Golden proportions as predictors of attractiveness and malocclusion

Ahluwalia Rajiv, Yadav Juhi

Objective: In recent years, the golden proportions have been evaluated by various researchers in the general population and orthodontic patients to establish their correlation with facial attractiveness and esthetics, but with conflicting results. The present study aimed to analyze the frontal facial golden proportions for three groups of young adult females, an attractive group, and two malocclusion groups. Our null hypothesis stated that the golden proportions of attractive females were analogous with or closer to the golden number than those with an established malocclusion.

Materials and Methods: Frontal facial photographs of 80 female dental students were scored for facial attractiveness by 10 dental specialists. Thirty females with scores greater than the median score of 48 formed the attractive group. Thirteen females with Class I malocclusion and 15 females with Class II division 1 malocclusion formed the two malocclusion groups. Ten landmarks and 19 golden proportions were calculated for all subjects. One-way ANOVA and unpaired Student’s t-test was used to analyze the differences in golden proportions between the attractive and malocclusion groups.

Results: Significant differences were observed for 10 proportions (P < 0.04 to < 0.0001). Five vertical proportions showed significant differences in both subgroups; Attractive versus Class I and Attractive versus Class II division 1; while one vertical and all transverse proportions showed significant differences only in Attractive versus Class II division 1 subgroup. The average values of these proportions varied both toward and away from the golden number for both attractive and malocclusion groups.

Conclusion: Facial proportions of the attractive females were significantly different from those with malocclusion, but did not show a constant trend of being closer to the golden number. Furthermore, the golden proportions were not analogous with the facial esthetics of the attractive females.

Key words: Facial esthetics, facial proportions, golden proportions, malocclusion
Luca Pacioli in the year 1509; it simply stated a geometrical proportion in which, a line AB was divided at a point C in such a way that AB/AC = AC/CB. Fibonacci later calculated the golden proportion mathematically and represented it by the symbol Φ (Phi); derived from the name of the Greek sculptor Phidias.\(^2\) the proportion had a calculated value of 1.618 or 0.618 and was denoted as the golden number.

In orthodontics, Ricketts\(^8\) was among the first to study the face and describe the importance of divine proportions. He formulated the proportions and stated that organisms, including humans that conformed to the divine proportion, were not only beautiful, but also biologically healthy.\(^8\) Jefferson\(^9\) established a biologic equation for all humans regardless of race, age and sex; he concluded that “divine proportion = facial beauty = temporomandibular joint health = psychologic health = physiologic harmony = fertility = total health and wellness = quality of life.”

In recent years, the golden proportions have been put to test by various studies in the general population and orthodontic patients to establish their importance in determining facial attractiveness and esthetics, but with conflicting results. Certain authors\(^9,10\) agreed with Ricketts findings. However, others\(^11,12\) failed to find any correlation at all.

As facial soft tissue analyses continue to attain more importance in orthodontic treatment planning, it seemed pertinent to determine the importance of golden proportions in diagnosis and classification of malocclusion. In the present study, we analyzed the golden proportions for two groups of young adult females, the attractive group, and the malocclusion group. Our null hypothesis stated that the golden proportions for attractive females were analogous with or closer to the golden number contrary to those with established malocclusion.

MATERIALS AND METHODS

Sample selection
In order to formulate the attractive group, an initial sample of 80 female dental students aged 18–25 years and originating from North Indian population were selected to obtain frontal facial nonsmiling photographs. Those who had undergone prior orthodontic or prosthodontic treatment and those with missing teeth or any gross facial asymmetry were excluded. The visual analogue scale (VAS)\(^13,14\) scoring system was used to score the frontal facial photographs of the initial sample for facial attractiveness on a scale of 0–10. All photographs were printed (9 cm × 13 cm) and mounted on a display board. They were individually assessed by 10 dental specialists, including 5 orthodontists and 5 oral and maxillofacial surgeons, for not more than 15 min each. General guidelines were given to all evaluators for scoring the photographs in a nonbiased manner, taking into consideration facial symmetry, structural balance and harmony, facial proportions, and cosmetic appeal. A one-way ANOVA model was used to find the intra-class correlation among the evaluators. Total scores were calculated by summing the scores for each photograph and median was calculated. Thirty females, who had total scores of more than the median, were considered as attractive and formed the attractive or control group.

The malocclusion groups comprised of randomly selected, pretreatment frontal facial photographs of female patients aged between 18 and 25 years, who presented to the Orthodontic Department. They were grouped according to the two most common types of malocclusion, prevalent in this region, in accordance with the angle’s classification of malocclusion; Class I neutroclusion with bi-maxillary dental protrusion (Class I Bimax) and Class II division 1 distocclusion with proclined maxillary incisors (Class II division 1).

The final samples included frontal facial nonsmiling photographs of 13 females in the Class I Bimax malocclusion group and 15 females in the Class II division 1 malocclusion group. The study sample consisted only of female subjects due to the prevalence of female patients in the Orthodontic Department where the study was conducted.

Photographic set-up and analyses
All photographs were standardized by using the same set-up consisting of a tripod and camera with a constant focal length of 85 mm and aperture at f/5.6. The tripod assisted in gaining stability and correct height of the camera according to the subject’s body height. It also ensured correct horizontal position of the optical axis of the lens. A single external flash was placed one foot behind and in line with the lens of the camera and a white background was used to get maximum illumination. Use of a slave flash unit allowed synchronization of the flash and camera via a wireless trigger, attached to the camera’s hot shoe port.

The subjects stood bare feet at a distance of 2 m from the camera on a line marked on the floor. They were instructed to look directly into and in line with the optical axis of the lens such that the inter-pupillary line was parallel to the floor. An inch ruler was hung down vertically with a plumb line held by a thick thread alongside the subject, the former allowed standardization of measurements while the plumb line indicated the true vertical [Figure 1].

The photographs were analyzed using Nemocceph 4.0\(^{\circledR}\) Nemotec Dental Systems, Madrid, Spain) cephalometric software program for the Windows operating system. The program calculated the measurements once all the landmarks were manually identified in the software by the same operator [Figure 2]. In order to simplify the description of all variables, planes, and proportions, the face was divided into multiple sections and defined only for this study [Table 1, Figure 3a and b]. Nineteen putative golden proportions were calculated from these measurements based
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on the previous works of Ricketts,[7,8] Baker and Woods[11] and Kiekens et al.[12] [Table 2 and Figure 4a-c].

Statistics

Dahlberg's formula was used to compute the error in plotting of landmarks and the data was analyzed by the SPSS version 12 (SPSS is a statistical analysis and data management solution software from IBM, www.spss.co.in) statistical software. A one-way ANOVA model was used to compare and compute significant differences in the presumed golden proportions, if any, in the three groups of female frontal facial photographs; the attractive group, the Class I Bimax group and the Class II division I group. The golden proportions that showed a significant variance on applying ANOVA were further analyzed using an unpaired Student’s t-test to compare each malocclusion group independently with the attractive group. Statistical significance was set at 5% (P ≤ 0.05). All proportions were also analyzed for equal variance using Bartlett's test for equal variances.

RESULTS

The maximum error in tracing of landmarks was observed for the landmark trichion, which was just over a millimeter. All other landmarks had an error of <1 mm, thus validating the method of measurement [Table 3]. The interclass correlation for the VAS scores was 0.667, which showed good agreement among the observers. Thirty females had attractiveness scores greater than the median score of 48 and they formed the attractive group.

Statistical analysis of the golden proportions in the attractive and malocclusion groups revealed significant differences for the proportions D (UFH: MFH), H (NH: ULH), J (MFH: MH), K (FH: MLFH), L (MFH: MLFH), O (MH: LFH), P (MH: ULH), Q (FW: ICW), R (ICW: SW), S (SW: NW); P ranging from <0.04 to <0.0001 [Table 4]. On further analysis,
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proportions D (UFH: MFH), J (MFH: MH), L (MFH: MLFH), O (MH: LFH), P (MH: ULH) showed significant variance for both sub groups; Attractive versus Class I Bimax and Attractive versus Class II division 1. Proportions K (FH: MLFH), Q (FW: ICW), R (ICW: SW) and S (SW: NW) showed significant variation only between the Attractive and Class II division 1 subgroup [Table 5]. The average values of all the significant proportions varied from 1.32 to 1.83 in attractive group, 1.26–1.89 in Class I Bimax group and 1.22–2.04 in Class II division 1 group from the ideal value of 1.618. The average value of proportion H (NH: ULH) was 0.81 in attractive group, 0.92 in Class I Bimax group and 0.94 in Class II division 1 group as compared to the ideal value of 0.618.

Bartlett’s test revealed significant variance in proportions C (FH: UFH), D (UFH: MFH), E (UFH: LFH) and F (FFH: UFH) with $P \leq 0.05$; their analyses should thus be considered with caution, even though none of these proportions showed any significant relation, except proportion D (UFH: MFH) [Table 6].

DISCUSSION

The golden proportions have been used for centuries to define and formulate mathematical equations to measure beauty. A number of researchers in the past studied facial features of celebrities of the fashion industry and winners of beauty pageants; however these individuals represented a very small percentage of the population. In the present study, we selected the attractive faces from a general population group who formed a larger part of the society than a few selected individuals. A significant variation was observed in the presumed golden proportions among the attractive group of females and those with orthodontic malocclusion, however, these proportions varied both towards and away from the golden number (1.618 or 0.618). Thus, the golden proportions did not correlate with either the attractive

Table 3: SE in millimeters using Dahlberg’s formula in tracing landmarks

<table>
<thead>
<tr>
<th>Landmarks</th>
<th>SE (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tr</td>
<td>1.06</td>
</tr>
<tr>
<td>FwR</td>
<td>0.21</td>
</tr>
<tr>
<td>FwL</td>
<td>0.13</td>
</tr>
<tr>
<td>CR</td>
<td>0.23</td>
</tr>
<tr>
<td>CL</td>
<td>0.26</td>
</tr>
<tr>
<td>AR</td>
<td>0.14</td>
</tr>
<tr>
<td>AL</td>
<td>0.10</td>
</tr>
<tr>
<td>LcR</td>
<td>0.24</td>
</tr>
<tr>
<td>LcL</td>
<td>0.24</td>
</tr>
<tr>
<td>Me</td>
<td>0.46</td>
</tr>
</tbody>
</table>

SE=Standard error, Tr=Trichion, CR=Lateral canthus right, CL=Lateral canthus left, AR=Ala right, AL=Ala left, LcR=Lip commissure right, LcL=Lip commissure left, FwR=Facial width right, FwL=Facial width left, Me=Menton

Table 4: One‑way ANOVA to compare the golden proportions between the three groups; Attractive, Class I Bimax and Class II division 1 groups

<table>
<thead>
<tr>
<th>Proportions</th>
<th>Attractive</th>
<th>Class I Bimax</th>
<th>Class II division 1</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.29±0.28</td>
<td>2.19±0.21</td>
<td>2.14±0.32</td>
<td>0.2849</td>
</tr>
<tr>
<td>B</td>
<td>1.85±0.16</td>
<td>1.94±0.20</td>
<td>1.89±0.17</td>
<td>0.3717</td>
</tr>
<tr>
<td>C</td>
<td>1.45±0.05</td>
<td>1.42±0.19</td>
<td>1.47±0.05</td>
<td>0.5432</td>
</tr>
<tr>
<td>D</td>
<td>1.83±0.13</td>
<td>1.62±0.22</td>
<td>1.63±0.09</td>
<td>0.0006***</td>
</tr>
<tr>
<td>E</td>
<td>1.63±0.17</td>
<td>1.53±0.25</td>
<td>1.53±0.10</td>
<td>0.2528</td>
</tr>
<tr>
<td>F</td>
<td>1.63±0.06</td>
<td>1.70±0.36</td>
<td>1.65±0.05</td>
<td>0.5707</td>
</tr>
<tr>
<td>G</td>
<td>1.76±0.06</td>
<td>1.69±0.10</td>
<td>1.69±0.06</td>
<td>0.0698</td>
</tr>
<tr>
<td>H</td>
<td>0.81±0.15</td>
<td>0.92±0.13</td>
<td>0.94±0.14</td>
<td>0.03*</td>
</tr>
<tr>
<td>I</td>
<td>1.81±0.15</td>
<td>1.91±0.13</td>
<td>1.91±0.14</td>
<td>0.0665</td>
</tr>
<tr>
<td>J</td>
<td>1.47±0.13</td>
<td>1.69±0.21</td>
<td>1.71±0.17</td>
<td>0.0002***</td>
</tr>
<tr>
<td>K</td>
<td>1.34±0.10</td>
<td>1.39±0.08</td>
<td>1.44±0.10</td>
<td>0.03*</td>
</tr>
<tr>
<td>L</td>
<td>1.688357237</td>
<td>1.593612951</td>
<td>1.591900918</td>
<td>0.0001***</td>
</tr>
<tr>
<td>M</td>
<td>1.49±0.08</td>
<td>1.49±0.06</td>
<td>1.49±0.06</td>
<td>0.9709</td>
</tr>
<tr>
<td>N</td>
<td>2.06±0.34</td>
<td>2.05±0.25</td>
<td>2.05±0.29</td>
<td>0.996</td>
</tr>
<tr>
<td>O</td>
<td>1.65±0.06</td>
<td>1.80±0.12</td>
<td>1.81±0.08</td>
<td>&lt;0.0001****</td>
</tr>
<tr>
<td>P</td>
<td>1.56±0.14</td>
<td>1.26±0.19</td>
<td>1.22±0.14</td>
<td>&lt;0.0001****</td>
</tr>
<tr>
<td>Q</td>
<td>1.46±0.04</td>
<td>1.44±0.06</td>
<td>1.41±0.05</td>
<td>0.0358*</td>
</tr>
<tr>
<td>R</td>
<td>1.87±0.14</td>
<td>1.89±0.09</td>
<td>2.04±0.14</td>
<td>0.0051**</td>
</tr>
<tr>
<td>S</td>
<td>1.32±0.11</td>
<td>1.33±0.07</td>
<td>1.19±0.14</td>
<td>0.0084**</td>
</tr>
</tbody>
</table>

*Slightly significant, **Significant, ***and ****Very significant. One‑way ANOVA (df ), $P>0.05$ not significant; $P\leq 0.05$ significant. SD=Standard deviation
or the malocclusion groups. The deviations ranged from 1.32 to 2.29 in the attractive females, 1.26–2.19 in Class I Bimax to 1.19–2.14 in Class II division 1 group. All facial proportions that incorporated the forehead height, except D (UFH: MFH) and K (FH: MLFH), did not affect the results significantly. Hence, the height of the forehead appeared to play little role in defining attractiveness or differentiating the facial features between attractive and malocclusion groups.

The proportions which demonstrated a significant deviation \((P \leq 0.05)\) from ideal were further analyzed using an unpaired Student’s \(t\)-test. All vertical proportions, except H (NH: ULH) and K (FH: MLFH), showed significant variations in both malocclusion subgroups when compared to the attractive group. Significant variations were observed in all horizontal proportions and the vertical proportions H (NH: ULH) and K (FH: MLFH) on comparing the Class II division 1 malocclusion group with the attractive group. The transverse facial features thus appeared to differ significantly in patients with Class II division 1 malocclusion. Discrepancies observed in their maxillary and mandibular skeletal bases, corresponding to the skeletal Class II morphology, may have been responsible for this trend.

Even though, ten of the 19 presumed golden proportions showed significant differences among the attractive and malocclusion groups, we failed to observe any trend of either group being constantly near or equal to the ideal golden proportion in the present study. A significant difference in the vertical and transverse ratios of the Class II division 1 group highlighted their variation in skeletal and soft tissue morphologies from the control group, however, the use of golden proportions was not deemed to be an ideal method to differentiate and classify facial types.

Kieken et al.\(^{[12]}\) analyzed the putative relationship between facial esthetics and golden proportions in white adolescents and found few proportions to significantly affect facial esthetics. Baker and Woods\(^{[11]}\) evaluated pre and post treatment lateral cephalograms, frontal (nonsmiling) and profile color facial photographs for patients treated by a combination of orthodontic/orthognathic surgical treatment. The authors found no relationship between changes in appearance as a result of the combined treatment and changes in the values of Rickett’s golden proportions. Panzerz et al.\(^{[10]}\) compared attractive and nonattractive patient groups and found larger deviations from the divine values in the nonattractive group. They concluded that attractive patients did have golden proportions closer to the ideal and facial beauty was measurable to some degree, which was contrary to our findings.

The characteristics of an attractive face may be partially governed by golden proportions but we failed to correlate attractive facial features to an ideal golden number. Some important elements which possibly affect facial attractiveness are the harmony, symmetry, dimorphism, balance, youthful appearance and ethnicity.\(^{[4]}\) In addition, the specific skin characteristics, such as texture or appearance, may be of great importance in the evaluation of natural attractiveness.\(^{[15]}\)

### CONCLUSIONS

The null hypothesis was rejected and it was concluded that:

- Majority of the presumed golden proportions of the attractive females were significantly different from those with orthodontic malocclusion, however, they did not significantly conform to the golden number
- Ideal golden proportions may partially govern the standards of beauty but they were not analogous to the beauty or facial esthetics of the attractive females in the present study
- Golden proportions would not be an ideal method of classifying malocclusion but may be useful in...
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Determining the pretreatment baseline and designing an optimum treatment plan for an esthetic result.

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