Putative golden proportions as predictors of facial esthetics in adolescents

Rosemie M. A. Kiekens,a Anne Marie Kuijpers-Jagtman,b Martin A. van ‘t Hof,c Bep E. van ‘t Hof,d and Jaap C. Maltha
Nijmegen, The Netherlands

Introduction: In orthodontics, facial esthetics is assumed to be related to golden proportions apparent in the ideal human face. The aim of the study was to analyze the putative relationship between facial esthetics and golden proportions in white adolescents. Methods: Seventy-six adult laypeople evaluated sets of photographs of 64 adolescents on a visual analog scale (VAS) from 0 to 100. The facial esthetic value of each subject was calculated as a mean VAS score. Three observers recorded the position of 13 facial landmarks included in 19 putative golden proportions, based on the golden proportions as defined by Ricketts. The proportions and each proportion’s deviation from the golden target (1.618) were calculated. This deviation was then related to the VAS scores. Results: Only 4 of the 19 proportions had a significant negative correlation with the VAS scores, indicating that beautiful faces showed less deviation from the golden standard than less beautiful faces. Together, these variables explained only 16% of the variance. Conclusions: Few golden proportions have a significant relationship with facial esthetics in adolescents. The explained variance of these variables is too small to be of clinical importance. (Am J Orthod Dentofacial Orthop 2008;134:480-3)

Many guidelines, norms, and standards have been proposed to describe ideal proportions in the human face, and, for a long time, golden proportions have supposedly been apparent in the ideal human face.1

The golden proportion was described geometrically in the 4th century BC by Euclid as the unique division of a line (AB) into 2 parts (AC and CB) in such a way that

\[
AB:AC = AC:CB.
\]

Although Euclid is the oldest known writer to describe the construction of this golden proportion, the proportion was probably already known by the ancient Egyptians, since this ratio can be recognized in the large Egyptian pyramids from the 3rd millennium BC. A more accurate mathematical approach came from Fibonacci in the 12th century, in which the golden proportion was defined as phi (ϕ), and was found to be equal to 1.618. Although questioned by some authors, the golden proportion is often associated with esthetics and harmony in many fields such as architecture, sculpture, music, poetry, the morphology of flowers, sea shells, mammals, and the human face.2

In orthodontics, Ricketts3,4 was the first to claim that the analysis of a physically beautiful face should be approached mathematically, and he advocated the use of golden proportions in that respect. He observed dozens of photographs of magazine models to select pairs of distances representing golden proportions in those beautiful faces. On this basis, he performed a small study using 10 beautiful faces and defined several golden proportions in them. Although objections were made against the study design,5 Ricketts’s articles3,4 appear to be key publications in orthodontics and oral surgery for facial esthetics.

More recently, Baker and Woods6 and Shell and Woods7 were unable to establish significant correlations between changes in golden proportions and changes in esthetic ratings after orthognathic treatment. Although most subjects were considered to be esthetically improved after treatment, the proportions were equally likely to move away from or toward the golden proportion. They therefore concluded that the achievement of golden proportions had little or no influence on the overall esthetic scores. Moss et al.,8 who used
3-dimensional optical surface scanning techniques to analyze facial traits in average male and female models, concluded that these facial traits did not meet the golden proportions.

However, since there is great interest in golden proportions as a measure for facial esthetics in the general public, and since several authors still consider the golden proportion an important factor in facial esthetics, there is a need to evaluate the relationship between facial esthetics and the golden proportions. Until now, an analysis of the relationship between facial esthetics as perceived by a panel of judges and the golden proportions has never been performed in adolescents.

We analyzed the putative relationship between appreciated facial esthetics and the golden proportions in the faces of a group of white adolescents. Our hypothesis was that the more beautiful a face was judged to be by the panel, the less the putative golden proportions would differ from the real golden value (1.618).

MATERIAL AND METHODS

We selected pretreatment sets of 3 photographs (frontal, three-quarter smiling, and lateral) of healthy adolescents from the 1990 to 2000 files of the Department of Orthodontics and Oral Biology of Radboud University Nijmegen Medical Centre, The Netherlands. The inclusion criteria were age between 10 and 16, white background, not wearing glasses, no dental or facial trauma, and no known congenital defects. From this group, sets of photographs of 64 subjects were selected, by using randomization in strata according to Angle Class and sex. The Angle Classes were defined as follows: Class I, neutroclusion and neutral relationship of the jaws; Class II Division 1, distoclusion and distal relationship of the jaws with proclined maxillary incisors; Class II Division 2, distoclusion and distal relationship of the jaws with retroclined maxillary incisors; and Class III, mesiocclusion and mesial relationship of the jaws. The stratification aimed for about 8 boys and 8 girls for each Angle Class, to obtain a wide range of dental and skeletal variations.

A panel of 78 adult laypeople with relatively high socioeconomic backgrounds evaluated the sets of photographs on a visual analogue scale (VAS) from 0 (very unattractive) to 100 (very attractive). The sets of photographs were placed in random order in a slide show, and each set was shown for 15 seconds on a wall screen. Scores were given in relation to a reference set of photographs with a known score, as described by Kiekens et al. The data of 2 panel members were excluded because of missing data. Statistical analysis of the VAS scores was performed on the ratings of the remaining 76 people.

From the scores of all panel members, the final facial esthetic score for a subject was determined as the mean of all VAS scores given for that subject. This method has been shown to yield reproducible results.

Putative golden proportions that can be identified on frontal photographs were taken from Ricketts, Baker and Woods, and Mack. In total, 19 proportions were selected that might be golden in the ideal face (Fig). The photographs were digitized at 500 × 751 pixels, and the pertaining 13 landmarks were identified on a screen by 3 independent observers using the Sigma Scan software (Jandel Scientific, San Rafael, Calif).

Data quality control of the landmark measurements included the elimination of outliers. To that end, the measurement variance of a specific point was calculated as the mean squared distance of the mean point between the 3 observations. The measurement error of a landmark was defined as the square root of the median measurement variance of a specific point was calculated as the mean squared distance of the mean point with a measurement error larger than 3 times the median measurement variance over all 64 photographic sets. After assessment of the measurement error of the landmarks, outliers were defined as individual points with a measurement error larger than 3 times the measurement error in the landmark. In total, 0.7% of all measurements appeared to be outliers and were excluded from further analysis.

The relationship between putative golden proportions and facial esthetics was determined. For each set of photographs, the accepted measurements were used to calculate the ratios as shown in the Table. The z-score of the deviation of a subject ratio (r) from the golden standard (φ) was calculated as

\[
z = \frac{[\text{individual } (r - \varphi) - \text{mean } (r - \varphi)]}{SD}
\]

For further analysis, the z-scores were dichotomized (Dz = dichotomized z-scores) as follows:

\[
Dz = 0 \text{ if } -0.5 \leq z \leq +0.5 \text{ and } Dz = 1 \text{ if } z < -0.5 \text{ or } z > +0.5.
\]

This dichotomization was performed to reduce the effect of outliers and to classify the proportions in only 2 groups. Within a range of 1 SD of the z-score (−0.5 ≤ z ≤ +0.5), the ratio was supposed to be close to the golden standard. Outside this area (z < −0.5 or z > +0.5), the ratio was supposed to be away from the golden standard. All individual Dz scores for each ratio were used as input for a subsequent correlation analysis with the VAS scores. A negative correlation meant that the averages of the VAS scores in the deviant group (Dz = 1) was lower than the VAS scores in the other...
RESULTS

The mean VAS scores for the photographs were 55.3 ± 8.9 for the boys and 52.6 ± 9.5 for the girls. The range of all VAS scores was 31.0 to 70.8.

The measurements of the landmarks included in the calculation of the putative golden proportions showed median measurement errors from 2.2 to 9.9 pixels. The largest measurement error was found for point 1: trichion (hairline at the midsagittal plane). The range of the median errors of the remaining landmarks was 2.2 to 5.7.

The means, standard deviations, and minimum and maximum absolute values of each putative golden proportion (r) are given in the Table. The means for the putative golden proportions (r) ranged from 1.366 to 1.845. The standard deviation varied from 0.062 to 0.230.

The correlation coefficients between the Dz and VAS scores with their P values are also given in the Table. The absolute value of the correlation coefficients ranged from <0.01 to 0.36, and the P values ranged from <0.01 to 1.00. Of the 19 putative golden proportions, only 4 showed a significant correlation with the VAS scores: J (r = –0.27, P = 0.03), L (r = –0.36, P <0.01), O (r = –0.32, P = 0.01), and P (r = –0.30, P = 0.02). These correlation coefficients were all negative; this means that the deviant group (Dz = 1) had lower esthetic scores than the other group (Dz = 0). However, the explained variance of each of these proportions was low: R² (J) = 0.07; R² (L) = 0.13; R² (O) = 0.10; R² (P) = 0.09. When the 4 significant proportions were summed (as Dz04), the correlation coefficient between Dz04 and the VAS scores was –0.40 (P < 0.01), and the explained variance increased to 0.16.

DISCUSSION

The distances in this study were calculated directly between the landmarks. No reference axes, projections, perpendiculars, or tangent lines were used. These re-
restrictions were followed to prevent projection errors and make the measurement technique simpler and more applicable in clinical practice.

Unlike in Ricketts’s approach, it was considered important that not only beautiful faces were used. We therefore used a random selection of untreated adolescents who visited our clinic. The reference level of the golden standard was defined as the group mean of $r$ minus $H$. Based on the work of Ricketts, Baker and Woods, and Mack, putative golden proportions were identified and related to the outcomes of the panel judgments. The $Dz$ scores of 12 of these proportions showed a positive correlation coefficient, indicating that the deviant group had higher VAS scores than the other group. None of these correlations was significant ($0.09 < P < 1.00$). The $Dz$ scores of the other 7 proportions pointed in the other direction, but only 4 showed a significant negative correlation with the VAS scores. The explained variance of these 4 $Dz$ scores was low ($0.07 \leq R^2 < 0.13$). The sum score of the 4 significant $Dz$ scores ($Dz04$) resulted in an increase of the explained variance to 0.16. Higher $Dz04$ scores gave lower VAS scores and vice versa. This means that more beautiful faces show less deviation from these 4 golden proportions than less beautiful faces. However, the explained variance is low, indicating that the perception of facial esthetics has minimal dependence on the golden proportions in the adolescent face.

**CONCLUSIONS**

Few golden proportions have a significant relationship with facial esthetics in adolescents. Moreover, the explained variance of the significant variables was too small to be clinically important.

We thank Frits Rangel, Bianca Vrijhoef, and Olivier Van Vlijmen for their kind cooperation, and Huub Straatman for his statistical assistance.

**REFERENCES**