Aesth Plast Surg (2016) 40:1–12
DOI 10.1007/s00266-015-0581-x

ORIGINAL ARTICLE AESTHETIC

The Role of Ideal Angles, Ratios, and Divine Proportions in Aesthetic Evaluation of Adolescents

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Received: 25 April 2015 / Accepted: 14 October 2015 / Published online: 28 October 2015

Abstract
Objectives The aim of our study was to investigate whether the parameters of ideal angles, ratios, and divine proportions that have been previously mentioned in the literature influence the aesthetic evaluation of Turkish adolescents.
Materials and Methods A total of sixty patients (30 males and 30 females) were enrolled in this study. Ages of the subjects ranged from 9 to 17. Pre-treatment extra-oral photographs were taken to evaluate facial aesthetics. Two distinct panels consisting of 50 orthodontists and 50 laypersons were created for scoring the photographs of the patients. Scoring was performed using the VAS scale. Twenty-seven ratios and 19 divine proportions were measured in frontal photographs, and 26 angles were measured in profile photographs.
Results Pearson correlation was used to determine the relationship between the photograph analysis measurements and VAS scores, and then regression analyses were performed to disclose to what extent significant values may warrant the term beauty.
Conclusion As a result of our investigations, none of the golden proportions was associated with facial aesthetics according to both orthodontists and laypersons. According to other angles and ratios that were measured, it was determined that orthodontists noticed the sagittal position of the lower jaw, the distance between the eyes and length of the face, whereas laypersons noticed only the distance between the eyes and length of the face.
Level of Evidence V This journal requires that the authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Divine proportions · Aesthetic evaluation · Adolescents · Orthognatic surgery · Facial beauty

Introduction

Fourth-century BC archaic Greek sculptures of Apollo Belvedere and Aphrodite represent ideal face ratios [1]. Pythagoras was the first in history to attempt to measure facial aesthetics mathematically. The divine proportion, in other words the golden ratio, which was inspired by his ideas, arose in the 5th and 6th centuries BC and was described for the first time by Euclid in his book Element II [2]. There is a common belief that facial ratios of individuals who are considered to be attractive in the population are very close to the average values of the population. Although the ratio is not the sole representative of attractiveness, it is one of the most important known factors. Despite it being obvious that facial aesthetics depend on other factors, such as color and tissue of the skin, and dental appearance, static facial morphology is of course an overriding factor [3].

Mainly, two-dimensional measurements and various ideal angles and ratios that should exist in an attractive face have been described in the literature [4]. However, some investigators created angles and ratios based on scientific foundations; generally selection criteria and the best value

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accepted are arbitrary and optional. Sometimes, average faces are considered as a source. By accepting an average face as attractive, average values become the ideal. Ideal angles and ratios are not frequently encountered in the literature for the adolescent population who comprise a large proportion of orthodontic patients [5]. The idea that certain facial ratios and certain golden ratios (divine proportions) might be used to evaluate facial beauty was first suggested by Ricketts in the history of orthodontics. Ricketts [6] examined dozens of magazine photographs to investigate divine proportions in beautiful faces. He discovered a few divine proportions in one study which investigated ten beautiful faces. Although objections were made in this study, articles of Ricketts are considered important in orthodontics and oral surgery [6, 7].

Ideal angles, ratios, and divine proportions that may be found in an attractive face exist in the literature. Although it is impossible to change non-ideal facial dimensions, ratios, and angles by orthodontic treatment, orthodontists take these measurements into consideration during treatment planning. However, the association between the ideal angles, ratios, and divine proportions and the facial aesthetics of adolescents was rarely evaluated. The aim of our study was to investigate whether the parameters of ideal angles, ratios, and divine proportions previously mentioned in the literature influence the aesthetic evaluation of Turkish adolescents.

Materials and Methods

The records of Turkish adolescents who applied to Selcuk University, Department of Orthodontics between 2000 and 2008, aged 9 to 17, and who had no dental or facial trauma and no known congenital defects, without supernumerary teeth, dental malformation, or deficiency in anterior dentition, and who had not received fixed orthodontic treatment previously were scanned. Sixty patients (30 boys and 30 girls) were selected from among over 2000 that had been scanned according to the Angle classification and gender. These patients were divided into four equal groups (Class I, Class II div 1, Class II div 2, Class III) according to Angle classification [8].

To evaluate facial aesthetics, three preoperative extra-oral photographs in the records (frontal resting, frontal smiling, and lateral resting) were used for each patient. Extra-oral lateral and frontal photographs of patients taken using a digital camera (Nikon D80; Nikon Corporation, Tokyo, Japan) and a telescopic lens (Micro-Nikkor 105 mm; Nikon Corporation) were obtained from medical archives. Frontal photographs were taken with the plane intersecting the pupils parallel to the ground, with the jaw in centric relation and with the lips closed without tension. Lateral photographs were taken with the soft tissue Frankfort horizontal plane parallel to the ground, the jaw in centric relation and the lips closed without tension.

The first step of the VAS measurement was the separate selection of reference photos for boys and girls. The second was the scoring of all the photos with the reference photos.

In the first step, for each patient, a slide showing a combination of photos showing pre-treatment frontal resting, frontal smiling, and lateral resting was prepared (Microsoft Office 2003, PowerPoint, Seattle, Washington, USA). Sixty slides were projected onto a curtain screen in random order. A total of 50 dental students (25 male and 25 female), aged 19–26, were asked to rate the photos of the slides using the VAS from 0 to 100, according to their aesthetic perception. Each slide was projected for 10 s. After scoring, mean and standard deviation values were calculated for each patient with scores given by dental students. A series of sets of three photographs with mean aesthetic scores close to general mean of 3000 scores (50 students $\times$ 60 patients) were selected as the reference photos (separate for boys and girls) among sixty sets of photographs.

In the second step, to perform the actual measurement system, the reference photo series were added to each series of sets of photographs, according to the gender of the patient. Instead of the selected reference patients, in accordance with the classification of gender and Angle, new patients were selected (again from archives) to bring the total number of patients to 60 (mean age $\pm$ SD: 12.96 $\pm$ 1.70).

Two separate panels were created to rank patient photographs: 50 orthodontists (mean age $\pm$ SD $= 42.39 \pm 4.48$) working in various universities or in their own clinics but not doctoral students or research assistants and 50 laypersons (mean age $\pm$ SD $= 42.33 \pm 8.88$) who accompanied a relative of theirs for orthodontic treatment in our clinic. Laypersons were university educated but not in dentistry and with a relatively high socio-economic status.

At the presentation of the survey to panel members, slides of the photo series were projected onto a wall in the form of a slide shown in random order with the help of Microsoft Office 2003, PowerPoint (Seattle, Washington, USA). Each patient's three photographs, with three photographs by reference on the same slide, were shown to members of the panel for 10 s. Members were asked to vote the photo series using the VAS from 0 to 100 (from very unattractive to very attractive), according to their aesthetic perception. To help the members of the panel, a vertical line showing 50 points and representing reference photos was used as a guide at the center of the scale. After scoring, the means of the scores for each set of photographs were calculated for each panel.

Particular markings and measurements were performed in the extra-oral lateral and frontal photographs using Sigma Scan (Systat Software GmbH, Erkrath, Germany) software. A total of 34 points were marked (15 in the frontal photographs and 19 in the lateral photographs) (Figs. 1, 2).

In our study, a total of 26 angles described by Peck and Peck [9], Cox and van der Linden [10], Hautvast [11], Lines et al. [12], Koury and Epker [13], Nanda et al. [14], Ferrario et al. [15], Nguyen and Turley [16], Auger and Turley [17], Fernandez-Riviero et al. [18], and Malkoc et al. [4] were examined on the lateral photos. As ideal ratios were rare for adolescents, ideal values recommended for young adults were used. Because of the low repeatability of the menton point used in the literature, the gnathion point was preferred instead of it [5] (Fig. 3).

Additionally, in this study, a total of 27 ratios described by Proffit et al. [19], Ricketts [6, 7], Powel and Humphreysi [20], Farkas et al. [21], Farkas and Munro [21], Koury and Epker [13], McNamara et al. [22], Arnett and Bergman [23, 24], Jacobson [25], and El-Mangoury et al. [26] were examined on the frontal photos. Because of the low repeatability of the soft tissue nasion point between the eyebrows, the nasion point at the bipupil line was preferred instead of it. Similarly, because of the low repeatability of

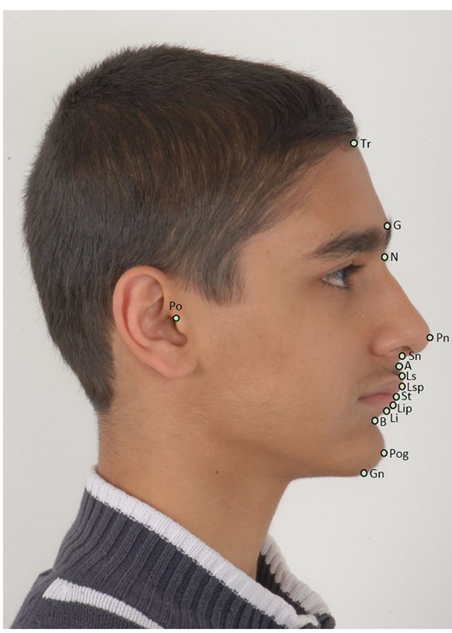

Fig. 1 Landmarks in lateral photos. *Tr* trichion, *G* glabella, *N* nasion, *Pn* pronasale, *Sn* subnasale, *A* A point (soft tissue), *Ls* labrale superior, *Lsp* labrale superior protrusive, *St* stomion, *Lip* labrale inferior protrusive, *Li* labrale inferior, *B* B point (soft tissue), *Pog* pogonion, *Gn* gnathion, *Po* porion

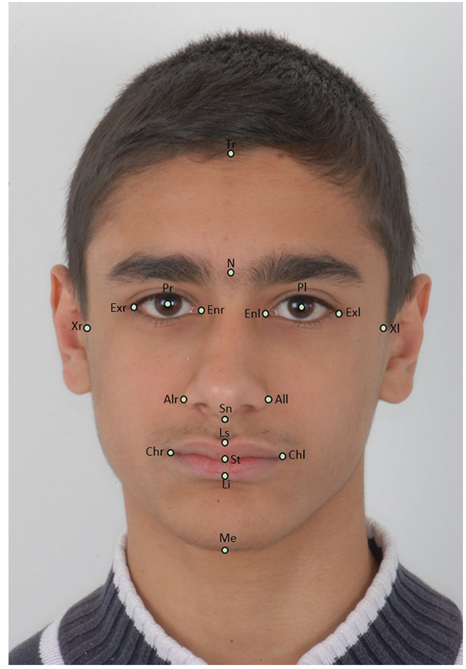

Fig. 2 Landmarks in frontal photos. *Tr* trichion, *N* nasion, *Sn*: subnasale, *Ls* labrale superior, *St* stomion, *Li* labrale inferior, *Me* menton, *Exr* exocanthion right, *Enr* endocanthion right, *Exl* exocanthion left, *Enl* endocanthion left, *Pr* pupil right, *Pl* pupil left, *Alr* alare right, *All* alare left, *Chr* cheilion right, *Chl* cheilion left, *Xr* the most right point at bipupil line, *Xl* the most left point at bipupil line

the zygion point, Xr and Xl points (the most right and left points at the bipupil line) were preferred instead of it [5] (Fig. 4).

Lastly, a total of 19 divine proportions described by Ricketts [6], Baker and Woods [27], and Mack [28] were examined on the frontal photos in our study (Fig. 5). In this study, distances were calculated between markings. No reference axis, verticals, or projections were used. Thus, both the development of projection errors was prevented and the technique of measurement became feasible and simpler for clinical practice.

To determine the sensitivity of the measurements performed, the model measurements, intra-oral photo measurements, and the lateral cephalometric measurements of the 60 patients included in the trial were re-measured a month later by the same investigator irrespective of the first measurement. The “Dahlberg Formula” ($\mathrm{ME} = \sqrt{\Sigma d2/2n}$) was used to assess the method error [29]. We observed that the error margins between the measurements made with a time interval of 1 month were insignificant and would not affect the results in this trial to a statistically significant extent.

The standard normal score or “z score” is the statistical value which demonstrates that an observation is statistically greater or smaller than predicted. The z score is

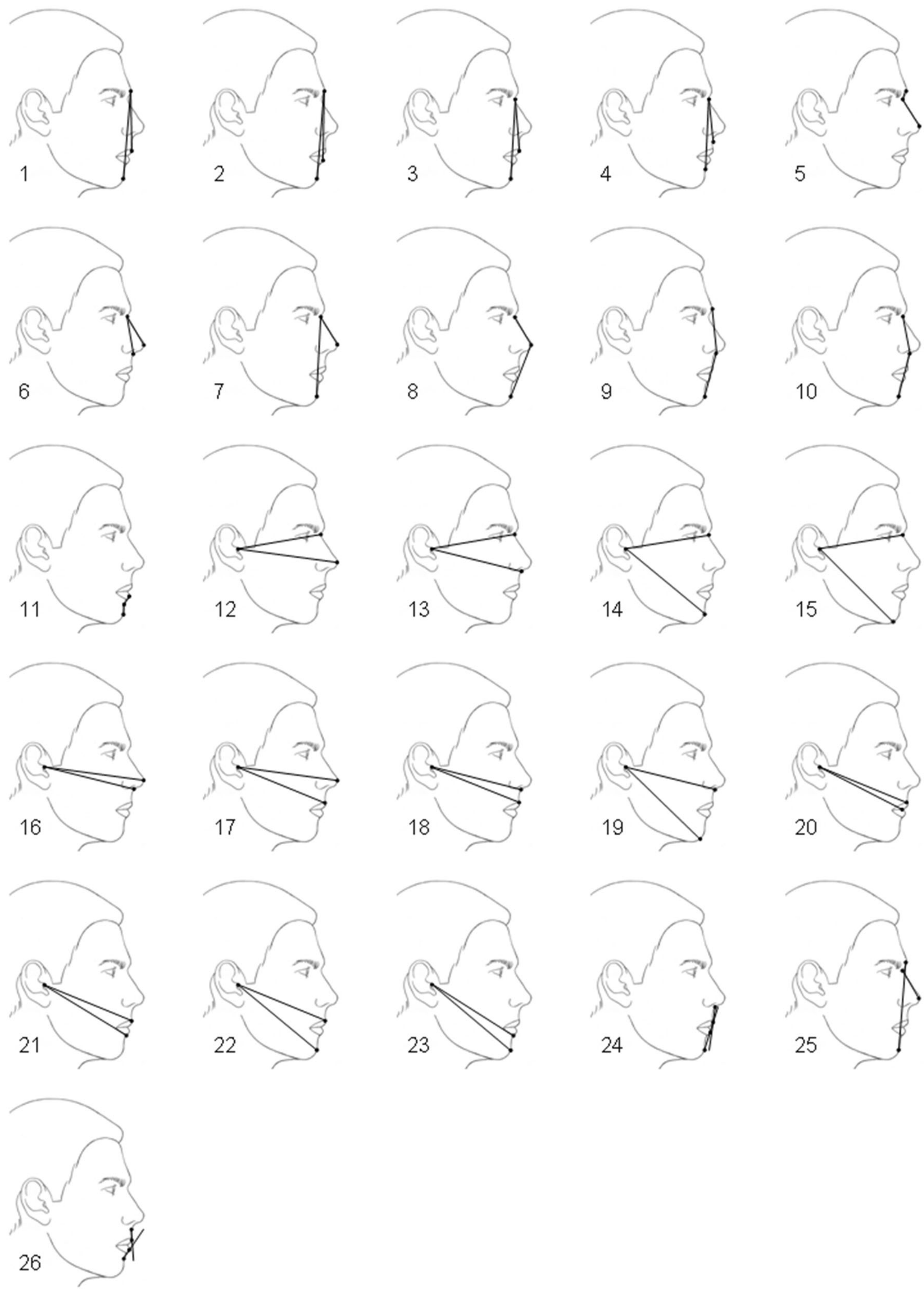

Fig. 3 Angles *1* Lsp-G-Pog, *2* Lip-G-Pog, *3* Lsp-N-Pog, *4* A-N-B *5* G-N-Pn, *6* Pn-N-Sn, *7* Pn-N-Pog, *8* N-Pn-Pog, *9* G-Sn-Pog, *10* N-Sn-Pog, *11* Lip-B-Pog, *12* N-Po-Pn, *13* N-Po-Sn, *14* N-Po-Pog, *15* N-Po-Gn, *16* Pn-Po-Sn, *17* Pn-Po-Ls, *18* Sn-Po-Ls, *19* Sn-Po-Gn, *20* Ls-Po-St, *21* Ls-Po-Li, *22* Ls-Po-Pog, *23* Li-Po-Pog, *24* Sn-Lsp/Pog-Lip, *25* G-Pog/N-Pn, *26* B-Lip/Lsp-A

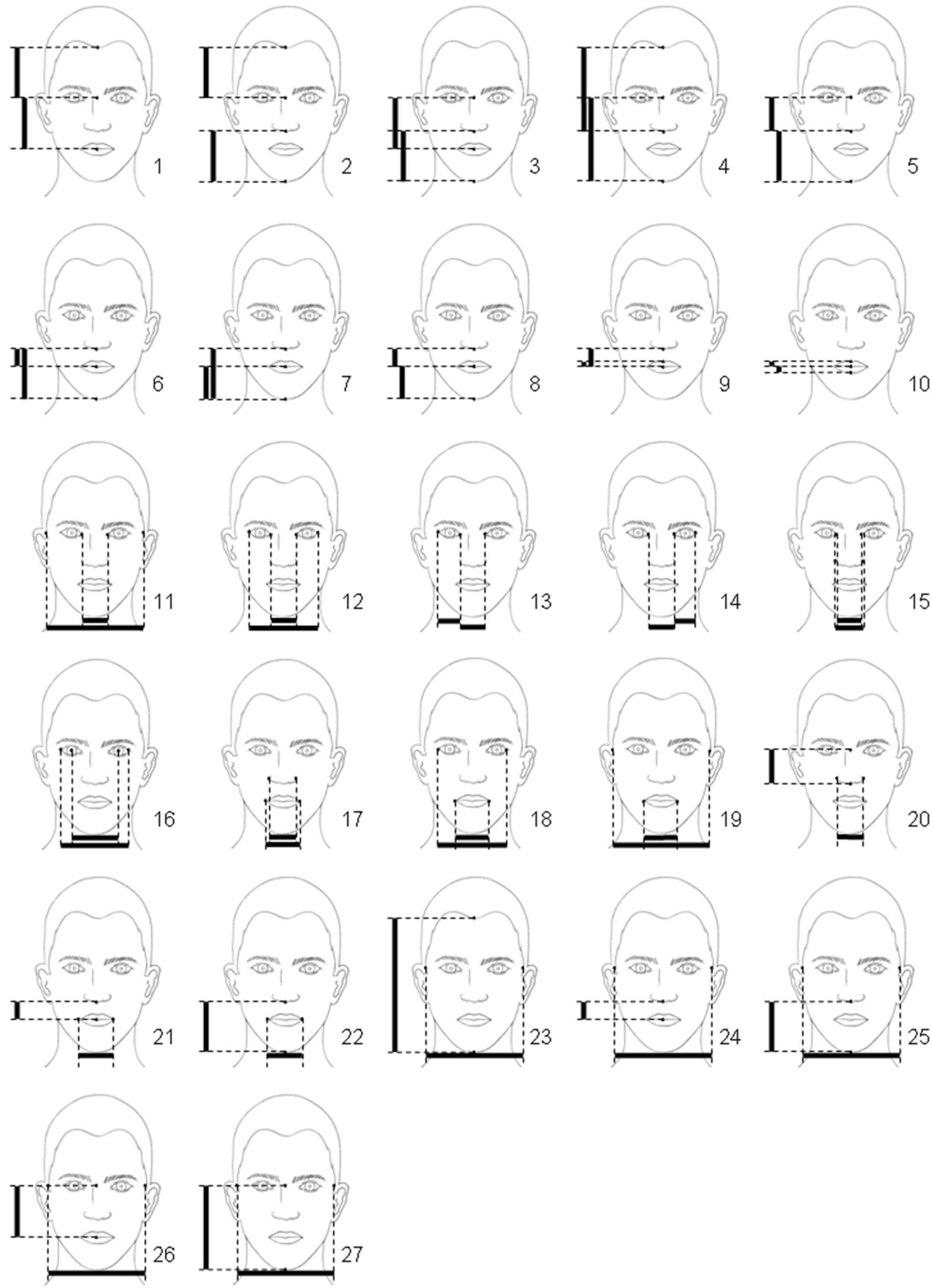

Fig. 4 Ratios. *1* Tr-N/N-St, *2* Tr-N/Sn-Me, *3* N-St/Sn-Me, *4* Tr-Sn/N-Me, *5* N-Sn/Sn-Me, *6* Sn-St/Sn-Me, *7* St-Me/Sn-Me, *8* Sn-St/St-Me, *9* Ls_St/Sn-St, *10* Ls-St/St-Li, *11* EnR-EnL/XR-XL, *12* EnR-EnL/ExR-ExL, *13* ExR-EnR/EnR-EnL, *14* EnL-ExL/EnR-EnL, *15* EnR-EnL/AIR-AIL, *16* PR-PL/ExR-ExL, *17* AIR-AIL/ChR-ChL, *18* ChR-ChL/ExR-ExL, *19* ChR-ChL/XR-XL, *20* AIR-AIL/N-Sn, *21* Sn-St/ChR-ChL, *22* Sn-Me/ChR-ChL, *23* XR-XL/Tr-Me, *24* Sn-St/XR-XL, *25* Sn-Me/XR-XL, *26* N-St/XR-XL, *27* N-Me/XR-XL

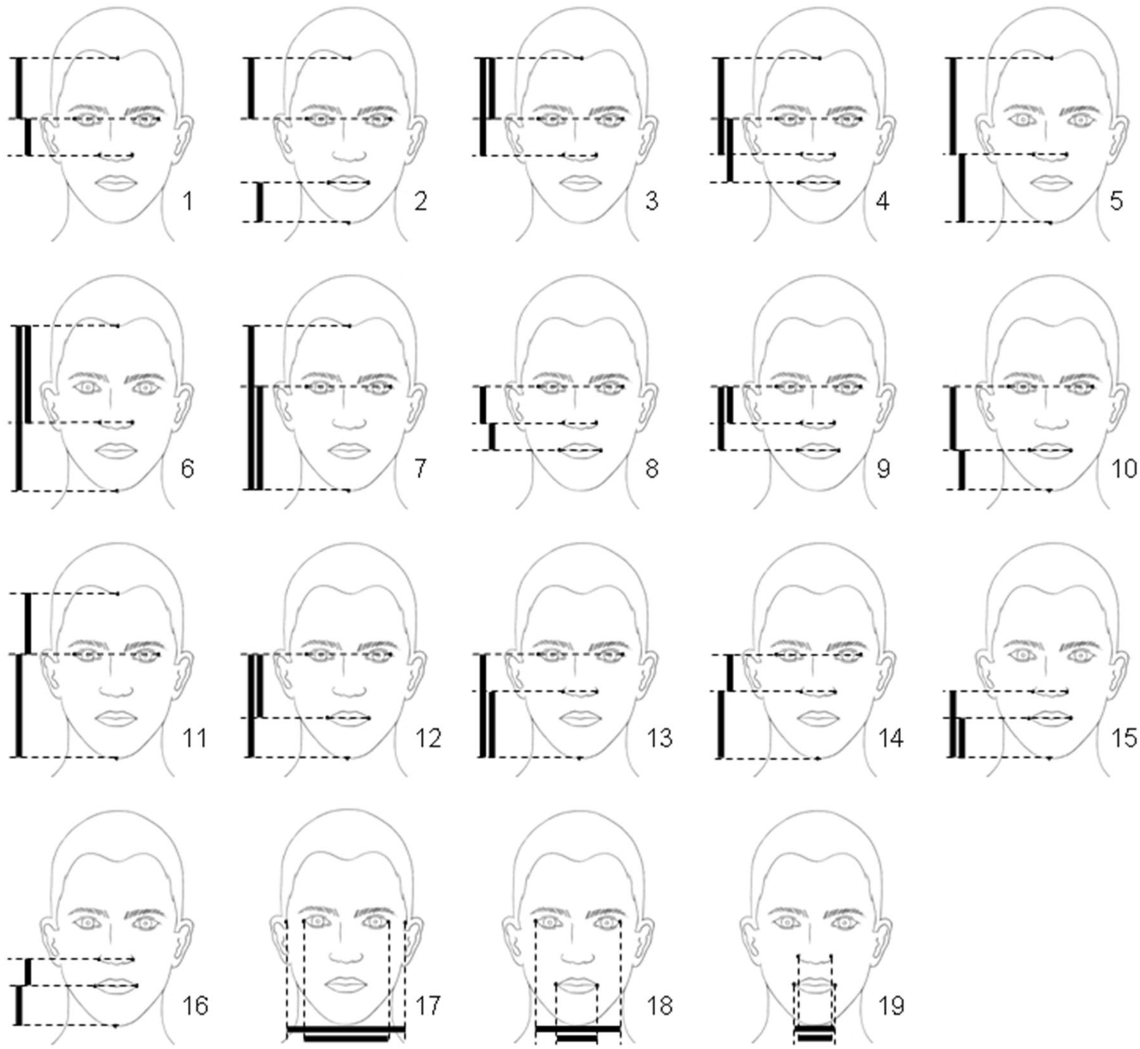

Fig. 5 Divine proportions. *1* Tr-Ex/Ex-Al, *2* Tr-Ex/Ch-Me, *3* Tr-Al/Tr-Ex, *4* Tr-Al/Ex-Ch, *5* Tr-Al/Al-Me, *6* Tr-Me/Tr-Al, *7* Tr-Me/Ex-Me, *8* Ex-Al/Al-Ch, *9* Ex-Ch/Ex-Al, *10* Ex-Ch/Ch-Me, *11* Ex-Me/Ex-Tr, *12* Ex-Me/Ex-Ch, *13* Ex-Me/Al-Me, *14* Al-Me/Ex-Al, *15* Al-Me/Ch-Me, *16* Ch-Me/Al-Ch, *17* XR-XL/ExR-ExL, *18* ExR-ExL/ChR-ChL, *19* ChR-ChL/AlR-AI

obtained when a test score of a subject is compared to an appropriate reference group:

$$Z = [\text{individual } (v - t) - \text{mean } (v - t)]/\text{SD}.$$

Here, the "v" represents variable and "t" represents ideal. On the basis of this knowledge, statistical analysis of angles, ratios, and divine proportions measured in photographs were assessed by calculating z scores. In each of the statistical analyses, the measurement-specific z score of each patient was compared with an individual final average VAS score according to Pearson correlation analysis, and then regression analysis was performed to disclose to what extent significant values may warrant the term beauty. The SPSS 17.0 (SPSS Inc., Chicago, IL, ABD) statistical package software was used for statistical analysis of data.

Results

Ideal Angles

According to the final average VAS scores created by VAS scores given by orthodontists for each patient, only Lsp-N-Pog (*P* 0.04), A-N-B (*P* 0.001), Pn-N-Pog (*P* 0.03), N-Pn-Pog (*P* 0.036), G-Sn-Pog (*P* 0.01), N-Sn-Pog (*P* 0.005), Lip-B-Pog ($P < 0.001$), and G-Pog/N-Pn (*P* 0.033) angles had a significant relationship among 26 angles measured in frontal photographs. According to the regression analysis, all of the 26 angles might explain 53 % of VAS scores, whereas the eight angles which have a significant relationship might explain 35 % of the VAS scores; in other words, the presence of these eight angles within normal limits in an individual patient ensures that orthodontists would find this patient beautiful with a probability of 35 % (Table 1).

According to the final average VAS scores created with the VAS scores given by the laypersons for each patient, Lip-B-Pog (*P* 0.001), Sn-Po-Ls (*P* 0.039), and Li-Po-Pog (*P* 0.012) angles were significantly related among 26 angles measured in the profile photographs. According to the regression analysis, all of the 26 angles might explain 54 % of VAS scores, whereas the three angles which have a significant relationship might explain 21 % of the VAS scores; in other words, the presence of these three angles within normal limits in an individual patient ensures that the laypersons would find this patient beautiful with a probability of 21 % (Table 1).

Table 1 The relationship between VAS scores and ideal angles on lateral resting photos

	Mean ± SD	Orthodontists		Laypersons	
		CC	P	CC	P
Lsp-G-Pog	6.34 ± 2.80	0.238	ns	0.108	ns
Lip-G-Pog	3.81 ± 1.88	0.045	ns	−0.072	ns
Lsp-N-Pog	8.24 ± 3.11	0.265	*	0.132	ns
A-N-B	8.06 ± 3.09	0.416	**	0.245	ns
G-N-Pn	146.76 ± 5.94	−0.104	ns	0.030	ns
Pn-N-Sn	19.51 ± 1.84	−0.245	ns	−0.253	ns
Pn-N-Pog	28.93 ± 3.42	0.280	*	0.094	ns
N-Pn-Pog	132.12 ± 5.56	−0.272	*	−0.064	ns
G-Sn-Pog	164.51 ± 7.78	−0.330	*	−0.184	ns
N-Sn-Pog	161.08 ± 7.54	−0.361	**	−0.205	ns
Lip-B-Pog	136.22 ± 13.08	−0.474	***	−0.409	**
N-Po-Pn	21.46 ± 2.20	−0.089	ns	−0.174	ns
N-Po-Sn	28.30 ± 2.45	−0.030	ns	−0.103	ns
N-Po-Pog	53.38 ± 3.64	−0.026	ns	−0.144	ns
N-Po-Gn	57.37 ± 4.05	−0.033	ns	−0.175	ns
Pn-Po-Sn	6.84 ± 0.88	0.139	ns	0.149	ns
Pn-Po-Ls	13.58 ± 1.38	−0.034	ns	−0.124	ns
Sn-Po-Ls	6.74 ± 1.13	−0.150	ns	−0.267	*
Sn-Po-Gn	29.08 ± 2.68	−0.022	ns	−0.169	ns
Ls-Po-St	5.09 ± 1.15	0.165	ns	0.212	ns
Ls-Po-Li	8.58 ± 1.78	0.244	ns	0.234	ns
Ls-Po-Pog	18.34 ± 1.96	0.075	ns	0.016	ns
Li-Po-Pog	9.76 ± 1.20	−0.238	ns	−0.322	*
Sn-Lsp/Pog-Lip	158.80 ± 13.15	−0.017	ns	0.034	ns
G-Pog/N-Pn	29.46 ± 3.21	0.275	*	0.087	ns
B-Lip/Lsp-A	126.90 ± 14.85	−0.227	ns	−0.204	ns

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

ns not significant, *SD* standard deviation, *P* significance, *CC* correlation coefficient

Ideal Ratios

According to final average VAS scores that were created by VAS scores given by orthodontists for each patient, only Ls-St/St-Li (*P* 0.02), EnR-EnL/XR-XL (*P* 0.031), EnR-EnL/ExR-ExL (*P* 0.023), EnL-ExL/EnR-EnL (*P* 0.011), XR-XL/Tr-Me (*P* 0.016), Sn-Me/XR-XL (*P* 0.011), and N-Me/XR-XL (*P* 0.011) ratios had a significant relationship among 27 ratios measured in front photographs. According to the regression analysis, all of the 27 ratios might explain 50 % of VAS scores, whereas the seven angles which have a significant relationship might explain 27 % of the VAS scores (Table 2).

Table 2 The relationship between VAS scores and ideal ratios on the frontal resting photos

	Mean ± SD	Orthodontists		Laypersons	
		CC	*P*	CC	*P*
Tr-N/N-St	1.07 ± 0.11	−0.099	ns	0.059	ns
Tr-N/Sn-Me	1.10 ± 0.13	0.056	ns	0.169	ns
N-St/Sn-Me	1.03 ± 0.09	0.175	ns	0.154	ns
Tr-Sn/N-Me	1.05 ± 0.07	0.055	ns	0.173	ns
N-Sn/Sn-Me	0.69 ± 0.09	0.159	ns	0.140	ns
Sn-St/Sn-Me	0.33 ± 0.02	0.107	ns	0.095	ns
St-Me/Sn-Me	0.67 ± 0.02	−0.107	ns	−0.095	ns
Sn-St/St-Me	0.50 ± 0.06	0.099	ns	0.093	ns
Ls_St/Sn-St	0.27 ± 0.06	−0.035	ns	0.027	ns
Ls-St/St-Li	0.63 ± 0.14	−0.299	*	−0.216	ns
EnR-EnL/XR-XL	0.24 ± 0.02	−0.279	*	−0.302	*
EnR-EnL/ExR-ExL	0.37 ± 0.02	−0.293	*	−0.344	**
ExR-EnR/EnR-EnL	0.86 ± 0.10	0.236	ns	0.287	*
EnL-ExL/EnR-EnL	0.85 ± 0.09	0.327	*	0.366	**
EnR-EnL/AIR-AIL	0.91 ± 0.09	−0.185	ns	−0.188	Ns
PR-PL/ExR-ExL	0.70 ± 0.02	−0.003	ns	−0.116	Ns
AIR-AIL/ChR-ChL	0.77 ± 0.07	−0.115	ns	−0.193	Ns
ChR-ChL/ExR-ExL	0.53 ± 0.04	0.114	ns	0.166	Ns
ChR-ChL/XR-XL	0.34 ± 0.03	0.054	ns	0.124	Ns
AIR-AIL/N-Sn	0.78 ± 0.07	−0.004	ns	−0.003	Ns
Sn-St/ChR-ChL	0.48 ± 0.06	−0.165	ns	−0.215	Ns
Sn-Me/ChR-ChL	1.44 ± 0.17	−0.251	ns	−0.294	*
XR-XL/Tr-Me	0.74 ± 0.04	0.310	*	0.226	Ns
Sn-St/XR-XL	0.16 ± 0.02	−0.181	ns	−0.193	Ns
Sn-Me/XR-XL	0.49 ± 0.04	−0.325	*	−0.325	*
N-St/XR-XL	0.50 ± 0.03	−0.147	ns	−0.180	Ns
N-Me-XR-XL	0.83 ± 0.04	−0.328	*	−0.347	**

* $P < 0.05$, ** $P < 0.01$,. *** $P < 0.001$

ns not significant, *SD* standard deviation, *P* significance, *CC* correlation coefficient

According to the final average VAS scores created with the VAS scores given by the layperson for each patient, EnR-EnL/XR-XL (P 0.019), EnR-EnL/ExR-ExL (P 0.007), ExR-EnR/EnR-EnL (P 0.026), EnL-ExL/EnR-EnL (P 0.004), Sn-Me/ChR-ChL (P 0.023), Sn-Me/XR-XL (P 0.011), and N-Me/XR-XL (P 0.007) ratios were significantly related among 27 ratios measured in the front photographs. According to the regression analysis, all of the 27 ratios might explain 40 % of VAS scores, whereas the seven ratios which have a significant relationship might explain 31 % of the VAS scores (Table 2).

Divine Proportions

According to final average VAS scores created by the VAS scores given by the orthodontists for each patient, none of the divine proportions had a significant relationship ($P > 0.05$). According to the regression analysis, all of the divine proportions might explain 25 % of VAS scores; in other words, the presence of these 19 divine proportions within normal limits in an individual patient ensures that laypersons would find this patient beautiful with a probability of only 25 % (Table 3).

Table 3 The relationship between VAS scores and divine proportions on the frontal resting photos

	Mean ± SD	Orthodontists		Laypersons	
		CC	P	CC	P
Tr-Ex/Ex-Al	2.11 ± 0.25	−0.099	ns	0.026	ns
Tr-Ex/Ch-Me	1.73 ± 0.21	0.063	ns	0.190	ns
Tr-Al/Tr-Ex	1.48 ± 0.06	0.112	ns	−0.017	ns
Tr-Al/Ex-Ch	1.66 ± 0.11	−0.071	ns	0.073	ns
Tr-Al/Al-Me	1.49 ± 0.14	0.081	ns	0.186	ns
Tr-Me/Tr-Al	1.68 ± 0.06	−0.077	ns	−0.185	ns
Tr-Me/Ex-Me	1.68 ± 0.07	−0.019	ns	0.133	ns
Ex-Al/Al-Ch	1.16 ± 0.14	0.082	ns	0.073	ns
Ex-Ch/Ex-Al	1.88 ± 0.11	−0.045	ns	−0.040	ns
Ex-Ch/Ch-Me	1.55 ± 0.14	0.190	ns	0.196	ns
Me-Ex/Ex-Tr	1.49 ± 0.15	0.030	ns	−0.125	ns
Ex-Me/Ex-Ch	1.65 ± 0.05	−0.224	ns	−0.226	ns
Ex-Me/Al-Me	1.48 ± 0.05	0.145	ns	0.139	ns
Al-Me/Ex-Al	2.10 ± 0.23	−0.134	ns	−0.132	ns
Al-Me/Ch-Me	1.72 ± 0.07	0.135	ns	0.148	ns
Ch-Me/Al-Ch	1.40 ± 0.13	−0.142	ns	−0.148	ns
XR-XL/ExR-ExL	1.56 ± 0.06	0.124	ns	0.093	ns
ExR-ExL/ChR-ChL	1.88 ± 0.15	−0.012	ns	−0.174	ns
ChR-ChL/AlR-AlL	1.32 ± 0.12	0.108	ns	0.189	ns

ns not significant, *SD* standard deviation, *P* significance, *CC* correlation coefficient

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

According to the final average VAS scores created by the VAS scores given by the layperson for each patient, none of the divine proportions had a significant relationship ($P > 0.05$). According to the regression analysis, all of the divine proportions might explain 27 % of VAS scores; in other words, the presence of these 19 divine proportions within normal limits in an individual patient ensures that laypersons would find this patient beautiful with a probability of only 27 % (Table 3).

Discussion

Because the majority of patients seeking orthodontic treatment are adolescents, patients between the ages of 9 and 17 were selected for this study. Including a wide range of dental and skeletal characteristics of individuals makes this study more powerful. Photos can be used for the assessment of facial aesthetics because there is a close relationship between the evaluation of the facial aesthetics of live images and that of color photographs [30, 31]. Proffit et al. [19], Peerlings et al. [32], and Kiekens et al. [33] recommended the separate use of reference photographs for boys and girls. According to these authors, reference photos ensure that the members of the panel can use the scale uniformly. Kiekens et al. [34] argue that panels consisting of seven laypersons and/or orthodontists would be sufficient to make reliable measures in clinical and epidemiological studies on adolescent facial aesthetics using the VAS scale. Using the VAS scale in studies on aesthetics has many advantages. Gould et al. [35] found VAS more meaningful because it allows the rater to assign a point in a continuous interval, rather than selecting one of a limited number of categories. Farkas and Munro [21] implied that the mean facial ratio difference was extremely low between two genders in subjects ranging from 6 to 18 years of age. Halazonetis [36] detected small differences in average facial shapes between girls and boys in subjects ranging from 7 to 17 years of age. Some facial ratios and angles may differ for adults and children [37] or men and women [12], and many orthodontists use ideal norms in all patients without discriminating their age and gender.

Some also define the golden ratio (divine proportion) as the "most aesthetic" ratio between the height and width of a rectangle (1,618). Controversial observations exist about the golden ratio. It has been suggested that some featured ratios found in the bodies of many animals (even in humans) and also in molluscs and cephalopods conform to the golden ratio; however, these featured ratios vary among individuals within a species, and this ratio is clearly different from the golden ratio [38]. Despite it being obvious that facial aesthetics depend on variables such as color and tissue properties of the skin, and dental appearance, static facial morphology is of course an overriding factor. There is controversy over which ratio and angle are valid and divine proportions are important according to some investigators and not so important to others. To reveal the validity of these ideas for Turkish individuals, we investigated whether the parameters of ideal angles, ratios, and divine proportions previously mentioned in the literature influence the aesthetic evaluation of Turkish adolescents.

According to the final average VAS scores created by the VAS scores given by the orthodontists for each patient, only eight angles were significantly related among 26 angles measured in profile photographs. Seven of these eight angles were related to the anteroposterior position of the lower jaw, whereas the remaining angles were related to the depth of the labiomental sulcus. All of these 26 angles might explain 53 % of VAS scores, and these eight angles with a significant relationship might explain 35 % of the VAS scores.

The angles Lsp-N-Pog, A-N-B, Pn-N-Pog, and G-Pog/N-Pn, which had a significant relationship with the anteroposterior position of the lower jaw, were in positive correlation with the VAS scores of orthodontists. In other words, appreciation of the orthodontists increased with the increasing values of this angle. On the other hand, the angles N-Pn-Pog, G-Sn-Pog, and N-Sn-Pog, which had a significant relationship to the anteroposterior position of the lower jaw, were in negative correlation. In other words, appreciation of the orthodontists increased with the decreasing values of this angle. All these seven angles, when taken into consideration together, allow us to conclude that orthodontists find those individuals with a lower jaw protruded in the sagittal plane less attractive.

The Lip-B-Pog angle, which reflects the depth of the labiomental sulcus, had the highest level of significance and displayed negative correlation. On this basis, it may be concluded that orthodontists strongly reject the presence of deep labiomental sulcus. According to the final average VAS scores created by the VAS scores given by the laypersons for each patient, only three angles were significantly related among 26 angles measured in profile photographs. Two of these three angles were related to the length of the lips, whereas the remaining angles were related to the depth of the labiomental sulcus. All of these 26 angles might explain 54 % of VAS scores, and these three angles which have a significant relationship might explain 21 % of the VAS scores.

Sn-Po-Ls and Li -Po-Pog are angles that had a significant relationship to the VAS scores of the laypersons and concern the length of the upper and lower lips, respectively. Both angles displayed negative correlation with the VAS scores of the patients. These two angles, when taken together, allow one to think that the height of the lower face might be important for laypersons.

The Lip-B-Pog angle which reflects the depth of the labiomental sulcus had the highest level of significance and displayed negative correlation for laypersons as it did for orthodontists. According to this finding, it is obvious that laypersons also prefer shallower labiomental sulci. The Lip-B-Pog angle, which reflects the depth of the labiomental sulcus, is the only profile angle associated with the appreciation of both orthodontists and laypersons. The fact that the sagittal position of the lower jaw, which was found significant for orthodontists, had no significant relationship to the appreciation of the laypersons suggests that orthodontists pay more attention to the position of lower jaw compared to the laypersons.

Kiekens et al. [5] investigated the relationship between soft tissue angles and VAS scores of laypersons in their study and they did not take into consideration the VAS scores of orthodontists. Only three angles used in our study were significantly related among 26 angles measured (Lsp-N-Pog, Ls-Po-Pog, Sn-Lsp/Pog-Lip). Variance of these three angles was measured to be 18.5 %, that is, these two ratios together explain the 18.5 % value of facial aesthetics. When it is remembered that the variance of the three angles that had a significant relationship in our study was also 21 %, it may be concluded that the angles in profile photographs are insufficient in explaining facial aesthetics.

Although our study revealed that the sagittal position of the lower jaw was an important feature for orthodontists, Knight and Keith [39] detected that there was very little relationship between soft tissue ANB and facial aesthetics. However, they observed that facial aesthetics was adversely affected when the soft tissue ANB angle diverges by five degrees. When the relationship between the ratios measured in the frontal photographs and VAS scores of orthodontists was investigated, the relation of seven of 27 ratios was found to be significant. Among these, the ratio of upper lip to lower lip displayed negative correlation. Among the ratios with a significant relationship, the ratios EnR-EnL/XR-XL and EnR-EnL/ExR-ExL displayed negative correlation and the ratio EnL-ExL/EnR-EnL displayed positive correlation. In other words, the distance between the eyes, which was reflected as the EnR-EnL distance, is better when lower, according to the preferences of the orthodontists. The remaining three ratios were as follows: XR-XL/Tr-Me displayed positive correlation, and Sn-Me/XR-XL and N-Me/XR-XL displayed negative correlation. This means that a decrease in height of the lower part and the whole of the face relative to face width gains appreciation by orthodontists. These seven ratios with a significant relationship may explain the 27 % of VAS scores.

When the relationship between the ratios measured in front photographs and VAS scores of laypersons was investigated, the relation of seven of 27 ratios was found to be significant again. However, some of these seven ratios varied according to the orthodontists. The ratios EnR-EnL/XR-XL EnR-EnL/ExR-ExL displayed negative correlation and the ratios ExR-EnR/EnR-EnL and EnL-ExL/EnR-EnL displayed positive correlation. In other words, the distance between the eyes, which was reflected as the EnR-EnL distance, is better when lower according to the preferences of the laypersons, as well. The remaining two ratios with a significant relationship, Sn-Me/XR-XL and N-Me/XR-XL, displayed negative correlation. This means that a decrease in the height of the lower part and the whole of the face relative to face width gains appreciation by laypersons, as well. The last remaining ratio with a significant relationship was the ratio between the height of the lower face to oral width (Sn-Me/ChR-ChL), and it displayed negative correlation. These seven ratios with significant relationships may explain 31 % of VAS scores.

Kiekens et al. [5] investigated the relationship between ratios and VAS scores of laypersons in their study, and they did not take into consideration the VAS scores of orthodontists. Only two ratios used in our study were significantly related among 27 ratios calculated (N-St/Sn-Me ile N-St/XR-XL). The variance of these two ratios was found to be 16.8 %, that is, these two ratios together explain 16.8 % of facial aesthetics. When it is remembered that the variance of the seven ratios with significant relationships in our study was also 31 %, it may be concluded that ratios in front photographs are insufficient in explaining facial aesthetics. The fact that seven different ratios had significant relationships in our study demonstrates that there are perceptional differences between cultures.

In our study, it is seen that both orthodontists and laypersons commented that the increase in the height of the lower part and the whole of the face relative to face width was negative. Previous studies also demonstrated that increasing facial height adversely affects facial aesthetics. Sassouni and Nanda [40], Poulton [41], and De Smit and Dermaut [42] suggested that elongation of facial soft tissue was not preferred in artificial face photographs. De Smit and Dermaut [42] advocated that the length of the face is more important than the anteroposterior position of the jaws in the evaluation of facial aesthetics. However, Cox and van der Linden [10] were of the opinion that the vertical dimension of the face is not important in the evaluation of facial aesthetics. Knight and Keith [39] detected the presence of a very small relationship between the height of the lower jaw and facial aesthetics and reached an interesting conclusion: increasing the values of the lower jaw height adversely affects facial aesthetics in girl patients, whereas the opposite is true for boys. In this study, according to final average VAS scores created by the VAS scores given by both the orthodontists and laypersons for each patient, none of the divine proportions had a significant relationship. All of the divine proportions explained as little as 25 % of the VAS scores given by the orthodontists and 27 % of the VAS scores given by the laypersons.

Baker and Woods [27] found no difference when the ratios in the face approach or diverge to the divine proportion by performing orthognathic surgery; these investigators found no significant relationship between aesthetic scores and divine proportions both before and after the treatment. Also, it could not be detected that there is a relationship between differences in divine proportions and differences in aesthetic scores after treatment. Shell and Wood [43] could not establish a relationship between differences in aesthetic measurements and differences in divine proportions after orthognathic surgery. Moss et al. [44] used a three-dimensional optical surface scanner and analyzed the facial templates of women and men, and detected that divine proportions were not observed in these facial templates.

Kawakami et al. [45] investigated the divine proportions in Japanese individuals and they found the validity of only a few soft tissue ratios. Nakajima and Yanagisawa [46] examined the frontal face photographs of Japanese individuals with Class II and Class III jaw structure and found that a ratio of 1.143 was more valid than the known divine proportion of 1.618 in their study group. They also suggested that this ratio was found in Japanese models, as well.

Kiekens et al. [5] found the presence of a significant relationship in only four of the 19 divine proportions that were also used in our study. However, the total variance of these four ratios, which display significance, was calculated as 16 %. In other words, these four ratios could explain only 16 % of the facial aesthetics. As stated by the authors, this ratio is extremely low and it should not be considered of clinical importance.

Orthodontists or plastic surgeons use dental, skeletal, and facial traits to diagnose and develop treatment plans. These provide important information but may offer only a limited insight into the facial changes that will result from treatment. The mean values obtained from the present sample can be used for comparison with records of subjects with the same characteristics and following the same photogrammetric technique. Photogrammetric analysis can provide orthodontists or plastic surgeon with a way of determining the problems associated with various soft tissue segments of the face [4].

Conclusion

According to the angles and ratios measured in the extra-oral photographs, it was observed that orthodontists noticed the sagittal position of the lower jaw and the distance between the eyes and length of the face, whereas laypersons noticed only the distance between the eyes and length of the face. No significant relationship was found between any of the divine proportions and facial aesthetics according to both orthodontists and laypersons.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflicts of interest to disclose.

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