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Assessment of the Aesthetic Proportions of the Anterior Maxillary Teeth among Dental Libyan Students: An Observational Study

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Abstract

Background Dental aesthetics and attractive, harmonious smiles contribute significantly to patients' decisions regarding treatment preference.

Aims This article investigates the existence and suitability of golden proportion, golden percentage, and recurring aesthetic dental (RED) proportion in Libyan dental students with natural dentition.

Methods This prospective cross-sectional observational study comprised 73 Libyan dental students who met the inclusion criteria (34.2% males and 65.8% females with a mean age of 25 ± 3.0 years). A photograph of the six anterior maxillary teeth was taken for each participant, and the apparent width of each was extracted digitally. Subsequently, the golden proportion, golden ratio, and the RED ratio were computed and compared with their corresponding standard notions. Descriptive and inferential analyses were performed at $p < 0.05$.

Results There were no significant sex differences for all variables. Therefore, the data was pooled together for further analysis. The Libyan golden proportion differed significantly from their corresponding standard values at $p < 0.05$. A similar significant discrepancy was observed in the golden percentage except for the maxillary left lateral incisors ($p = 0.206$). Furthermore, the mean values of the RED proportion were not constant, and the mean ratio increased moving distally, which did not align with the standard RED proportions.

Conclusion The proposed golden proportions, golden percentage, and RED rations were not pertinent to our cohort of Libyan dental students. Anterior tooth proportions vary among populations according to their ethnicity and geographic background. Therefore, proportions should be utilized based on the same population and ethnicity.

Keywords
- aesthetics
- golden proportion
- golden percentage
- recurrent esthetic dental ratio
- Libyan students

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ملخص المقال باللغة العربية

تقييم النسب الجمالية للأسنان العلوية الأمامية بين طلاب طب الأسنان الليبيين: دراسة رصدية

المؤلفون: تيسير قنيبر 1 ، ايمان بوقعيقيص 2.

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خلفية: تساهم جماليات الأسنان والابتسامات الجذابة والمتناغمة بشكل كبير في قرارات المرضى فيما يتعلق بالعلاج المفضل.

الهدف: تهدف هذه الدراسة إلى التحقيق في وجود وملاءمة النسبة الذهبية، النسبة الذهبية المئوية، ونسبة الأسنان الجمالية المتكررة لدى طلاب طب الأسنان الليبيين ذوي الأسنان الطبيعية.

الطُرق: شملت هذه الدراسة الرصدية 73 طالبًا في طب الأسنان من ليبيا استوفوا معايير الإدراج (34.2% ذكور و 65.8% إناث بمتوسط عمر 25 ± 3.0 سنوات). تم التقاط صورة لأسنان الفك العلوي الستة الأمامية لكل مشارك، وتم استخراج العرض الظاهر لكل منها رقمياً. بعد ذلك، تم حساب النسبة الذهبية، والنسبة الذهبية المئوية، ونسبة الأسنان الجمالية المتكررة ومقارنتها بالمعايير القياسية المعتمدة عالميا. تم إجراء التحليلات الوصفية والاستنتاجية عند P<0.05.

النتائج: لم تكن هناك فروق ذات دلالة إحصائية بين الجنسين لجميع المتغيرات. لذلك، تم تجميع البيانات معًا لمزيد من التحليل. اختلفت النسبة الذهبية لدي عينة الطلاب إحصائياً بشكل ملحوظ عن القيم القياسية المعتمدة المقابلة لها عند P<0.05. لوحظ كذلك فرق إحصائي كبيرة مماثل للنسبة الذهبية لعينة الطلبة مقارنة بالمعايير القياسية باستثناء القواطع الجانبية اليسرى للفك العلوي (p=0.206). علاوة على ذلك، لم تكن القيم المتوسطة لنسبة الأسنان الجمالية المتكررة ثابتة، وزادت النسبة المتوسطة عند الانتقال نحو الطرف ، وهو مالم يتوافق مع المعايير القياسية لنسبة الأسنان الجمالية المتكررة.

الاستنتاج: لم تكن النسب الذهبية المقترحة، والنسبة الذهبية المئوية، ونسبة الأسنان الجمالية المتكررة لطلاب طب الأسنان الليبيين متوافقة مع المعايير القياسية. تختلف نسب الأسنان الأمامية بين السكان وفقًا لعرقهم وخلفيتهم الجغرافية. لذلك، يجب استخدام النسب بناءً على نفس السكان والعرق.

الكلمات المفتاحية: الجماليات،النسبة الذهبية، نسبة الأسنان الجمالية المتكررة، الطلاب الليبيون.

Introduction

Dental aesthetics and attractive, harmonious smiles contribute significantly to patients' decisions regarding treatment preferences. Aesthetic dental treatment outcomes have become progressively essential for patient satisfaction and self-esteem. A pleasant aesthetic smile relies on multiple characteristics such as a harmonious curved smile line, gingival color and biotype, level of gingival exposure, gingival zenith, maxillary incisors and canine tooth morphology, and their proportionality with each other as well as with the corresponding facial form.[1–3] These aspects are shaped by personal preferences, cultural perspectives, and sociodemographic factors, and interpersonal aesthetic perception may vary greatly, as "*the beauty is in the eyes of the beholder*."

Despite the subjective concept of aesthetics, numerous notions have been introduced to attain the most accurate aesthetic dental harmony benchmarks. The most well-known concepts are the golden proportion, golden percentage, and recurring aesthetic dental (RED) proportion.[4] The golden proportion was introduced in dentistry by Levin in 1987 as a fundamental principle within a pleasant smile design philosophy in restorative and aesthetic dentistry.[5] From a frontal view perspective, Levin[5] observed that a maxillary lateral incisor mesio-distal (MD) width demonstrates a golden proportion to its corresponding central incisor and canine width.

Orthodontists have long employed the concept of proportions to determine anticipated facial and dental parameters by applying macro- and microaesthetic geometric ratios as an essential part of patient diagnosis and treatment planning. Ricketts[6] originally developed a golden proportion based on caliper measurements to determine and assess ratios among different facial parameters associated with attractiveness. In 1999, Snow[7] employed the Lombardi[8] golden proportion ratio of 1.618:1, respectively, or the smaller object is 62% of the larger object for the central incisor, lateral incisor, and canine in this order to present the golden percentage. Snow[7] recommended further investigations to investigate the applicability of his proposal in different settings and other populations.

Ward[9] proposed the RED ratio, in which the proportion of the consecutive visible width of the maxillary anterior teeth stays constant, moving distal to the midline. The reported applicability of the tooth golden and RED proportions was inconsistent in various populations, including Americans,[10] Indians,[11,12] Malaysians,[13] and Saudi Arabia.[14,15] Accordingly, a recent systematic review concluded that golden proportion and golden percentage vary among different populations, races, and geographic places.[15] Another systematic review reported a similar conclusion concerning the applicability of the RED proportion.[16] Both reviews recommended further research concerning these notions for every population and ethnicity. Up to date, no similar investigation has been performed on Libyan subjects. Therefore, this study aimed to investigate the existence and suitability of golden proportion, golden percentage, and RED proportion in Libyan dental students with natural dentition, using digital photographs and computer analysis.

Materials and Methods

Study Setting and Sample Size

This prospective cross-sectional observational investigation was undertaken at the Faculty of Dentistry, University of

Benghazi. The ethics committee of the same faculty granted ethical approval. The sample size was determined to be 70 considering a 62% prevalence of crown ratio based on the Lombardi[8] hypothesis that the smaller object is 62% of the larger object[18] with a power of 85% and α (the probability of committing a type I error) = 0.05.

The sample comprised male and female dental students who consented to participate in this study. Each participant had to have a full permanent dentition, no spacing or crowding between the incisors, no gingival or periodontal disease with a normal range of overjet and overbite, no anterior restorations, and no history of orthodontic treatment. All the participants were satisfied with their smiling appearance, further ensuring the investigation results.

A Sony DSC-W180 digital camera captured each participant's standardized frontal facial image during a smile. The camera had a built-in magnification lens of 18 to 55 mm to photograph sharp and accurate images. An adjusted 1:1 macrosetting was used to closely acquire the six maxillary anterior teeth. The camera was installed on a tripod at 60 cm from the subject and adjusted to obtain a sharp image of the face, from the tip of the nose to the tip of the chin. Each subject was positioned in the natural head position. A cheek retractor was placed to acquire a complete view of the maxillary anterior teeth. A meter ruler was affixed to a face-bow assembly in a perpendicular orientation to the floor to determine the conversion factor to enable the correlation between the picture's dimensions and the teeth's true measurements. Images of a full face and anterior teeth were captured under a standard light source.

The images were then downloaded to a personal computer and processed in the *Imc Test & Measurement GmbH program*. The perceived MD width of the maxillary anterior teeth was extracted, resulting in a distinct contour. Three sets of readings were acquired, and the average of those values was utilized for tabulation.

Measurements

The golden proportion was computed for the maxillary (both right and left) anterior teeth as follows: the perceived MD width of each maxillary central incisor was multiplied by 62% and compared with the recognized MD width of the sided lateral incisor. Similarly, the perceived width of the lateral incisor is assessed, multiplied by 62%, and compared with the recognized MD widths of its adjacent canine. The conversion factor, present in the fraction's numerator and denominator, was disregarded when calculating the tooth ratios. Similar values indicate that the maxillary anterior teeth align with the golden proportions, and the opposite is true.

The golden percentage was determined by dividing the apparent MD width of each central incisor, lateral incisor, and canine by the total MD width of the maxillary anterior six teeth. Actual values corresponding to 10% for the canine, 15% for the lateral incisor, and 25% for the central incisor of each side correspond to the golden percentage.

The RED proportion was calculated by dividing the width of each lateral incisor by the width of the adjacent central incisor, and the resulting number was multiplied by 100. Similarly, the width of each canine was divided by the width of the adjacent lateral incisor, and the resulting number was multiplied by 100. If the values obtained were constant, it means that the central incisor, lateral incisor, and canine are in RED proportion.

Statistical Analysis

The statistical package of the Social Sciences Software (SPSS Inc, Chicago, Illinois, United States) version 26 was used. The Levene and Shapiro–Wilk tests evaluated the data homogeneity and normality. A paired *t*-test and intraclass correlation coefficient (ICC) were used to evaluate the intraexaminer measurement reliability. Paired *t*-test was performed to assess the male/female statistical differences among all variables. Descriptive statistics extracted the mean and standard deviation of each variable. The unpaired *t*-test evaluated the statistical discrepancies between the ideal and actual golden proportion estimates. The significance level was set at 5% ($p < 0.05$).

Intraoperator Reproducibility Study

To determine the intraoperator reliability, one examiner (T.G.) reexamined 15 randomly selected photographs at a 2-week interval. A paired *t*-test revealed no significant differences between measurements at $p > 0.05$. The ICC was found to be greater than 0.90, indicating an excellent level of reproducibility between both trials.

Results

The Levene test confirmed data homogeneity, and the Shapiro–Wilk analysis confirmed their normal distribution. The total sample size was 73 subjects (24.8 ± 1.6-year-old males, 34.2% of the sample, and 26.4 ± 3.4-year-old females, 65.8% of the cohort). The unpaired *t*-test revealed no significant sex differences among the analyzed variables; therefore, the data was pooled and analyzed in one group. The mean cohort age was 25 ± 3.0 years (►**Table 1**).

The Golden Proportions

A paired *t*-test revealed a statistically significant increase in the Libyan golden proportions compared with their corresponding standard values at $p < 0.05$ (►**Table 2**). Out of the total sample, 19.2% of the right central incisors were in golden proportion to the right lateral incisors, and 33.3% had right lateral incisors in golden proportion to the right canines. Furthermore, 20.5% of the left central incisors were in golden proportion to the left lateral incisors, and 29.6% of individuals had right lateral incisors in golden proportion to the right canines.

The Golden Percentage

►**Table 3** and ►**Fig. 1** illustrate the mean values of golden percentage in our sample, starting from the right side canine to the left side canine were 11.7, 15.4, 22.8, 22.9, 15.2, and 11.8%, which were statistically significantly different ($p \leq 0.023$) from the corresponding golden percentage proposed

Table 1 Displays the total, male, female number and percentage (%) comprising the examined cohort

Sex	Number	(%)	Age in years ± SD
Males	25	34.2	24.8 ± 1.6
Females	48	65.8	26.4 ± 3.4
Total sample	73	100	25 ± 3

Abbreviation: SD, standard deviation.
Note: The age ± SD for each category is presented in the last column.

Table 2 A paired *t*-test revealed a statistically significant increase in the Libyan golden proportions compared with their corresponding standard values ($p < 0.05$)

Tooth proportion	Mean ± SD	% within the golden proportions	*p*
Upper right Width of lateral incisors/width of central incisors	0.79 ± 1.02	19.2	< 0.001
Upper right Lateral incisor/canine	0.62 ± 1.12	33.3	< 0.001
Upper left Lateral incisor/central incisors	0.80 ± 1.2	20.5	< 0.001
Upper left Lateral incisor/canine	0.61 ± 1.1	29.6	< 0.001

Abbreviation: SD, standard deviation.
Note: The third column displays the percentage (%) of each ratio in the Libyan subjects lying within the golden proportions.

Table 3 Mean and standard deviation (SD) of the golden percentage (%) of the Libyan cohort

	Actual mean ± SD, %	Expected mean, %	*p*
Upper right central incisor	22.8 (1.13)	25	< 0.001
Upper right lateral incisor	15.4 (1.4)	15	< 0.023
Upper right canine	11.7 (1.6)	10	< 0.001
Upper left central incisor	22.9 (1.1)	25	< 0.001
Upper left lateral incisor	15.2 (1.3)	15	0.206
Upper left canine	11.8 (1.7)	10	< 0.001

Note: The proposed golden percentage and the p-values detected by the unpaired *t*-test.

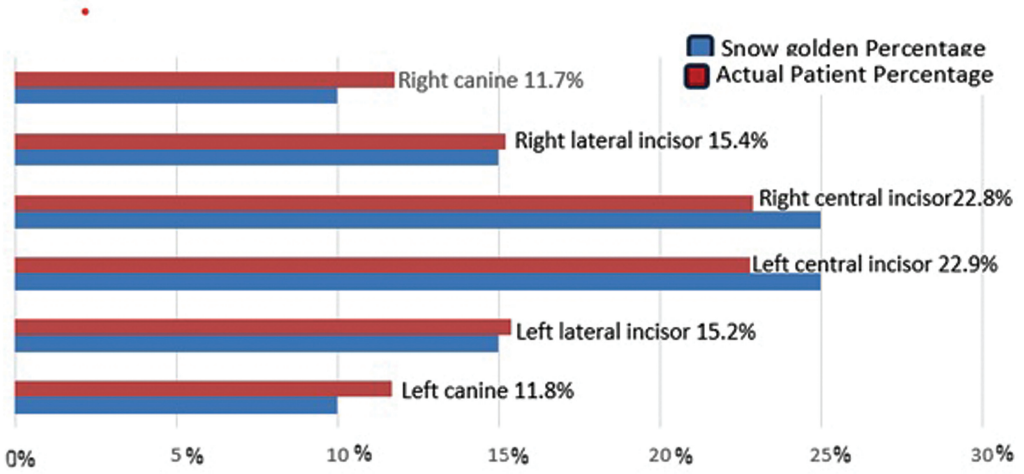

Fig. 1 Snow's golden percentage (blue) and the mean actual percentage of the maxillary six anterior teeth of the Libyan cohort (red).

Table 4 The mean percentage (%) values and standard deviation (SD) of the recurring aesthetic dental (RED) proportion of the Libyan cohort

RED proportions	Mean (%)	±SD
Upper right Canine/lateral incisor right side	76.8	±8.7
Upper right Lateral incisor/central incisor	67.8	±7.6
Upper left Lateral incisor/central incisor	66.7	±7.7
Upper left Canine/lateral incisor	78	±9.4

by Snow[7] of 10, 15, 25, 25, 15, and 10% except for the left lateral incisor where their mean percentage value (15.2%) was similar to the Snow golden percentage (15%) at $p = 0.206$.

The RED Proportion

►**Table 4** displays the mean RED proportion between the central and lateral incisors ($\geq$ 66.7% and $\leq$ 67.8%) and the mean RED proportion between the canine and lateral incisors ($\geq$ 76.8% and $\leq$ 78%).

Discussion

Patient satisfaction with postorthodontic treatment dental appearance, along with functional occlusion, is of paramount importance to dental practitioners. The trend toward aesthetic dentistry has led to increasing interest in determining mathematical formulas that would guide dental experts to provide a predictable, pleasing aesthetic outcome.[1,3] The size and shape of the maxillary anterior teeth are commonly visible in a smile and vastly contribute to dental and facial aesthetics and beauty. Establishing a mathematical or geometrical correlation between the front teeth is central to a visually pleasing outcome.[1,3]

This observational cross-sectional clinical study evaluated the applicability of three recognized notion analyses used in orthodontics, prosthodontics, and aesthetic dentistry. The geometrical parameters of the dental and facial forms must be customized and examined for each individual. Furthermore, the basic tooth form must be customized and examined within macro-, mini-, and microcharacteristics representing dental smile and facial parameters.[1,2,17,18] Despite ample publications on this subject, a scientifically validated protocol for determining tooth form has yet to be proposed.

The Libyan population is relatively heterogeneous,[19] with numerous facial and dental disparities. Hence, information concerning golden proportion and percentage, as well as the RED ratios between aesthetically relevant dental aspects, might be helpful to specialists in the dentofacial aesthetic fields, considering racial variations.

The central incisor parameter remains important in aesthetically pleasing maxillary anterior teeth ratios in all the reported geometrical equations. Therefore, the present study assessed the correlation between the perceived width of the maxillary central, lateral, and canine to be compared with the corresponding standard Snow values. This investigation observed that our cohort's mean dental proportions (from right canine to left canine; 19.2, 33.3, 20.5, and 29.5%) are higher than the frequencies reported for the dental golden proportions of dental students in Pakistan,[16] India,[11] Malay,[13] Turkey,[20] and Saudi Arabia.[15,21] However, our mean values and the reported findings of the studies mentioned above were significantly lower than Snow's golden proportion. Our results align with the Ahmed et al[15] systematic review of 52 publications concluding that golden proportion and golden percentage vary among different populations, races, and geographic places.[15]

Our mean perceived golden percentage was significantly different from the standard golden percentage proposed by Snow (10, 15, and 25%) for canine, lateral incisor, and central incisor, respectively, except for a similar mean percentage for the maxillary left lateral incisor. These significant discrepancies from Snow's standard was reported for other populations such as Pakistanis,[22] Indians,[11] Malayans,[13] Turkish,[20] and Saudi Arabians.[15,21] These variations might be attributed to the different races of the examined groups.[7,15] However, the similarity between the recommended Snow's percentage of the lateral incisor and our cohort (around 15%) was observed in three investigations undertaken on Pakistani dental students in three different dental faculties[22–24] and a Saudi Arabian investigation.[21] This might indicate that racial factors significantly influence the golden proportion and golden percentage concepts. Thus, establishing an adapted version of Snow's proposed theory for each population might be more appropriate.

The mean values of the RED proportion between the right central to the right lateral incisor and the left central incisor to the left lateral incisor for Libyan dental students were 66.7 and 67.8%, respectively. The mean RED ratio between the right canine and the right lateral incisor and the left canine to the left lateral incisor was higher at 76.8 and 78%, respectively, indicating that this ratio increases moving distally, which does not align with the standard RED proportions. A recent systematic review[16] of 17 articles reported that the difference in tooth proportions was greatest in European subjects, ranging from 55.80 to 89% and lowest in the Western Asian populations with a minimum ratio of

67.80% and a maximum ratio of 88.46%, concluding that there was no consensus concerning the applicability of the RED ratio to different races and geographic locations.

Limitations of the Study

Although the present investigation's sample size was comparable to similar previous studies, the participants were confined to a single center, which might have influenced the investigation's outcome. A multicenter investigation with a greater sample size and cultural multiplicity is advised. Furthermore, the evolution of artificial intelligence, the advancement in computer graphics technology, and the availability of precise three-dimensional photographic cameras widen the perspective of replicating this study using more efficient and versatile tools.

Conclusion

Within the limitations of the current investigation, it could be concluded that Snow's proposed golden proportions, golden percentage, and RED ratios were not pertinent to our cohort of Libyan dental students. Anterior tooth proportions vary among populations according to their ethnicity and geographic background. Therefore, proportions should be utilized based on the same population and ethnicity. Furthermore, tooth proportion indices should be combined with dentofacial characteristics, occlusal harmony, and patient perspective of a pleasant smile.

Conflict of Interest
None declared.

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