Original Article

Craniofacial Evaluation of Class I Turkish Adults: Bimler Analysis

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ABSTRACT

Objective: The aim of this study was to evaluate the facial type and skeletal relationships of Class I Turkish male and female adults by using Bimler cephalometric analysis.

Materials and Method: The study sample included 82 randomly selected Turkish adults (42 female, 40 male) with an age range of 18–23 years. Cephalometric measurements defined by Bimler were used to determine skeletal relationships, including his suborbital facial index on lateral cephalometric radiographs. Variance analysis (ANOVA) was used for statistical assessment of the results.

Results: The whole sample was found to be in the medium range according to Bimler. For all parameters, except the mandibular flexion (Cgo/CV), which showed hyperflexion with a mean 4.23° in female patients and 3.78° in male patients, Turkish adults show appropriate characteristics as defined by Bimler. There were no significant differences between men and women in most of the angular and linear measurements. Craniofacial height and depth values were significantly higher in men, showing a sex-based difference ($p<0.001$), whereas differences between the sexes concerning suborbital facial index (H/D) were nonsignificant.

Conclusions: Ranges of Turkish population show similarity to those reported by Bimler. The whole sample was found to be in the medium range according to Bimler. Craniofacial height and depth values were significantly higher in men, showing sex-based difference. The mandible showed hyperflexion in both groups which indicates reduction of the height of the middle part of the face. (*Turkish J Orthod* 2014;26:169–176)

KEY WORDS: Bimler analysis, Cephalometric analysis, Craniofacial characteristics, Facial type, Skeletal Class I, Turkish population

INTRODUCTION

A scientific approach to analyze the human craniofacial patterns was first initiated by anthropologists and anatomists by recording various dimensions of dry skulls. The measurements of the dry skull from osteological landmarks were then applied to living subjects.[1] Since the introduction of cephalometric radiography, there have been many reports on cephalometric analyses.[2–6]

Most of the different cephalometric analyses are based on established norms derived from population samples to define dentofacial and craniofacial morphology. They provide means to compare individual dentofacial characteristics with a population average in order to identify areas of significant deviation and to describe the spatial relationship between various parts of craniofacial structures.[1–6] On the other hand, each cephalometric analysis has its limitations.[1,7–10] In addition, the skeletal and facial characteristics are under the influence of hereditary, and thus racial factors, and patients need to be examined according to their own norms for their racial or ethnic groups.[11–17]

In recent years, the number of cephalometric studies for Turkish population has increased.[8,18–21]

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However, the applicability of the norms described in these analyses to Turkish people is controversial. For each type of variable, subtle differences were reported between the cephalometric values in adult Turkish subjects and the ideal values defined by other investigators.[19] Therefore, various craniofacial structures should be evaluated in further studies.

Bimler analysis[1,5,6] includes tracings that assess more details than the routinely used anatomical parts with a different approach. Bimler classifies facial types of the individuals by using the suborbital facial index, creating a major difference from the other analyses. Thus, the craniofacial structures can be evaluated in a specific conception, which makes the method appreciable. Also, in this analysis he does not compare the patient's morphological characteristics to established population norms, instead he evaluates subjects individually by considering the relationships of the individual morphological and functional components. He believes that norms are merely statistical averages of sample groups. He prefers a range of variability for cephalometric measurements, and their comparison with the whole individual as to whether these given measurements either lend to harmony or disharmony for the individual patient.[1,5,6]

The aim of this study was both to attract attention to Bimler cephalometric analysis because no previous studies were found and to use his methods to evaluate the facial type and the skeletal relationships of Turkish individuals with Class I characteristics and to determine possible differences between female and male features.

MATERIALS AND METHODS

For this retrospective study, 125 patients showing skeletal Class I characteristics treated by the authors were randomly selected, and their pretreatment materials (lateral cephalometric radiographs and orthodontic models) were evaluated. Young adult subjects whose parents were Turkish without any interracial marriage having skeletal Class I relationship (ANB: 0.5°–4°) and optimum mandibular plane angles (GoGn/SN: 26.5°–37.5°) with no previous loss of primary molars, congenitally missing teeth, or stainless steel crowns, facial and/or dental trauma, or systemic diseases were selected. Finally, 82 subjects with an age range of 18–23 years, having normal overjet and overbite relationships, having minor crowding, no anterior and/or posterior crossbites, and no history of previous orthodontic or prosthodontic treatment were included in the study. A sample size of 82 patients at $\alpha = 0.05$ yields statistical power 0.93 for this kind of study.

Two groups were constructed; group 1: female subjects (n=42) and group 2: male subjects (n=40).

All subjects were positioned in the cephalostat with the Frankfort plane parallel to the floor and the teeth in centric occlusion with the lips relaxed. The lateral cephalometric radiographs were taken at a standard source to cassette holder distance of 120 mm with OP100 Cephalometer (Instrumentarium, Tuusula, Finland). The image enlargement was 8.0%, and the data were not corrected for this enlargement.

Eight angular and three linear measurements defined by Bimler[1,5] were used to evaluate the lateral cephalometric radiographs (Figs. 1 and 2a,b). One parameter (H/D) was derived from those measured directly on the lateral cephalometric radiographs. The explanations of the measurements used and their ranges are defined in the Appendix.

Each cephalometric radiograph was traced, and all parameters were measured by the same investigator and were recorded to the nearest 0.5 mm and degrees. The tracing and measurements were repeated by the same investigator on 20 randomly selected radiographs after an interval of 20 days. The error of the method was calculated by Dahlberg formula: $Si = \sqrt{\sum \frac{d^2}{2n}}$, and it did not exceed 0.25 mm and 0.5° for any of the variables investigated.

Analysis of variance (ANOVA) was used to compare the measurements of the male and female subjects. Statistical analysis was completed using computer software (SPSS version 13.0, SPSS Inc, Chicago, IL, USA). Data were expressed as "mean (standard deviation)" and minimum-maximum; $p < 0.001$ was considered statistically significant.

RESULTS

The mean and range values for the study sample (n=82) are shown in Table 1. The comparison of the mean values for the 2 groups are shown in Table 2.

The whole sample was found to be in the medium range according to Bimler analysis as defined in the Appendix. Ranges of Turkish population show similarity to those announced by Bimler (Table 1).

The sagittal craniofacial relationship differences, according to ANB angle and A′B′ distance (bony overjet) were found to be nonsignificant between male and female patients (Table 2), whereas, significant differences were found in the vertical craniofacial relationship, according to GoGn/SN angle, between male and female patients with mean 30.03° and 32.73°, respectively ($p < 0.001$) (Table 2). On the other hand, no sex-related differences were found in the Bimler mandibular plane angle (FMPA). The mean FMPA was 24.31° in female patients and 23.05° in male patients, which were evaluated as medium (Table 2).

The palatal plane inclination (PP/FH) was not found to be significantly different between the sexes (Table 2).

The clivus inclination (CliCls/FH) was in the neutral or medium range with a mean 61.41° (Table 1). Both the upper basic angle (C angle) and the lower basic angle (B angle) were in the medium range expressing the mesoprosopic face type with mean 61.86° and 23.32°, respectively (Table 1). The differences between male and female patients in these 3 parameters were not found to be significant.

When the mandibular flexion (factor 8) Cgo/CV was evaluated, the mandible showed hyperflexion in both sex groups with a mean 4.23° in female and 3.78° in male patients. Statistically, no significant differences were found between male and female patients (Table 2).

Although there were statistically significant differences both in height and depth values between male and female patients ($p < 0.001$ for each), no significant differences were found concerning the suborbital facial index (H/D). Female and male patients were found to be mesoprosopic, in other words, medium face, as the mean values were 1.81 and 1.78, respectively (Table 2).

DISCUSSION

This investigation is the first to evaluate the facial type and the skeletal relationships of Class I Turkish individuals by Bimler analysis. Currently, insufficient published data exist to establish cephalometric values useful for diagnosis and treatment planning for Turkish adults.[19]

Bimler[1,5,6] introduced his cephalometric analysis, which considerably differs from the routinely used analyses that are based on statistical norms comparing the subjects' morphology. Bimler analysis particularly emphasizes the relationships of the individual's morphological and functional components. In addition, Bimler analysis drives attention to differential diagnosis of craniofacial structures. In accordance with these relative benefits, Bimler analysis was used for the anthropological evaluation of adult Turkish people in this study. The data were separated according to sex to obtain more specific and useful cephalometric values.

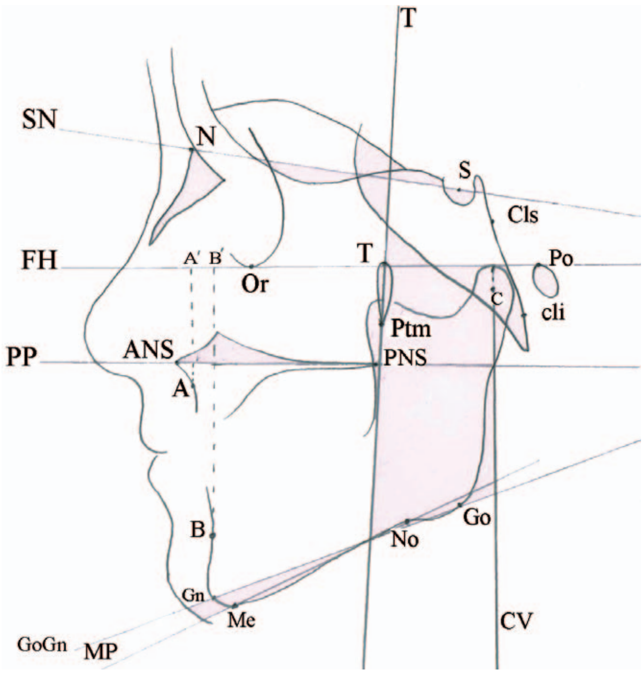

Figure 1. Cephalometric landmarks used in the present study. N, indicates nasion; S, sella; Go, gonion; Me, menton; Gn, gnathion; A, A-point; B, B-point; ANS, anterior nasal spine; PNS, posterior nasal spine; Or, orbitale; Po, anatomic porion; Ptm, pterygomaxillary fissure; No, mandibular notch; C, capitulare (the arbitrary center of the head of condyle); Cls, clivion superior (a point in the upper third of the clivus, limiting the straight center part of this bone); and Cli, clivion inferior (a point in the lower third of clivus, limiting the straight center part of the caudal end). Cephalometric planes used in the present study. SN, SN plane; FH, Frankfort horizontal plane; PP, palatal plane; GoGn, GoGn plane; MP, mandibular plane (a line extending from menton to a point tangent to the highest elevation of the outline of the antegonial notch); T, T vertical (a vertical line through the pterygomaxillary fissure perpendicular to FH; CV, C vertical (a vertical line extends from FH down through C to about the level of Go perpendicular to FH); and A′ and B′, vertical projections of A-point and B-point on the FH.

In Bimler analysis, the entire complex of dentofacial relations is divided into different regions and factors. The assessment of the individual details is achieved by the so-called "factor analysis." A factor is defined as the inclination of a line connecting 2 reference points with regard to the orthogonial reference system consisting of Frankfort horizontal and a vertical, the pterygomaxillary fissure. By use of the factor analysis, all measurements can be checked against each other, disclosing all such deceptive assessments.[1,5,6] In this study, all factors

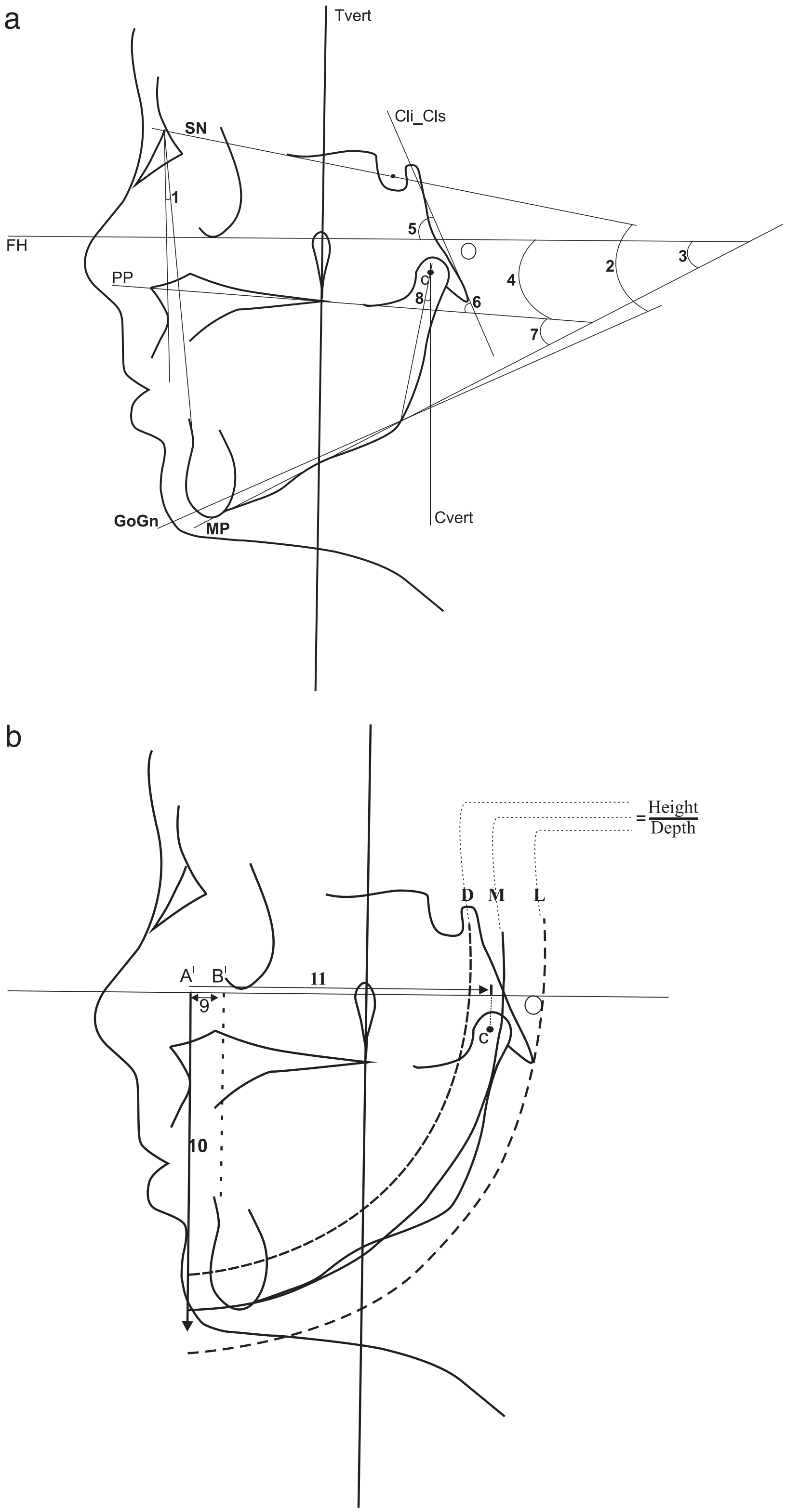

Figure 2. Measurements used in the present study. (A) Angular measurements. 1. ANB; 2. GoGn/Sn; 3. FMPA, the angle formed by Frankfort horizontal and mandibular plane; 4. PP/FH, the angle formed by the palatal plane (ANS-PNS) and Frankfort horizontal; 5. CliCls/FH, the inclination of the line connecting clivion superior and inferior to Frankfort horizontal; 6. C (upper basic angle), formed by the line running tangent to the clivus, and the line of the palatal plane; 7. B (lower basic angle), formed by the intersection of the palatal plane and the mandibular plane; 8. CgoCV (mandibular flexion), inclination of the ramal line which is the connecting line from point C (capitulare) to point Go (gonion) to the vertical. (B) Linear measurements and suborbital facial index (H/D): 9. A′B′ (mm); 10. height, distance between Frankfort horizontal to point M; 11. depth, distance between the projection of point A on Frankfort horizontal and point C; 12. H/D suborbital facial index (D indicates dolichoprosopic; L, leptoprosopic; M, mesoprosopic).

Table 1. Descriptive statistics of the total sample (n=82)[a]

Variables	X	SD	Min	Max
1. ANB	2.49	1.00	0.50	4.00
2. GoGn/SN	31.56	3.17	26.50	37.50
3. FMPA	23.76	4.48	13.00	31.50
4. PP/FH	−0.17	3.57	−7.50	8.00
5. CliCls/FH	61.41	4.98	46.00	72.00
6. C	61.86	5.73	46.00	72.50
7. B	23.32	5.37	9.00	35.00
8. Cgo/CV	4.03	3.34	−3.50	13.50
9. A′B′	5.51	2.35	1.00	13.00
10. Height	98.18	6.67	77.00	115.00
11. Depth	85.27	4.67	77.00	100.00
12. H/D	1.80	0.44	00.00	2.00

[a] X indicates mean; SD standard deviation; Min, minimum; Max, maximum.

and the index could not be included because of the volume of data; they will, however, be published in the near future.

Factor Analysis

The mandibular inclination-FMPA (factor 3). In this study, the whole sample was found to be in average FMPA, evaluated as medium by Bimler.[1,5,6] No significant differences were found between sexes. On the contrary, the parameter GoGn/SN representing the mandibular inclination in Steiner analysis, showed significant sex-related differences ($p<0.001$). These 2 parameters, though both defining the mandibular plane inclination, revealed different results. This might be because of the difference in the reference planes; SN line in Steiner and Frankfort horizontal line in Bimler analysis and the mandibular planes.

Bimler's FMPA range is announced as 15°–30°, and it was found to be 13°–31.5° in the Turkish population, which is in the range of variability according to Bimler.

Maxillary inclination (factor 4). Maxillary inclination shows discrepancies in midfacial development either anteriorly or posteriorly. In this study, the mean degree of PP/FH was 0.38° in female patients and −0.89° in male patients. Although the PP/FH revealed differentially positive and negative values, the difference was found to be nonsignificant between the sexes. The maxillary inclination has been proven to be one of the most indicative features for detecting disturbances in the balance of the facial structures. A negative angle indicates a retardation or reduction in the development of the anterior middle face. This inclination of the maxilla, which has been described as microrhinic dysplasia, produces an upper frontal protrusion; the degree of flexion of the mandible can often be affected as well. A negative angle indicates a poor prognosis in open bite cases, but there is some hope for compensation in closed bite cases.[1,5,6]

Clivus inclination (factor 5). The posterior part of the cranial base, the clivus, has long been neglected in cephalometrics—possibly because the ear rods tend to overshadow this region on head films. However, Bimler claims that clivus inclination is correlated to facial type and influences the position of the joints and thus the occlusion. In this study, the clivus inclination was in the neutral or medium range

Table 2. Descriptive statistics of each group and the comparison of the 2 groups[a]

	Female Patients (n=42)				Male Patients (n=40)				
Variables	X	SD	Min	Max	X	SD	Min	Max	*p*
1. ANB	2.52	1.01	0.50	4.00	2.45	1.00	1.00	4.00	0.764
2. GoGn/SN	32.73	3.09	27.00	38.00	30.03	2.60	26.50	37.00	0.000***
3. FMPA	24.31	4.28	14.00	31.50	23.05	4.70	13.00	31.00	0.232
4. PP/FH	0.38	3.53	−7.50	7.00	−0.89	3.56	−7.00	8.00	0.130
5. CliCls/FH	61.26	5.30	46.00	72.00	61.61	4.60	52.50	71.00	0.768
6. C	61.71	6.40	46.00	72.50	62.05	4.82	51.50	70.00	0.807
7. B	23.98	5.80	12.00	35.00	22.45	4.71	9.00	32.00	0.229
8. Cgo/CV	4.23	3.23	−2.00	12.00	3.78	3.52	−3.50	13.50	0.574
9. A′B′	5.12	2.04	1.00	12.00	6.03	2.65	2.00	13.00	0.098
10. Height	94.85	5.02	77.00	105.00	102.56	6.05	90.00	115.00	0.000***
11. Depth	82.99	3.54	77.00	90.50	88.28	4.29	77.00	100.50	0.000***
12. H/D	1.81	0.40	1.00	2.00	1.78	0.49	0.00	2.00	0.785

[a] X indicates mean; SD standard deviation; Min, minimum; Max, maximum.
*** $p<0.001$.

(60°–70°) in the total sample, and no significant differences were found between the sexes.

Posterior profile angle (basic angle). Nearly every cephalometric analysis system is preoccupied with the anterior profile of the face. Differently, Bimler[1,5,6] also developed an angular measurement system to describe the variations within a given facial type in more detail—the posterior profile angle (basic angle). This portion of the analysis is concerned with the angulation of certain portions of the osseous anatomy of the deep structures of the maxillofacial complex.

The clivus-mandibular plane angle is called the “basic angle of the face.” This angle is used to supplement the suborbital facial index. The basic angle corresponds with the facial type, in that the deeper the face, the more acute the angle, whereas, the longer the face, the more obtuse the basic angle will appear.

There is a high correlation between facial types and the basic angle in harmonious faces, whereas in clinical orthodontics, disharmonious faces must be considered. Upper and lower components of total basic angle are more indicative of facial disharmony than the overall basic angle. Posterior profile angle (basic angle) is divided into 2 subdivisions: the upper and the lower basic angle; and the facial type is expressed as the combined relationship of the upper and lower basic angles. Visually observed clinical phenomena may be basically described with these upper and lower angles cephalometrically. For example, the maximum bite closing effect would be signified by the posterior profile angle formula L/D. Correspondingly, the maximum bite opening effect would be depicted as D/L.

In this study both the upper basic angle (C angle) and the lower basic angle (B angle) were in the medium range expressing the mesoprosopic face type.

Mandibular flexion Cgo/CV (factor 8). Differing from others, in this analysis the vertical position of the mandible is determined by measuring the inclination of the ramal line, which connects point C (capitulare) and point Go (gonion) to the vertical. This position depends on a number of facial features and varies with the tonus of the masticatory muscles as long as the mouth is open or the mandible is in rest position. Bimler[1,5,6] was concerned with the mandible’s position in occlusal contact, which depends primarily on the maxillary inclination, the height of the alveolar process, and the degree of dental eruption or absence of teeth.

Mandibular flexion shows how much the patient has compensated for vertical discrepancies. In harmonious faces (orthoflexion), the posterior border of the ramus will be more or less vertical and the angle close to 0°. A positive angle indicates overclosure (hyperflexion); this results from a short middle face (reduction of height of the middle part of the face) or loss of teeth, as in edentulous elderly patients. A negative angle indicates a premature stop of the closing movement (hypoflexion). In this study, the mandible showed hyperflexion in both groups.

Suborbital facial index. Bimler developed suborbital facial index, a facial typing system that could be applied to a lateral projection of the maxillofacial complex and relates facial height to facial depth. This concept is one of the major differences from the others.[2–4]

In this study, male patients showed vertically and horizontally (anteroposterior) larger skeletal values than the female patients. This finding is in accordance with other research defining that the linear measurements in male patients are larger than in female patients.[18–20,22]

Although there are significant differences in the height and depth values of the cranium between male and female patients ($p < 0.001$), it is worthwhile to note the similarity on proportions as observed from the suborbital facial index (H/D). Female and male patients were found to be mesoprosopic, in other words, medium face.

Bone overjet. Evaluation of the sagittal apical base relationship has been given considerable emphasis in orthodontic diagnosis and treatment planning. ANB angle is the most commonly used measurement in evaluating the sagittal apical base relationship. However, many factors have been reported to affect the reliability of this angle, as well as angles SNA and SNB. Such variation in spatial position of nasion horizontally and/or vertically and point A and B vertically affect the ANB angle readings.[2,4]

Bimler[5,6] determines the anteroposterior jaw relationship by measuring the distance between perpendiculars drawn from point A and B onto the Frankfort horizontal plane. The sagittal relation of the dental arches depends primarily on the size of the maxilla and mandible. Independent of the absolute sizes of these bones, the overjet of basal bone (A′-B′ on FH) indicates discrepancies between them. This method eliminates nasion and is not affected by the vertical displacement of these points.

However, controversy continues concerning the reliability and stability of the Frankfort horizontal plane. Chang[4] reported that the AF-BF distance is the true measurement of anteroposterior relationship of the maxilla to the mandible along the Frankfort horizontal plane. Huang *et al*.[10] defined that the AF-BF measurement, using a "horizontal" reference line (FH plane), is affected less by the inclination of the reference plane. On the other hand, Oktay[8] defined that Wits, AF-BF, and APDI apical base assessment criteria are not more reliable than ANB angle in clinical diagnosis.

In this study, although all patients were Class I according to Steiner analysis, some of them were found to be Class 2 in Bimler analysis (0–10 mm, Class I) as the range was 1.00–13.00 mm in both sexes. In the total sample, the bony overjet or A′B′ distance was in the medium range with a mean 5.51 mm. Although male patients have greater A′-B′ value than the female patients, the differences were nonsignificant between the sexes.

Huang *et al*.[10] reported female patients had smaller AF-BF values compared to male patients in their study. This measurement can be affected by the inclination of the FH plane, the AB distance, and the angle between the AB line and the FH plane. The FH plane, though used as a horizontal reference plane for years, has not been studied for sex-based differences in its inclination. Greater horizontal growth of the mandible may be another factor responsible for these findings.

Considering ethnic facial features of subjects play a critical role for achieving successful orthodontic treatment, each population would be best treated according to its individual's characteristics to reach an esthetically pleasing face. In accordance with Bimler's point of view, it is indispensable to use a special standard for each age group, sex, and population, but utilization of ranges would be more beneficial to determine facial harmony.

CONCLUSIONS

1. There were no significant differences between male and female patients in most of the angular and linear measurements.
2. The whole sample was found to be in the medium range according to Bimler. Class I Turkish adults show appropriate characteristics as defined by Bimler. Ranges of Turkish population show similarity to those announced by Bimler.
3. There were significant sex-based differences in craniofacial height, depth, and the mandibular plane angle, Go-Gn/SN values.
4. The results showed differentiations between the Bimler analysis and the commonly used Steiner analysis.
5. The mandible showed hyperflexion in both groups, which indicates overclosure, and this results from a short middle face, reduction of the height of the middle part of the face.

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APPENDIX

FMPA: the mandibular inclination (factor 3); Frankfort-mandibular plane angle; the inclination of the line connecting menton on the symphysis and the highest point of the antegonial notch to Frankfort horizontal. (0°–15° flat horizontal, 15°–30° medium neutral, 15°–45° steep vertical).

PP/FH: maxillary inclination (factor 4); the angle formed by the palatal plane (ANS-PNS) and Frankfort horizontal. (–) negative when ANS is higher than PNS and positive when ANS is lower than PNS; (+); forward, downward, (–); forward, upward.

CliCls/FH: clivus inclination (factor 5); the inclination of the line connecting clivion superior and inferior to Frankfort horizontal. (50°–60° flat horizontal, 60°–70° medium neutral, 70°–80° steep vertical).

Basic angle of the face; the clivus-mandibular plane angle is formed by the tangents to the clivus and the lower border of the mandible.

C: upper basic angle; formed by the line running tangent to the clivus, and the line of the palatal plane (ANS-PNS) (50°–60° dolicho, 60°–70° meso, 70°–80° lepto).

B: lower basic angle; or maxillomandibular plane angle, formed by the intersection of the palatal plane and the mandibular plane (0°–15° dolicho, 16°–29° meso, 30°–46° lepto).

Cgo/CV: mandibular flexion (factor 8); is the inclination of the ramal line which is the connecting line from point C (capitulare) to point Go (gonion) to the vertical. (Hyperflexion = + degrees, Go more anterior than C; orthoflexion = 0 degrees, Go vertically in line with C; Hypoflexion= – degrees, Go more posterior than C).

A′B′: bone overjet; anteroposterior jaw relationship by measuring the distance between perpendiculars drawn from A-point and B-point onto the Frankfort horizontal plane. An A′-B′ distance of 4–8 mm is considered Class I. Anything over 8 mm is Class II, and a negative value represents Class III.

Suborbital facial height; is the distance between Frankfort horizontal to point Me (menton).

Suborbital facial depth; is the distance between the projection of point A on Frankfort horizontal and point C (capitulare).

H/D: suborbital facial index; the index can be established by measuring suborbital facial height with a caliper and transforming the measurement to Frankfort horizontal. If the intersection is in front of the point C, then the facial depth as viewed horizontally from a lateral view is greater than the height. This makes it dolichoprosopic (deep-faced). If the intersection is behind the clivus, it is qualified as leptoprosopic or long-faced because the height is greater than the depth. If the intersection is between C point and the clivus the face is mesoprosopic or medium faced, that suborbital facial height is the distance between Frankfort horizontal and menton, and the facial depth is the distance between the anterior vertical through A point and the posterior vertical through C point.