ASSESSMENT OF THE GOLDEN RATIO IN PLEASING SMILES

Aims: The golden ratio is a guideline to help harmoniously restore or replace missing teeth. However, this concept is controversial. This study assesses the validity of the golden ratio between the widths of the maxillary anterior teeth in individuals presenting with an attractive/nonattractive smile. Material and Methods: A double-stage random cluster sample cross-sectional study included 903 students whose ages ranged from 18 to 30 years and met the inclusion criteria. Image-measurement software was used to assess the perceived mesiodistal widths of the maxillary anterior teeth on scanned photographs. A jury of two dental professionals, a portrait photographer, and a painter, along with the respective subject as the fifth judge, determined the attractiveness of each smile on a visual analog scale. The mean value determined whether an individual was allocated to the attractive or nonattractive smile group. Finally, the prevalence of the golden ratio was investigated in these two groups. Intraobserver correlation coefficient was 0.966. Cochran's chi-square test was used for data analysis. Results: According to the jury, 143 individuals had an attractive smile and 289 had a nonattractive smile. Maxillary central to lateral incisor ratio showed the golden proportion in 50.3% of the students with an attractive smile as compared to 38.1% in the nonattractive smile group (P = .014). However, the golden ratio between the maxillary lateral incisors and the canines existed in only 16.8% of the individuals with an attractive smile as compared to 12.1% in the nonattractive smile group (P = .223). Conclusion: The golden ratio can be useful to achieve esthetic restorations of the maxillary central and lateral incisors. However, the golden ratio between the perceived widths of the maxillary lateral incisors to the canines does not seem to be decisive for an attractive smile and other factors should be considered. World J Orthod 2009;10:224–228.

Key words: anterior teeth, esthetics, golden proportion, golden ratio, smile

Esthetics is a demanding, but not easy, concept to achieve to imitate natural beauty. There was never any constant definition of this concept, which is why mathematical ratios have sometimes been used to make it measurable. One of these ratios is the golden ratio, usually denoted ϕ (phi, from Phidias, an ancient Greek sculptor). Two quantities fulfill the golden ratio if the sum of those quantities and the larger one is the same as the ratio between the larger and the smaller one. The golden ratio, also termed divine proportion or golden proportion is calculated according to the formula:

\[ \phi = \frac{1 + \sqrt{5}}{2} = 1.61803989 \]

The ancient Greeks ascribed the discovery of this figure to Pythagoras, who

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tried to define the proportions of bodies mathematically. The golden ratio can be found not only in geometrical elements, but also in living subjects such as the human body.²

Lombardi suggested that the ratio of the visual perceived widths of the central and lateral incisors should be continued as moving distally.³ Levin stated that if precisely seen in frontal view, the observable widths (not the actual size) of the maxillary central and lateral incisors, as the observable widths of the maxillary lateral incisors and maxillary canines, meet the golden ratio.⁴ Considering a range of 0.61 to 0.63 for the golden ratio, Preston found it in only 17% of his sample between the widths of the maxillary central and lateral incisors.⁵ Moreover, he did not observe this ratio between the widths of the maxillary central incisors and canines. In contrast, Snow emphasized that this ratio can be useful in the diagnosis of symmetry and proportion and in the creation of an esthetically pleasing smile.⁶ Rufennacht, Shillingburg et al, and Goldstein have recommended the golden ratio for the restoration of anterior teeth.⁷–¹⁰

Conversely, Rosenstiel et al reported that the majority of surveyed dentists preferred the use of the golden ratio only in patients who, when smiling, exhibit very long teeth.¹¹ However, this ratio was the least preferred in normal, short, or very short teeth. Hasanreisoglu et al did not find the golden ratio or any other continuous proportion for anterior teeth.¹² Mahshid et al took photos of pleasing smiles and measured the width of the incisors¹³ to come to the conclusion that the golden ratio does not exist in pleasing smiles. Also, according to Ong et al, the golden ratio is not a decisive factor in determining dental attractiveness.¹⁴

Because of the contradictions among the aforementioned publications and on account of the need for information gathered through a standardized method, the purpose of this study was to investigate the existence of the golden ratio between the perceived mesiodistal width of the maxillary anterior teeth in individuals having an attractive or nonattractive smile. Perceived width in this study was the widest distance between the mesial and distal sides of a specific tooth as seen directly from the front.¹²

**MATERIAL AND METHODS**

The inclusion criteria in this cross-sectional study were: (1) no missing teeth (except third molars); (2) no unpleasant tooth alignment (severe crowding, spacing, tipping, or rotations); (3) no remarkable malformations or structural tooth deformities; (4) no history of orthodontic treatment, maxillary anterior restorations, or maxillofacial surgery; (5) no severe dento facial deformities, obvious asymmetries, or scars; and (6) no gingival recessions in the anterior teeth (Fig 1).

A double-stage, random cluster sampling method was used. Ten government faculties in Tehran were selected by chance. From these, students were randomly selected. It was estimated that 35% of the population would demonstrate
the golden ratio in the proportion of their teeth. Considering that $\alpha = 0.05$ and $\beta = 0.20$ (power = 80%), to detect a 10%, 15%, and 20% difference between an attractive and nonattractive smile group, 96, 170, or 376 individuals, respectively, would have been needed in each group. In the current study, 903 students were chosen, of whom 432 met the inclusion criteria (47.8%). Among these, 143 (33.1%) had an attractive smile according to the judges (Fig 2, Table 1).

If necessary, scaling and polishing was performed on individuals who met the inclusion criteria. Then, a frontal photograph was taken of each individual with the upper lip retracted in centric occlusion to clearly display the maxillary anterior teeth and their gingiva (Fig 3). A camera (Yashica Dental Eye III, Kyocera) with a 100-mm f/4.0 macro lens was used under standard light conditions and a constant lens-to-subject distance. Each person was seated in a dental chair with the head upright, supported by the headrest, and the occlusal plane of the maxillary teeth parallel to the floor. To further ensure standardization, all photographs were taken by the same person. All photographs were scanned (Pixma MP500, Canon) and analyzed by only one person with an image-measurement program (VixWin 2000 1.9, Dentsply Gendex), which registered the perceived mesiodistal width of each tooth from canine to canine to the nearest 0.1 mm. Only individuals having a ratio between 0.61 to 0.63 bilaterally were considered to have a golden proportion.

The jury that distinguished the attractiveness of a person’s smile consisted of an orthodontist and a prosthodontist, a professional portrait photographer, and a painter. To include the individual’s idea of beauty, each subject served as the fifth evaluator. Each judge scored every smile on a 100-mm visual analog scale between 0 (extremely unattractive) and 10 (extremely attractive). Afterward, the mean value for each person was calculated. A value of 0.0 to 1.9 was considered to reflect a very nonattractive smile, 2.0 to 3.9 as unattractive, 4.0 to 5.9 as fair, 6.0 to 7.9 as attractive, and 8.0 to 10.0 as attractive.

![Fig 2](image1.png) Frontal view of a smile that was evaluated as attractive.

![Fig 3](image2.png) Frontal view with lips retracted, clearly displaying the perceived widths of the maxillary anterior teeth and their gingiva.

| Table 1 Number of students with an attractive and nonattractive smile in regard to sex |
|---------------------------------|-----------------|-----------------|
| Attractive smile | Nonattractive smile |
|------------------|-------------------|-----------------|
| Male             | 71                | 124             |
| Female           | 72                | 165             |
| Total            | 143               | 289             |

![Table 1](image3.png)
very attractive. The latter two groups were pooled and defined as the group with an attractive smile.

Statistical analysis was performed with SPSS 10 (SPSS). Cochran’s chi-square test with df = 1 (df, degree of freedom) was used to compare the individual groups, taking sex as a stratifying factor. 

P < .05 was set as the level of significance.

RESULTS

The intraobserver reliability was assessed through a triple measuring of 20 photographs on day 0, 7, and 14. The intraclass correlation coefficient amounted to 0.966 (95% CI: 0.954 to 0.978). The interobserver reliability of the measurements was evaluated on 20 randomly selected photographs measured by the observer and two other experienced individuals. The interclass correlation coefficient amounted to 0.941 (95% CI: 0.926 to 0.956).

In Table 2, the prevalence of the golden ratio in the widths between the maxillary central and lateral incisors in the two groups is shown. Cochran’s chi-square test showed that the difference between these two groups was significant ($\chi^2 = 6.021$, P = .014) but independent of sex ($\chi^2 = 0.001$, P = .977).

The percentages of individuals who had a maxillary lateral incisor to canine perceived width golden ratio in the two groups are shown in Table 3. The difference between these two groups was not significant ($\chi^2 = 1.485$, P = .223) and also not sex-related ($\chi^2=0.030$, P = .861).

DISCUSSION

Due to increased esthetic demands, dental professionals must rely more than ever on esthetic principles. Consequently, analyses of pleasing smiles and dental appearance are repeatedly carried out using the golden ratio as one standard.\textsuperscript{3,4,6,7–10} Still, only a few investigations have examined the presence of the golden ratio in the maxillary anterior teeth in relation to the attractiveness of an individual’s smile.\textsuperscript{2,13}

As the distinction between an attractive and nonattractive smile is crucial, it should not be determined only by dental professionals. Patient approval should also be taken into consideration. This is all the more essential, because there is an obvious difference between the layperson’s and professional’s perception of esthetics, although both may consider function to be more important than esthetics.\textsuperscript{15} Therefore, Mahshid et al also considered patients’ opinions in selecting attractive smiles.\textsuperscript{13}

Dong et al included in their selection process of pleasing smiles the curve of the maxillary anterior incisal edges to the lower lip and how many teeth were displayed while smiling.\textsuperscript{16} de Castro et al used a combination of dental, gingival, and labial factors for this determination.\textsuperscript{2}

The significant relationship between the maxillary central to lateral incisor width ratio and an attractive smile observed in the present study is in agreement with Lombardi and Levin.\textsuperscript{3,4}

The fact that the lateral incisors to canines widths ratio did not meet the golden ratio could be explained by varia-

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Number of students with a golden ratio for the widths of the maxillary central and lateral incisors in relation to the attractiveness of the smile and sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attractive smile</td>
</tr>
<tr>
<td>Male</td>
<td>35 (49.3%)</td>
</tr>
<tr>
<td>Female</td>
<td>37 (51.4%)</td>
</tr>
<tr>
<td>Total</td>
<td>72 (50.3%)</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
<th>Table 3</th>
<th>Number of students with a golden ratio for the widths of the maxillary lateral incisors and canines in relation to the attractiveness of the smile and sex</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Attractive smile</td>
</tr>
<tr>
<td>Male</td>
<td>14 (19.7%)</td>
</tr>
<tr>
<td>Female</td>
<td>10 (13.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>24 (16.8%)</td>
</tr>
</tbody>
</table>
tions in the maxillary arch form (tapered, ovoid, square, etc). This is all the more likely because it is the canine area where the difference between various arch-forms most often manifests.

Differences between this study and others can also be explained by varying methods; for instance, Preston and Gillen et al used dental casts for their investigations. However, it seems more meaningful to use photographs because they reflect more realistically the situation in which one person sees another and they better acknowledge the perceived widths of the maxillary anterior teeth.

The limitations of the present study affecting the measurements could have been (1) minor positional differences during photographing (no head fixation), and (2) no differentiation of the individual arch form (influencing the perceived widths).

CONCLUSION

Within the limitations of the present study, it can be concluded that the golden ratio between the widths of the maxillary anterior teeth cannot be considered a valid method of assessing an attractive smile.

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REFERENCES