Original Article

Standards of CentroGraphic Analysis in an Anatolian Turkish Population

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ABSTRACT

Aim: The aims of this study were to evaluate different facial-form assessment concepts (conventional numeric cephalometric approach and geometric centroid-oriented individualized cephalomorphic approach), to establish cephalomorphic norms from lateral cephalograms of Anatolian Turkish young adults, and to identify possible gender differences between Anatolian Turkish young men and women.

Materials and Methods: The subjects included 28 Turkish men (mean age, 24.33±1.66 years) and 40 Turkish women (mean age, 23.12±2.24 years) ranging from 20 to 31 years old. Conventional cephalometric analysis and CentroGraphic analysis were applied to each lateral cephalogram. To determine the errors associated with radiographic measurements, 20 radiographs were selected randomly. Their tracings and measurements were repeated 8 weeks after the first measurements. A paired sample *t* test was applied to the first and second measurements. An independent-samples *t* test was performed for statistical evaluation of gender differences.

Results: Generally, some differences were observed, but most of the values for skeletal measurements in Anatolian Turkish adults for cephalometric analysis were found to be similar to the ideal norms of different authors. According to statistical analysis, cephalometric and cephalomorphic measurements were similar for men and women, except facial centroid (FC) value. The FC value for women was statistically greater than that for men ($p<0.05$) CentroGraphic analysis results show that Anatolian Turkish adults have protrusive mandibular and retrusive upper lip.

Conclusions: It is appropriate to put these practical CentroGraphic norms into daily orthodontic practice when an Anatolian Turkish population is being treated. (*Turkish J Orthod* 2013;26:36–44)

KEY WORDS: CentroGraphic Analysis, Cephalometry, Gender Characteristics, Norms, Turkish Population

INTRODUCTION

Numerous cephalometric analyses have been developed to establish norms for ideal facial proportions, presenting average measurements of skeletal or dental patterns.[1,2] Cephalometric norms for different ethnic and racial groups have been presented in many studies.[3–6] It is important to compare a patient's cephalometric findings with the norms for his or her ethnic group for an accurate diagnostic evaluation, while considering treatment goals and needs.

Gazilerli[7] evaluated the Steiner norms in a group of Turkish children with ideal occlusion. Oktay[8] examined the relationships among ANB, Wits, perpendiculars from points A and B to the Frankfort horizontal plane, and anteroposterior dysplasia indicator measurements and found high correlations among these values in Turkish subjects. Erbay *et al*.[9] investigated the horizontal lip position of Anatolian Turkish adults cephalometrically, using the soft tissue analyses of Steiner, Ricketts, Burstone, Sushner, and Holdaway. Erbay and Canikliogˇlu[10] evaluated orthodontists' perceptions of Anato-

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lian Turkish adults' beauty. Basciftci *et al*.[6] determined Holdaway soft tissue standards for Anatolian Turkish young adults. Uysal *et al*.[11] established standards of soft tissue Arnett analysis for surgical planning in Turkish adults. They determined that soft tissue thicknesses were greater and facial lengths (except upper incisor exposure) were longer in Turkish males than females.

The centroid analysis was introduced by Johnson[12] and Johnson and Hubbold[13] and modified by Fishman.[14] In the original CentroGraphic analysis, Johnson described the use of the center of gravity as a fixed reference point. He used a novel model that required cutouts of cephalometric tracings suspended twice in different locations on pins with a vertical line. The center of gravity was determined by the intersection of the 2 lines. When Johnson[12] applied this method to 50 cephalograms of Chinese and English children, he concluded that these centers provided stable reference points generating a stable reference plane to which linear distances could be measured. When Johnson and Hubbold[13] used the same technique to obtain centers on a larger population of randomly selected Chinese children, the conclusions were the same, because he compared the sella (S)-nasion (N) reference plane with planes obtained with the method described earlier. When a vastly simplified analysis was published, Johnson and Hubbold[13] compared lines representing measures commonly identified in cephalometric analyses and coined the term *centroid*.

Fishman[14] published a centroid-based analysis, using principles developed by Johnson and Hubbold.[13] This analysis reduces the task to the construction of 4 centroids with common and simple methods of tracing and landmark identification, no angles to measure, and no normative values to compare. The CentroGraphic analysis is unique to each patient; it supplies independent identification of anteroposterior positions of the maxilla and the mandible, vertical facial proportion inequalities, and a stable reference plane, which can be used for longitudinal cephalometric superimposition.[15] Much information can be obtained from the 4 triangles, their respective centroids, and some additional lines to complete the depiction.

The aims of this study were to evaluate different facial-form assessment concepts (conventional numeric cephalometric approach and geometric centroid-oriented individualized cephalomorphic approach), to establish standards from lateral cephalograms of Anatolian Turkish young adults, and to identify possible gender differences between Anatolian Turkish young men and women.

MATERIAL AND METHODS

At the start of this study, a power analysis established by G*Power version 3.0.10 (Franz Faul Universität, Kiel, Germany) software to estimate sample size. A sample size of 65 patients would give more than 70% power to detect significant differences with 0.50 effect size and at the $\alpha = 0.05$ significance level.

Lateral cephalometric radiographs were taken from 68 nongrowing Turkish adults (28 men, mean age 24.33±1.66 years, minimum 21.25, maximum 30.90; 40 women, mean age 23.12±2.24 years, minimum 21.12, maximum 29.78). They met the following criteria[4,6]:

- Turkish with Turkish parents
- Age 20 to 31 years old
- Class I occlusion with minor or no crowding
- Normal growth and development
- Well-aligned maxillary and mandibular dental arches
- No congenitally missing or extracted teeth
- Good facial symmetry, determined clinically and radiographically
- No significant medical history and no history of trauma
- No deformity in the nasomaxillary complex
- No previous orthodontic or prosthodontic treatment or maxillofacial or plastic surgery

The lateral cephalometric radiograph of each subject was taken with the same cephalometer (OP100, Instrumentarium, Tuusula, Finland). All subjects were positioned in the cephalostat with the sagittal plane at a right angle to the path of the x-rays, the Frankfort plane parallel to the horizontal, the teeth in centric occlusion, and the lips lightly closed.[9]

Conventional cephalometric analysis and CentroGraphic analysis were applied to each lateral cephalogram. Cephalograms were traced and measured by hand, and whole measurements were done by one investigator (A.Y.).

Conventional Cephalometric Analysis

Seventeen measurements, 6 linear and 11 angular, were done on each radiograph for conventional cephalometric analysis. The landmarks were identified according to the definitions provided by Swler-

Table 1. Skeletal, dental, and soft tissue landmarks used in the study for cephalometric analysis.

Skeletal angular and linear measurements
SNA angle (SNA): inward angle toward the cranium between the NA line and the sella-nasion (SN) plane
SNB angle (SNB): inward angle toward the cranium between the NB line and the SN plane
ANB angle (ANB): angle between the NA and NB lines, obtained by subtracting SNB from SNA
SN plane to mandibular plane angle (SN-MP): angle between the SN plane and the mandibular plane (MP)
A point to nasion perpendicular (A to N perp): distance between A point and N perpendicular line measured perpendicular to N perpendicular line
Pogonion to N perpendicular (Pog to N perp): distance between pogonion and N perpendicular line measured from the perpendicular to N perpendicular line
Frankfurt horizontal plane to mandibular plane angle (FMA): angle between the Po-Or line and the mandibular plane
Dental angular and linear measurements
Maxillary central incisor to mandibular central incisor (U1-L1) (interincisal angle): angle is measured between the extension of the maxillary and mandibular incisor long axis line; the most posterior angle is measured
Maxillary incisor to NA plane (U1-NA): distance between the tip of the upper incisor and a line from N to point A
Maxillary incisor-NA angle (U1-NA): angle formed by the long axis of the upper incisor to a line from N to point A
Mandibular incisor to NB (L1-NB): distance between the tip of the mandibular incisor and a line from nasion to point B
Mandibular incisor-NB angle (L1-NB): angle formed by the long axis of the mandibular incisor to a line from N to point B
Mandibular incisor to Frankfurt horizontal plane (FMIA): long axis of the mandibular incisor is measured to Frankfurt horizontal plane
Soft tissue angular and linear measurements
Nasolabial angle (Prn-Sn-upper lip): angle formed by the labial surface of the upper lip to a line from sinusale to tip of nose
Upper lip to E plane: distance between the upper lip and a line from the tip of the nose to the end of the chin
Lower lip to E plane: distance between the lower lip and a line from the tip of the nose to the end of the chin

enga *et al*.[16] and presented in Table 1. Landmarks used in the study are shown in Figure 1.

CentroGraphic Analysis

The centroid analysis was done as described by Fishman.[14] Only five points (S, N, Ba, A, and Pog) and four lines (S-Na, Na-Ba, Ba-A, and Ba-Gn) are drawn on the x-ray tracing for analysis. This analysis establishes the location of centroids within the following 4 anatomically determined triangular areas:

- Cranial centroid (CC): triangle (Ba-S-Na)
- Facial centroid (FC): triangle (Ba-Na-Gn), total face (Fig. 2)
- Upper centroid (UC): triangle (Ba-Na-A), upper face (Fig. 3)
- Lower centroid (LC): triangle (Ba-A-Gn), lower face (Fig. 4)

The centroid of each triangle is determined CentroGraphically by drawing a line from the vertex of the respective triangle and bisecting the opposite leg of the triangle. This is done at a second vertex to the opposite leg. The intersection of these 2 lines determines the centroid and serves as the point of reference for analysis in the sagital aspect (Fig. 6). This is done on all 4 triangles. The centroid plane is constructed as a perpendicular to Ba-A through the FC (Fig. 5).

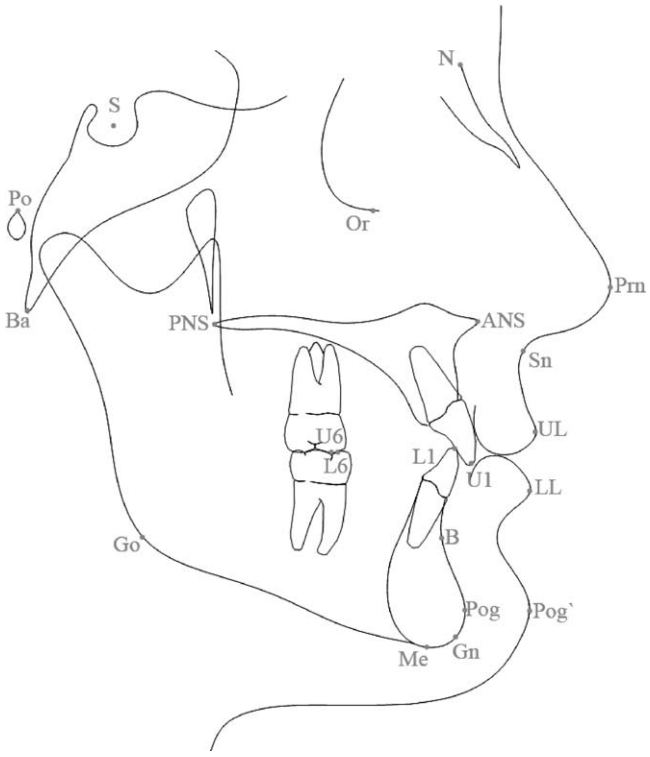

Figure 1. Hard and soft tissue landmarks used in study. *S*, sella; *N*, nasion; *Or*, orbitale; *ANS*, anterior nasal spine; *PNS,* posterior nasal spine; *Prn*, prosthion; *A*, A-point; *Sn*, subnasale; *U1*, maxillary incisor; *L1*, mandibular incisor; *UL*, upper lip; *LL*, lower lip; *B*, B-point; *Pog*, pogonion; *Pog*', soft tissue pogonion; *Gn*, gnathion; *Me*, menton; *Go*, gonion; *Ba*, basion; *Po*, porion; Ptg, pterygoid.

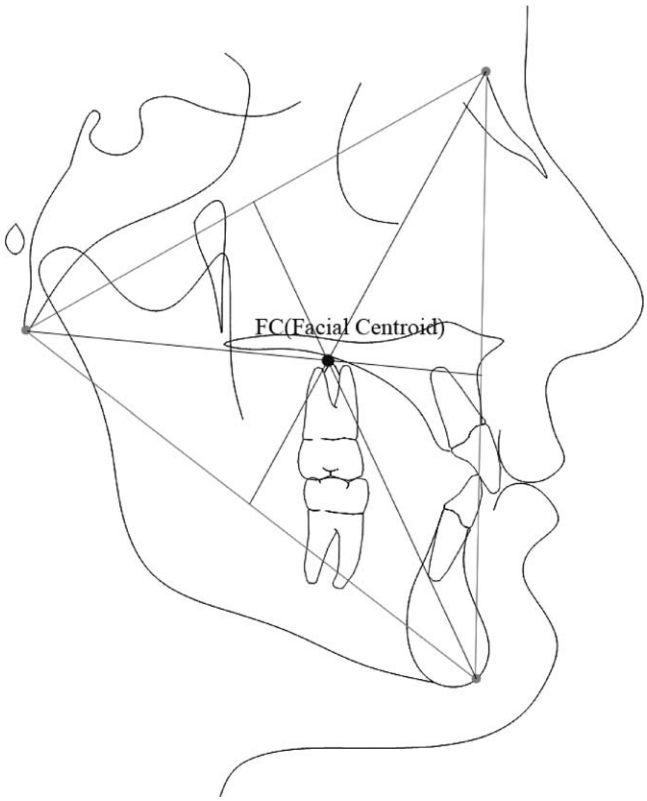

Figure 2. Facial centroid (total face); Ba-Na-Gn triangle.

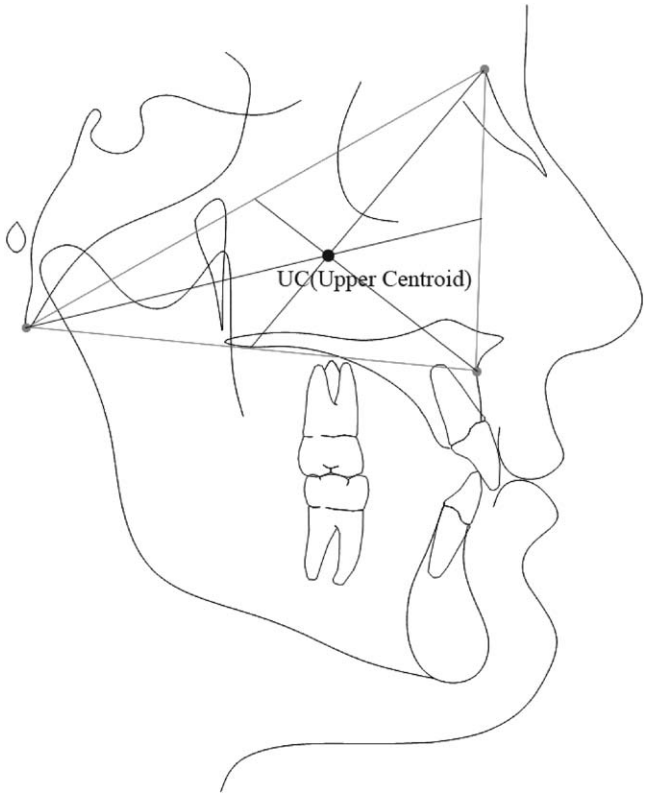

Figure 3. Upper centroid (upper face); Ba-Na-A triangle.

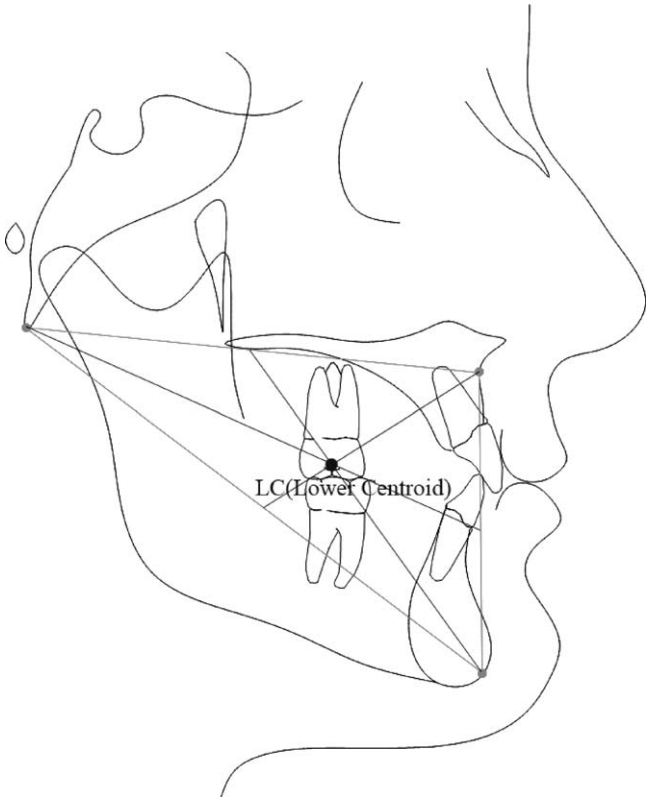

Figure 4. Lower centroid (lower face); Ba-A-Gn triangle.

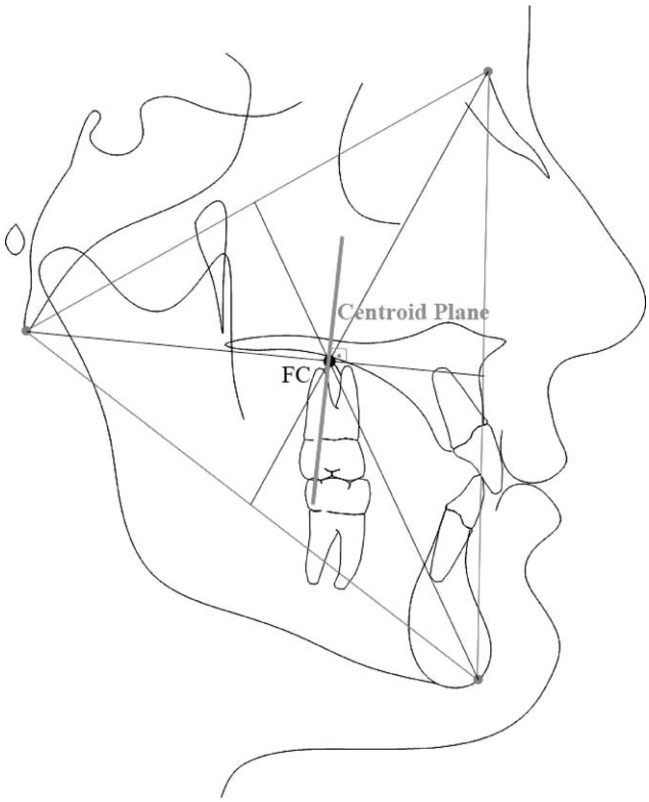

Figure 5. The centroid plane is constructed as a perpendicular to Ba-A through the facial centroid.

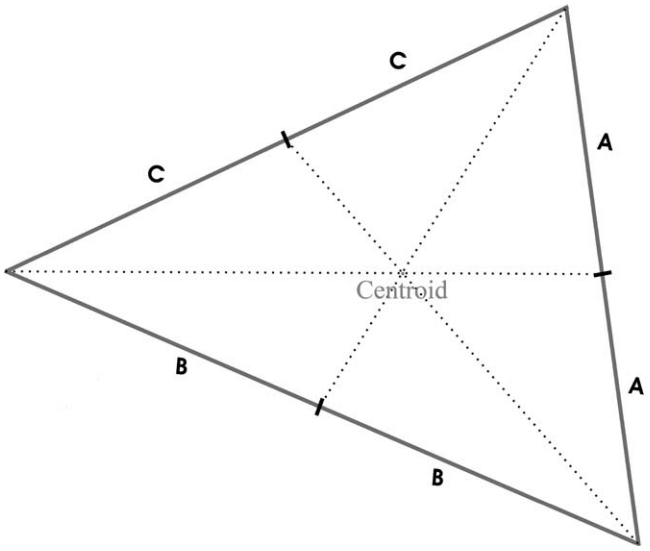

Figure 6. The intersection of these 2 lines determines the centroid and serves as the point of reference for analysis in the sagittal aspect.

In the vertical plane, the subjects were categorized as deficient, excessive, or neutral based on the vertical position of FC to a line formed by Ba-A-pt. In persons with balanced vertical skeletal harmony, the FC is located directly on the Ba-A plane, the constructed division between the upper and lower faces.[14] In persons with a deficiency in vertical development of the lower face, the FC is positioned within the upper face. In persons with an excess in vertical development of the lower face, the FC is positioned within the lower face.

Horizontal skeletal imbalance is evaluated by assessing the anteroposterior positions of UC and LC to the centroid plane. For example, if UC is posterior to the centroid plane, the subject is maxillary retrognathic. If LC is anterior to the centroid plane, the subject is mandibularly prognathic.

Soft-tissue pogonion to subnasale (inner profile) and soft-tissue pogonion to nasal tip (outer profile) planes are used together to evaluate positional balance of the lips. A desirable relationship can be described as both lips being positioned relatively equal within the space between the 2 planes in an at-rest position and in occlusion. In the present method, we drew an angle bisector to subnasale-soft tissue pogonion-nasal tip angle and then measured upper and lower lip projection to bisector (Fig. 7).

Statistical Analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (Windows, version 13.0, SPSS Inc, Chicago, IL, USA). Arithmetic mean and standard deviation values were calculated for each conventional and CentroGraphic measurements.

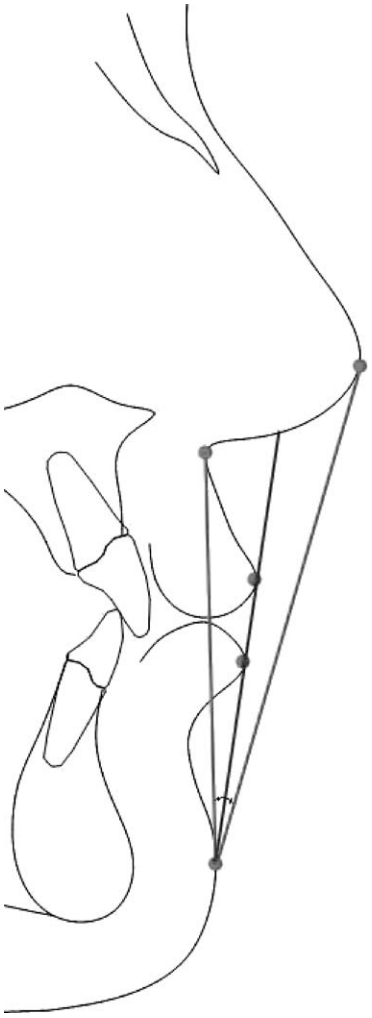

Figure 7. Soft tissue pogonion to subnasale (inner profile) and soft tissue pogonion to nasal tip (outer profile); planes are used together to evaluate positional balance of the lips.

To determine the errors associated with radiographic measurements, 20 radiographs were selected randomly. Their tracings and measurements were repeated 8 weeks after the first measurement. A paired sample *t* test was applied to the first and second measurements. It was found that the difference between the first and second measurements of the 20 radiographs was insignificant. Correlation analysis applied to the same measurements showed that the highest *r* value was 0.990 for the FC measurements and the lowest *r* value was 0.802 for FMA measurements. An independent-samples *t* test was performed for statistical evaluation of gender differences.

RESULTS

Combined cephalometric norms, means, and standard deviations for Anatolian Turkish adults are shown in Table 2. Generally, some differences were observed, but most of the values for skeletal measurements in Anatolian Turkish adults were found to be similar to the ideal norms of different authors.

Descriptive statistics of the cephalomorphic norms of Anatolian Turkish adults are shown in Table 3. These centroid-based results show that Anatolian Turkish adults have protrusive mandibular and retrusive upper lip.

The following results were obtained through the independent-samples *t* test applied to compare the measurement differences between men and women. Of the 22 measurements, only one (FC vertical) showed statistically significant gender differences (Table 4). The FC value was statistically greater in women ($p<0.05$).

DISCUSSION

The subjects investigated in this study were untreated Turkish adults with ideal occlusion and well-balanced faces. The inclusion criteria and methodology were oriented to identify normative values that can assist in the diagnosis and treatment planning for Turkish adults seeking orthodontic treatment or orthognathic surgery. Young adults (20 to 31 years old) of both genders were included because most orthognathic surgeries are performed in this age group. The data were separated according to gender to obtain more specific and useful cephalometric normative values.

We aimed to obtain a representative sample of clinically normal Anatolian Turkish subjects, so we did not include patients who had received orthodontic or facial surgical treatment. Extreme differences exist between normal and esthetically pleasing profiles, and difficulties in the application of supernormal cephalometric data have been related to cultural differences.[17,18] Thus, normal occlusion, which is not necessarily related to beauty, was the main criterion used to select the subjects.[17,19]

To eliminate interexaminer variability, a single investigator traced and measured all radiographs. Moreover, landmark identification error was minimized by a repeated check by the same author and by a test of intraexaminer reliability.

Basciftci *et al*.[4] concluded that there are differences in dentofacial relationships between various ethnic and racial groups. Only a few studies have found significant differences in analyses comparing different ethnic groups. Basciftci *et al*.[4] compared norms for Anatolian Turkish adults with Steiner norms and found significant differences only in lower anterior facial height. In another study, Basciftci *et al*.[6] found difference for soft tissue chin thickness

Table 2. Combined cephalometric norms, means, and standard deviations for Anatolian Turkish adults

		Anatolian Turkish Norms	
Measurement	**Normative Values**	**Mean**	**SD**
SNA (°)	82.00	80.45	3.76
SNB (°)	80.00	78.19	3.26
ANB (°)	2.00	2.26	2.05
Maxillary skeletal (A-Na Perp) (mm)	1.00	0.07	3.66
Mandibular skeletal (Pg-Na Perp) (mm)	(−2–+4)	–1.81	7.05
FMIA (L1-FH) (°)	60.30	61.78	7.00
FMA (MP-FH) (°)	26.00	24.14	5.92
SN-GoGn (°)	32.00	31.18	6.19
U1-NA (mm)	4.00	4.61	2.61
U1-NA (°)	22.00	22.88	6.54
IMPA (L1-MP) (°)	95.00	94.06	7.54
L1-NB (mm)	4.00	4.95	2.16
L1-NB (°)	25.00	26.07	6.19
Interincisal angle (U1-L1) (°)	130.00	128.77	9.27
Nasolabial angle (Col-Sn'-ULA) (°)	108.20	106.38	9.03
Lower lip to E-plane (mm)	–2.00	–2.90	2.74
Upper lip to E-plane (mm)	–4.00	–5.41	2.44

Table 3. Descriptive statistics of the cephalomorphic norms of Anatolian Turkish adults[a]

		Anatolian Turkish Norms	
Measurement	**Norms**	**Mean**	**SD**
FC (upper [+] lower [–])	0.00	0.20	2.30
UC (anterior [+] posterior [–])	0.00	–0.19	1.60
LC (anterior [+] posterior [–])	0.00	1.81	1.53
Upper lip (anterior [+] posterior [–])	0.00	–1.03	1.95
Lower lip (anterior [+] posterior [–])	0.00	–0.16	2.31

[a] FC indicates facial centroid; UC, upper centroid.

and basic upper lip thickness compared with Holdaway norms. In this study, skeletal cephalometric measurements were generally found to be similar to previous norms of Turkish adults.[4]

Fishman[14] suggested that even persons with well-balanced skeletal and soft tissue profiles and normal occlusion demonstrate wide variations in craniofacial structure and he also described CentroGraphic analysis. The CentroGraphic Analysis is not a cephalometric analysis but a cephalomorphic approach to diagnosing, planning, and monitoring orthodontic or surgical treatment.[14] He indicated that normal numeric standards for CentroGraphic Analysis did not exist when derived from varying subsamples of people.[20] But different ethnic groups have different norms. Thus, we determined any differences from Fishman's[14] norms in young Turkish Anatolian adults. Fishman introduced this analysis as a nonnumeric approach. However, to make evaluations and comparisons, measurements should be performed. For the same reasons, Dolce *et al.,*[15] Murata[21], Murata *et al.*[22] used a numeric approach for the centroid method.

Consequently, in contrast to Fishman's idea, the present study showed that the LC measurement was greater and the upper lip measurement was smaller

Table 4. Means and standard deviations of cephalometric and centrographic measurements of Anatolian Turkish young adult men and women[a]

	Males (n=28)		Females (n=40)		
Measurement	**Mean**	**SD**	**Mean**	**SD**	***t* Test**
SNA (°)	80.757	3.674	80.245	3.859	NS
SNB (°)	78.546	3.386	77.945	3.193	NS
ANB (°)	2.211	2.387	2.310	1.827	NS
Maxillary skeletal (A-Na Perp) (mm)	–0.361	3.470	0.375	3.803	NS
Mand. skeletal (Pg-Na Perp) (mm)	–2.500	7.461	–1.340	6.809	NS
FMIA (L1-FH) (°)	61.089	7.862	62.268	6.396	NS
FMA (MP-FH) (°)	25.461	7.376	23.220	4.522	NS
SN-GoGn (°)	31.396	7.561	31.040	5.135	NS
U1-NA (mm)	4.954	2.253	4.378	2.849	NS
U1-NA (°)	23.107	5.095	22.728	7.457	NS
IMPA (L1-MP) (°)	93.439	8.398	94.508	6.971	NS
L1-NB (mm)	5.486	2.516	4.585	1.820	NS
L1-NB (°)	26.411	7.092	25.835	5.569	NS
Interincisal ngle (U1-L1) (°)	128.261	8.464	129.133	9.889	NS
Nasolabial angle (Col-Sn'-ULA) (°)	107.189	10.065	105.820	8.320	NS
Lower lip to E-plane (mm)	–2.668	3.155	–3.075	2.449	NS
Upper lip to E-plane (mm)	–5.168	2.421	–5.585	2.473	NS
FC (upper [+] lower [–])	–0.579	2.098	0.758	2.446	0.19*
UC (anterior [+] posterior [–])	–0.161	1.839	–0.220	1.441	NS
LC (anterior [+] posterior [–])	1.886	1.788	1.765	1.347	NS
Upper lip (anterior [+] posterior [–])	–0.614	1.960	–1.333	1.912	NS
Lower Lip (anterior [+] posterior [–])	0.218	2.520	–0.440	2.146	NS

[a] NS indicates not significant; * $p < .05$

than Fishman's values. Therefore, we concluded that Anatolian Turkish adults have protrusive mandibular and retrusive upper lip. Taher and Abd El-Aziz[23] assessed various patterns of craniofacial growth based on 2 different facial-form assessment concepts: a conventional numeric cephalometric approach and a geometric centroid-oriented individualized cephalomorphic approach. They found a disagreement between applied conventional numeric cephalometric and centroid-oriented cephalomorphic analyses in reaching a precise diagnosis regarding the anteroposterior and vertical facial form. However, in the current study, harmony was found between cephalometric and cephalomorphic assessments.

Basciftci *et al*.[4] showed that Turkish men have greater total anterior facial height values than women. Uysal *et al*.[11] indicated that Turkish men have greater soft tissue thicknesses and longer facial lengths than women. Gulsen *et al*.[24] found significant gender differences for nasal length, nasal depth, and soft tissue facial convexity. In a different study, Basciftci *et al*.[6] investigated Holdaway soft tissue norms in Turkish adults. They determined statistically significant gender differences for nose prominence, upper lip strain, soft tissue chin thickness, and upper lip thickness. However, the cephalometric values obtained in this study did not show any significant statistical difference between Turkish men and women. Only one cephalomorphic measurement (FC) was found to be statistically significant between men and women. The anterior edge of the facial centroid triangle, an increase in Na-Gn measurment might be responsible for this difference as it was found to be greater in men, as reported in a previous study[4] in the Turkish population.

CONCLUSION

Fishman centrographic analysis was not based on numeric evaluation; in the present study a numeric consideration method was used, and some centrographic measurements were found to be different from Fishman claims. Anatolian Turkish adults have protrusive mandibular and retrusive upper lip. This study also indicated cephalometric norms for Anatolian Turkish adults.

Conflict of interest

The authors have reported no conflicts of interest.

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