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COMPARISON OF THREE-DIMENSIONAL CEPHALOMETRIC MEASUREMENTS OF DIFFERENT POPULATIONS

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Abstract

Objective: The purpose of this study is to compare three-dimensional cephalometric measurements of the skeleton and dentoalveolar region between Turkish individuals and individuals from other populations.

Methods: This is a single-center, retrospective study using cone beam computed tomography images (CBCT). Individuals have no missing teeth, are between the ages of 18 and 30, have a balanced profile, and have an Angle Class I relationship. The CBCT images were obtained in DICOM format and analyzed in DOLPHIN 11.8 software. 61 parameters were measured on the CBCT images, and 14 parameters were contrasted with individuals from other populations.

Results: Mandibular values were more protrusive in Korean and Chinese populations than in Turkish and Cypriot individuals. Similarly, upper facial height (N- ANS distance) was found to be much higher. It was found that the length of the mandibular corpus was shorter and the angle of convexity was higher in Turks and Cypriots than in Koreans and Chinese populations.

Conclusion: Ethnic facial and skeletal characteristics play a fundamental role in the outcome and course of orthodontic treatment. Gender differences also play an important role when facial sizes and proportions are compared in different societies.

Keywords: *Cephalometric measurements, ethnic facial type, CBCT, 3-Dimensional imaging.*

Introduction

Cephalometric analysis has occupied a respectable position in diagnosis and treatment planning for orthodontic and orthognathic surgery patients. Inaccuracies in defining the anatomical points of two-dimensional (2D) cephalometric radiographs, defects in the two-dimensional projection of these points, and the superposition of anatomical structures and head orientation have raised questions about the reliability of the analyses.[1,2] Cone-beam computed tomography (CBCT) is preferred because it eliminates the disadvantages mentioned.[3]
Studies have shown the ease of point identification and high sensitivity in the registration of images in CBCTs.[4,5] With the increase in three-dimensional imaging data, studies have increased to produce population-specific measurements.
In 2011, Cheung et al.[6] published 3-dimensional (3D) cephalometric norms based on CBCT scans obtained from the Chinese population. Comparative studies were conducted in North Karnataka, India, on male and female adults with a balanced facial profile and ideal Class 1 occlusion who were not receiving orthodontic treatment.[7]
Researchers conducting cephalometric evaluation studies have added some new measurements in addition to traditional cephalometric measurements, such as the basal bases and folded structures of the mandible and maxilla, and the degree of curvature.[7,8]
The aim of our study is to create a table of skeletal and dentoalveolar mean values by analyzing 3D cephalometric images obtained by CBCT of adult subjects without orthodontic treatment with a dental class 1 occlusion and balanced facial contours.

Methods

Our study was carried out within the framework of the Kırıkkale University Faculty of Dentistry Specialization Program, with the permission of the Kırıkkale University Clinical Research Ethics Committee dated 06.07.2015 and decision number 19/11, at Kırıkkale University Faculty of Dentistry. The material for our study was created by selecting from the CBCT records of patients who applied to a special imaging center for diagnosis or check-up purposes.
As a result of the evaluation performed with the criteria of having a balanced facial appearance as determined by two different orthodontists using CBCT images; a class I molar relationship; inclusion of all teeth except the third molar in the dentition; a maximum of 2-4 mm inconsistency in the arc length for each joul; compatible facial and dental midlines; having no extensive prosthetic or amalgam restoration; not having received orthodontic treatment previously; having no fixation screws or plates on the facial area; and no morphological anomalies in the temporamandibular joint; CBCT records of a total of 150 patients were selected for the study.
The voxel size of CBCT images from the ILUMA, IMTEC Europa, Oberursel, Germany tomography device used in the study is 0.3 mm. The device operates at 120 kVp and 3.8 mA electric fluid. It scans a field of 18x14 cm in approximately 40 seconds by rotating 360° around the patient. During the irradiation, the patient is in a sitting position, and the patient's head is fixed at the jaw and forehead. The midsagittal plane was perpendicular to the ground, the Frankfurt Horizontal plane was parallel to the ground, and the teeth were in maximum intercuspation. Primary and secondary reconstruction of the raw data obtained from CBCT scans was made with the software of the manufacturer (ILUMAVision, IMTEC Europa, Oberursel, Germany) and the reconstructed data were saved as a DICOM file. The data of 150 patients in the study group in DICOM format prepared by the ILUMA Vision program were transferred to the computer on which the Dolphin Imaging 11.8 software was installed. To bring the image to the desired orientation, the "Orientation" option was selected and orientation was performed in three planes.[9]
The location definitions of anatomical landmarks on three-dimensional images are shown in Tables 1, 2, and, 3 and Figures 1, 2, 3, and 4.[9,10].
The measurements of 30 randomly selected patients were repeated by the same researcher (Ö.D.Ö.) 1 month after the first graphics, to evaluate the intraobserver reliability of the method error control results regarding the reproducibility of the measurements. In order to test the reliability, the intraclass correlation coefficient (ICC) was calculated. ICC values ranged between 0.947 and 0.986, with high reliability between measurements. The fact that the reliability coefficient was close to 1 showed that the cephalometric drawing and measurements could be repeated with an error that was not statistically significant.
The measurement values we obtained from Turkish individuals were compared with the measurement values specified in similar studies[6,8,11] conducted with different populations, without using a statistical method, through mean values.
As a result of the power analysis performed to test the adequacy of the sample size used in our study, it was found that a sample size totaling 100 individuals would yield an accurate result with an effective width of 0.5 and a power of 98% at a significance level of α 0.05.[7]
The Shapiro-Wilk test was performed to verify that the measurements used in our study were normally distributed. It was found that all the parameters examined as a result of the test showed that the measured values were normally distributed. Since it was found that all the parameters studied with the Shapiro-Wilk test were normally distributed, the independent T-test, one of the parametric tests, was used to compare the measurements obtained from the data.
The SPSS (Statistical Package for Social Sciences) (Version 18.0) package program was used in the statistical analyses. In addition, Power analysis (G*Power; Franz Foul, Universitët Kiel, Germany) (Version 3.1.3) was used to test the adequacy of the number of samples in our study. In these evaluations, a *p* value of 0.05 was taken as the level of significance.

Results

The mean age of the 150 individuals (87 females, 63 males) included in the study was 22.52 ± 4.45 years. The mean age of women was 21.95 ± 4.19, while it was 23.31 ± 4.72 for men.
In measurements including bilateral jaw and facial landmarks (such as Porion, Orbitale, Gonion) of the patients, the positions of these points on the right and left sides were determined, and all measurements and graphics were created separately for both the right and left sides of the patients.
To assess the asymmetry between the patients, the obtained analysis values for the right and left sides were evaluated with an independent t-test.
There was no statistically significant difference between the variables on the right and left sides of the craniofacial structures obtained from the anatomical points of the youl and face of the patients (Table 4). In the analyses in sagittal, vertical, and dental directions, the data acquired from the

right and left sides of the subjects were averaged and written as a single value.

A comparison of the sagittal and vertical values of males and females is shown in Table 5.

There was no statistically significant difference between men and women in dental measurements. (p>0.05) (Table 6).

Compared to the Korean and Chinese populations, the Turkish and Cypriot populations had more protrusive mandible values, lower facial heights (N-ANS distance) and lower mandibular body lengths (Go-Pg), while convexity angle (NA-APg) was found to be higher (Table 7).

Table 1. The location definition of anatomical points on three-dimensional images

1. A Point (A):	In the sagittal view, the deepest point of the bone tissue concave between supradentale and anterior nasal spina, the anterior and middle point of the premaxilla in the axial image, and the middle point between the root tips of the upper central incisors in the coronal image
2.Nasion (Na):	Frontal point of frontonasal suture in axial and sagittal view, and middle point in coronal view
3.Gnathion (Gn):	Lower and anterior point of the tip of the chin in the sagittal image, the anterior and the most central point in the axial image, the middle and the lowest point in the coronal image
4.Menton (Me):	The lowest point of the mandible in the sagittal and coronal images, and the middle point in the axial image
5. Point B:	In the sagittal view, the deepest point of the mandibular alveolar process and the bone tissue concavity between the pogonion is the deepest, and in the axial view the anterior and middle point
6.ANS Point:	Anterior Nasal Spina is the anterior point in the sagittal view, and the midpoint in the axial view
7.Articulare (Ar):	The point where the condyle head intersects with the skull base in the sagittal image, the most convex point of the condyle head in the axial image
8. Center of Symphysis (D):	Geometric midpoint of symphysis in sagittal, axial and coronal images
9.Gonion (Go):	In the sagittal image, the angle formed by the lines formed by the lines tangent to the mandible corpus and the ramus, the point where the bisector of the angle cuts the mandible, the posterior point of the corpus in the axial view and the lower point of the ramus in the coronal view.
10.Condillion (Co):	The most broad view of the mandibular condyle head in the coronal image in the horizontal direction is the highest in the cross-section, the highest peak of the condyle in the axial image and the highest peak of the cone in the section where the condyle is the widest from the anterior posterior direction in the sagittal view.
11.Ramus point (Rp):	In the sagittal images, the mandible is the posterior point of the ramus, and in the coronal view, the middle of the place where the condyle neck ends.
12. Sella (S):	Geometric midpoint of Sella Tursika in sagittal, axial and coronal images
13.Orbital (Or):	Lower and middle point of the eye socket in sagittal, axial and coronal images
14.Porion (Po):	The upper part of the meatus acusticus externus in the sagittal view and the most convex point of the ear bone in axial and coronal views
15.PNS:	The posterior nasal spina in the sagittal view is the posterior point, and the middle point in the axial and coronal images
16.Pogonion (Pog):	The anterior point of the mandibular symphisis in the sagittal view, the anterior and middle line in the axial view, and the lowest point in the coronal view
17. U1 Type:	The cutting point of the most advanced incisor in the sagittal image, the middle of the incisional edge of the incisor in the axial image, and the lowest and middle point in the coronal image
18. U1 Root:	The most extreme point of the root of the most advanced upper incisor in the sagittal image, and the middle point of the root tip in the coronal image
19. L1 Type:	The cutting point of the most advanced incisor in the sagittal image, the midpoint of the cutting edge in the axial image, and the top and middle point of the cutting edge in the coronal image
20. L1 Root:	In the sagittal view, the tip of the root of the lower most advanced incisor, and in the coronal view, the lowest and middle point of the root tip of the incisor
21.Upper 6 Occlusal:	The lower point of the mesiobuccal tubercle of the upper first molar tooth in the sagittal view, the midpoint of the central fossa in the axial view, and the midpoint of the buccallolatinal width in the coronal view
22.Lower 6 Occlusal:	The midpoint of the mesiobuccal tubercle of the lower first molar tooth in the sagittal view, the midpoint of the central fossa in the axial view, and the midpoint of the buccalingual width in the coronal view

Table 2. Skeletal and dental angular measurements used in our study

Skeletal Angular Measurements	Definitions of Angles
1. SNA Angle (º)	The angle between the S-N and N-A lines.
2. SNB Angle (º)	The angle between the S-N and N-B lines.
3. ANB Angle (º)	Angle between N-A and N-B lines.
4. SND Angle (º)	The angle between the S-N and N-D lines.
5. SN-GoGn Angle (º)	The angle between the S-N and Go-Gn lines.
6. FMA Angle (º)	The angle between FH and Go-Me lines.
7. FMIA Angle (º)	The angle between the lines FH and L1.
8. Y axis-SN Angle (º)	Angle between Y axis and Sella-Nasion lines.
9. Articular Angle (S-Ar-Go) (º)	The angle formed at the Articular point between the Sella-Articulare-Gonion points.
10. PP-MP Angle (º)	Angle between the palatinal plane and the mandibular plane.
11. Sella Angle (º) points.	The angle formed in Sella between Nasion-Sella-Articular points.
12. Convex Angle (NA / APog) (º)	Angle formed at point A between N-A and A-Pog lines.
13. Facial Angle (FH-NPo) (º)	Angle between the porion orbital line and the nasion pogonion line.
14. Occlusal Plan-SN (º)	Angle between Sella nasion line and occlusal plan.
15.Mandibular Plan-Occlusal Plan (º)	The angle between the menton gonion line and the occlusal plan.
16. MP - SN (º)	Angle between the mandibular plan and the sella nasion line.
17. SN-Palatal Plane (º)	Angle between Sella nasion line and palatal plane.
18. Palatal Plan-Occlusal Plan (PP-OP) (º)	Angle between the palatal plan occlusal plan.
19. Gonial Angle (Ar-Go-Me) (º)	The angle between artculare, gonion, mentone.
20. Upper Gonial Angle (Ar-Go-Na) (º)	The angle between the articular, gonion nasion.
21. Lower Gonial Angle (Na-Go-Me) (º)	Angle between nasion, gonion, mentone.
22. The sum of the posterior angles (Björk) (º)	The sum of the posterior angles. Sum of the sella, articular and gonial angle.
23. Facial Plan- SN (SN-NPog) (º)	Sella nasion, the angle between the Nasion pogonion lines.
Dental Angular Measurements	**Definitions of Angles**
1. U1-NA Angle (º):	The narrow angle between the long axis of the forward upper middle incisor and the NA lines.
2. L1-NB Angle (º):	The narrow angle between the long axis of the most advanced lower middle incisor and the NB lines.
3. U1-L1 (º):	Angle between the long axes of the upper and lower forward middle incisors.
4. IMPA (º):	The angle between the Go-Me line and the longest axis of the most advanced lower middle incisor.
5. U1-SN Angle (º):	Angle between the longest axis of the upper most forward middle incisor and the plane SN.
6.U1 - Palatal Plan (º):	The angle between the U1 type, U1 root points and the lines formed by ANS PNS points.
7.U1-APo (º):	The angle formed by the line between the upper incisors tooth line (point u1 and u1 root) pogonion.
8.U1 - FH (º):	The angle formed by the upper incisors by the frankurt horizontale.
9.FMIA (L1-FH) (º):	The angle formed by the L1 cutting axis with frankfurt horizontal.
10.U1 - Occlusal Plan (º):	Angle of the upper incisors with the occlusal plan of the tooth axis.
11.L1 - Occlusal Plan (º):	L1 is the angle of the cutting axis with the occlusal plan.
12.L1-APo (º):	The angle L1 makes with A Pogonion line.

Table 3. Skeletal and dental longitidunal measurements used in our study

Skeletal Longitidunal Measurements	Definitions of Angles
1. SL (mm):	The distance between point S and point L (the projection point of the Pogonion point perpendicular to the line S-N).
2. SE (mm):	Distance between point S and point E (projection point perpendicular to the S-N line of the back of the condyle head).
3. Anterior Cranial Base (S-N) (mm):	The distance between the S and N points.
4. Wits Appraisal (mm):	The distance between points A and B perpendicular projection from the occlusal plane.
5. Posterior Cranial Base (S-Ar) (mm):	Distance between S and Ar (Articulare) points.
6. Ramus Height (Ar-Go) (mm):	Distance between Ar and Go points.
7. Total Facial Height (N-ANS) (mm):	Distance between N and ANS points.
8. Posterior facial Height (S-Go) (mm):	Distance between Sella and Gonion points.
9. Anterior facial height (N-Me) (mm):	Distance between Nasion and Menton points.
10. Midface length (Co-A) (mm):	Distance A to Condilyon.
11. Mandibular length (Co-Gn) (mm):	Distance between condylon anatomical gnathion.
12. Mx / Md difference (Co-Gn - Co-A) (mm):	Difference between mandible maxilla.
13. Maxilla skeletal distance (A-Na Perp) (mm):	Distance of point A with nasion perpendicular.
4. Mandibular skeletal distance (Pg-Na Perp) (mm):	Pogonion point's distance from the nasion perpendicular.
15. Mandibula Corpus Length (Go-Pg) (mm):	It is the length of the mandible corpus. Distance between Go and Pg.
16. Y-Axis Length (mm):	Distance between S and Gn points.
17. Lower Face Height (ANS-Gn) (mm):	Distance between ANS and Gn points.
18. Total Face Height (N-Gn) (mm):	Distance between Na and Gn points.
19. Back / Front Face Ratio (S-Go / N-Me) (%):	Jarabak rate. S Go is the ratio of the distance Na Na distance.
Dental Longitidunal Measurements	**Definitions of Angles**
1. U1-NA Distance (mm):	The perpendicular distance from the most convex point to the NA line on the vestibular face of the upper most advanced middle incisor.
2. L1-NB Distance (mm):	The steep distance from the most convex point on the vestibular face of the lower most advanced middle incisor to the NB line.
3. Pg-NB Distance (mm):	Distance from Pog point to NB line.
4.U-Protrusion (U1-APo) (mm):	Distance of type point U1 to line A Po.
5.L1 Protrusion (L1-APo) (mm):	Distance of type point L1 to line A Po.
6.Po & L1 - NB Difference (mm):	Holdaway distance, nasion lower cutter peak point pogonion B distance.
7.Overjet (mm):	Distance of U1 to L1 in sagittal direction.
8.Overbite (mm):	The amount of covering in U1's L1i transverse direction.

Figure 1. Skeletal angular measurements; 1. SNA Angle 2. SNB Angle 3. ANB Angle 4. SND Angle 5. SN-GoGN Angle 6. FMA Angle 7. FMIA Angle 8. Y Axis-SN Angle 9. Articular Angle 10. PP-MP Angle 11. Sella Angle 12. Convexity Angle 13. Facial Angle (FH-NPg) 14. Occlusal Plan - SN 15. Mand Plan-Occlusal Plan 16. MP - SN 17. SN-Palatal Plan 18. PP-OP 19. Gonial angle (Ar -Go-Me) 20. Upper Gonial Angle (Ar-Go-Na) 21. Lower Gonial Angle (Na-Go-Me)

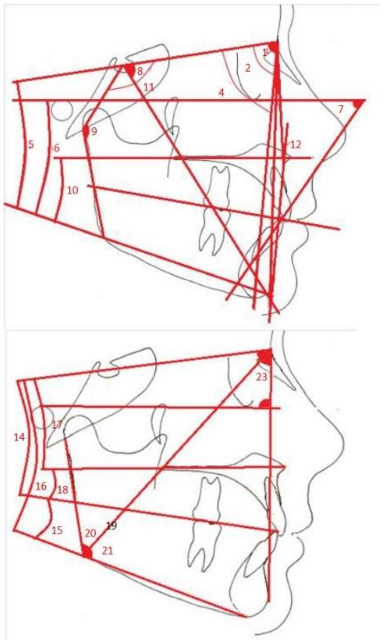

Figure 2. Dental angular measurements; 1. Angle U1-NA 2. Angle L1-NB 3. U1-L1 4. Angle IMPA 5. Angle U1-SN 6. U1 - Angle PP 7. Angle U1-APo 8. U1 - Angle FH 9. FMIA (L1 -FH) Angle 10. U1 - OP Angle 11. L1 - OP Angle 12. L1- APg Angle.

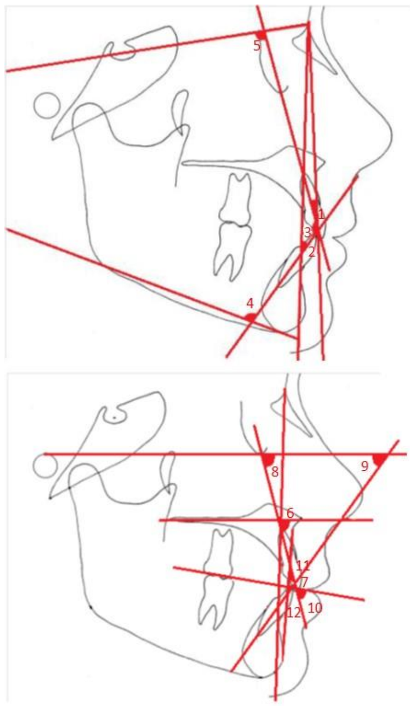

Figure 3. Skeletal dimensional measurements; 1. SL Distance 2. SE Distance 3. SN Distance 4. Wits Value 5. Rear Head Base Length 6. Ramus Height 7. Upper Face Height 8. Back Face Height 9. Front Face Height 10. Mid Face Length (Co-A) 11. Mandibular length (Co-Gn) 12. Mk/Md difference (Co-Gn - Co-A) 13. Maxilla skeletal (A-Na Perp) 14. Mand. skeletal (Pg-Na Perp) 15. Mandible basal length (Go-Pg) 16. Y-Axis length 17. Lower face height (ANS-Gn) 18. Total face height (N-Gn).

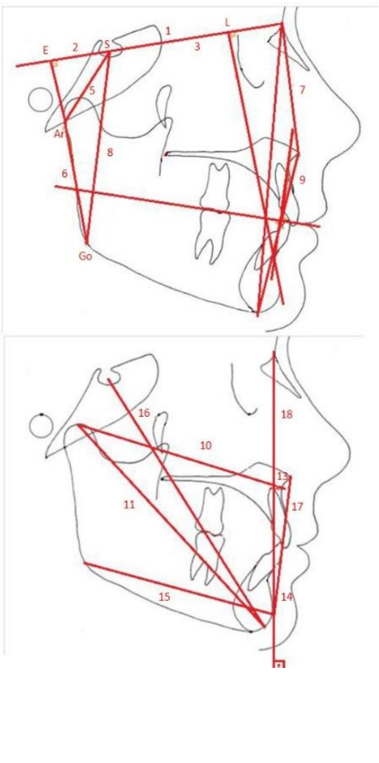

Figure 4. Dental dimensional measurements; 1. U1-Na Distance 2. L1-NB Distance 3. Pg-NB Distance 4. U1-APog 5. L1-APog 7. Overjet 8. Overbite.

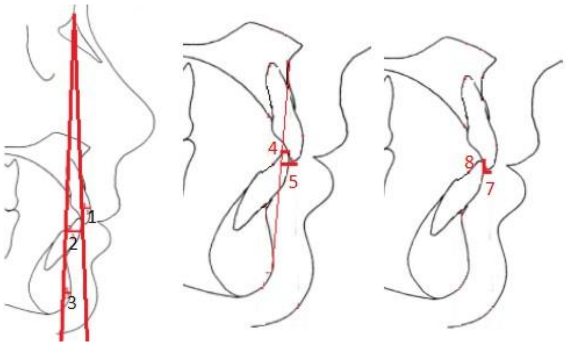

Table 4. Comparison of mean of all patients with independent t-test, right and left side values, right and left side measurements.

Variable	Mean	Right	Left	*p*-value
Co-A (mm)	82.67±4.79	82.75±4.54	82.59±5.07	.842
Co-Gn (mm)	110.11±5.92	110.20±5.81	110.00±6.07	.842
S-E distance (mm)	17.66±3.35	17.84±3.26	17.47±3.45	.519
Mandible Body length (Go-Pg) (mm)	72.40±5.20	72.34±5.19	72.47±5.25	.881
Rear Head Base (S-Ar) (mm)	29.79±3.89	30.12±3.91	29.44±3.87	.301
Face Angle (FH-NPo) (º)	89.13±3.42	88.72±3.24	89.56±3.58	.148
Convexity Angle (NA-APo) (º)	4.11 ± 6.06	3.60±6.08	4.64±6.02	.309
FMA (MP-FH) (º)	22.97±5.40	23.36±5.52	22.56±5.28	.375
SN - GoGn (º)	29.12±5.36	29.18±5.47	29.06±5.28	.891
PP-MP (º)	22.09±5.81	21.97±5.81	22.21±5.85	.808
MP-OcP (º)	17.29±4.28	17.42±4.31	17.15±4.27	.715
MP-SN (º)	31.69±5.41	31.86±5.53	31.52±5.32	.706
Sella Angle (SN-Ar) (º)	126.77±6.35	126.75±6.70	126.78±6.01	.978
Gonial Angle (Ar-Go-Me) (º)	122.31±8.39	122.76±7.60	121.83±9.18	.513
Upper Gonial Angle (Ar-Go-Na) (º)	48.71±5.22	48.94±4.56	48.26±6.26	.460
Lower Gonial Angle (Na-Go-Me) (º)	73.68±5.04	73.81±4.95	73.55±5.17	.753
Articular Angle (S-Ar-Go) (º)	142.63±10.19	142.31±9.42	142.96±11.00	.704
SUM of Angles (Björk) (º)	391.72±5.39	391.85±5.55	391.58±5.25	.768
Posterior Height (S-Go) (mm)	77.27±6.69	77.45±7.24	77.08±6.10	.747
Facial Height (Na-Me) (mm)	114.16±7.31	114.62±7.24	113.67±7.40	.445
Posterior / Anterior Facial Ratio (S-Go / N-Me)	67.72±4.68	67.56±4.89	67.88±4.48	.681
Ramus Height (Ar-Go) (mm)	51.65±5.01	51.58±5.36	51.72±4.66	.870

Values are mean ± standard deviation. Independent t-test; * p<0.05, ** p<0.001

Table 5. Comparison of sagittal and vertical measurements of patients with independent t-test in terms of gender

Sagittal Measurements	Mean	Female	Male	*p*-value
SNA (º)	82.36±2.98	82.33 ±3.04	82.40±2.92	.883
SNB (º)	79.35±3.09	79.30±3.22	79.43±2.92	.813
ANB (º)	3.01±2.24	3.04±2.32	2.96±2.14	.853
SND (º)	76.97±3.17	76.85±3.31	77.16±2.96	.568
Wits appraisal (mm)	.65±2.63	.40±2.66	1.02±2.57	.167
Midfasial lenght (Co-A) (mm)	82.67±4.79	80.56±3.80	85.83±4.39	**<.001****
Mandibular lenght (Co-Gn)(mm)	110.11±5.92	107.24±4.94	114.38±4.55	**<.001****
Mx/Md Different (Co-Gn - Co-A)(mm)	27.42±4.00	26.69±4.16	28.52±3.51	**.006****
Max. Skeletal (A-Na Perp) (mm)	1.13±3.46	1.18±3.25	1.05±3.79	.829
Mand. Skeletal (Pg-Na Perp) (mm)	-1.69±6.42	-1.54±6.31	-1.91±6.63	.736
S-L (mm)	48.37±7.51	47.05±7.12	50.33±7.70	**.010***
S-E (mm)	17.66±3.35	17.02±3.067	18.62±3.54	**.005***
Anterior Kranial Base (SN) (mm)	66.45±3.82	64.69±2.96	69.09±3.45	**<.001****
Mandibular Corpus Lenght (Go-Pg)(mm)	72.40±5.20	70.52±4.95	75.22±4.24	**<.001****
Posterior Kranial Base (S-Ar) (mm)	29.79±3.89	28.47±3.48	31.75±3.66	**<.001****
Facial Angle (FH-NPo) (º)	89.13±3.42	89.19±3.46	89.03±3.40	.791
Convexity Angle NA-APo (º)	4.11 ± 6.06	4.21±6.02	3.95±6.15	.801
Facial Plan-SN (SN-NPog) (º)	80.45 ± 3.30	80.39±3.42	80.53±3.15	.804
Vertical Measurements	**Mean**	**Female**	**Male**	***p*-value**
FMA (MP-FH) (º)	22.97±5.40	23.40±4.82	22.34±6.15	.253
SN - GoGn (º)	29.12±5.36	29.70±4.91	28.26±5.90	.116
OcP-SN (º)	14.38±4.39	14.89±4.39	13.61±4.31	.089
PP-MP (º)	22.09±5.81	22.92±4.87	20.85±6.84	**.037***
MP-OcP (º)	17.29±4.28	17.31±3.90	17.26±4.82	.942
MP - SN (º)	31.69±5.41	32.21±5.01	30.93±5.92	.170
SN-PP (º)	9.59±3.61	9.28±3.31	10.04±3.99	.221
PP-OP (º)	4.79±4.15	5.58±3.67	3.60±4.56	**.005***
Y-Axis Angle (SGn-SN) (º)	67.67±3.65	67.64±3.64	67.71±3.71	.907
Y-Axis Lenght (mm)	124.12±7.19	120.51±5.71	129.50±5.68	**<.001****
Upper Facial Height (N-ANS) (mm)	51.99±3.64	50.46±3.04	54.27±3.27	**<.001****
Lower Facial Height (ANS-Gn) (mm)	65.38±5.73	63.55±4.91	68.09±5.82	**<.001****
Total Facial Height (N-Gn) (mm)	116.40±7.47	113.02±6.08	121.44±6.48	**<.001****
Sella Angle (SN-Ar) (º)	126.77±6.356	127.14±6.59	126.22±6.00	.400
Gonial Angle (Ar-Go-Me) (º)	122.31±8.39	122.76±8.70	121.64±7.93	.437
Upper Gonial Angle (Ar-Go-Na) (º)	48.71±5.22	48.93±5.79	48.37±4.27	.531
Lower Gonial Angle (Na-Go-Me) (º)	73.68±5.04	73.86±4.91	73.41±5.26	.604
Articulare Angle (S-Ar-Go)(º)	142.63±10.19	142.30±11.00	143.10±8.91	.649
SUM of Angles (Björk) (º)	391.72±5.39	392.20±5.01	390.99±5.88	.191
Anterior Cranial Base (SN) (mm)	66.45±3.82	64.69±2.96	69.09±3.45	**<.001****
Posterior Cranial Base (SGo) (mm)	77.27±6.69	74.27±5.17	81.75±6.21	**<.001****
Anterior Facial Height (NaMe) (mm)	114.16±7.31	110.69±5.79	119.33±6.24	**<.001****
Posterior/Anterior Facial Rate (S-Go/N-Me) (%)	67.72±4.68	67.16±4.32	68.55±5.09	.082
Ramus Height (Ar-Go) (mm)	51.65±5.01	49.98±4.26	54.14±5.05	**<.001****

Values are mean ± standard deviation. Independent t-test; * p<0.05, ** p<0.001

Table 6. Comparison of dental measurements of patients, in terms of gender with independent t-test.

Variable	Mean	Female	Male	*p*-value
U1 - SN (º)	102.78±8.40	102.67±8.44	102.95±8.42	.847
U1 - NA (º)	20.39±8.43	20.26±8.23	20.58±8.81	.822
U1- NA (mm)	3.63±2.54	3.55±2.50	3.76±2.63	.626
U1 - PP (º)	112.35±8.55	111.92±8.00	113.00±9.33	.464
U1 - FH (º)	111.48±8.36	111.43±8.38	111.55±8.41	.931
L1 - NB (º)	26.83±6.91	26.81±7.18	26.85±6.54	.973
L1 - NB (mm)	4.83±2.26	4.68±2.02	5.07±2.58	.307
IMPA (L1-MP) (º)	95.76±7.32	95.31±8.08	96.44±6.02	.371
FMIA (L1-FH) (º)	61.25±8.17	61.28±8.49	61.20±7.74	.955
U1-L1 (º)	129.72±10.17	129.76±10.51	129.65±9.72	.946
U1 - OcP(º)	62.80±7.49	62.48±7.46	63.28±7.57	.533
L1 - OcP (º)	66.92±6.46	67.38±6.70	66.24±6.09	.306
U1-APo (º)	24.54±7.10	24.47±7.02	24.63±7.28	.896
U1-APo (mm)	5.17±2.29	5.09±2.05	5.30±2.62	.605
L1 to A-Po (º)	25.71±5.44	25.67±5.95	25.94±4.6	.775
L1-APo (mm)	2.14±2.26	2.02±1.92	2.31±2.70	.470
Pog - NB (mm)	2.03±2.00	1.99±1.75	2.10±2.34	.741
Pog & L1 - NB Difference (mm)	2.81±3.76	2.69±3.22	2.98±4.48	.659
Overjet (mm)	3.08±1.07	3.10±1.09	3.04±1.04	.730
Overbite (mm)	1.73±1.40	1.74±1.37	1.72±1.45	.914

Values are mean ± standard deviation. Independent t-test; * *p*<0.05, ** *p*<0.001

Table 7. Comparison of Measurements of Turkey, Cyrprus, S.Korea, China

Variable	2017 (Turkey)	2016 Vahdettin et al. (Cyprus)	2013 Bayome et al. (S.Korea)	2011 Cheung et al. (China)
SNA (º)	82.36	81.5	81.84	84.90
SNB (º)	79.35	78.73	79.83	81.36
ANB (º)	3.01	2.8	2.09	3.43
Anterior Cranial Base (SN) (mm)	66.45	67.82	-	62.36
Mandibular Corpus Lenght (Go-Pg)(mm)	75.40	70.09	(Go-Me) 87.98	(Go-Me) 85.23
Facial Angle (FH-NPg) (º)	89.13	87.48	90.40	86,74
Convexity Angle (NA-APg) (º)	4.11	4.99	2.94	-
Pg- NB mesafesi (mm)	2.03	1.83	1.56	0.69
Facial Plan-SN (SN-NPg) (º)	80.45	-	80.51	-
Upper Facial Height (N-ANS) (mm)	51.99	51.55	54.13	(N-A) 61.14
Anterior Facial Height (N-Me)(mm)	114.16	117.31	121.04	(N-Gn) 116.08
Lower Facial Height (ANS-Gn) (mm)	65.38	64.62	67.72	65.62
Ramus height (mm)	51.65	-	57.57	-
Gonial Angle (°)	122.31	-	115.46	-

Discussion

Ethnic facial types and skeletal characteristics play an important role in the determination, course, and outcome of orthodontic treatment.

With the increasing demand for orthodontic treatment, especially with the increase in orthodontic surgery cases, there is a need for a consensus on what ideal aesthetic facial proportions should be. Orthodontists should be careful about what cephalometric standards they use when evaluating patients. It is important to know which population the patient belongs to; thus, the ideal treatment plan appropriate for the patient can be more accurately created.[8]

Traditional two-dimensional cephalometric analyses are associated with difficulties related to the two-dimensional technique, and this can lead to errors. Therefore, three-dimensional analyses are important to overcome this weakness.[1,2] For this reason, CBCT images were used in our study.

In the literature, the age range in such adult cephalometric assessment studies is limited to the thirties.[6-8] To eliminate the effect of growth, we limited our sample to young adults because it is known that there are changes in facial structures with age.[12,13]

Vahdettin et al.[11] performed cephalometric analyses with CBCT on Turkish individuals in Cyprus. In this study conducted with 62 female and 59 male individuals aged 20-45 years, in class 1 occlusion, with a balanced and symmetrical facial structure, the results of 38 angular and 28-dimensional measurements in the sagittal, vertical, and dental directions were published. They compared the findings of the study with the findings of cephalometric analysis studies conducted on different populations in various regions. Vahdettin et al.[11] compared their findings with the findings of other researchers and evaluated only by looking at the compatibility of the parameters.

They compared cephalometric values of populations regardless of differences in imaging techniques (CBCT, CT, traditional X-ray films), analytical methods (Dolphin, Invivo, Maxilim), and sample sizes.

These comparison results may be erroneous, especially since the difference in imaging technique (2D or 3D), magnification values, and head position have significant effects.

In a study conducted in Korea, 2D cephalometric norms of individuals who do not need orthodontic treatment and have a balanced, symmetrical face structure in class 1 occlusion were examined.[14] The values obtained by Lee et al.14 in their study on 2D images are similar to the findings of the study by Bayome et al.[8] in their study on 3D images of the population with balanced and symmetrical facial structure living in the same region, having ideal Class 1 occlusion, and not requiring orthodontic treatment. However, there are significant differences in linear measurements. Bayome et al.[8] compared their data with 2D studies conducted in the same Korean population and published the differences between 3D and 2D.[8,14]

As in the study by Bayome et al.[8] which was conducted in a population with a balanced and symmetrical facial structure in ideal class 1 occlusion, who do not need orthodontic treatment, there were differences in several vertical measurements (front face height, upper face height, lower face height, maxilla height, ramus length) between males and females in our study. Men have significantly higher values than women in all other vertical parameters, except for the gonial angle. Gonial angle was significantly higher in women than men. In our study, the gonial angle was found to be higher in women than in men, but this height was statistically significant. There was no significant difference between men and women in sagittal direction angles (SNA, SNB, ANB, SNPg, Facial angle (FH-NPo), and Convexity angle (NA/APog). Vertical measurements are compatible with similar 3D cephalometric studies in that dimensional parameters (anterior face height, upper height, lower face height, maxilla height, ramus length) are higher in males.[7,8,13] Bayome et al.[8] found no difference in angular variables (SNA, SNB, ANB) evaluating the sagittal relationship between the skull base, maxilla, and mandible between male and female individuals. In our study, there were no significant differences in sagittal direction angular measurements. Similar results were obtained with the findings of other researchers who conducted 3D analysis studies.[6-8]

When comparing the data of Bayome et al.[8] from the South Korean population with the data of Cheong et al.[6] from the Chinese population, the facial height and lower facial height were higher in the Korean group than in the Chinese group, while the upper facial height was lower. This may have resulted from ethnic differences and different anatomical points. In addition, the facial angle (between the Frankfurt Horizontale and Nasion-Pogonion line) was higher in the Korean population than in the Chinese; this is a finding that indicates a more protruding mandible.[6,8] According to Bayome et al.[8] SNA and SNB values are more protrusive in the Chinese population than in the South Korean population.[6,8]

Devanna[7] performed cephalometric dimensional measurements on the maxilla and mandible in the cephalometric 3D analysis study they performed on an Indian population consisting of 40 males and 40 females with a balanced and symmetrical facial structure who did not receive orthodontic treatment in ideal class 1 occlusion and formed norm data for women and men.

The ramus length and gonial angle were evaluated only in Korean and Turkish individuals. The ramus length was longer in Korean individuals and the gonial angle was lower, possibly due to the use of the Condylion point instead of the Articulate point in the Korean study.[8]

Devanna[7] found the anterior mandibular length to be significantly longer in Indian men than in women, confirming prominent jowls. Additionally, in the same study it was found that the length from the anterior maxilla to the cranial base was increased. They emphasized that this clinically explains the gummy smile, which is common in Indian women.[7] In our study, no excess was observed in the measurements concerning the maxilla in female individuals. Considering that Devanna[7] attributes the elevation in this parameter to the presence of gummy smiles in Indian women, the cephalometric data in our study might confirm that there is no clinically common gummy smile in Turkish women.

Conclusion

We expect that the values obtained as a result of our study will be useful as a reference for evaluating orthodontic problems and treatment outcomes in young adults. Gender is a factor that must be considered in orthodontic diagnosis and treatment planning.

Conflict of Interest

The authors have no conflicts of interest to disclose.

Compliance with Ethical Statement

The study was approved by Kırıkkale University Clinical Research Ethics Committee dated 06.07.2015 and decision number 19/11.

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Author Contributions

ODO, TSE: Design; ODO, TSE: Analysis; ODO: Literature Search; ODO, TSE, FEO: Manuscript writing; ODO, TSE, FEO: Critical Review

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