry*, **9**, 370-380.

[21] Sah, S.K., *et al.* (2014) Maxillary Anterior Teeth Dimensions and Proportions in a Central Mainland Chinese Population. *Chinese Journal of Dental Research*, **17**, 117-124.

[22] Hasanreisoglu, U., Berksun, S., Aras, K. and Arslan, I. (2005) An Analysis of Maxillary Anterior Teeth: Facial and Dental Proportions. *Journal of Prosthetic Dentistry*, **94**, 530-538. https://doi.org/10.1016/j.prosdent.2005.10.007

[23] Beyuo, F. and Wilson, N.H.F. (2016) Assessment of Upper Anterior Tooth Dimensions and Relationships in a Young Adult Black Urban Zimbabwean Population. *EC*

Dental Science, **5**, 949-963.

[24] Shetty, T., Beyuo, F. and Wilson, N.H.F. (2017) Upper Anterior Tooth Dimensions in a Young-Adult Indian Population in the UK: Implications for Aesthetic Dentistry. *British Dental Journal*, **223**, 781-786. https://doi.org/10.1038/sj.bdj.2017.986

[25] Brisman, A. (1980) Esthetics: A Comparison of Dentists' and Patients' Concepts. *Journal of the American Dental Association*, **100**, 345-352. https://doi.org/10.14219/jada.archive.1980.0093

[26] Lavelle, C. (1972) Maxillary and Mandibular Tooth Size in Different Racial Groups and in Different Occlusal Categories. *American Journal of Orthodontics*, **61**, 29-37. https://doi.org/10.1016/0002-9416(72)90173-X

[27] Moorrees, C. and Reed, R. (1964) Correlations among Crown Diameters of Human Teeth. *Archives of Oral Biology*, **9**, 685-697. https://doi.org/10.1016/0003-9969(64)90080-9

[28] Rosenstiel, S.F., Land, M.F. and Fujimoto, J. (2001) Contemporary Fixed Prosthodontics. 3rd Edition, CV Mosby, St. Louis, 598-599.

[29] Condon, M., Bready, M., Qunin, F., O'Connell, B., Houston, F. and O'Sullivan, M. (2010) Maxillary Anterior Tooth Dimensions and Proportions in an Irish Young Adult Population. *Journal of Oral Rehabilitation*, **38**, 501-508. https://doi.org/10.1111/j.1365-2842.2010.02181.x

[30] Mavroskoufis, F. and Ritchie, G. (1980) Variation in Size and Form between Left and Right Maxillary Central Incisor Teeth. *Journal of Prosthetic Dentistry*, **43**, 254-257. https://doi.org/10.1016/0022-3913(80)90398-4

[31] Garn, S., Lewis, A. and Kerewsky, R. (1964) Sex Difference in Tooth Size. *Journal of Dental Research*, **43**, 306-306. https://doi.org/10.1177/00220345640430022401

[32] Magne, P., Gallucci, G. and Belser, U. (2003) Anatomic Crown Width/Length Ratios of Unworn and Worn Maxillary Teeth in White Subjects. *The Journal of Prosthetic Dentistry*, **89**, 453-461. https://doi.org/10.1016/S0022-3913(03)00125-2

[33] Goncalves, L., Gomes, V., De Lima Lucas, B. and Monteiro, S. (2009) Correlation between the Individual and the Combined Width of the Six Maxillary Anterior Teeth. *Journal of Esthetic and Restorative Dentistry*, **21**, 182-191. https://doi.org/10.1111/j.1708-8240.2009.00260.x

[34] Scandrett, F., Kerber, P. and Umrigar, Z. (1982) A Clinical Evaluation of Techniques to Determine the Combined Width of the Maxillary Anterior Teeth and the Maxillary Central Incisor. *Journal of Prosthetic Dentistry*, **48**, 15-22. https://doi.org/10.1016/0022-3913(82)90041-5

[35] Gomes, V.L., *et al.* (2006) Correlation between Facial Measurements and the Mesiodistal Width of the Maxillary Anterior Teeth. *Journal of Esthetic and Restorative Dentistry*, **18**, 96-205. https://doi.org/10.1111/j.1708-8240.2006.00019_1.x

[36] Lombardi, R. (1973) The Principles of Visual Perception and Their Clinical Application to Denture Esthetics. *Journal of Prosthetic Dentistry*, **29**, 358-382. https://doi.org/10.1016/S0022-3913(73)80013-7

[37] Isa, Z., Tawfiq, O., Noor, N., Shamsudheen, M. and Rijal, O. (2010) Regression Methods to Investigate the Relationship between Facial Measurements and Widths of the Maxillary Anterior Teeth. *Journal of Prosthetic Dentistry*, **103**, 182-188. https://doi.org/10.1016/S0022-3913(10)60028-5

[38] Chander, N.G., Kumar, V.V. and Rangarajan, V. (2012) Golden Proportion Assessment between Maxillary and Mandibular Teeth on Indian Population. *The Journal of Advanced Prosthodontics*, **4**, 72-75.

https://doi.org/10.4047/jap.2012.4.2.72

[39] Hegde, M. and Malhotra, S. (2016) Evaluation of Golden Proportion between Maxillary Anterior Teeth of South Indian Population. *The Open Dentistry Journal*, **2**, 137-141. https://doi.org/10.17140/DOJ-2-125

[40] Mahajan, V., Nagpal, A., Gupta, R., Vaidya, S., Jabeen, F., Thakur, K. (2019) Comparative Evaluation of Golden Proportion, Recurring Esthetic Dental Proportion and Golden Percentage in Himachal Demographic. *Journal of Advances in Medicine and Medical Research*, **29**, 1-7. https://doi.org/10.9734/jammr/2019/v29i1030133

[41] Abdallah, M.F., *et al.* (2021) Golden Standard and Golden Proportion of Maxillary Anterior Teeth among Saudi Population in Makkah. *Journal of International Society of Preventive and Community Dentistry*, **11**, 294-306.

[42] Al-Marzok, M.I., Majeed, K.R. and Ibrahim, I.K. (2013) Evaluation of Maxillary Anterior Teeth and Their Relation to the Golden Proportion in Malaysian Population. *BMC Oral Health*, **13**, Article No. 9. https://doi.org/10.1186/1472-6831-13-9

[43] Yang, H.X., Li, F.L. and Li, L. (2022) Esthetic Proportions of Maxillary Anterior Tooth among 300 Normal Occlusion College Students in Shanxi Province. *Chinese journal of Stomatology*, **57**, 352-357.

[44] Bailit, H.L. (1975) Dental Variations among Populations: An Anthropologic View. *Dental Clinics of North America*, **19**, 125-139. https://doi.org/10.1016/S0011-8532(22)00661-9