Evaluation of "Golden Proportion" in Individuals with an Esthetic Smile

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ABSTRACT

Background: One of the most important tasks in esthetic dentistry is creating harmonious proportions between the widths of maxillary anterior teeth when restoring or replacing these teeth. The "golden proportion" is a main guideline introduced in this field.

Purpose: This study aimed to investigate the existence of the golden proportion between the widths of the maxillary anterior teeth in individuals with an esthetic smile.

Materials and Methods: This study was conducted with 157 dental students (75 women and 82 men), with ages ranging from 18 to 30 years. Students whose natural smile did not develop any visual tension (see below) with regard to the study's and their own criteria were selected as having esthetic smile. An image measurement program was used to measure the apparent mesiodistal widths of six maxillary anterior teeth on the scanned photographs of these subjects. The existence of the golden proportion was investigated in the width ratios of maxillary anterior teeth.

Results: The golden proportion was not found to exist between perceived maxillary anterior teeth widths of individuals with an esthetic smile.

Conclusion: The golden proportion is not a common factor in esthetic smiles.

CLINICAL SIGNIFICANCE

This article suggests considering the dentofacial specificities of each individual and also the wide variety of natural teeth proportions when restoring or replacing the maxillary anterior teeth. However, individual cultural characteristics and perception of beauty must be considered.

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A considerable number of studies have shown that people are more concerned about missing anterior teeth and their replacement than about posterior ones as esthetics seems to be more important than the function of the teeth.¹ One of the most important tasks in esthetic dentistry is the creation of harmonious proportions between the widths of maxillary anterior teeth when restoring or replacing them.

The concept of the "golden proportion" has often been offered as a cornerstone of smile design theory.²

Aristotle pointed out the value of proportion in esthetics as early as

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the fourth century BC. The golden proportion was described by the Pythagoreans in the sixth century BC, and a little later by the Greek geometrician Euclid. However, long before the Greeks, the Egyptians had found and set up the golden number ϕ (1.618), as the width to length ratio in the Egyptian rectangle was 0.6 (ϕ') .³ The golden proportion was used in ancient Greek architecture to design the Parthenon, and also in da Vinci's classic drawings of human anatomy. This ratio is approximately 1.61803:1; that is, the smaller section is about 62% the size of the larger. The uniqueness of this ratio is that the ratio of the smaller part to the larger part is the same as the ratio of the larger part to the whole.⁴

Ricketts devised a golden proportion caliper to establish and evaluate the ratios between various elements of the attractive face.⁵ Lombardi was the first to propose the application of the golden proportion in dentistry, but he also stated, "It has proved too strong for dental use."6 In addition, he defined the idea of a repeated ratio, which implies that in an optimized dentofacial composition from the frontal aspect, the lateral to central width and the canine to lateral width are repeated in proportion.⁶ 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."²

He also devised a grid with the spaces in golden proportion and suggested that this grid be used to evaluate and develop well-proportioned teeth.² Shoemaker has also endorsed the use of the golden proportion in anterior esthetics.^{7,8}

Preston measured 58 computergenerated images of dental casts with an image-measurement program and evaluated the frequency of the golden proportion (considered to be in the range of 0.61-0.63) in the ratios of the perceived maxillary lateral to central incisors and canine to lateral incisors.9 He found that natural teeth were rarely in the golden proportion (17% maxillary lateral to central and 0% canine to lateral). He also reported that the mean perceived maxillary lateralto-central incisor ratio was 0.66 and the mean perceived maxillary canine-to-lateral incisor ratio was 0.84.9 Gillen and colleagues, in a study of 54 subjects, found that the golden proportion was rarely seen.¹⁰ Their measurements were made directly on the casts, rather than on the frontal images.

Snow stated that the concept of the golden percentage is a useful application in the diagnosis and development of symmetry, dominance, and proportion for an esthetically pleasing smile.¹¹ Some other authors have also mentioned the use of this proportion in anterior esthetics.^{12,13} Rosenstiel and colleagues generated some computer images of the six maxillary anterior

teeth, which had been categorized according to different tooth heights and proportions.¹⁴ The images were sent via e-mail to dentists in 38 countries to determine their esthetic preferences. It was reported that the dentists preferred the golden proportion when viewing very tall teeth and that they considered this proportion less desirable for teeth of normal height or shorter teeth.¹⁴ Ward believed that when the golden proportion is used, the lateral incisor appears too narrow and the resulting canine is not prevalent enough.¹⁵ He preferred using the 70% proportion, and he also recommended adhering to the concept of repeated ratio, which had been defined by Lombardi in 1973.⁶

Surprisingly, according to Levin's idea,² the golden proportion has been introduced in most textbooks as an esthetic guideline in maxillary anterior teeth restoration.^{4,16–19} Consequently, when using golden proportion, we deal with various and sometimes contradictory issues, which is confusing for both the clinician and technician.

Therefore, the object of this study was to investigate the existence of the golden proportion between the widths of the maxillary anterior teeth in individuals having an esthetic smile. The null hypothesis of this study was that there is no golden proportion for the perceived maxillary anterior teeth widths. The working hypothesis was that the golden proportion exists between the widths of the maxillary anterior teeth.

MATERIALS AND METHODS

In this descriptive study, sequential sampling was employed. Those students entered into the study did not have any missing teeth, except for possibly the third molar. In addition, none of the students had received any orthodontic treatment. Those with maxillary anterior restorations, trauma, or any maxillofacial surgery were excluded from the study. The individuals whose natural smile did not develop visual tension with regard to the study's and their own criteria were considered to have an esthetic smile (Figure 1). The approval to use human subjects was obtained from the governing body of the Shahid Beheshti University of Medical Science.

The following were considered within study parameters to consti-

tute visual tension if they disturbed the balance of dentofacial composition during smiling (Figure 2)¹⁶:

- Unpleasant dental alignment (crowding, spacing, rotation, or severe dental tilt)
- Remarkable malformations, discoloration, or structural deformities of the teeth
- Unpleasant fractured teeth
- Severe dentofacial deformities
- Unpleasant gingival color or contour
- Obvious asymmetries

Those students whose smile created visual tension according to study criteria were not enrolled in the study.

Individuals who did not develop visual tension according to the criteria of the study were asked if they were pleased with the color of their teeth, the color of their gums, their tooth visibility, their gum visibility, and their tooth form (eg, square, oval) during smiling. Those who expressed their dissatisfaction with two or more of the above items or who were not satisfied with their smile at all were classified as having visual tension per their own judgment. All such individuals were also excluded from the study.

A frontal photograph was taken of each individual with an esthetic smile. The upper lip was retracted in all photographs to clearly display the maxillary anterior teeth as well as its respective gingiva (Figure 3A). Lighting and staging were kept constant. All photographs were scanned and saved in a personal computer using an imagemeasurement program (Dimaxis® 2.3.3, Planmeca, Helsinki, Finland). This was to enable measurement of the apparent mesiodistal width of each tooth from canine to canine. All measurements were performed by one individual. The zoom function of the program was used to



Figure 1. A, B, Individuals with an esthetic smile.



Figure 2. The study's criteria for visual tension: A, unpleasant dental alignment; B, unpleasant dental discoloration and gingival contour; C, unpleasant dental alignment and remarkable malformation of teeth; D, unpleasant dental alignment and dentofacial deformity.



Figure 3. A, The upper lip was retracted in all photographs to clearly display maxillary anterior teeth as well as their respective gingiva. B, Magnification of the images (zoom function), providing precise indication of the mesial and distal contour of the tooth and measurement.

achieve a more precise measurement and indication of the mesial and distal contour of the anterior teeth (Figure 3B).

Ten images were remeasured by the two other investigators to establish the validity of the measurements. The Test Re Test examination indicated a correlation of .95 for the three measurements. Furthermore, 10 of the images were remeasured under the same conditions 10 days later to establish the reliability of the measurements. The Test Re Test examination showed a correlation of .97 for the measurements.

The golden proportion (0.618) was calculated at 0.6.¹⁸ This was evaluated within the range of 0.55 to 0.64 for the perceived maxillary lateral-to-central incisor ratio and the maxillary canine-to-lateral incisor ratio. However, it was calculated at 0.62 (rounded from 0.618) and investigated within the 0.61 to 0.63 range.⁹

Because of the negative effect of some factors, including rotation, spacing, overlapping, and other malalignments of teeth, on the relative proportion of each anterior tooth as seen in the frontal view,¹¹ all photographs were evaluated again. Any individuals exhibiting such factors were excluded from the study (Figure 4). The golden proportion was also investigated within Preston's range in each individual who had completely aligned maxillary anterior teeth,⁹ with an additional comparison made to the subjects excluded from further classification.

The golden proportion in maxillary anterior teeth was then evaluated according to sex. Chi-square statistical analysis was performed on the data to look for the possible differences.

RESULTS

The present study involved 338 dental school students, from which

47.6% were excluded because of their visual tension according to the study's criteria. A further 11.3% were excluded because of their own perceptions of visual tension. Finally, 157 subjects, 82 males and 75 females, ages 18 to 30 years, were considered to have an esthetic smile, and the golden proportion was investigated in their perceived maxillary anterior teeth width ratios.

The golden proportion of 0.6 was found in 34.9% of the perceived lateral-to-central incisor ratios and in < 10% of the perceived canineto-lateral incisor ratios, within the 0.55 to 0.64 range. Within Preston's range (0.61-0.63),⁹ the proportion was found in 11.1% of lateral-to-central incisor widths and < 5% of canine-to-lateral incisor widths. Furthermore, the existence of the golden proportion was found to be similar in the left and right side and for both sexes. As a result, the golden proportion was not determined to be correlated



Figure 4. A, B, Individuals with malaligned forms of the maxillary anterior teeth (eg, tilt, rotation, and overlapping).

TABLE 1. PRESENCE OF THE GOLDEN PROPORTION.		
Group	Lateral-to-Central Incisor Ratio	Canine-to-Lateral Incisor Ratio
A* $(n = 73)$	18 (24.7%)	4 (5.5%)
$\mathbf{B}^{\dagger} \ (n = 84)$	17 (20.2%)	3 (3.6%)

*Those with maxillary anterior teeth that were not completely aligned. [†]Those with completely aligned maxillary anterior teeth.

with the relationship between the perceived maxillary anterior teeth in all conditions.

Reevaluation of the images indicated that 73 individuals (46.5%) had some degree of malalignment in the maxillary anterior teeth (group A), whereas 84 students (53.5%) had completely aligned maxillary anterior teeth (group B). The existence of the golden proportion was compared for groups A and B (Table 1). The mean perceived lateral-to-central incisor ratio for groups A and B was 0.67 ± 0.07 (range 0.47-0.92). The mean ratio was the same in individuals with completely aligned maxillary anterior teeth, but the range was 0.51 to 0.86. The mean perceived lateralto-central incisor ratio was not different between men and women.

The mean perceived canine-tolateral incisor ratio for groups A and B was 0.84 ± 0.15 (0.86 in men and 0.82 in women), with a range of 0.37 to 1.23. The mean ratio was 0.86 ± 0.13 (0.87 in men and 0.85 in women) in individuals with completely aligned maxillary anterior teeth, with a range of 0.58 to 1.23. The mean perceived canineto-lateral incisor ratio was therefore higher in men compared with women.

DISCUSSION

Although golden proportion has been proposed in the literature as a useful application for achieving proportion and esthetics,^{4,16–19} no one has yet evaluated this proportion in esthetically accepted cases. This investigation is therefore considered the first step taken in this regard. The measurements were also made with maximum effort for their validity and reliability.

Several other studies have estimated the esthetic quality of smiles by employing a judgment panel (including nondentist volunteers,²⁰ or dentists and fine art professors²¹). The differences of opinion between dentist and nondentist groups suggest that it is wise to seek patients' opinions regarding dental appearance.²² The present study tried to use defined criteria of the study and the subjects, rather than the judgment of a panel. The aim was to augment the objectivity and reduce the subjectivity of selecting esthetic smiles.

Preston's findings regarding the golden proportion in terms of per-

ceived maxillary anterior teeth width ratios and the mean perceived lateral-to-central incisor and canineto-lateral incisor ratios were similar to findings of this study.⁹ Gillen and colleagues found a poor correlation between tooth dimensions and the golden proportion.¹⁰ However, because their measurements were made directly on casts, those findings could not be compared to findings in the current study.

Rosenstiel and colleagues found that golden proportion was preferred only with regard to tall teeth.¹⁴ This might confirm present findings on the golden proportion. However, our findings corroborated Ward's idea to refuse the use of golden proportion,¹⁵ but they do not prove his preference for using the 70% ratio since the mean lateral-to-central incisor ratio was 0.67 in the selected cases of this study, with the mean canine-tolateral incisor ratio being 0.84. The range of existing ratios was so extensive in the present study that it might be wise to rethink Lombardi's theory defining the repeated ratio for the first time.⁶

Attempts have been made to find the right magnification in photographs. Preston positioned a millimeter ruler directly below the cast during photography.⁹ Ward suggested computing a conversion factor that came from the division of the cast dimension by the image dimension.¹⁵ This was to correlate the size of the image to the actual size of the teeth. As this

factor appears in both the numerator and denominator of the fraction for calculating the ratio of the teeth, it was ignored in the present study.

Snow's suggestion regarding the use of the golden proportion in the diagnosis and development of symmetry, dominance, and proportion for an esthetically pleasing smile is not based on research and could not be compared with our findings.¹¹

Levin was the first to assert the existence of the golden proportion in 1978.² This proportion was employed to determine the relationship between maxillary anterior teeth widths. Levin's golden proportion has been proposed in many articles and textbooks as an esthetic guideline for restoring and replacing maxillary anterior teeth.4,6-19 Since his assertion was not based on research findings and his devised grid was not precise enough to allow the evaluation of the existence of this proportion relative to the present study's and Preston's findings,⁹ Levin's idea about the golden proportion can no longer be considered valid.

Shillingburg and colleagues stated the golden proportion to be 0.6.¹⁸ Although the range was wide (0.55–0.64), the golden proportion was not found to exist in this study.

CONCLUSIONS

Even though textbooks have suggested that using the golden proportion develops pleasing proportions, the results of the present study have shown that this golden proportion did not exist between the widths of the maxillary anterior teeth in individuals who have an esthetic smile. The alignment of the maxillary anterior teeth and the sex of the individual did not affect the existence of the golden proportion. The mean perceived lateral-to-central incisor ratio was 0.67, and the mean perceived canine-to-lateral incisor ratio was 0.84.

Because of the variety in nature, esthetics in dentistry cannot be justified mathematically; individuals should not be standardized in the same way. Although we dentists should follow some fundamental guidelines in esthetic treatment planning, it should be acknowledged that esthetics varies greatly from person to person. It is therefore important to consider the dentofacial specificities of each individual and the wide variety of natural teeth proportions when restoring or replacing the maxillary anterior teeth. In addition, individual cultural characteristics and perceptions of beauty must be considered.

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