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Three-dimensional cephalometric norms of Turkish Cypriots using CBCT images reconstructed from a volumetric rendering program in vivo

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Background/aim: The aim of this study was to create a database of 3D cephalometric measurements of Turkish Cypriot patients using a 3D rendering software program.

Materials and methods: The study population comprised 121 subjects who had undergone cone beam CT imaging (CBCT). Invivo 5.1 software was used to generate cephalograms from the CBCT dataset that were then linked to the 3D hard-tissue surface representations. In total, 38 angular and 28 linear widely used measurements were recorded.

Results: The results demonstrated that males had significantly larger mean values than females for all linear measurements, except for dentoalveolar parameters ($P < 0.05$). Additionally, significant differences were found in most of the mandibular anteroposterior and vertical measurements, especially SNB, GoGn/SN, FMA, and MP/SN, between the sexes ($P < 0.05$).

Conclusion: This is the first population-based study to focus solely on Turkish Cypriots' craniofacial anatomy and orthodontic characteristics. The present findings will produce 3D cephalometric normative data for the Cypriot population and will be valuable for oral and maxillofacial surgeons and orthodontists in Cyprus, the UK, Australia, Turkey, and other European countries who treat a large number of Turkish Cypriot patients.

Key words: Three-dimensional cephalometrics, three-dimensional diagnosis and treatment planning, ethnic norms

1. Introduction

The information provided by cephalograms is limited by its two-dimensional (2D) nature. 2D imaging has been reported to have several disadvantages, including lack of perspective, imaging artifacts, errors in projection, landmark identification, head position difficulties, and superimposition (1).

In order to compensate for the shortcomings of 2D imaging methods, new technologies have been adapted to evaluate maxillofacial structures, such as multislice CT (MDCT), cone beam CT (CBCT), and MRI (2). MDCT has been used successfully to represent the true three-dimensional (3D) morphology of the skeletal structures of the cranium (3). Superimposition and problems related to magnification are avoided with 3D CT, which is able to visualize craniofacial structures more precisely than 2D cephalometry (4). Although 3D computed tomography is a major improvement that has yielded accurate and reliable orthodontic evaluations, its effective dose is much higher than that of conventional cephalometry and its higher cost limits its use for routine orthodontic assessments (5).

The use of CBCT was first reported by Mozzo et al. (2) and it has been proposed in the last decade for maxillofacial imaging (6). A CBCT scan uses a different type of acquisition than that used in medical MDCT. Rather than capturing an image as separate slices as in MDCT, CBCT produces a cone-shaped X-ray beam that allows an image to be captured in a single shot. The resultant volume can be reformatted to provide multiple reconstructed images (e.g., sagittal, coronal, and axial) that are similar to traditional MDCT images (2). CBCT thus offers the distinct advantage of a lower radiation dose than MDCT and the possibility of importing and exporting individualized reconstructions with no overlap (7).

Evaluating the accuracy of measurements obtained with cephalometric images generated or reconstructed from 3D CT and CBCT data is important for orthodontists. Several studies have examined the accuracy of linear and

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3D measurements using CBCT (8,9). Most reported that both CBCT and CT techniques can be used to obtain dimensionally accurate linear and angular measurements (8–10). However, few studies have used CBCT-generated cephalograms using rendering programs in vivo (8,9). Moreover, knowledge of the 3D cephalometric norms for different populations is also very limited (11–13). As far as we are aware, no study has examined the 3D cephalometric norms in Turkish Cypriot patients using CBCT and 3D rendering software.

Due to economic and political issues, Turkish Cypriots have been emigrating from Cyprus since the 1920s, especially to the UK, Australia, Turkey, and other European countries. Recent estimates suggest that there are now 500,000 Turkish Cypriots living in Turkey, 300,000 in the United Kingdom, 120,000 in Australia, 5000 in the United States, 2000 in Germany, 1800 in Canada, and 1600 in New Zealand with a smaller community in South Africa. Unfortunately, analyses of ethnic populations residing in various countries for maxillofacial and orthodontics purposes have been insufficient. Although many Turkish Cypriots now reside abroad, little is known about the craniofacial norms. Such knowledge would facilitate orthodontic treatment and maxillofacial surgery in this population. Hence, the aim of this study was to create a database of 3D cephalometric measurements in Turkish Cypriot patients using the 3D rendering software Invivo 5.1 (Anatomage Inc., San Jose, CA, USA).

2. Materials and methods

The study population comprised 121 subjects [62 (51.2%) females, 59 (48.8%) males] who had undergone CBCT imaging for paranasal sinus or airway evaluation or for impacted third molar examination. The average age of patients was 31.85 (SD, 9.57) years (range: 20–45 years). The mean age of the male patients was 34.36 (SD, 9.19; n = 59) years (range: 20–45 years), while the mean age of the female patients was 29.47 (SD, 9.39; n = 62) years (range: 20–45 years).

The study protocol was carried out according to the principles of the Helsinki Declaration, including all amendments and revisions. Collected data were accessible by only the researchers. Patients gave informed consent prior to radiography, and the consent forms were reviewed and approved by the institutional review board of the faculty. Subjects with evidence of current orthodontic treatment, who were missing permanent incisors or first molars, who had erupted or supernumerary teeth overlying incisor apices, or who had gross skeletal asymmetries or bone diseases were excluded from the study. Subjects between 20 and 45 years of age of Turkish Cypriot ethnicity (i.e. both parents have Turkish Cypriot descent) with well-balanced facial profile, Angle Class I molar relationship with overbite and overjet between 1 and 4 mm, crowding less than 3 mm, and no facial asymmetry were included in the study.

Landmark identification and measurement for 3D cephalometric analyses were performed by an independent and calibrated orthodontic consultant (LV) experienced in the measurement of 3D images. In total, 38 angular and 26 linear widely used measurements were recorded (Tables 1–4). Figure 1 shows the landmarks investigated.

CBCT scans were obtained using a Newtom 3G (Quantitative Radiology s.r.l., Verona, Italy). Despite recent studies indicating that small variations in head position do not influence the accuracy of measurements from 3D CBCT (14), all CBCT scans were obtained according to the strict standardized scanning protocol used in our clinic. Patients were placed in a horizontal position, checked to ensure that their mouths were closed in a normal and natural occlusive position, and instructed to lie still throughout the duration of the scan. Images were obtained using a field of view (FOV) of 30.48 cm to ensure inclusion of the entire facial anatomy, with 0.3-mm-thick axial slices and isotropic voxels. Axial images were exported in the DICOM file format with a 512 × 512 matrix and exported to Invivo 5.1 (Anatomage Inc.).

All 3D measurements were taken using the Invivo 5.1 software. The landmarks were identified by a cursor-driven pointer in a 3D generated skull and reconstructed on a 54.102-cm flat-panel color active matrix TFT medical display (Nio Color 3MP, Barco, France) with a resolution of 76 Hz, 0.2115 mm pitch, and 10-bit color. The examiners were also permitted to use enhancements and orientation tools such as magnification, brightness, and contrast to improve visualization of the landmarks.

2.1. Statistical analysis

Statistical analysis was carried out using SPSS 15.0.0 (SPSS, Chicago, IL, USA). To avoid interobserver bias, a single consultant performed all CBCT measurements twice at 2-week intervals. To assess intraobserver reliability, the Wilcoxon matched-pairs signed rank test was used for repeat measurements. An independent samples t-test and the Mann–Whitney U test were performed to evaluate differences between sexes and measurements. $P \leq 0.05$ was considered to indicate statistical significance.

3. Results

Repeated CBCT evaluation and measurements indicated no significant intraobserver difference ($P > 0.05$). The overall intraobserver consistencies were 90% and 92% between linear and angular measurements, respectively. All measurements were found to be highly reproducible.

Descriptive statistics for the cephalometric measurements are reported in Tables 1–4. Additionally, comparative charts are provided for the purpose of

Table 1. Descriptive statistics of 3D cephalometric measurements of overall facial features.

Parameters	Sex	n	Mean	SD	P-value
Overall facial features					
Cranial base					
SN/Ba (cranial base angle)†	Male	59	127.92	6.1	0.045*
	Female	62	130	5.13	
	Total	121	128.99	5.7	
S – N (anterior cranial base length)†	Male	59	70.16	3.4	0.001*
	Female	62	65.59	2.4	
	Total	121	67.82	3.71	
FH/SN (anterior cranial base to FH)†	Male	59	7.4	3.41	0.115
	Female	62	8.36	3.26	
	Total	121	7.89	3.35	
Nba/FH (cranial base angle)†	Male	59	152.41	3.03	0.881
	Female	62	152.49	2.92	
	Total	121	152.45	2.96	
Overall facial height (vertical)					
N – Me (total anterior facial height)†	Male	59	121.47	7.63	0.001*
	Female	62	113.36	6.1	
	Total	121	117.31	7.98	
N – Gn (total anterior facial height)†	Male	59	119.54	7.51	0.001*
	Female	62	111.45	6	
	Total	121	115.4	7.88	
ANS – Gn (lower third of facial height)†	Male	59	66.87	6	0.001*
	Female	62	62.49	5.72	
	Total	121	64.62	6.23	
ANS – Me (lower third of facial height)†	Male	59	69.15	6.08	0.001*
	Female	62	64.71	5.89	
	Total	121	66.87	6.36	
S – Go (posterior face height)†	Male	59	87.45	5.38	0.001*
	Female	62	76.54	5.61	
	Total	121	81.86	7.74	
N – ANS (upper third of facial height)†	Male	59	53.46	3.38	0.001*
	Female	62	49.74	2.89	
	Total	121	51.55	3.64	
Ratio in facial height					
Sgo/NMe (PA face height ratio)†	Male	59	0.72	0.04	0.001*
	Female	62	0.68	0.05	
	Total	121	0.7	0.05	
Overall facial profile (anteroposterior)					
NA/APog (angle of facial convexity)†	Male	59	4.82	3.42	0.609
	Female	62	5.14	3.42	
	Total	121	4.99	3.41	
Npog/FH (facial angle)†	Male	59	87.72	4.02	0.499
	Female	62	87.25	3.44	
	Total	121	87.48	3.73	

†Independent samples, *P < 0.05.

Table 2. Descriptive statistics of 3D measurements of maxilla/midface and mandible.

Parameters	Sex	n	Mean	SD	P-value
Maxilla and midface					
SNA†	Male	59	82.16	4.23	0.077
	Female	62	80.87	3.68	
	Total	121	81.5	3.99	
A – N perpendicular†	Male	59	–0.77	3.96	0.909
	Female	62	–0.84	3.12	
	Total	121	–0.81	3.54	
A – NPog†	Male	59	1.67	2.55	0.626
	Female	62	1.88	2.27	
	Total	121	1.78	2.4	
Co – A (maxillary length)†	Male	59	82.64	5.6	0.001*
	Female	62	78.27	5.09	
	Total	121	80.4	5.75	
ANS – PNS (palatal plane)‡	Male	59	54.21	3.67	0.001*
	Female	62	50.72	4.24	
	Total	121	52.42	4.33	
PrNA‡	Male	59	3.14	1.61	0.006*
	Female	62	3.89	1.28	
	Total	121	3.53	1.49	
Vertical					
SN/ANS – PNS†	Male	59	7.78	3.61	0.363
	Female	62	8.42	4.05	
	Total	121	8.11	3.84	
Mandible					
Anteroposterior					
Go – Pog (mandibular body length)†	Male	59	72.32	5.84	0.001*
	Female	62	67.97	4.81	
	Total	121	70.09	5.74	
Go – Me (mandibular body length)†	Male	59	69.06	6.04	0.001*
	Female	62	65.5	4.68	
	Total	121	67.24	5.66	
Co – Gn (mandibular length)†	Male	59	113.02	6.66	0.001*
	Female	62	106.24	5.51	
	Total	121	109.54	6.96	
SNB†	Male	59	79.5	4.07	0.036*
	Female	62	77.99	3.76	
	Total	121	78.73	3.97	
Pog – N perpendicular†	Male	59	–5.03	8.06	0.723
	Female	62	–5.51	6.6	
	Total	121	–5.28	7.33	
SNPog†	Male	59	80.5	3.88	0.022*
	Female	62	78.89	3.76	
	Total	121	79.68	3.89	
Pog – NB†	Male	59	2	2.29	0.386
	Female	62	1.68	1.76	
	Total	121	1.83	2.03	
IdPg/MP (chin angle)†	Male	59	64.51	7.05	0.033*
	Female	62	61.97	5.85	
	Total	121	63.21	6.56	
Vertical					
GoGn/SN†	Male	59	26.31	5.22	0.001*
	Female	62	30.42	5.67	
	Total	121	28.42	5.81	
MP/FH (FMA; mandibular plane angle)†	Male	59	21.35	5.29	0.002*
	Female	62	24.46	5.53	
	Total	121	22.94	5.61	
MP/SN (mandibular plane angle)†	Male	59	28.57	5.22	0.001*
	Female	62	32.82	5.92	
	Total	121	30.75	5.96	
MP/OP (mandibular/occlusal plane angle)†	Male	59	16.12	5.04	0.393
	Female	62	16.86	4.36	
	Total	121	16.5	4.7	
SGn/FH (Y-axis)†	Male	59	60.25	4.71	0.955
	Female	62	60.2	3.78	
	Total	121	60.23	4.24	
SGn/SN†	Male	59	67.46	4.38	0.143
	Female	62	68.57	3.85	
	Total	121	68.03	4.14	

†Independent samples t-test, ‡Mann–Whitney U test, *P < 0.05.

Table 3. Descriptive statistics of 3D measurements of dentoalveolus.

Parameters	Sex	n	Mean	SD	P-value
Dentoalveolus					
Maxillary dentoalveolus					
U1 – NA (U1 protrusion)†	Male	59	4.37	2.63	0.286
	Female	62	4.81	1.85	
	Total	121	4.59	2.27	
U1/NA (U1 proclination)†	Male	59	18.86	7.51	0.596
	Female	62	19.56	7.07	
	Total	121	19.22	7.27	
U1 – NB (U1 protrusion)†	Male	59	7.81	2.84	0.254
	Female	62	8.34	2.24	
	Total	121	8.08	2.56	
U1 – Aperp (U1 protrusion)†	Male	59	4.34	2.22	0.57
	Female	62	4.55	1.81	
	Total	121	4.45	2.02	
U1 – Apog (U1 protrusion)‡	Male	59	5.33	2.64	0.355
	Female	62	5.91	1.97	
	Total	121	5.63	2.33	
U1/SN (U1 proclination)†	Male	59	100.91	8.85	0.75
	Female	62	100.43	7.41	
	Total	121	100.66	8.12	
U1/FH (U1 proclination)†	Male	59	108.12	8.83	0.65
	Female	62	108.79	7.38	
	Total	121	108.47	8.1	
U1/ANS – PNS (U1 proclination)†	Male	59	108.69	8.63	0.911
	Female	62	108.85	7.27	
	Total	121	108.77	7.93	
U1/OP (U1 proclination)†	Male	59	65.92	8.84	0.088
	Female	62	63.37	7.44	
	Total	121	64.61	8.22	
U1/APog (U1 proclination)†	Male	59	21.99	7.08	0.213
	Female	62	23.51	6.27	
	Total	121	22.77	6.69	
Mandibular dentoalveolus					
L1/FH (FMIA; L1 proclination)†	Male	59	62.63	7.71	0.134
	Female	62	60.42	8.33	
	Total	121	61.5	8.07	
L1/OP (L1 proclination)†	Male	59	68.09	8.3	0.904
	Female	62	68.26	7.6	
	Total	121	68.18	7.92	
L1/MP (IMPA; L1 proclination)†	Male	59	96.02	7.82	0.516
	Female	62	95.12	7.42	
	Total	121	95.56	7.6	
L1/Apog (L1 proclination)†	Male	59	23.5	6.4	0.221
	Female	62	24.86	5.75	
	Total	121	24.2	6.09	
L1/NB (L1 proclination)‡	Male	59	24.09	7.39	0.149
	Female	62	25.93	6.84	
	Total	121	25.03	7.14	
L1 – NB (L1 protrusion)‡	Male	59	4.81	1.83	0.674
	Female	62	4.9	1.92	
	Total	121	4.86	1.87	
L1 – Apog (L1 protrusion)‡	Male	59	2.89	1.98	0.732
	Female	62	2.87	2.16	
	Total	121	2.88	2.07	

†Independent samples t-test, ‡Mann–Whitney U test, *$P < 0.05$.

Table 4. Descriptive statistics of 3D measurements of soft tissue and maxillomandibular discrepancy.

Parameters	Sex	n	Mean	SD	P-value
Lips and chin (soft tissue)					
Upper lip					
Ls – Eplane (upper lip protrusion)†	Male	59	–6.56	4.49	0.192
	Female	62	–5.68	2.69	
	Total	121	–6.11	3.69	
Lower lip					
Li – Eplane (lower lip protrusion)‡	Male	59	–4.76	3.08	0.01*
	Female	62	–3.51	4.09	
	Total	121	–4.12	3.68	
Li - Hline (Lower lip protrusion)‡	Male	59	–0.63	5.17	0.364
	Female	62	0.01	3.95	
	Total	121	–0.3	4.58	
Overall facial profile					
N'Pog'/FH (soft tissue facial angle)‡	Male	59	89.51	5.2	0.477
	Female	62	89.91	4.05	
	Total	121	89.71	4.63	
Maxillomandibular discrepancy					
ANB†	Male	59	2.66	2.02	0.437
	Female	62	2.93	1.87	
	Total	121	2.8	1.95	
ANPog (jaw relation angle)†	Male	59	2.43	1.79	0.647
	Female	62	2.58	1.75	
	Total	121	2.51	1.76	
CoA – CoGn (Max-Mand differential)†	Male	59	30.38	4.64	0.005*
	Female	62	27.97	4.64	
	Total	121	29.15	4.78	
AB/NPog (A – B plane angle)‡	Male	59	–3.8	3.92	0.928
	Female	62	–3.99	3.67	
	Total	121	–3.89	3.78	
PP/MP (palatal/mandibular plane angle)†	Male	59	20.78	5.18	0.001*
	Female	62	24.4	6.4	
	Total	121	22.64	6.09	
OP/SN (occlusal plane angle)†	Male	59	13.56	5.44	0.001*
	Female	62	16.91	4.6	
	Total	121	15.28	5.28	
OP/FH (occlusal plane angle)†	Male	59	9.16	4.74	0.984
	Female	62	9.18	3.65	
	Total	121	9.17	4.15	
(ANS – PNS)/OP†	Male	59	8.15	3.98	0.941
	Female	62	8.22	4.66	
	Total	121	8.19	4.36	
U1/L1 (interincisal angle)†	Male	59	134.51	11.56	0.15
	Female	62	131.63	10.31	
	Total	121	133.03	10.99	
OP/AB‡	Male	59	85.04	5.49	0.656
	Female	62	86.41	2.8	
	Total	121	85.74	4.37	
Overjet‡	Male	59	2.56	1.02	0.278
	Female	62	2.78	0.84	
	Total	121	2.67	0.93	
Overbite‡	Male	59	1.72	1.43	0.492
	Female	62	1.61	0.75	
	Total	121	1.66	1.13	

†Independent samples t-test, ‡Mann–Whitney U test, *P < 0.05.

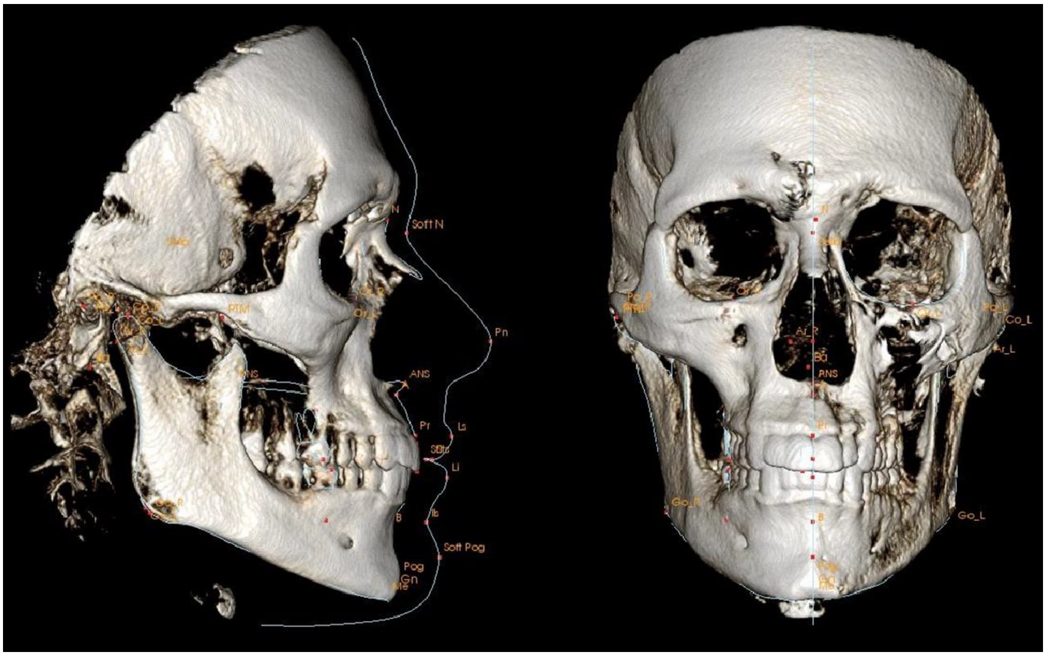

Figure 1. Hard and soft tissue landmarks used in the cephalometric analysis.

emphasizing ethnic differences between the current results and previously published data in Figures 2–5. Males showed significantly larger mean values for the anterior cranial base (SN), facial height measurements (N – Me, N – Gn, ANS – Gn, ANS – Me, S – Go, N – ANS), maxillary length (Co – A), palatal plane length (ANS – PNS), mandibular length (Co – Gn), mandibular body length (Go – Pog, Go – Me), and maxillary mandibular differential measurement (CoA – CoGn) than females ($P < 0.05$). The posterior face height was relatively longer than the anterior face height in males, as indicated by the P – A face height ratio (SGo/NMe). Males also showed significantly greater mean values for SNB, SNPog, and chin angle (IdPog/MP), while females showed significantly greater mean values for cranial base angle (SN/Ba), PrNA angle, palatal/mandibular plane angle (ANS – PNS/MeGo), GoGn/SN, OP/SN, and mandibular plane angle (MP/FH and MP/SN) ($P < 0.05$). The lower lip (Li) to E plane measurement was also significantly greater in females than males ($P < 0.05$).

4. Discussion

To our knowledge, no previous study has examined the 3D cephalometric norms of untreated Turkish Cypriot adults with ideal occlusion and well-balanced faces.

4.1. Overall facial features

4.1.1. Cranial base

Table 1 and Figure 2 show the cranial base measurements of the subjects. The cranial base angle (SN/Ba) was 128.99 ± 5°. This result is similar to Bell, Proffit, and White norms (15) but conflicts with Bacon et al. (16). In our study, the NBa/FH measurement was 152.45 ± 2.96°. This result is similar to that reported by Bacon et al. (16). Moreover, the anterior cranial base length (SN) measurements of Turkish Cypriots were found to be shorter than those of French and Cameroonian populations (16) and longer than those of the Chinese population (11).

4.1.2. Overall facial height

Table 1 and Figure 2 show overall facial height measurements. Based on a 2D cephalometric study of the Korean population (17), our results were smaller than in Korean patients, except for the posterior face height measurement in males. Additionally, the lower face height measurements of Mexican-Americans (18), McNamara norms (15), and the Japanese (19) were larger than those of our population. When compared to Anatolian Turks (20), Turkish Cypriots' upper and lower face height measurements were found to be smaller. On the other hand, in another Turkish sample (21), those measurements were similar to ours. Additionally, a previous study of a Chinese (11) population and a Korean 3D cephalometric study (13) reported results similar to ours. In this study, the facial height measurements were significantly larger in males than females, which agreed with the findings of Bascifci et al. (20), Cheung et al. (11), and Miyajima et al. (19).

4.1.3. Overall facial profile

The facial angle (NPog/FH) of our population was 87.72° in males and 87.25° in females. Our results were similar to the Downs' norms (22) and Chinese (11) and North Indian (23) populations, but lower than in Koreans (13,17), Cameroonians, the French (16), and the Japanese (19).

Figure 2. Comparison of cephalometric norms among varying types of measurements in different ethnic groups: [a]Nanda and Nanda, North Indians; [b]Miyajima et al., Japanese females; [c] Bacon et al., Cameroonians; [d]Bell, Proffit, and White female norms; [e] Bell, Proffit, and White male norms.

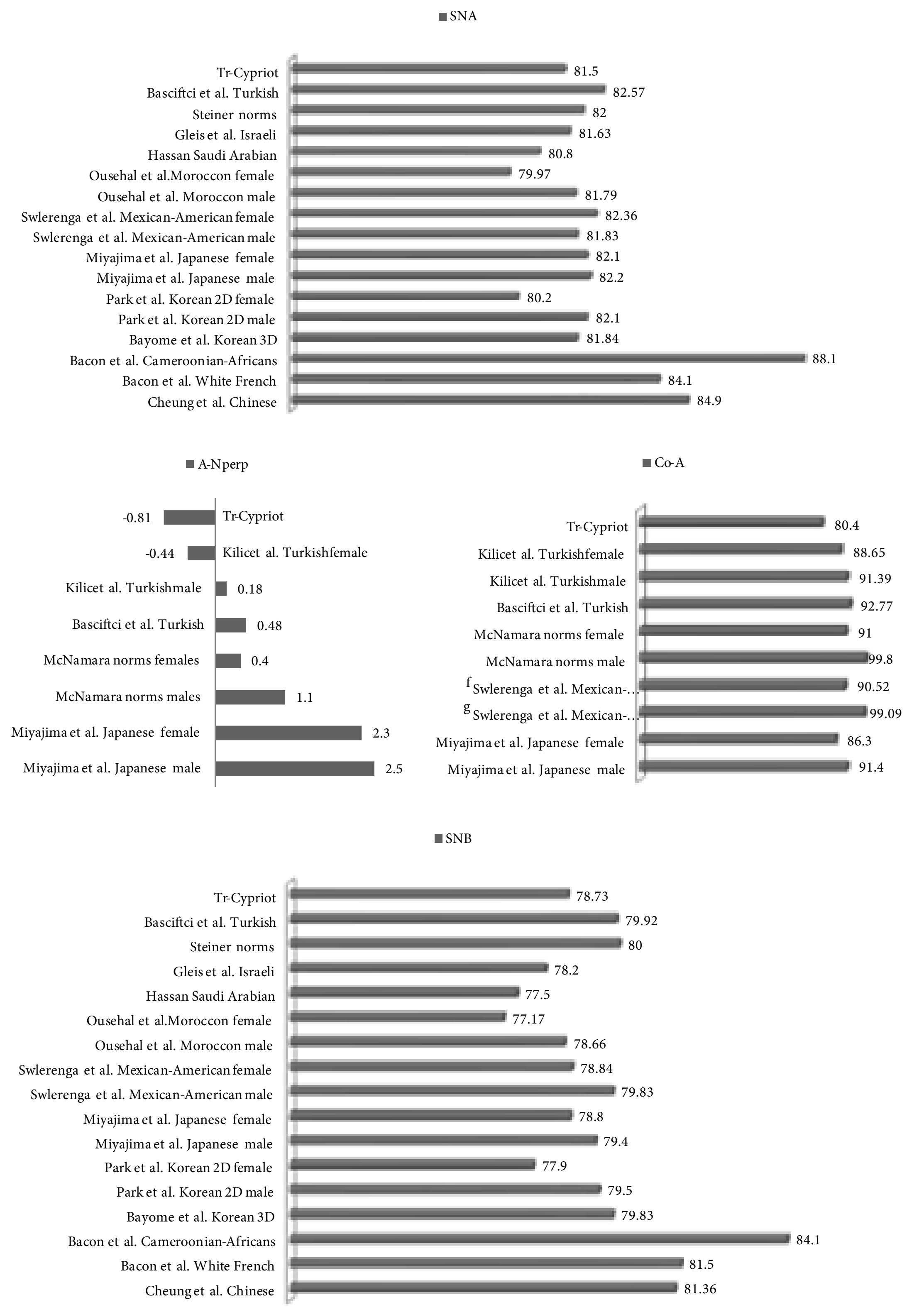

Figure 3. Comparison of cephalometric norms among varying types of measurements in different ethnic groups: [f]Swlerenga et al., Mexican-American females; [g] Swlerenga et al., Mexican-American males.

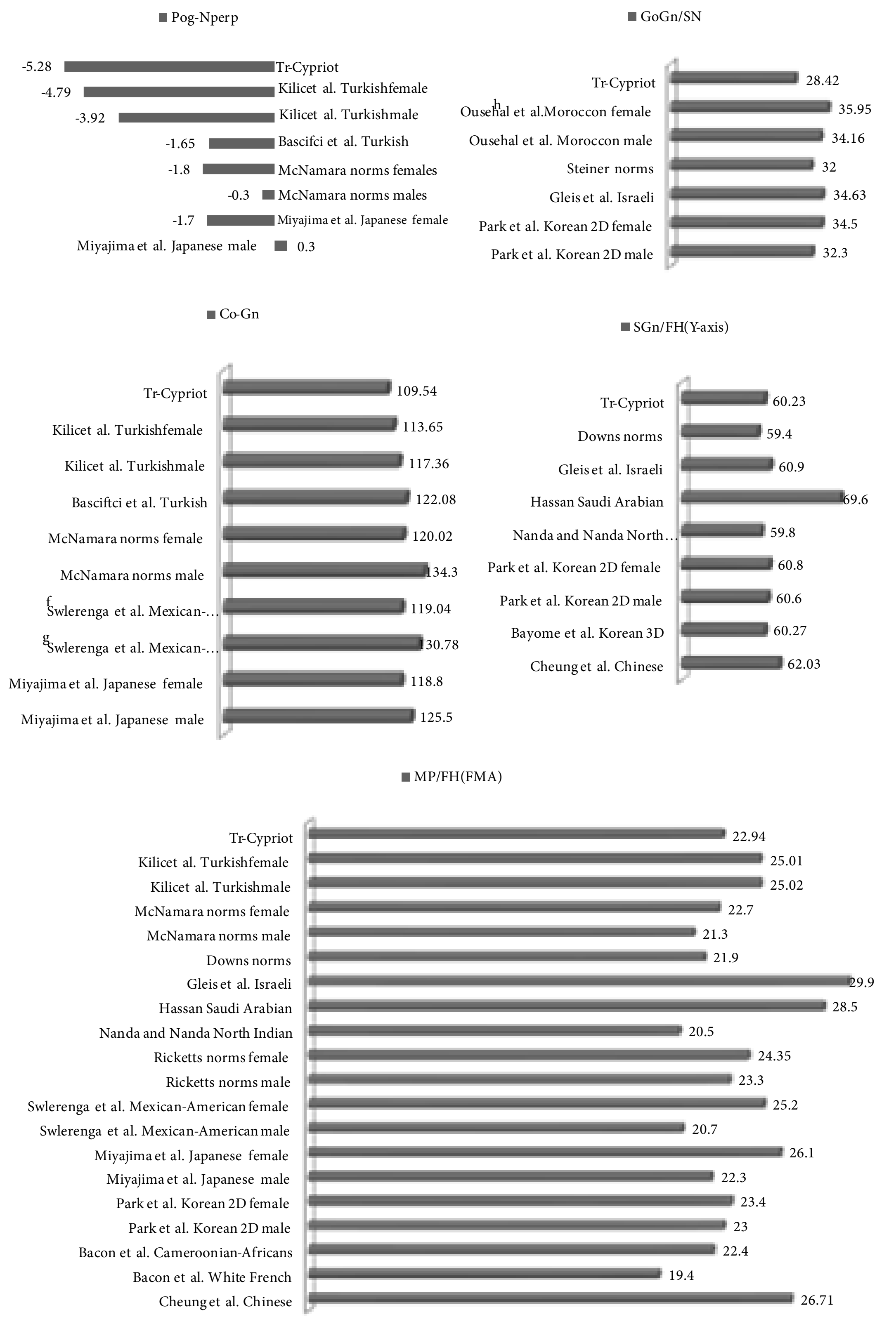

Figure 4. Comparison of cephalometric norms among varying types of measurements in different ethnic groups: [f]Swlerenga et al., Mexican-American females; [g]Swlerenga et al., Mexican-American males; [h]Ousehal et al., Moroccan females.

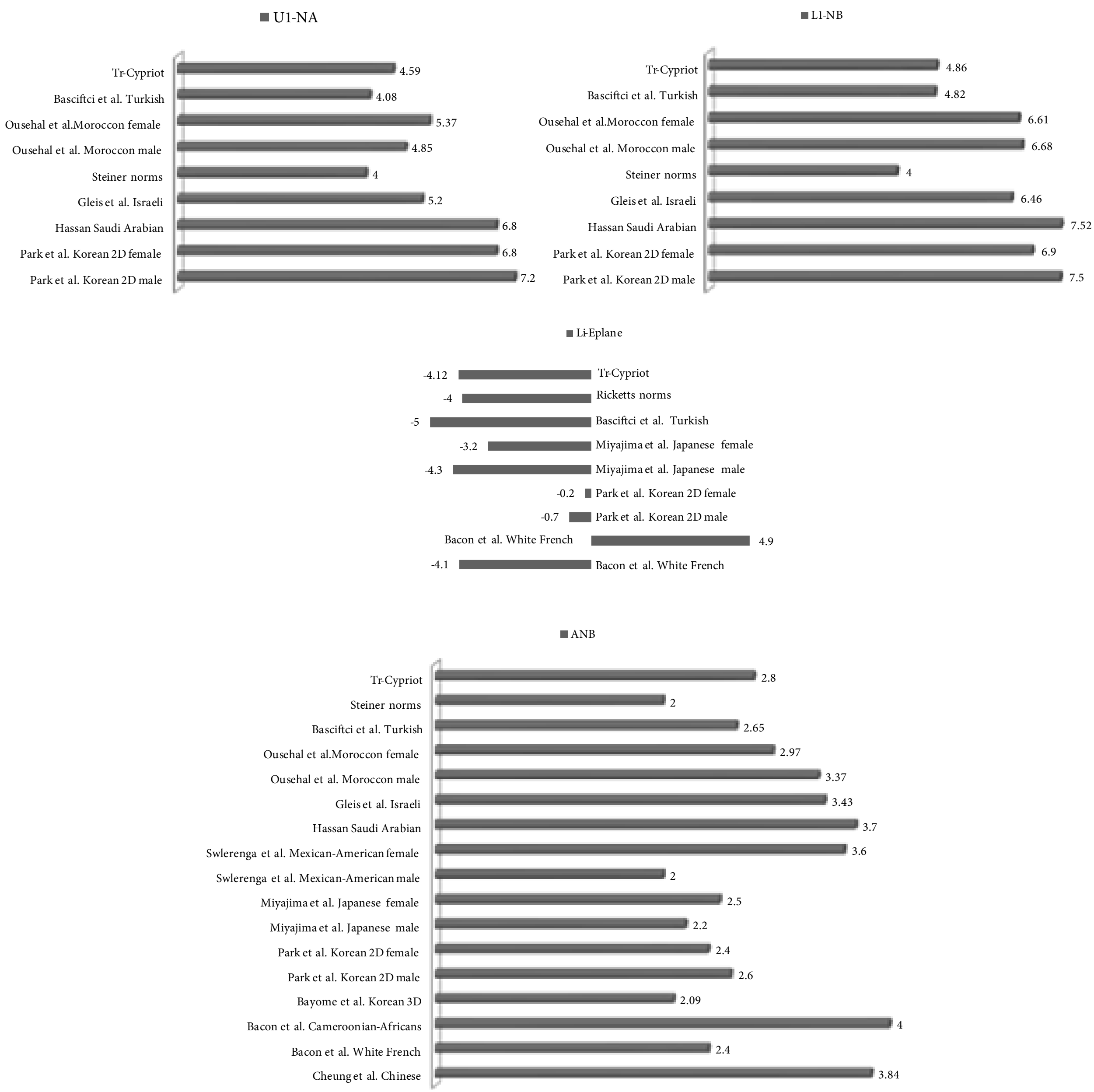

Figure 5. Comparison of cephalometric norms among varying types of measurements in different ethnic groups.

In our study, the angle of facial convexity of the Turkish Cypriot population (NA/APog: 4.82° in males and 5.14° in females) was greater than those of Koreans (13,17), Japanese (19), North Indians (23), and Downs' norms (22), but more straight than those of Saudi Arabs (24) and Israelis (25).

4.2. Maxilla and midface

Table 2 and Figure 3 show maxilla and midface measurements. The SNA was found to be similar to those of Caucasians (26), Koreans (13,17), Anatolian Turks (20), Moroccans (27), Mexican-American males (18), Japanese males (19), and Israelis (25), but lower than those of the Chinese (11), Cameroonians, the French (16), Mexican-American females (18), and Japanese females (19).

A to NPog measurements were found to be similar to those of the French (16) and Koreans (13,17), but lower than those of Cameroonians (16). The A – Nperp was found to be lower than those of the Japanese (19), Anatolian Turks (20), and the McNamara (15) norms, whereas Kilic et al.'s (21) results were in line with ours.

The maxillary length (Co – A) was significantly longer in males, in agreement with the findings of Bascifci et al. (20) and Mijama et al. (19) The maxillary lengths of Turkish Cypriots were shorter than those of Anatolian Turks (20,21), Mexican-Americans (18), the Japanese (19), and the McNamara norms (15).

4.3. Mandible

4.3.1. Anteroposterior

Table 2 and Figure 3 show the mandibular anteroposterior measurements. The SNB angle was similar to those reported for Korean (13,17), Anatolian Turk (20), Caucasian (26), Moroccan (27), Mexican-American (18), Japanese (19), and Israeli (25) populations but lower than that of Chinese subjects (11), Cameroonians, and the French (16) and higher than that of Saudi Arabs (24). In our study, the SNB angle of male patients was significantly higher than that of females, in agreement with the reports by Hassan (24) and Ousehal (27).

According to a parameter (Pog – Nperp) used to determine the relationship of the mandible to the cranial base, our population was found to be more retrusive than Anatolian Turks (20,21), the Japanese (19), and the McNamara norms (15) (Figure 4).

In this study, the mandibular length of males (Co – Gn) was significantly longer than that of females. When compared with Anatolian Turks (20,21) the mandibular length of our population was shorter, which was also the case for Mexican-Americans (18), the Japanese (19), and the McNamara norms (15). Mandibular lengths were significantly longer in males than females, in agreement with the findings of Cheung et al. (11) (Figure 4).

4.3.2. Vertical

Table 2 and Figure 4 show mandibular vertical measurements. The FMA was significantly larger in females, similar to the Japanese (19) but different from the Chinese (11) and Saudi Arabs (24). If males were investigated separately the results would be similar to the Downs norms (22) and that of Mexican-Americans (18) but lower than Cameroonians (16), Koreans (17), the Chinese (11), the Ricketts norms (15), Saudi Arabs (24), the Japanese (19), and Israeli (25) populations and higher than those of the French (16) and North Indians (23). With regard to females, our results were closer to those of Koreans (17), Turks (21), Mexican-Americans (18), and the Ricketts norms (15), while they were lower than Chinese (11), Saudi Arab (24), and Japanese (19) findings but higher than the Downs norms (22) and those of Cameroonians, the French (16), and North Indians (23).

Females had a significantly larger GoGn/SN angle than males. These results were lower than the Steiner norms (26) and those of Koreans (17), Moroccans (27) and Israelis (25). The MP/SN angle was also significantly smaller in males (28.57°) than females (32.82°), in agreement with the findings of Hassan (24). Our results were lower than those for Saudi Arabs (24), the Chinese (11), and Anatolian Turks (20), except for females.

The Y-axis (SGn/FH) measurements in Turkish Cypriots were similar to the ideal norms of Koreans (13,17), North Indians (23), Israelis (25), and Caucasians (22), but smaller than the Chinese norms (12). SGn/SN measurements in Turkish Cypriots were lower than those of Saudi Arabs (24).

4.4. Dentoalveolus

Table 3 and Figure 5 show maxillary and mandibular dentoalveolus measurements. The lower and upper incisors of Turkish Cypriots were found to be protrusive in comparison to the Downs norms (22) and similar to the Steiner norms (26), but the axial inclination of Turkish Cypriots was ~3° less than the Steiner norms (26).

The L1 – MP measurements of Turkish Cypriots were found to be similar to those of Anatolian Turks (20) and Koreans (17); however, the upper and lower incisors of our population were more retrusive and retroclined than those of Moroccans (27), Israelis (25), Saudi Arabs (24), Cameroonians (16), Mexican-Americans (18), and Koreans (17). The lower incisors of Turkish Cypriots were more proclined than those of the Chinese (11) and the Ricketts norms (15), but similar to that of the Anatolian Turkish (20,21) and French (16) populations.

4.5. Lips and chin (soft tissue)

Table 4 and Figure 5 show soft tissue measurements. According to Ricketts (28), the lower lip (Li) was located a mean distance of 4 mm posterior to the aesthetic line and the upper lip (Ls) was slightly posterior to the lower lip when related to that line. The lips of Turkish Cypriots were found to be retrusive compared to those of Anatolian Turks (20), Cameroonians (16), Koreans (17), and the Japanese (19).

Our findings suggest that the lips become more retrusive with age, which was supported by a recent report on the Anatolian Turkish population (29). Moreover, Ricketts (30) also reported that the lips continue to retract in adults. Additionally, the male patients in our study had significantly more retruded lower lips than did the female patients.

4.6. Maxillomandibular discrepancy

Table 4 and Figure 5 show maxillomandibular discrepancy measurements. In our study, the PP/MP angle of female patients was significantly higher than that of male patients. This result conflicts with Cheung et al. (11) Additionally, the ANB angle was similar to those reported for Caucasians (26), Koreans (13,17), Anatolian Turks (20), the French (16), Moroccans (27), and Mexican-Americans (18) but lower than that of the Chinese (11), Cameroonians (16), and Saudi Arabs (24). In our study, the maxillomandibular differential of male patients was significantly larger than that of female patients. These results were lower than that of McNamara norms (15).

In our study, the degree of overjet was found to be similar to that in the Japanese population (30) and the Ricketts norms (15), but smaller than Koreans (17). Our results for overbite were similar to those of the Japanese (19) population but smaller than that of Koreans (17) and the Ricketts norms (15). For the interincisal angle, our results were larger than those of most other studies (11,16–18,23–27), particularly Anatolian Turks (20).

This is the first population-based Turkish Cypriot study that can serve as a guide to the craniofacial anatomy and orthodontic norms of this group. The data can be compared with those of other populations and will facilitate diagnosis and treatment planning of Turkish Cypriot adults seeking orthodontic treatment or orthognathic surgery. This study will also be of value for oral and maxillofacial surgeons and orthodontists in the UK, Turkey, and Germany who treat a significant number of Turkish Cypriot patients.

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References

1. Macri V, Athanasiou AE. Sources of error in lateral cephalometry. In: Athanasiou AE, editor. Orthodontic Cephalometry. London, UK: Mosby-Wolfe; 1995. pp. 125-140.
2. Mozzo P, Procacci C, Tacconi A, Martini PT, Andreis IA. A new volumetric CT machine for dental imaging based on the cone-beam technique: preliminary results. Eur Radiol 1998; 8: 1558-1564.
3. Cattaneo PM, Bloch CB, Calmar D, Hjortshøj M, Melsen B. Comparison between conventional and cone beam computed tomography-generated cephalograms. Am J Orthod Dentofacial Orthop 2008; 134: 798-802.
4. Kumar V, Ludlow JB, Mol A, Cevidanes L. Comparison of conventional and cone beam CT synthesized cephalograms. Dentomaxillofac Radiol 2007; 36: 263-269.
5. Swennen GRJ, Schutyser F. Three-dimensional cephalometry: Spiral multi-slice vs cone beam computed tomography. Am J Orthod Dentofacial Orthop 2006; 130: 410-416.
6. Kalender A, Orhan K, Aksoy U. Evaluation of the mental foramen and accessory mental foramen in Turkish patients using cone-beam computed tomography images reconstructed from a volumetric rendering program. Clin Anat 2012; 25: 584-592.
7. Liang X, Jacobs R, Hassan B, Li L, Pauwels R, Corpas L, Souza PC, Martens W, Shahbazian M, Alonso A et al. A comparative evaluation of cone beam computed tomography (CBCT) and multi-slice CT (MSCT). Part I: On subjective image quality. Eur J Radiol 2010; 75: 265-269.
8. Kumar V, Ludlow J, Soares Cevidanes LH, Mol A. In vivo comparison of conventional and cone beam CT synthesized cephalograms. Angle Orthod 2008; 78: 873-879.
9. Oz U, Orhan K, Abe N. Comparison of linear and angular measurements using two-dimensional conventional methods and three-dimensional cone beam CT images reconstructed from a volumetric rendering program in vivo. Dentomaxillofac Radiol 2011; 40: 492-500.
10. Longoni S, Sartori M, Braun M, Bravetti P, Lapi A, Baldoni M, Tredici G. Lingual vascular canals of the mandible: the risk of bleeding complications during implant procedures. Implant Dent 2007; 16: 131-138.
11. Cheung LK, Chan YM, Jayaratne YS. Three-dimensional cephalometric norms of Chinese adults in Hong Kong with balanced facial profile. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 112: e56-73.
12. Gateno J, Xia JJ, Teichgraeber JF. New 3-dimensional cephalometric analysis for orthognathic surgery. J Oral Maxillofac Surg 2011; 69: 606-622.
13. Bayome M, Park JH, Kook YA. New three-dimensional cephalometric analyses among adults with a skeletal Class I pattern and normal occlusion. Korean J Orthod. 2013; 43: 62-73.
14. Hassan B, van der Stelt P, Sanderink G. Accuracy of three-dimensional measurements obtained from cone beam computed tomography surface-rendered images for cephalometric analysis: influence of patient scanning position. Eur J Orthod 2009; 31: 129-134.
15. Bosch C, Athanasiou AE. Landmarks, variables and norms of various numerical cephalometric analyses – cephalometric morphologic and growth data references. In: Athanasiou AE, editor. Orthodontic Cephalometry. London, UK: Mosby-Wolfe; 1995. pp. 241-292.
16. Bacon W, Girardin P, Turlot JC. A comparison of cephalometric norms for the African Bantu and a caucasoid population. Eur J Orthod 1983; 5: 233-240.
17. Park IC, Bowman D, Klapper L. A cephalometric study of Korean adults. Am J Orthod Dentofacial Orthop 1989; 96: 54-59.
18. Swlerenga D, Oesterle LJ, Messersmith ML. Cephalometric values for adult Mexican-Americans. Am J Orthod Dentofacial Orthop 1994; 106: 146-155.
19. Miyajima K, McNamara JA Jr, Kimura T. Craniofacial structure of Japanese and European-American adults with normal occlusions and well-balanced faces. Am J Orthod Dentofacial Orthop 1996; 110: 431-438.
20. Basciftci FA, Uysal T, Buyukerkmen A. Craniofacial structure of Anatolian Turkish adults with normal occlusions and well-balanced faces. Am J Orthod Dentofacial Orthop 2004; 125: 366-372.

21. Kilic N, Catal G, Oktay H. McNamara norms for Turkish adolescents with balanced faces and normal occlusion. Aust Orthod J 2010; 26: 33-37.

22. Downs WB. Variations in facial relationships: Their significance in treatment and prognosis. Am J Orthod 1948; 34: 812-840.

23. Nanda R, Nanda RS. Cephalometric study of the dentofacial complex of North Indians. Angle Orthod 1969; 39: 22-28.

24. Hassan AH. Cephalometric norms for Saudi adults living in the western region of Saudi Arabia. Angle Orthod 2006; 76: 109-113.

25. Gleis R, Brezniak N, Lieberman M. Israeli cephalometric standards compared to Downs and Steiner analyses. Angle Orthod 1990; 60: 35-40.

26. Steiner CC. Cephalometrics for you and me. Am J Orthod 1953; 39: 729-755.

27. Ousehal L, Lazrak L, Chafii A. Cephalometric norms for a Moroccan population. Int Orthod 2012; 10: 122-134.

28. Ricketts RM. Esthetics, environment, and the law of lip relation. Am J Orthod 1968; 54: 272-289.

29. Vahdettin L, Altug Z. Longitudinal soft-tissue profile changes in adolescent Class I subjects. J Orofac Orthop 2012; 73: 440-453.

30. Ricketts RM. Perspectives in the clinical application of cephalometrics. Angle Orthod 1981; 51: 115-150.