Proportional and Angular Photogrammetric Analysis of the Soft Tissue Facial Frontal View of Young Adults in Shiraz, Iran

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Abstract

Introduction:
Facial beauty is becoming more and more important worldwide. This is defined as being close to what is advertised as attractiveness by the media and is determined mainly by golden proportions. This study aimed to observe the soft tissue facial angular and proportional norms of South Iranian population attending Shiraz Dental School's clinic.

Materials and methods:
Seventy subjects (34 males and 36 females; 16 - 30 years of age) with Persian origin who had a skeletal class I pattern and almost well-aligned maxillary and mandibular dental arches who participated in this cross-sectional study were selected from patients attending Shiraz Dental School's orthodontic clinic in 2013. Standardized frontal facial view digital photographs were taken from subjects and were traced. Four angular and eight proportional facial variables were analyzed using AutoCAD software. For statistical evaluation, a Student's t-test was used and the reliability of the method was assessed using Inter-class Correlation Coefficient within a four-week interval.

Results:
Men had a higher facial asymmetry, a higher facial Index, a higher proportion of the distance between inner canthus of the eyes divided by the mean of the width of the right and left eyes, and a lower facial aperture modified angle average compared to females.

Conclusion:
The average measurements of most facial variables of this study's population deviated from the ideal values suggested in texts and from those of the comparison population.

Key words:
•Esthetics •Photogrammetry •Cosmetic Dentistry

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Introduction

Considering the fact that physical appearance and facial beauty play significant roles in the life of individuals, one of the orthodontists' assignments is to improve the patients' facial beauty. Orthodontic treatments that solely focus on dentoskeletal complex without con-

cerning the overlying soft tissue are no longer acceptable.[1] Many factors such as sex, race, genetic and age can affect facial soft tissue features. However, in all cases, facial attractiveness depends deeply on facial proportions.[2,3]

Soft tissue facial analysis can be conducted using a variety of extra-oral radiographs. However, there are limitations to the precision of soft tissue findings on radiographs, especially when analyzing the frontal view. The measurement can be done on patients' actual face as well. However, using photographs as a means of soft tissue analysis has proved to be both more convenient and more reliable. The digital phenomenon has made the soft tissue photogrammetric assessment easy and accurate, and as a result it is the first choice for studying facial variables.[4]

Ricketts et al. conducted a comprehensive study on details of the face that lead to facial beauty in the early 1980s that defined some important soft tissue facial measurements as "divine proportions".[2,5]

Several other researchers followed their work to assess the most popular facial measurements in other populations, and some ideal ranges for facial variables were set and globally accepted by both researchers and clinicians.[6,7]

There have been agreements in what qualifies as ideal details of the face, such as the "facial one-fifth proportion" in horizontal dimension and the one-third proportion of vertical dimension.[8,9]

It had been shown that angular and proportional measurements are more crucial.[10]

Although most facial proportional and angular variables seem to have common normative ranges among races, some differences have also been reported.[12]

The relationship between facial esthetics and the so-called "golden proportions" was assessed in a recent Indian study. Their subjects showed a shorter lower anterior facial height and smaller mouth and nose compared to what is mostly reported in white populations.[11]

Another investigation revealed that the middle face of Igbo Nigerian adult men was shorter than their lower face. They also had a moderate glabella, but a more protruded nose and a less protruding chin compared to white populations.[13] Few studies have assessed the facial soft tissue on Iranian population. One study, conducted by Sepehr et al., compared the normative quantitative ranges of anthropometric measurements of subjects' faces with those reported for North American white women. Significant differences were seen in 18 out of 26 assessed anthropometric measurements between Persian women and North American white women.[14]

Another study had evaluated the angular photogrammetric measurements of the facial soft tissue profile view of Iranian young adults and showed gender dimorphism in three of the measurements: the nasofrontal, the nasal and the vertical nasal angles.[15]

Although there have been several studies assessing proportional facial analysis, many controversies exist in facial soft tissue relationships among different ethnic clusters.[16] This is partially because studying the soft tissue facial variables is a relatively new science when compared to the hard tissue study. However, one main reason for the variations in study findings is the natural variations that exist in different ethnicities and populations. Therefore, more studies should be carried out on different populations to collect sufficient data and, eventually, understand the norms and normal variation.[17]

The norms and effects of sex on the angular and proportional measurements in frontal view have not been evaluated in an Iranian population. Therefore, the purpose of this study was to measure angular and proportional photogrammetric normal range of soft tissue facial frontal variables in Iranian male and female populations with normal skeletal features.

Materials and Methods

This study had a cross sectional design. Ethical permission was obtained from the international branch of Shiraz University of Medical Sciences (ID:8693075). Seventy patients (34 males and 36 females) was selected among those who had attended Shiraz Dental School's orthodontic clinic in 2013 for minor dental corrections. Four hundred lateral cephalograms were chosen randomly. The radiographs were scanned with Fujitsu scanner (output resolution: up to 600 dpi, speed: 200 or 300 dpi, gray scale and monochrome). Each cephalogram was assessed by two calibrated orthodontists for selection of appropriate subjects. Cephalometric tracing for

detecting skeletal class I cases (FMA = 25°, Wits appraisal = -1 & 0 mm, ANB = 2°) was done by OnyxCeph image software in two dimensions; sagitally and vertically.

A unique ID number was allocated to each cephalogram that was recognized appropriately. A simple randomized method was used to draw 70 ID numbers. Selected patients were consented and assured of the confidentiality of their information and their privacy. Those who were not from Persian origin, or had a history of trauma to face and jaws, prior orthodontic treatments, or maxillofacial or plastic surgeries were also excluded from the study and replaced by new subjects drawn randomly.

Figure 1. Photometric Points: Gl'– soft tissue glabella ;N'-soft tissue nasion ;Exd–right external corner of the eye; Exe–left external corner of the eye; End–right internal corner of the eye; Ene– left internal corner of the eye; V–Point V; Sn–subnasal ;Ald– right alar point; Ale–left alar point;F-lower philtrum ;Ls - upper philtrum ;Li-lower lip; Abd-right mouth angle;Abe–left mouth corner; Es-stomium; Zid–right zigion; God'-right gonion;Goe'-left gonion; Me'-Menton.

Standard frontal photographs were taken from subjects by a professional photographer. All photographs were obtained by one camera and in the same condition: Canon EOS 60 D digital camera with a 100-mm macro canon lens, f/9, ISO = 200, shutter speed = 1/60 second. Subject-camera distance was fixed at two meters. The camera was secured on a tripod. The subjects were asked to stand on a line marked on the floor two meters away from the camera's tripod. They were also asked to remove their glasses and hats and hold their heads in natural head position facing the camera so that their hair line, forehead, neck, and ear were all clearly visible from the frontal view. Two main flash lamps (430EX) with soft boxes were used at 45 degrees to the subject for an evenly distributed illumination without shadows.

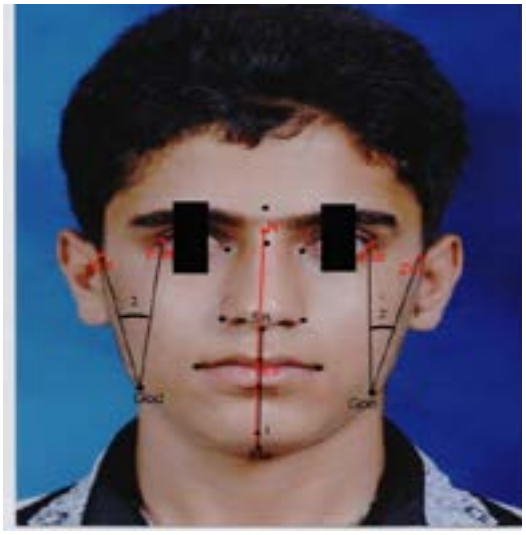

Figure 2. Angular measures 1and 2:1) Facial symmetry angle- angle formed between facial midline (N'-F)and Sn'Me' line.2) Symmetry between left and right side of the face-the difference between left and right angle measurements formed by intersection of Zi'-Go' and Ex-Go' lines.

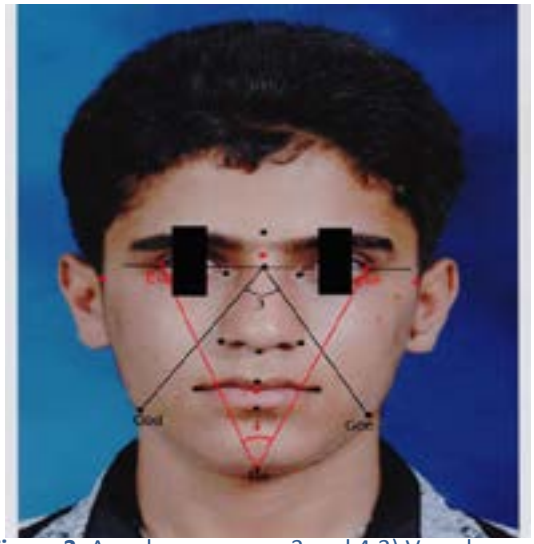

Figure 3. Angular measures 3 and 4:3) V angle-angle formed by lines extending from V to God' point and from V to Goe' ;4) Facial aperture modified angle-angle formed by right and left lines extending from Exd to Exe to Me' point.

Figure 4. Proportional measures–Facial Index: lower; Facial Height Proportion: upper lip proportion.

Facial analysis

Photometric tracing was performed on frontal view by AUTOCAD image software (Autodesk American company, version: 13). Twenty reference points were marked on each photograph (Figure 1). Twelve soft tissue variables (four angular and eight proportional measurements) derived from previous studies [12] were assessed. They are shown and briefly defined in Table 1 and shown in Figures 2, 3, 4, 5. The measurements were made by a final year dental student. To determine method error, landmark markings on each photograph and measuring variables for each individual were conducted twice two weeks apart.

table 1. Brief definitions and the average (± SD) values of angular (1 to 4) and proportional (5 to 12) facial variables assessed in this study

	Variable	Brief definition	Average ±SD	Gender
1	Facial symmetry angle	Formed between facial midline (N'-F) and Sn'Me'line	1.05 ± 0.84	Male Female
2	Symmetry between left and right of the face	The difference between left and right angles formed by intersection of Zi'-Go' and Ex-Go' lines	0.89 ± 0.99	Male Female
3	V angle	Formed by lines extending from V to God point and from V to Goe	71.01 ± 5.33	Male Female
4	Facial aperture modified angle	Formed by right and left lines extending from Exd to Exe to Me' point	45.26 ± 3.65	Male Female
5	Facial index	Facial height (N'-Me')/ Upper facial width (Zid'-Zie')	90.20 ± 5.89	Male Female
6	Lower facial height proportion	Middle facial height (Gl'-Sn)/ lower facial height (Sn-Me')	2.42 ± 11.47	Male Female
7	Upper lip proportion	Sn-Es/ Sn-Me	0.32 ± 0.04	Male Female
8	Distance between inner canthus of the eyes/ Mean of the width of the right and left eyes	End to Ene / Mean of the width of Exd to End and Exe to Ene	1.02 ± 0.11	Male Female
9	Width of the right outer canthus to right zygoma/ Width of the right eye	Exd to Zid/ Exd to End	0.68 ± 0.10	Male Female
10	Width of the left outer canthus to left zygoma/ Width of the left eye	Exe to Zie/ Exe to Ene	0.65 ± 0.10	Male Female
11	Width of the inter commissural/ Width of the inter iris of both eyes	Abd to Abe/ Distance between inter iris of eyes	0.82 ± 0.07	Male Female
12	Width of the inter alar/ Distance between inner canthus of eyes	Ald to Ale/ End to Ene	1.11 ± 0.09	Male Female

*Significant at α = 0.001 level

**Significant at α = 0.05 level

Statistical analysis

The Statistical Package for the Social Sciences SPSS 20.0 (SPSS Inc, Chicago, IL) software for windows was used for data analysis. A test-re-test reliability assessment within a 4-week interval showed that the Cronbach's alpha of the two measurements of the assessed variables was between 0.91 and 1.00.

The p-value of the intra-class correlation test of the two measuring occasions for all variables was less than 0.001. Although the two sets of measurements were very close to each other, their average values for each variable was used for each subject.

The main objectives of this study were fulfilled by descriptive statistics; an independent t-test was used to compare the differences between the male and female subjects. A sample t-test was also used to compare the proportional values with the divine proportions described in the literature for vertical and transverse dimensions (Table 2).

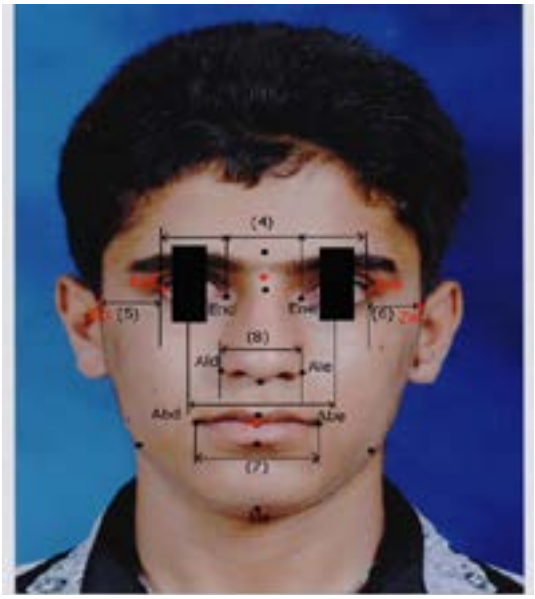

Figure 5. Proportional measures(table 1)

table 2. Comparison of five proportional soft tissue facial variables between this study and the suggested ideal value of 1.0

	Variable	Average ±SD	Suggested ideal value	P-value
8	Distance between inner canthus of the eyes/ Mean of the width of the right and left eyes	1.02 ± 0.11	1.00	0.103
9	Width of the right outer canthus to right zygoma/ Width of the right eye	0.68 ± 0.10	1.00	<0.001*
10	Width of the left outer canthus to left zygoma/ Width of the left eye	0.65 ± 0.10	1.00	<0.001*
11	Width of the inter commissural/ Width of the inter iris of both eyes	0.82 ± 0.07	1.00	<0.001*
12	Width of the inter alar/ Distance between inner canthus of eyes	1.11 ± 0.09	1.00	<0.001*

*Significant at α = 0.001 level.

Results

Data derived from 34 males (48.6%) and 36 females (51.4%) were used in the final analysis. The average values of the assessed angular and proportional facial variables are given in Table 1. The mean age of sample was 22.91 ± 4.61, with no significant difference between males (22.21 ± 4.34) and females (23.58 ± 4.81).

Comparing the average facial measurements between males and females, the greatest difference was seen in the facial symmetry angle, where males possessed an average value (1.64 ± 0.92) of about 2.5 than females (0.66 ± 0.61). The difference showed that male participants were more likely to have higher natural facial asymmetry ($p < 0.001$). Another significant difference in angular facial variables was found in the average of the facial aperture modified angle, which was significantly lower in males (43.67 ± 2.86) than in females (46.77 ± 3.72) ($p < 0.001$). There was no significant difference between males and fe-

males in terms of the other two assessed angular variables: the symmetry between left and right of the face ($p = 0.209$) and the V-angle ($p = 0.256$). Significant differences were seen between males and females in two out of the eight assessed proportional facial variables. The average values of both the Facial Index ($p < 0.001$) and the distance between inner canthus of the eyes divided by the mean of the width of the right and left eyes ($p = 0.011$) were higher in males than in females. The average values of the Width of inter alar divided by the distance between inner canthus of eyes was almost the same between males and females ($p = 0.965$).

The ideal values for the five out of eight assessed proportional soft tissue facial variables are suggested as 1.0 in the literature. [7] As presented in Table 2, the difference from the ideal proportional value was statistically significant for four variables ($p < 0.001$ for all four variables). The average of the present study's three variables: the width of the right outer canthus to right zygoma divided by the width of the right eye, the width of the left outer canthus to left zygoma divided by the width of the left, and the proportion of the width of the inter commissural to the width of the inter iris of both eyes was lower than the ideal. However, the proportion of the width of the inter alar to the distance between inner canthus of eyes obtained in the current study was significantly higher than the ideal, despite it was clinically close.

The proportion of the distance between inner canthus of the eyes to the mean of the width of the right and left eyes obtained in this study (1.02 ± 0.11) was not statistically different from the ideal 1.0 ($p = 0.103$). However, as the average of this variable was significantly different between males and females of the study, the one-sample t-test was repeated for the males and females separately. The results showed that males with an average of 1.05 ± 0.11 were significantly different from the ideal 1.0 ($p = 0.007$), while females with an average of 0.99 ± 0.10 were not ($p = 0.541$).

Discussion

Although beauty perceptions are considered subjective, the concept of "normality" as a guide during orthodontic treatment planning is the safe margin. This study, in the absence of a study reporting the norms for South Iranian population, was conducted to assess the average of the proportional and angular soft tissue facial frontal measurements of a group of patients who attended the Shiraz Dental School Clinic for minor dental malocclusion correction. Defining the normative measurements of Iranian population and their differences with those of western white population would help the regional orthodontists, surgeons, and all other health professionals that work on facial aesthetics to make the best decisions when suggesting a treatment plan to patients. This is especially important to those patients willing to maintain their ethnic originality after their aesthetic treatment.

As shown in Table 2, the proportional variables of the Iranian population in this study were significantly different, on average, from the suggested ideal proportions in the western population. Apart from ethnic differences, some researchers claim that the facial proportions might be in close relationship with body height.[18] On the other hand, the average height of Iranian youth has shown a decrease during the past decades and is lower than the norms of western countries that are, as an example, published in the 2000 CDC growth charts.[19,20] Therefore, the difference of facial proportional variables of Iranian subjects from the western population could be justified by the difference in average height of Iranian subjects from western norms.

Morosini et al. used a similar methodology to the current study to assess the facial measurements of 85 Brazilian Caucasian women with a mean age of 23 years and 9 months.[10] They have reported linear and angular facial measurements. In the current study, the results were comparable to this study; the proportional facial variable, Facial Index in Brazilian women was reported as 85.03 ± 3.85. As shown in this study, Iranian women had longer facial height or lower facial width than Brazilian women. However, the facial aperture modified angle was much lower in Brazilian women than what this study found it to be in Iranian women.

Dawei et al. in a study of Chinese adults (105 males and 101 females, 18 – 25 years old), reported that nose width corresponding to one-quarter

of the face width was seen significantly more frequently in Chinese participants (51.5%) than Caucasian adults (36.9%). The nose was narrower than one-quarter of the face width in 38.8% of North American Caucasians and in 21.8% of Chinese, this difference was also statistically significant.[21] Also, in the current study the width of the nose was more than the proportion defined for the North American Caucasians.[7]

Porter et al. determined the average facial proportions of 109 men of African American descent aged between 18 and 30 years and compared the results with the neoclassical canons of facial proportions and the standard for the North American white man. Proportional facial relationships of the African American man differed significantly from those of the North American white man and from neoclassical standards. African American men vary primarily in the mid-face from their white counterparts. The most dramatic differences in the African American man were shorter nasal length and wider alar width. In this study the width of the inter alar to the distance between inner canthus of eyes was significantly higher than the ideal, despite the fact that it was clinically close.[22]

In Sepehr et al.on average, in the upper third of the face (Gl'-hair line), Persian women (PW) between the ages of 18 and 40 had a shorter forehead (trichion to glabella), a smaller eye fissure height, a smaller eye fissure width, and a smaller antimongoloid slant to the eyes. A shorter columella, a wider nose, a wider nasal base, and a thinner alar were observed in the middle third of PW compared to North American White women. In the lower third of the face (Sn-Me'): PW were found to have a smaller, lower face height, a thinner upper vermilion, and a narrower mouth.[14] In the current study the proportion of the width of the intercommissural to the width of the inter iris of both eyes was lower than the ideal and lower facial height was not significantly different between males and females.

The use of highly standardized photographs, along with appropriate digital software and reliable measuring methods warrants the accuracy of the average measurements obtained in this study. Although being single-centered with a limited sample size, the averages and ranges reported in this study could not be generalized to the whole South Iranian population, they provide a vital insight for both researchers and clinicians. Relative to surgical planning for cosmetic procedures and treatment of facial disorders, we believe our results can be used to re-assess the norms used by clinicians and improve the natural appearance for young Iranian subjects. These results confirm that a database for facial patterns used by clinicians in facial surgery for young Iranian subjects should be racially sensitive if the goal is to attain a "natural" facial appearance that is consistent with Iranian norms. The differences in our results with benchmark studies of other ethnic groups further validate the need for racial-ethnically tailored cosmetic treatment plans. Further, future studies on the subjects from other neighboring cities, probably on field derived samples (not attending patients) could be used for better understanding of the norms of the facial variables of this population and the differences between this population and others.

Conclusion

A few differences were observed between men and women in terms of the angular and proportional measurements of their face. The average measurements of most facial variables of this study's population deviated from the ideal values suggested in texts and from those of the Brazilian Caucasian population. These differences should be considered when planning orthodontic or other esthetic treatment plans for the South Iranian population.

Conflict of Interest

The authors declare that they have no conflict of interest.

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