EVALUATING THE VALIDITY OF MATHEMATICAL PROPORTIONS IN MAXILLARY ANTERIOR TEETH IN JORDANIAN POPULATION

1AHMAD M ALHABAHBAH
2KHUZAMA K ABURUMMAN
3RAGHDA AL-SHAMOUT
4WASFI A ALMANASEER
5ALI IBRAHEEM ZYOD

ABSTRACT

Study was conducted to determine the best mathematical proportion that exists between the maxillary anterior teeth widths among Jordanian population.

A randomly selected 150 (78 male and 72 female) patients were subjected to clinical examination and maxillary teeth impressions. For each subject, a stone cast was placed on a flat surface and grid lines were drawn for the perceived width of the six anterior teeth and measured with a digital caliper. Width dimensions were quantified by geometric proportions, related to each other and compared with golden proportion, recurring esthetic dental proportion (RED) and golden percentage. Data were analyzed statistically using the Chi-square test and t-test (SPSS-V17.0) at 95% confidential interval. Level of significance was set to 0.05.

The mean age of subjects was 24.8±4.2 years, with insignificant gender differences. The mean perceived widths of anterior teeth were significantly larger for males compared to females, however, there were no right to left side differences. Golden proportion for the widths of central incisors to that of lateral incisors existed in 22% and in 11% for the widths of lateral incisors to that of canines. Females significantly had more values compared to males for the widths of central incisors to that of lateral incisors. The golden percentage was rather constant in terms of relative tooth width. The width of the central incisor represents 22.1%, the lateral incisor 14.7%, and the canine 9.8% of the width of the six maxillary anterior teeth as viewed from the front. The values of the RED proportion were not constant and existed in only 15% of subjects.

The golden proportion and RED were not existed between the perceived widths of maxillary anterior teeth. However, the golden percentage seems to be acceptable for Jordanian population.

Key Words: Maxillary anterior teeth, golden proportion, recurring esthetic dental proportion (RED), golden percentage, esthetic dentistry, Jordan.

INTRODUCTION

The perception of dental esthetics varies significantly among dental professionals, although substantial efforts have been made to establish common standards.1 Maxillary anterior teeth are the most prominent and important teeth in the smile. Knowledge of the ideal dimensions and proportions of maxillary anterior teeth is a key component in creating an attractive smile during operative, orthodontic, and prosthodontic procedures.2

Dimensions of maxillary anterior teeth are effect-ed by many factors like: sexual dimorphism, ethnic background, genetics, and environment, so it may vary significantly from person to person.3 So it is better to quantify the relationship between these dimensions by geometric proportions several theories have suggested to relate teeth dimensions to each other, such as golden proportion, recurring esthetic dental proportion (RED), and golden percentage.4

The size and form of the maxillary anterior teeth are important factors in dental and facial esthetics. The goal of dental techniques is to have the maxillary...
Validity of mathematical proportions in maxillary anterior teeth

anterior teeth restore optimal dentolabial relations in harmony with the overall facial appearance. Several studies have reported race and gender as effective factors in the average dimensions of maxillary anterior teeth. When evaluating the natural beauty of normal arches, we observe the presence of a mathematical relation: 1:1.618. This ratio is termed the divine or golden proportion; it is believed that this harmonic composition generates beauty and well-being to the human perception, providing equilibrium and symmetry.

When the Golden proportion formula is used, the lateral incisor appears too narrow and the resulting canine is not prevalent enough. Therefore, Ward introduced the RED Proportion concept, stating that clinicians may use a proportion of their own choice, as long as it remains consistent, proceeding distally in the arch. The successive width proportion, when viewed from the facial aspect, should remain constant as we move posteriorly from the midline. This offers great flexibility to match tooth properties with facial proportions. Generally, the values of the RED proportion used are between 60% and 80%.

Snow considered a bilateral analysis of apparent individual tooth width as a percentage of the total apparent width of the six anterior teeth. He proposed the golden percentage wherein the proportional width of each tooth should be: canine 10%, lateral 15%, central 25%, central 25%, lateral 15%, and canine 10% of the total distance across the anterior segment in order to achieve an esthetically pleasing smile.

Finding the most accurate proportion between maxillary anterior teeth widths will facilitate distributing the space when restoring the anterior segment or during orthodontic treatment. The null hypothesis of the study was that the golden proportion, RED and golden percentage is not existed in maxillary anterior teeth widths among Jordanians. Therefore this study was conducted to investigate the best mathematical proportion that existed between the maxillary anterior teeth widths in a young Jordanian population.

METHODOLOGY

A cross-sectional study of fully dentate Jordanian males and females in the City of Amman, who attended the Conservative Clinics, Department of Dentistry, Al-Hussein Hospital, King Hussein Medical Center, Royal Medical Services. Random samples for the study were selected from the general population, who fulfilled objective diagnostic criteria and underwent clinical oral and dental examinations.

Ethical approval

The study was conducted for all patients who provided verbal informed consent after it was approved by Head of the Dental Specialities of the Department of Dentistry and The Human Research Ethics Committee (No:4 dated 7th March 2016) at the Royal Medical services.

Inclusion/exclusion criteria

Subjects with age ranged between 18 and 30 years who accepted to participate were fully dentate with complete set (with no missing of anterior) teeth, with no dental anomaly and with no history of congenital abnormality, no periodontal diseases and with no spacing, crowding, extruded, intruded, or rotated anterior teeth, those who were not exposed to any orthodontic treatment or orthognathic surgical procedure, and with no extensive restorative procedure (i.e. crown and bridge work); and accepted to undergo clinical oral and dental examination, were able to understand and agreed with procedures carried out and used (such as taking alginate maxillary impressions) in the study and who were willing to accept the protocol and gave informed consent were included. Exclusion criteria were subjects with history of orthognathic surgery, missing teeth, crown and bridge work, removable partial denture prostheses, as well as those who did not agree to participate.

Participants

A total of 150 (72 females and 78 males) fully dentate Jordanian subjects with mean age of 24.8±4.2 (ranged between 18 and 30) years; were subjected to clinical examination, a specially designed form concerning the patient’s demographic data including age, gender, medical insurance number, occupation and residence was filled by one of the authors.

Impressions, cast formation and Measurements

For each participant a maxillary arch impression was taken with irreversible hydrocolloid (alginate) impression material and poured in type II dental stone to form a stone cast (positive replica). The measurements were performed by placing the cast on a flat surface and a grid lines are drawn for the perceived width of the six anterior teeth (Fig 1) and measured using Fowler electronic digital caliper, the accuracy of the measurements was set at ±0.01 mm (Fig 2). Linear measurements were taken for central incisor, lateral incisor and canine on both sides and recorded on a specially designed sheet. Teeth dimensions were quantified by geometric proportions, related to each other and compared with golden proportion, recurring esthetic dental proportion (RED), and golden percentage.

In this study the golden proportion was taken as 62%. Therefore, for estimation of the existence of golden proportion the measured width of the central incisor was multiplied by 62% and compared with that of the adjacent lateral incisor. Similar values indicated that the width of the central incisor is in golden proportion.
Validity of mathematical proportions in maxillary anterior teeth

to the width of the lateral incisor. Similarly by comparing the width of the lateral incisor after multiplying by 62% with that of the canine, it was determined whether the width of the lateral incisor is in golden proportion to the width of the canine. The golden percentage was calculated by dividing the width of each central incisor, lateral incisor and canine by the total width of all six maxillary anterior teeth and multiplying the resulting value by 100. If the resulting width of the canines, lateral incisors and central incisors showed 10%, 15%, 25% respectively of the intercanine distance they were taken as following golden percentage. For RED proportion, ratio of the width of lateral incisor and central incisor was compared to that of canine and lateral incisor. Constant values indicated existence of RED proportion. The method of estimating geometric proportion was essentially the same as that reported by Azam et al.9

Methods error

Reliability of examiners was assessed by examining internal consistency and reproducibility. Clinical examinations and measurements were performed by two independent examiners (72 female subjects from one examiner and 78 males from another examiner). They used the same evaluation in the clinical examination for case selection and inclusion and standard method in the measurements. Inter-examiner variability and bias in evaluation were assessed by performing clinical examination 15 (10%) randomly selected subjects and re-measuring their casts by each examiner. Student’s t-test were performed for inter-examiner reliability evaluation.

Statistical analysis

Statistical analysis was performed using SPSS Statistic Version 17 (SPSS Corporation, Chicago, IL, USA). Student’s t-test were used to compare the means of dimension measured on the casts between genders. 2-sample t-test was used to compare differences in the mean widths between the right and left sides. Chi square test was used to test the association between the calculated ratios of the measured values in the study with those in geometric proportions. Ninety-five percent confidence intervals about the mean was constructed for differences. Level of significance was set at 0.05.

RESULTS

Paired t-test revealed no statistically significant deviation between the examiners’ clinical examination evaluation at a 5% significance level (in 93%). Paired t-test revealed no statistically significant deviation between the examiners’ measurements at a 5% significance level (mean difference 0.75±0.08; p = 0.854). As there was strong association and small mean difference between the two examiners, it was assumed that the other data collected from clinical examinations and measurement evaluations would be reliable.

TABLE 1: MEASUREMENTS OF THE PERCEIVED WITHDS OF MAXILLARY ANTERIOR TEETH IN RELATION TO GENDER

<table>
<thead>
<tr>
<th>Width</th>
<th>Central</th>
<th>Lateral</th>
<th>Canine</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>8.75 ±1.54</td>
<td>8.71 ±1.23</td>
<td>5.77 ±0.97</td>
<td>5.81 ±0.92</td>
</tr>
<tr>
<td>Female</td>
<td>8.31 ±1.06</td>
<td>8.35 ±1.18</td>
<td>4.91 ±0.85</td>
<td>4.89 ±0.77</td>
</tr>
<tr>
<td>Mean</td>
<td>8.53 ±1.35</td>
<td>8.54 ±1.20</td>
<td>5.34 ±0.92</td>
<td>5.36 ±0.85</td>
</tr>
<tr>
<td>t-test</td>
<td>4.16</td>
<td>3.92</td>
<td>2.76</td>
<td>2.95</td>
</tr>
<tr>
<td>P value</td>
<td>0.014</td>
<td>0.023</td>
<td>0.037</td>
<td>0.031</td>
</tr>
<tr>
<td></td>
<td>0.045</td>
<td>0.043</td>
<td>0.011</td>
<td>0.016</td>
</tr>
</tbody>
</table>

TABLE 2: GOLDEN PROPORTION RELATIONSHIP OF RIGHT AND LEFT SIDES OF MAXILLARY ANTERIOR TEETH IN MALE AND FEMALE SUBJECTS (PERCENTAGE OF TEETH IN GOLDEN PROPORTION)

<table>
<thead>
<tr>
<th></th>
<th>Central / Lateral</th>
<th>Lateral / Canine</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Male</td>
<td>18.6 %</td>
<td>20.4%</td>
</tr>
<tr>
<td>Female</td>
<td>23.4%</td>
<td>25.1%</td>
</tr>
<tr>
<td>Total</td>
<td>42.0%</td>
<td>45.5%</td>
</tr>
<tr>
<td>P value</td>
<td>0.0175</td>
<td>0.0241</td>
</tr>
<tr>
<td>chi test</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Mean %</td>
<td>21.9%</td>
<td>11.0%</td>
</tr>
</tbody>
</table>

*p value <0.05, NS: not significant
Validity of mathematical proportions in maxillary anterior teeth

Of the 150 subjects, there were 78 (52%) males with mean age 25.2±4.7 (ranged 21-30) and 72 (48%) females with mean age 24.4±3.7 (ranged 18-29) years. Females were slightly younger than males, but the difference were not significant (t-test=0.397; p=0.87).

The mean values of the perceived widths of right and left maxillary anterior teeth in both genders are shown in Table 1. Two-sample t-test revealed statistically significant gender differences in the mean perceived widths of maxillary anterior teeth. Significantly male subjects had wider anterior teeth than females (p<0.05). However, right-left side differences in the mean values of widths recorded were not significant.

Analyses of data using chi square test showed that significantly (p<0.05) female subjects recorded more central/lateral teeth in golden proportion compared to males. The golden percentage in right and left maxillary anterior teeth for male and female subjects is shown in Table 3. The ratios of lateral incisor to central incisor and canine to lateral incisor measured for both right and left sides for comparison with red proportion (paired t-test) are given in Table 4.

Table 5 presents the existence of the red proportion in maxillary anterior teeth. Of the 150 subjects, there were 78 (52%) males with mean age 25.2±4.7 (ranged 21-30) and 72 (48%) females with mean age 24.4±3.7 (ranged 18-29) years. Females were slightly younger than males, but the difference were not significant (t-test=0.397; p=0.87).

The mean values of the perceived widths of right and left maxillary anterior teeth in both genders are shown in Table 1. Two-sample t-test revealed statistically significant gender differences in the mean perceived widths of maxillary anterior teeth. Significantly male subjects had wider anterior teeth than females (p<0.05). However, right-left side differences in the mean values of widths recorded were not significant.

Analyses of data using chi square test showed that significantly (p<0.05) female subjects recorded more central/lateral teeth in golden proportion compared to males.
to males (48.5% vs 39.0%; respectively). However, there were no significant gender differences in lateral incisor/canine teeth ratios. In addition, right-left side differences for teeth in golden proportion were found insignificant. The results showed that 18.6% of males and 23.4% of females have the widths of their right central incisors in golden proportion to the width of their right lateral incisors. However, 9.7% of male subjects and 10.5% of female subjects have the widths of their right lateral incisors in golden proportion to the widths of their right canines. Moreover, the data shows 20.4% of the male subjects and 25.1% of the female subjects have the widths of their left central incisors in golden proportion to the widths of the left lateral incisors, while 11.5% of males and 12.4% of females have the widths of the left lateral incisors in golden proportion to the widths of their left canines (Table 2).

The golden percentage for male and female subjects are shown in Table 3. The results revealed no statistical gender differences in the golden percentage (p>0.05). However, for calculated percentages, it was shown that females recorded more values compared to males. In addition, although the right side values were higher than that of left sides, but the differences were statistically insignificant (p>0.05).

Table 4 compares the ratios of lateral incisor to central incisor and canine to lateral incisor measured for both right and left sides for comparison with RED proportion. Analyses of data using paired t test revealed that P value was found to be statistically insignificant (P>0.05). So this suggests that RED proportion is not constant in natural maxillary anterior teeth. In addition, the ratio of width of canine to lateral incisors as viewed from front is always less than that of lateral incisor to central incisor. Comparing the ratio of the width of lateral incisor to central incisor with the ratio of the width of canine to lateral incisor in each subject revealed that the recurring proportion existed in 16.7% of women, 14.1% of men, and 15.3% of all subjects. The Chi-squared homogeneity test revealed that there is no significant difference between men and women (P > 0.05). (Table 5).

**DISCUSSION**

This study was conducted to relate the best mathematical proportion that existed between the maxillary anterior teeth widths, the sample was representative of a group of Jordanian population of dental patients that attended conservative dental clinics. The size and shape of the maxillary anterior teeth especially when perceived from front have considerable implications for esthetic diagnosis and treatment planning. These have an effect on the space availability, stability of dentition, esthetics and health of the periodontium.

It is important to determine a mathematical or geometrical relationship between teeth in order to achieve an esthetic restorative result. It would be helpful if statistically reliable relationships existed to support existing relationship theories. In this study, more 52% of the participants were men, although there was no statistically significant difference in the mean age between genders, women were slightly younger than men. In addition, the age distribution was limited with 18-30 in order to eliminate the variations in proportions related to age. In the present study, gender-related differences were recorded in all width measurements. When comparing width dimensions with regard to gender, it was found that they are remarkably higher in males than females. These findings are in accordance with a previous study. As it can be derived from these results, no statistically significant variances were found between right and left sides in widths of maxillary anterior teeth.

Information concerning the existence of a mathematical or geometrical relationship is crucial so as to achieve the best esthetic restorative outcome. In this study, poor correlations between the dimensions of the teeth and the various esthetic proportions suggested in the literature were found.

The results of the present study revealed the mean value for golden proportion was approximately 22% between the central incisor and the lateral incisor and only 11% between lateral incisor and canine widths. These values are higher than those reported by Azam et al, who found that golden proportion existed in the relationship between the maxillary central and lateral incisors in only 10% and 2% of the perceived canine to lateral incisor ratio on the right side and 6% on the left side. The difference in results may be attributed to several factors, the least of which are differences in research methodology as well as the differences in the ethnicities of the subjects. However comparable findings have been reported previously. The occurrence of golden proportion on the right and left side was found in different subjects therefore it did not exist in the maxillary anterior teeth.

The results in this study contradicts the golden percentage theory as the values of 22.1%, 14.7% and 9.8% were recorded for centrals, lateral and canines, respectively. The value for lateral incisors corresponds to that as proposed by Snow but the percentage obtained for central incisors is slightly lower and for the canines is slightly higher than the one suggested by Snow. However, the results for golden percentage in this study correspond to the values reported by another study.

Of all the esthetic proportions that have been suggested to relate the width of maxillary anterior teeth, golden percentage theory has been recommended if the percentages are adjusted taking into consideration the ethnicity of the population. Therefore, the current values which were calculated for the golden percentage might serve as a guideline to create harmonious proportions in maxillary anterior teeth for Jordanian population.
In this study, in order to evaluate the existence of the RED proportion, the ratio of the width of maxillary lateral incisor to central incisor was compared with the ratio of the width of maxillary canine to lateral incisor in each subject. The RED proportion was observed in 15.3% of subjects. The overall result revealed that 10%-20% of the population of the study has the RED proportion. Although more females reported RED proportion compared with males but the differences were insignificant. It has been concluded that the RED proportion is an unsuitable method for creating harmony in the width of the maxillary anterior teeth. Although, the results of this study are in agreement with a previous study, it seems unsuitable to calculate the proportional means and compare them together, because the recurring proportion should be evaluated for each person, one by one. So, by modifying the evaluation method, considering the limitations of this study, it can be concluded that there is no evidence to support the application of RED proportion to natural teeth. This is also supported by several studies.

Since esthetics is subjective and depends on the patient’s and clinician’s perceptions, it is therefore difficult to obtain specific guidelines that will lead to consistent results. Therefore, it is suggested that neither of the proportions can be taken as a sole criterion to determine the width of maxillary anterior teeth and modifications should be done according to age, sex, ethnicity, personality and profession of the individual.

Although many researches studied the differences in the maxillary anterior proportions in various types of geometric patterns, but it was difficult to compare their results with ours due to variations in the variables incorporated and racial differences. One of the limitations of this study was small sample size and limited participation rate, thus it does not represent Jordanian population as a whole. In addition, the method used gives information about tooth width ratios mathematically ignored the perceived personal judgment.

Therefore, further research is still needed to overcome the limitations of this study which includes studying a larger sample and including other methods of anterior teeth esthetic determination, different age groups and incorporation of mandibular arch form may be needed before the results of this study can be applied on the general population.

**CONCLUSION**

Within the limitations of this study, the following conclusions can be withdrawn:

1. The golden proportion and RED were not existed between the perceived widths of maxillary anterior teeth.

2. The golden percentage although can not be applied on subject of this study, but it seems to be considered for Jordanian population.

**REFERENCES**


11. Rose AK. Esthetic impact of width/length ratios of the maxillary central incisor in patients with different racial types. MS thesis.


