DIVINE PROPORTIONS IN ATTRACTIVE AND NONATTRACTIVE FACES

Aim: To test Ricketts’ 1982 hypothesis that facial beauty is measurable by comparing attractive and nonattractive faces of females and males with respect to the presence of the divine proportions. Methods: The analysis of frontal view facial photos of 90 cover models (50 females, 40 males) from famous fashion magazines and of 34 attractive (29 females, five males) and 34 nonattractive (13 females, 21 males) persons selected from a group of former orthodontic patients was carried out in this study. Based on Ricketts’ method, five transverse and seven vertical facial reference distances were measured and compared with the corresponding calculated divine distances expressed in phi-relationships ($\phi = 1.618$). Furthermore, transverse and vertical facial disproportion indices were created. Results: For both the models and patients, all the reference distances varied largely from respective divine values. The average deviations ranged from 0.3% to 7.8% in the female groups of models and attractive patients with no difference between them. In the male groups of models and attractive patients, the average deviations ranged from 0.2% to 11.2%. When comparing attractive and nonattractive female, as well as male, patients, deviations from the divine values for all variables were larger in the nonattractive sample. Conclusion: Attractive individuals have facial proportions closer to the divine values than nonattractive ones. In accordance with the hypothesis of Ricketts, facial beauty is measurable to some degree. World J Orthod 2010;11:27–36.

Key words: divine proportions, facial proportions, attractiveness, esthetics

In 1982, Ricketts presented a much-debated article in which he concluded: “The study strongly suggests that esthetics can indeed be made scientific rather than the need to resort to subjective perceptions as in the past.”

The scientific value of Ricketts’ study is, however, questionable. He analyzed the divine proportions in only the faces of 10 individuals using frontal photographs taken from magazine advertisements. Allegedly, all were selected for outstanding beauty and presented a variety of races.

Therefore, the purpose of this investigation was to test the conclusion of Ricketts by assessing the existence of divine proportions in the faces of a large and racially homogenous sample. As nonattractiveness and sex differences have not been considered in previous publications, attractive and nonattractive females and males were compared with each other.

FACIAL BEAUTY AND ATTRACTIVENESS

Facial beauty implies social success and has a positive influence in all areas of modern society. Facial esthetics do not depend on any single feature. The eyes, nose, oral region, and complexion...
contribute to overall attractiveness.\textsuperscript{7,8} There is evidence that a public agreement of facial beauty exists\textsuperscript{9–11} and that facial attractiveness is less subjective than generally believed.\textsuperscript{1,9}

The golden (divine) section is named Phi after the famous Greek artist Phidias, who used it in his architecture, including the temple of Parthenon. However, the golden section is very likely to have been known long before Phidias. Euclid’s “Elements” was the first known work to define it.

The golden section is said to have a unique quality in the description of beauty, harmony, and balance. It is defined as follows: Line \( AB \) is sectioned at point \( C \) in accordance with the golden ratio when the two subsections \( AC \) and \( CB \) correspond to each other as does the whole distance \( AB \) to the section \( AC \) (Fig 1). This relationship is the phi value \( (\phi = 1.618) \).

Sixty years ago, Ghyka\textsuperscript{12} presented a detailed analysis of the golden (divine) proportions in relation to the human face, and Bashour\textsuperscript{13} more recently gave an overview of the current concepts to analyze facial attractiveness. The divine proportions are used as a guide in facial reconstructive surgery.\textsuperscript{14,15} Furthermore, the divine proportions were used in studies to evaluate the faces of models in commercial photos\textsuperscript{1} and agreeable smiles,\textsuperscript{16} on cephalometric radiographs from attractive and nonattractive individuals,\textsuperscript{2} and of manipulated frontal facial photographs.\textsuperscript{17}

**MATERIALS**

Frontal view facial photographs with the lips in a relaxed closed position from two samples were examined:

- Ninety models (50 females, 40 males) from the covers of renowned fashion magazines who were considered to be attractive and to represent the current ideal of a beautiful face. All subjects were Caucasian.
- Three hundred ninety-eight (201 females, 197 males) individuals randomly selected from the files of the Department of Orthodontics, University of Giessen (patients) (Fig 2). Their ages ranged from 14 to 25 years of age for the females and from 16 to 25 years for the males. Orthodontic treatment was completed in all subjects.

The facial photos of these 398 patients were examined as a slideshow by a panel of 54 dental students (29 females, 25 males) who themselves had an average age of 21 years.

Every examiner had to categorize each facial photo into one of the following categories:

- Most pleasing look
- Pleasing look
- Least pleasing look

**Fig 1 (above)\hspace{1cm}** Arithmetic expression of the golden (divine) ratio: \( \frac{AC}{CB} = \frac{AB}{AC} \).

**Fig 2 (right)\hspace{1cm}** The procedure that led to the classification of individuals as having attractive and nonattractive faces.
After this subjective assessment, the photos were divided into two groups with respect to facial attractiveness, based on the 54 panel votes:

- Attractive face: > 44 votes for a most pleasing or pleasing look
- Nonattractive face: > 44 votes for a least pleasing look

Finally, there were 34 attractive (29 females, 5 males) and 34 nonattractive (13 females, 21 males) faces. The remaining 330 photos did not fulfill the requirements for being categorized into either one of two these groups.

**METHODS**

All facial photos from the models and the two patient groups were analyzed based on the method of Ricketts (Figs 3 and 4), assessing the divine proportions in the transverse and vertical facial planes.

If a reference point could not be clearly identified on a photo (because of a hairstyle, for example), the visible contralateral point was taken for reference.

To reduce the method error, all photos were measured twice by one investigator (A.H.) and the mean value was used for the final calculation.
In the transverse plane, NW-NW (nose width) was used as base value (1.0), whereas in the vertical plane, it was AL-MW (nose-lip distance). These two base values were used to calculate the ideal values for all distances using the phi relationship (Tables 1 and 2). The ideal values were compared with the measured reference distances, and the percentage differences were calculated.

**Facial disproportion index**

Transverse and vertical facial disproportion indices were generated by calculating the quotient of the sum of the absolute percentage deviations of all measured distances from their divine (ideal) values and the number of the five transverse and seven vertical reference distances.

**Statistical methods**

For each variable, the arithmetic mean (mean) and standard deviation (SD) were calculated. All data were checked with the Kolmogorov-Smirnov test for normal distribution \( (P = .05) \). As the test results revealed, there was no continuous distribution for all test groups and the non-parametric Mann-Whitney test was used to identify significant differences among groups. Graphically, the results are depicted as box plots. The levels of significance were set at .001 (***) , .01 (*), and .05 (**); any probability ≥ .05 was considered not significant.

**Method error calculation**

The total method error (locating and marking the reference points and measuring the reference distances) was calculated for each variable on the base of the duplicate registrations using Dahlberg's formula (Table 3).

### Table 1 Transverse reference distances and their phi \((\phi)\) values

<table>
<thead>
<tr>
<th>Transverse reference distance</th>
<th>Calculation of the ideal values on the basis of the divine proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW-NW</td>
<td>Base value = 1.0</td>
</tr>
<tr>
<td>NB-NB</td>
<td>1 : (\phi) = 0.618</td>
</tr>
<tr>
<td>MW-MW</td>
<td>(\phi)^2 = 2.618</td>
</tr>
<tr>
<td>HW-HW</td>
<td>(\phi^3) = 4.236</td>
</tr>
</tbody>
</table>

### Table 2 Vertical reference distances and their phi \((\phi)\) values

<table>
<thead>
<tr>
<th>Vertical reference distance</th>
<th>Calculation of the ideal values on the basis of the divine proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL-MW</td>
<td>Base value = 1.0</td>
</tr>
<tr>
<td>EW-AL</td>
<td>(\phi) = 1.618</td>
</tr>
<tr>
<td>MW-ME</td>
<td>(\phi) = 1.618</td>
</tr>
<tr>
<td>HL-HW</td>
<td>(\phi^2) = 2.618</td>
</tr>
<tr>
<td>AL-ME</td>
<td>(\phi^2) = 2.618</td>
</tr>
<tr>
<td>EW-MW</td>
<td>(\phi^2) = 2.618</td>
</tr>
<tr>
<td>EW-ME</td>
<td>(\phi^3) = 4.236</td>
</tr>
</tbody>
</table>

### Table 3 Method error calculation for the various reference distances and groups

<table>
<thead>
<tr>
<th>Reference distance (mm)</th>
<th>Models (n = 90)</th>
<th>Attractive (n = 34)</th>
<th>Nonattractive (n = 34)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NB-NB</td>
<td>0.30</td>
<td>0.44</td>
<td>0.32</td>
</tr>
<tr>
<td>MW-MW</td>
<td>0.30</td>
<td>0.42</td>
<td>0.40</td>
</tr>
<tr>
<td>EW-EW</td>
<td>0.41</td>
<td>0.55</td>
<td>0.44</td>
</tr>
<tr>
<td>HW-HW</td>
<td>0.68</td>
<td>0.77</td>
<td>0.69</td>
</tr>
<tr>
<td>EW-AL</td>
<td>0.40</td>
<td>0.54</td>
<td>0.38</td>
</tr>
<tr>
<td>MW-ME</td>
<td>0.27</td>
<td>0.39</td>
<td>0.49</td>
</tr>
<tr>
<td>HL-HW</td>
<td>0.76</td>
<td>0.81</td>
<td>0.75</td>
</tr>
<tr>
<td>AL-ME</td>
<td>0.33</td>
<td>0.44</td>
<td>0.51</td>
</tr>
<tr>
<td>EW-MW</td>
<td>0.35</td>
<td>0.51</td>
<td>0.48</td>
</tr>
<tr>
<td>EW-ME</td>
<td>0.52</td>
<td>0.63</td>
<td>0.53</td>
</tr>
</tbody>
</table>
RESULTS

Models

Transverse distances (Table 4, Fig 5). In females, the largest and smallest average deviations from the ideal values were found for mouth width (MW-MW) and for nose bridge width (NB-NB), respectively. In males, the largest and smallest average deviations from the ideal values were found for head width (HW-HW) and for nose bridge width (NB-NB), respectively.

Vertical distances (Table 4, Fig 5). In females, the largest average deviations from the ideal values were found for forehead height (HL-HW) and for nose height (EW-AL). The smallest deviation was seen for total face height (EW-ME).
In males, the largest and smallest average deviations from the ideal values were found for forehead height (HL-HW) and lower face height (AL-ME), respectively.

Disproportion indices (Table 4, Fig 6). In females, the disproportion index for the transverse reference distances was 2.6% and 3.5% for the vertical reference distances.

In males, the disproportion index for the transverse distances was 4.4% and 5.0% for the vertical reference distances.

Comparison of sex (Table 4, Figs 5 and 6). In the transverse plane, males had significantly smaller eye width (EW-EW) \( (P < .001) \) and head width (HW-HW) \( (P < .01) \) than females.

In the vertical plane, males had significantly larger chin height (MW-ME) \( (P < .01) \) and lower face height (AL-ME) \( (P < .01) \) than females.

The transverse \( (P < .01) \) and vertical \( (P < .05) \) disproportion indices were significantly larger in males than in females.

Attractive patients

Transverse distances (Table 5, Figs 7 and 8). In females, the largest and smallest average deviations from the ideal values were found for head width (HW-HW) and eye width (EW-EW), respectively.

In males, the largest and smallest average deviations from the ideal values were found for mouth width (MW-MW) and nose bridge width (NB-NB), respectively.

Vertical distances (Table 5, Figs 7 and 8). In females, as well as in males, the largest average deviations from the ideal values were found for nose height (EW-AL).

The smallest average deviations from the ideal values were seen for chin height (MW-ME) in females and for lower face height (AL-ME) in males.

Disproportion indices (Table 5, Fig 6). In females, the disproportion index for the transverse reference distances was 3.0% and 4.0% for the vertical reference distances.

In males, the disproportion index for the transverse distances was 4.7% and 5.1% for the vertical reference distances.
Comparison of sex (Table 5, Figs 6 to 8). As the attractive male patient group comprised only five individuals, the two sexes were not compared.

Nonattractive patients

Transverse distances (Table 5, Figs 7 and 8). In females and males, the largest and smallest average deviations from the ideal values were found for mouth width (MW-MW) and for nose bridge width (NB-NB), respectively.

### Table 5   Percent deviations (mean and SD) of all transverse and vertical reference distances from their ideal values calculated on the basis of the divine proportions for attractive and nonattractive patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Attractive</th>
<th>Nonattractive</th>
<th>Attractive–nonattractive</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female (n = 29)</td>
<td>Male (n = 5)</td>
<td>Female (n = 13)</td>
</tr>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
<td>Mean ± SD</td>
</tr>
<tr>
<td>Transverse distances</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NB-NB</td>
<td>+1.9 ± 3.3</td>
<td>−1.3 ± 3.7</td>
<td>+0.6 ± 8.3</td>
</tr>
<tr>
<td>MW-MW</td>
<td>−3.2 ± 4.1</td>
<td>−6.4 ± 4.0</td>
<td>−9.7 ± 11.0</td>
</tr>
<tr>
<td>EW-EW</td>
<td>−0.7 ± 2.1</td>
<td>−3.4 ± 3.2</td>
<td>−4.4 ± 9.1</td>
</tr>
<tr>
<td>HW-HW</td>
<td>−3.8 ± 3.3</td>
<td>−5.8 ± 1.7</td>
<td>−8.2 ± 8.1</td>
</tr>
<tr>
<td>Transverse index</td>
<td>3.0 ± 1.9</td>
<td>4.7 ± 2.0</td>
<td>9.4 ± 3.1</td>
</tr>
<tr>
<td>Vertical distances</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EW-AL</td>
<td>−7.8 ± 5.7</td>
<td>−11.2 ± 3.3</td>
<td>−10.9 ± 8.3</td>
</tr>
<tr>
<td>MW-ME</td>
<td>+0.3 ± 4.4</td>
<td>+3.1 ± 3.6</td>
<td>+5.7 ± 11.0</td>
</tr>
<tr>
<td>HL-HW</td>
<td>−3.4 ± 5.2</td>
<td>−4.2 ± 3.6</td>
<td>−6.3 ± 12.7</td>
</tr>
<tr>
<td>AL-ME</td>
<td>+1.0 ± 3.2</td>
<td>+2.6 ± 3.1</td>
<td>+3.1 ± 7.0</td>
</tr>
<tr>
<td>EW-MW</td>
<td>−3.6 ± 3.2</td>
<td>−5.9 ± 3.9</td>
<td>−5.7 ± 5.7</td>
</tr>
<tr>
<td>EW-ME</td>
<td>−2.7 ± 3.2</td>
<td>−3.6 ± 3.4</td>
<td>−2.0 ± 7.0</td>
</tr>
<tr>
<td>Vertical index</td>
<td>4.0 ± 2.8</td>
<td>5.1 ± 2.0</td>
<td>8.7 ± 3.0</td>
</tr>
</tbody>
</table>

+ implies a value that is larger than ideal; − implies a value that is smaller than ideal.

### Fig 7   Box plots of the transverse and vertical reference distance deviations from their ideal values (0) calculated on the basis of the divine proportions in the 29 attractive and 13 nonattractive female patients.
Vertical distances (Table 5, Figs 7 and 8). In females, the largest and smallest average deviations from the ideal values were found for nose height (EW-AL) and total face height (EW-ME), respectively.

In males, the largest and smallest average deviations from the ideal values were found for nose height (EW-AL) and lower face height (AL-ME), respectively.

Disproportion indices (Table 5, Fig 6). In females, the disproportion index for the transverse reference distances was 9.4% and 8.7% for the vertical reference distances.

In males, the disproportion index for the transverse reference distances was 8.8% and 9.9% for the vertical reference distances.

Comparison of sex (Table 5, Figs 6 to 8). When comparing nonattractive female and male patients, no significant differences were found for any variable.

Comparison of attractive and nonattractive patients (Table 5, Figs 6 to 8). A statistical group comparison was performed for only females because the attractive male group comprised just five subjects.

In the transverse plane, nonattractive females exhibited significant larger deviation values for mouth width (MW-MW) \( (P < .01) \) and eye width (EW-EW) \( (P < .05) \) than attractive females. In the vertical plane, no group differences existed.

The transverse and vertical disproportion indices were significantly larger \( (P < .001) \) in nonattractive than in attractive female patients.

DISCUSSION

It has been said that beauty lies in the eye of the beholder. This statement is basically still true as the assessment of facial attractiveness is very complex. Results from studies evaluating computer-manipulated male and female faces indicate that bilateral symmetry,\(^{20–23}\) average-ness,\(^{22,24–26}\) hormone markers,\(^{23,24,27}\) and the menstrual cycle\(^{26,29}\) influence the perception of attractiveness.

Ricketts\(^{1,30}\) was the first to stipulate that instead of resorting to a subjective perception, a face’s beauty should be mathematically analyzed on the basis of the golden proportions. This was performed
in the present investigation, allowing an appropriate comparison with Ricketts’ and other researchers’ results. Frontal photographs were taken because this is the perspective from which most cover models are normally seen and what was used in other studies.\textsuperscript{1,18}

The composition of an examination panel may have an effect on the ranking of facial esthetics, but the relevant literature is not clear about the influence of professional background,\textsuperscript{31,32} age,\textsuperscript{31,33} and sex\textsuperscript{32–34} on the panel’s decisions. Panel size is another issue of controversy.\textsuperscript{32,34–36} As the panel of the present investigation was large and uniform (54 young adult dental students evenly distributed with respect to sex), common esthetic norms were expected to exist.

Strict criteria were used to assign the 398 former orthodontic patients to either the attractive or nonattractive group. At least 44 of 54 (81\%) votes were necessary for each face to be distinctly grouped.

Differences in size of facial dimensions amongst individuals will have an input on whether a particular individual has a normal or ideal facial relationship. The use of the divine proportions overcomes this problem.

The results of the present investigation revealed for both attractive and nonattractive females and males large interindividual variations of the different transverse and vertical parameters. For all variables in the female models and, with one exception, in the attractive female patients, the average deviations from the divine proportions were rather small (between 0.3\% and 3.6\%). The exception was nose height (EW-AL) in female patients, in which the deviation amounted to 7.8\% (shorter nose).

In male models and attractive male patients, the average deviations of the variables from their ideal values were somewhat larger in general. The deviations ranged between 0.2\% and 6.3\%, except for nose height (EW-AL), which amounted to 11.2\% (smaller nose).

The sex differences found for the models could be explained by different esthetic standards for females and males,\textsuperscript{23,24,27,29} eg, in males, a prominent chin (MW-ME) and an increased lower face height (AL-ME) are favored as they are considered masculine. Thus, attractive male faces were less often verified by the divine proportions than the female ones.

In this context, it must be pointed out that all vertical measurements are affected by the head position. Most likely, females were photographed with their heads tilted more forward than the males as this adds to their attractiveness. The geometric consequence of this head tilt would be a relatively shorter lower face.

When comparing the female models with the attractive female patients, similar deviations from the ideal proportions for the different variables were found. However, when comparing attractive and nonattractive females, as well as male patients, larger deviations from the ideal values became obvious for the nonattractive subjects. This was especially apparent when using the disproportion index. The present study indicates that facial attractiveness is partially related to the divine proportions and is measurable, as Ricketts\textsuperscript{1} stated.

It should be kept in mind that the divine proportions are not absolute determinants of facial attractiveness as they are subjected to the same limitations as other methods. While faces conforming to the divine proportions may well be conceived as esthetically pleasing, it is quite possible that other methods of evaluation would lead to an equally favorable outcome. Thus, it seems that it is the individual esthetic character of facial features, not just their proportions, that significantly influence the assessment of facial beauty and attractiveness.

**CONCLUSION**

The facial proportions of the attractive individuals were closer to the divine proportions compared to those of the nonattractive ones. Attractive females exhibited facial proportions nearer to the divine values than males. In accordance with Ricketts’ hypothesis, this study indicates that facial beauty, at least to some degree, is based on the divine proportions and can be measured.
REFERENCES


