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CLINICAL & BASIC RESEARCH

Cephalometric Norms in an Omani Adult Population of Arab Descent

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المعايير الطبيعية لقياس الرأس لدى السكان العمانيين العرب البالغين

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abstract: ***Objectives:*** This study aimed to establish cephalometric norms for an Omani population of Arab descent and to compare these with established cephalometric values for Caucasians. ***Methods:*** This cross-sectional study was conducted at the Military Dental Centre and Oman Dental College in Muscat, Oman, between May 2014 and October 2016. A total of 150 Omani patients between 20–29 years old seeking orthodontic treatment were included. All participants had a symmetrical face, class I molar and canine relationships, proper intercuspation, a normal overjet/overbite (<3 mm) and mild spacing/crowding of the teeth (≤3 mm). Lateral cephalography was performed in centric occlusion with the lips relaxed and the head in a natural position. Cephalometric measurements were then compared with Eastman Standard norms. ***Results:*** The Omani subjects were found to have a slightly retrusive *maxilla*, an increased angle between the maxillary and mandibular planes and shorter facial heights in comparison to the Eastman Standard norms. Furthermore, incisor relations were edge-to-edge in nature and the interincisal angle was reduced, suggesting that the Omani subjects had more proclined incisors. In addition, the lips were more protrusive and the nasolabial angle was more obtuse. ***Conclusion:*** In the Omani sample, increased proclination of the incisors was observed in comparison to Eastman Standard norms. As such, slightly more proclined incisors should be considered acceptable and natural among Omani patients of Arab descent. The cephalometric findings of this study may be helpful in the diagnosis and treatment planning of orthodontic problems among Omanis of Arab descent.

Keywords: Cephalometry, standards; Population Characteristics; Ethnic Groups; Arabs; Orthodontics; Oman.

الملخص: الهدف: هدفت هذه الدراسة إلى وضع معايير لقياس الرأس لدى السكان العمانيين العرب ومقارنتها مع قيم قياسات الرأس المعتمدة لدى القوقازيين. **الطريقة:** أجريت هذه الدراسة المقطعة العرضية في مركز طب الأسنان العسكري وكلية عمان لطب الأسنان في مسقط، عمان، بين عامي 2014 و 2016. تم اختيار مجموعة من 150 مريضا عمانيا بين سن 29–20 عاما كانوا يبحثون عن علاج لتقويم الأسنان. كان لدى جميع المشاركين وجه متماثل، إطباق الرحى والأنياب من الدرجة الأولى، تشابك حدبات متكافئ، قياس طبيعي لتراكب العضة العمودي والأفقي (أقل من 3 ملم)، وكان التباعد/الرصص السني معتدل بين الأسنان (≤3 ملم). تم إجراء أشعة الرأس الجانبية في وضع إنطباق مركزي للأسنان مع ارتخاء الشفاه والرأس في وضعها الطبيعي. تم بعد ذلك مقارنة قياسات الرأس مع معايير إيستمان القياسية. **النتائج:** وجد أن المجموعة العمانية لديها تراجع بسيط في الفك العلوي، زيادة الزاوية بين مستوى الفك العلوي والسفلي وقصر في ارتفاعات الوجه مقارنة بمعايير إيستمان القياسية. كما كان طابع العلاقة بين القواطع من الحافة الى الحافة، وزاوية الإنقسام بينهم منخفضة العلاقات بين القواطع ذات طبيعة من الحافة إلى الحافة، وانخفاض في زاوية الانقسام بين القواطع، مما يوحي بأن المجموعة العمانية لديهم قواطع أكثر إنحراف إلى الأمام. بالإضافة إلى ذلك، كانت الشفتين أكثر بروزا وكانت الزاوية الأنفية الشفوية أكثر انفراجا. **الخلاصة:** في المجموعة العمانية، لوحظ تزايد تداخل القواطع بالمقارنة مع المعايير الشرقية القياسية. على هذا النحو، ينبغي اعتبار القواطع المنحرفة للأمام بشكل طفيف مقبولة وطبيعية بين المرضى العمانيين العرب. قد تكون نتائج قياسات الرأس في هذه الدراسة مفيدة في تشخيص وعلاج مشاكل تقويم الأسنان بين العمانيين العرب.

الكلمات المفتاحية: قياسات الرأس؛ معايير؛ خصائص السكان؛ فئات أثنية؛ عرب؛ تقويم الأسنان؛ عمان.

Advances in Knowledge

- *To the best of the authors' knowledge, this study is the first to establish cephalometric norms for an Omani population of Arab descent.*

Application to Patient Care

- *Establishing cephalometric norms for Omanis of Arab descent could help dentists to detect any orthodontic deviations for diagnostic or treatment purposes.*

The diagnosis of potential orthodontic anomalies necessitates the comparison of an individual patient's cephalometric values with those of established norms.[1] However, the patient's ethnic background needs to be taken into consideration because cephalometric norms vary widely between different ethnic groups.[1–3] While minor differences between an individual's cephalometric values and those of the respective norms is routine, major differences may indicate a structural deviation. Knowledge of the

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way in which an individual's cephalometric values differ from accepted norms will allow clinicians to conclude whether the anomaly is dento-alveolar or skeletal in origin and undertake corrective measures if necessary.[4]

In a comparison of cephalometric norms between Egyptian adolescents and those of a sample in Iowa, USA, Bishara *et al.* concluded that Egyptian boys tended to have bimaxillary dental protrusion and greater posterior facial heights (PFHs), whereas Egyptian girls had mandibular dental protrusion and more convex skeletal profiles.[5] In a Jordanian population, Hamdan *et al.* concluded that, in comparison to a British sample, Jordanians had reduced lower facial heights and more proclined upper incisors (UIs) and lower incisors (LIs); this finding was substantiated by a reduced interincisal angle.[3] Al-Awwad *et al.* compared the cephalometric norms of a sample of adult Kuwaitis with those of previously published Caucasian norms, reporting that the Kuwaiti subjects had more proclined incisors and significantly more obtuse nasolabial angles; moreover, females had more protrusive lower lips with more proclined LIs compared to males.[6] Another study found that adolescent Kuwaitis had a steeper mandibular plane (MN) and a more convex profile, with reduced chin protrusion and more protrusive dentition compared to published norms.[4]

Shalhoub *et al.* established cephalometric radiographical norms for Saudi Arabian adults by comparing normal facial proportions with a North American sample; the Saudi subjects showed reasonably normal dental relationships, with no severe anteroposterior, vertical or transverse skeletal discrepancies.[7] In western Saudi Arabia, previous findings have suggested that western Saudis have an increased A point/*nasion*/B point (ANB) angle due to the retrognathic nature of the mandible and bimaxillary dento-alveolar protrusion, with males having a steeper MN angle.[2] Among Saudi Arabian students with acceptable profiles and occlusion, a craniofacial analysis indicated the students had a slightly protrusive *maxilla*, with a tendency towards class II facial patterns, high MN angles and procumbent maxillary and mandibular incisors in comparison to Caucasian subjects.[8]

In Oman, the native population has a unique culture and lineage, with a history of considerable ethnic diversity.[9] Although previous studies have attempted to set normative standards in the Arabian Gulf region, none have so far focused on Omanis of Arab descent.[2–4,7,8] Therefore, the present study aimed to establish cephalometric standards for an Omani population of Arab descent and compare these with Eastman Standard norms.[10–27]

Methods

This cross-sectional study was conducted at the Military Dental Centre and Oman Dental College in Muscat, Oman, from May 2014 to October 2016. A sample of 150 Omani patients aged 20–29 years old seeking orthodontic treatment at these two institutions were selected. All subjects were of Arab descent from both parents' side, without any history of interracial marriages occurring for at least two generations. Each subject underwent a clinical examination by two orthodontists to ensure they had a symmetrical face (in which a line drawn from the forehead to the chin would yield measurements conforming to the mathematical concept of the golden ratio), class I molar and canine relations with proper intercuspation and an acceptable overjet and overbite (<3 mm), mild spacing/crowding (≤3 mm), no transverse discrepancies and no detectable lateral and sagittal

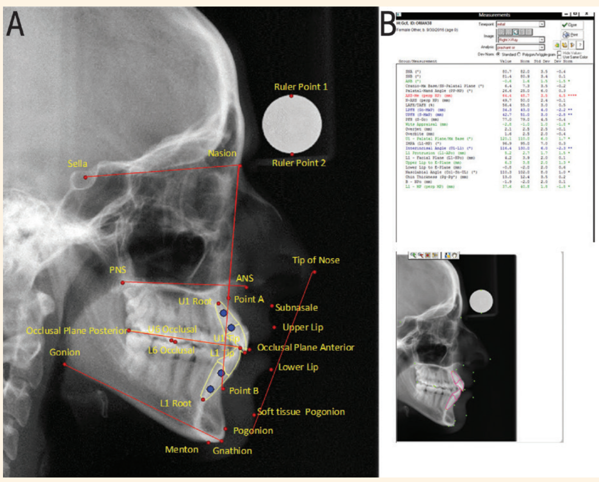

Figure 1: Example of a cephalogram with (**A**) identified anatomical landmarks and (**B**) automated cephalometric measurements generated using imaging software.
ANS = anterior nasal spine; UI = upper incisor; LI = lower incisor.

shifts. Medically compromised subjects and those with congenital abnormalities, facial trauma, missing/extracted teeth or a history of orthodontic treatment, orthognathic surgery or plastic surgery were excluded from the study, as such individuals were deemed not to represent the typical facial characteristics of an Arab Omani population.

The sample size was calculated using nMaster software, Version 1.0 (Department of Biostatistics, Christian Medical College, Vellore, India) based on the following formulae:

$$N = \frac{2Sp^2\,[Z_{1-\frac{a}{2}} + Z_{1-B}]^2}{D^2}$$

$$Sp - \text{pooled SD} = \frac{\text{SD of males} + \text{SD of females}}{2}$$

Where *Sp* is the target population, *Z* is the confidence interval (1.96), a is the α error (assumed to be 1%), B is the β error (assumed to be 10% at a power of 90%), *D* is the effect size (i.e. the mean difference between males and females) and SD is the standard deviation. The mean and SD of randomly selected variables, including the ANB, *sella*/*nasion* (SN) line to the maxillary plane (MP) and the lower dental facial height (LDFH), defined as the distance between the LI tip to the MN, was estimated based on 15 male and 35 female subjects. The minimum sample size was therefore calculated to be 35 subjects of each gender. However, in order to improve the statistical power of the results, the sample size was increased to a total of 150 subjects.

All of the subjects underwent routine two-dimensional (2D) lateral cephalography in centric

Table 1: Definition of various cephalometric parameters used in the current study

Parameter	Definition
Skeletal	
SNA	Position of the *maxilla* in relation to the skull base (i.e. the angle between the SN and NA planes)
SNB	Position of the mandible in relation to the skull base (i.e. the angle between the SN and NB planes)
ANB	Sagittal relationship between the *maxilla* and mandible (i.e. the angle between the NA and NB planes)
SN-MP	Vertical relationship between the *maxilla* and cranium (i.e. the angle between the SN and ANS and PNS planes)
PPL-MN	Angle between the PPL and MN
LAFH	Distance between the Me and MP (i.e. distance between the Me and ANS)
UAFH	Distance between the N and MP (i.e. distance between the N and ANS)
LAFH/TAFH	Ratio of LAFH to the TAFH (i.e. ratio of the N-ANS to the ANS-Me)
LPFH	Distance between the Go and MP (i.e. distance between the Go and PNS)
UPFH	Distance between the S and MP (i.e. distance between the S and PNS)
PFH	Distance between the S and Go
Wits appraisal	Extent to which the jaws are related to each other*
Dental	
Overjet	Horizontal overlap of the incisors from the labial aspect of the LI to the incisal edge of the UI
Overbite	Vertical overlap of the incisors from the incisal edge of the UI to the incisal edge of the LI
UI-MP	Angle between the UI axis and MP
LI-MP	Angle between the LI axis and MP
UI-LI	Angle between the UI and LI axes
LI protrusion	Distance between the incisal edge of the LI and the line joining point A to Po
LI-FP	Distance between the incisal edge of the LI and the line joining N to Po
B-NPo	Distance between point B and the line joining N to Po
LDFH	Distance between the tip of the LI and the MP
Soft tissue	
UL-EP	Distance between the UL and Ricketts' E line†
LL-EP	Distance between the LL and Ricketts' E line†
NLA	Angle between the Co and Sn of the UL
Chin thickness	Distance between the hard and soft tissue Po

SNA = sella (S)/nasion (N) point A; SNB = SN point B; ANB = A point/N/B point; MP = maxillary plane; ANS = anterior nasal spine; PNS = posterior nasal spine; PPL = palatal plane; MN = mandibular plane; LAFH = lower anterior facial height (AFH); Me = menton; UAFH = upper AFH; TAFH = total AFH; LPFH = lower posterior facial height (PFH); Go = gonion; UPFH = upper PFH; LI = lower incisor; UI = upper incisor; Po = pogonion; FP = facial plane; LDFH = lower dental facial height; UL = upper lips; EP = E plane; LL = lower lips; NLA = nasolabial angle; Col = columella; Sn = philtrum.

**Measured by drawing perpendicular lines from points A and B on the maxilla and mandible, respectively, to the occlusal plane through the region of overlapping cusps of the first premolar and first molars. †Measured by drawing a line from the tip of the nose to the soft tissue Po.*

occlusion with the lips relaxed and a natural head position, in which the Frankfort plane was parallel to the floor. The cephalograms were taken from a distance of 150 cm away using an Orthophos XG 5 SD X-ray unit (Dentsply Sirona, York, Pennsylvania, USA). Although three-dimensional (3D) cephalometric analyses have recently gained popularity, recent research has indicated that 3D analysis does not ensure more accurate results than conventional 2D analysis.[28] Subsequently, digital versions of the lateral cephalograms were examined using Dolphin imaging software, Version 11.8 (Dolphin Imaging & Management Solutions, Chatsworth, California, USA). A single examiner identified anatomical landmarks on the cephalogram directly on the monitor using markings on a ruler to calibrate the magnification. A dot was placed and moved around on the image until the examiner was satisfied that the position of the landmark had been accurately recorded. After all of the landmarks were clearly identified, various linear and angular measurements were automatically generated by the program [Figure 1]. In order to assess if any errors were made while localising the landmarks, 10 random radiographs were retraced after three weeks to determine examiner error and confirm the reproducibility of measurements at a 95% confidence interval. There were very few measurement errors for all of the variables tested, except for PFH, measured from the *sella* to the *gonion*, which resulted in an intra-class correlation coefficient of 0.504 for the male subjects. Table 1 lists the definitions used in the measurement of each cephalometric parameter.

Table 2: Cephalometric norms according to gender in an adult Omani population (N = 150)

Parameter	Mean ± SD		*P* value
	Males (n = 59)	Females (n = 91)	
Skeletal			
SNA in degrees	80.94 ± 4.7	81.44 ± 4.23	0.498
SNB in degrees	80.00 ± 4.77	78.98 ± 3.92	0.157
ANB in degrees	1.04 ± 2.84	2.46 ± 2.31	0.001
SN-MP in degrees	7.57 ± 4.04	9.22 ± 3.65	0.010
PPL-MN in degrees	28.22 ± 5.69	25.95 ± 5.15	0.012
LAFH in mm	60.87 ± 10.31	58.38 ± 6.45	0.070
UAFH in mm	49.59 ± 6.39	49.93 ± 3.56	0.674
LAFH/TAFH ratio in %	34.90 ± 27.75	38.24 ± 25.32	0.449
LPFH in mm	34.08 ± 7.09	34.21 ± 5.85	0.902
UPFH in mm	41.20 ± 5.90	39.05 ± 4.26	0.011
PFH in mm	73.95 ± 9.92	71.99 ± 6.18	0.138
Wits appraisal in mm	-1.47 ± 3.73	-0.03 ± 2.79	0.008
Dental			
Overjet in mm	2.21 ± 1.91	2.79 ± 2.16	0.095
Overbite in mm	1.12 ± 1.77	1.68 ± 1.8	0.063
UI-MP in degrees	116.61 ± 7.22	115.51 ± 8.77	0.423
LI-MN in degrees	93.91 ± 8.17	96.54 ± 7.53	0.046
UI-LI in degrees	121.25 ± 10.06	121.78 ± 11.59	0.773
LI protrusion in mm	3.11 ± 2.89	2.54 ± 2.44	0.202
LI-FP in mm	2.83 ± 3.07	3.27 ± 2.84	0.368
B-NPo in mm	-1.59 ± 1.82	-1.47 ± 1.19	0.632
LDFH in mm	38.23 ± 5.02	36.54 ± 3.33	0.014
Soft tissue			
UL-EP in mm	2.76 ± 3.71	2.43 ± 2.86	0.533
LL-EP in mm	-1.00 ± 2.27	-0.7 ± 1.84	0.380
NLA in degrees	106.00 ± 8.82	105.31 ± 10.34	0.672
Chin thickness in mm	12.17 ± 2.60	11.81 ± 2.48	0.390

SD = standard deviation; SNA = sella (S)/nasion (N) point A; SNB = SN point B; ANB = A point/N/B point; MP = maxillary plane; PPL = palatal plane; MN = mandibular plane; LAFH = lower anterior facial height (AFH); UAFH = upper AFH; TAFH = total AFH; LPFH = lower posterior facial height (PFH); UPFH = upper PFH; UI = upper incisor; LI = lower incisor; FP = facial plane; B-NPo = point B/N/pogonion; LDFH = lower dental facial height; UL = upper lips; EP = E plane; LL = lower lips; NLA = nasolabial angle.

Microsoft Excel, Version 2007, (Microsoft Corp., Redmond, Washington, USA), and the Statistical Package for the Social Sciences (SPSS), Version 10.0 (IBM Corp., Armonk, New York, USA), were used for data entry and analysis. The data were tested for normalcy as per previously described methods.[29] The results were presented as means ± SD for continuous variables and numbers and percentages for discrete variables. Due to the large sample size and normal distribution of the results, parametric tests were applied. Each of the parameters for male and female subjects were compared using an independent samples t-test. A one-sample t-test was used for comparison between published Eastman Standard values and those of the current study.[10–27] The level of statistical significance was set at P <0.050.

Ethical approval to conduct this study was obtained from the Research & Ethical Review & Approval Committee of the Ministry of Health in Oman (#MH/DGP/R&S/30/2013). All of the subjects included in the study were informed of the nature and purpose of the study and the radiographic procedures involved. Verbal consent was provided for the use of the radiographs for research purposes, under the condition that the subjects' anonymity was maintained.

Results

A total of 150 Omani subjects of Arab descent were included in the study, of which 91 (60.7%) were female and 59 (39.3%) were male. The mean age was 25.3 ± 0.5 years old. In terms of gender, males had significantly higher palatal-MP angles compared to females (28.22 ± 5.69

degrees versus 25.95 ± 5.15 degrees; *P* = 0.012). However, females had higher ANB (2.46 ± 2.31 degrees versus 1.04 ± 2.84 degrees; *P* = 0.001) as well as SN-MP (9.22 ± 3.65 degrees versus 7.57 ± 4.04 degrees; *P* = 0.010) angles. As per the Wits appraisal value, jaw disharmony among males was significantly more severe compared to females (-1.47 ± 3.73 mm versus -0.03 ± 2.79 mm; *P* = 0.008). Females had significantly higher LI-MN angles (96.54 ± 7.53 degrees versus 93.91 ± 8.17 degrees; *P* = 0.046) and lower LDFHs (36.54 ± 3.33 mm versus 38.23 ± 5.02 mm; *P* = 0.014) when compared to males [Table 2].

Table 3: Comparison of cephalometric norms in an adult Omani population (N = 150) with Eastman Standard norms[10–27]

Parameter	Mean ± SD		*P* value
	Arab Omanis (N = 150)	Eastman Standard norms	
Skeletal			
SNA in degrees	81.24 ± 4.40	82.01 ± 3.89[12]	0.036
SNB in degrees	79.38 ± 4.28	79.77 ± 3.69[12]	0.272
ANB in degrees	1.90 ± 2.61	2.04 ± 1.81[12]	0.517
SN-MP in degrees	8.57 ± 3.87	7 ± 3[13]	<0.001
PPL-MN in degrees	26.84 ± 5.46	25 ± 6[14]	<0.001
LAFH in mm	59.35 ± 8.24	64.95 ± 3.55[11]	<0.001
UAFH in mm	49.79 ± 4.85	52.35 ± 2.8[15,16]	<0.001
LAFH/TAFH ratio in %	36.92 ± 26.25	55[17]	<0.001
LPFH in mm	43.00 ± 34.50	43.0 ± 4[18]	<0.001
UPFH in mm	39.89 ± 5.06	52.25 ± 1.95[13]	<0.001
PFH in mm	72.75 ± 7.89	79.0 ± 4.5[13]	<0.001
Wits appraisal in mm	-0.59 ± 3.25	0.59 ± 1.84[19]	<0.001
Dental			
Overjet in mm	2.56 ± 2.07	3.2 ± 0.5[20,21]	<0.001
Overbite in mm	1.45 ± 1.80	3.2 ± 0.7[20,21]	<0.001
UI-MP in degrees	115.93 ± 8.18	112 ± 6[13]	<0.001
LI-MN in degrees	95.50 ± 7.86	91.4 ± 3.78[10]	<0.001
UI-LI in degrees	121.57 ± 10.98	135.4 ± 5.76[10]	<0.001
LI protrusion in mm	2.76 ± 2.62	1 ± 2[22]	<0.001
LI-FP in mm	3.10 ± 2.93	1.6 ± 2[23]	<0.001
B-NPo in mm	-1.52 ± 1.46	-2 ± 2[27]	<0.001
LDFH in mm	37.20 ± 4.14	40 ± 2[15,16]	<0.001
Soft tissue			
UL-EP in mm	2.55 ± 3.21	-5.4 ± 2[22]	<0.001
LL-EP in mm	-0.82 ± 2.01	-2.0 ± 2[22]	<0.001
NLA in degrees	105.57 ± 9.74	102.0 ± 4[24]	<0.001
Chin thickness in mm	11.95 ± 2.52	12.65 ± 1.9[25,26]	<0.001

SD = standard deviation; SNA = sella (S)/nasion (N) point A; SNB = SN point B; ANB = A point/N/B point; MP = maxillary plane; PPL = palatal plane; MN = mandibular plane; LAFH = lower anterior facial height (AFH); UAFH = upper AFH; TAFH = total AFH; LPFH = lower posterior facial height (PFH); UPFH = upper PFH; UI = upper incisor; LI = lower incisor; FP = facial plane; B-NPo = point B/N/pogonion; LDFH = lower dental facial height; UL = upper lips; EP = E plane; LL = lower lips; NLA = nasolabial angle.

In comparison with Eastman Standard norms, statistically significant differences were noticed for all of the mean cephalometric values of the Omani subjects, apart from SN point B (SNB) and ANB values. The Omani subjects had a significantly smaller SN point A (SNA) value (81.24 ± 4.40 degrees versus 82.01 ± 3.89 degrees; *P* = 0.036), suggesting a retro-positioned *maxilla*.[12] In addition, the Omani subjects had slightly more divergent basal planes, as indicated by their significantly higher palatal-MP (26.84 ± 5.46 degrees versus 25 ± 6 degrees; *P* <0.001) and SN-MP (8.57 ± 3.87 degrees versus 7 ± 3 degrees; *P* <0.001) angles.[12,13] In addition, the Omani subjects had significantly smaller anterior and PFHs (*P* <0.001 each).[11,13–16] According to the Wits appraisal value, the SD value of jaw disharmony of the Omani population was just over 1 mm less than that of the Eastman Standard norms (-0.59 ± 3.25 mm versus 0.59 ± 1.84 mm; *P* <0.001).[19] Both the overjet and overbite of the Omani subjects was significantly decreased in comparison to Eastman Standard norms (*P* <0.001 each), with the Omani subjects having more proclined incisors.[20,21] With regards to soft tissue parameters, the upper and lower lips were significantly more protrusive in the Omani subjects and the nasolabial angle was significantly more obtuse (*P* <0.001 each) [Table 3].[10–27]

Discussion

During orthodontic evaluation, a cephalometric analysis can reveal important anatomical information regarding the internal structures of the facial complex, particularly in terms of skeletal and dento-alveolar anomalies.[30] While various cephalometric norms have been published in an attempt to define normal skeletal characteristics, most attempts have utilised populations of North American or European Caucasians.[10,11,31,32] However, it is apparent that the cephalometric norms for one ethnic group do not necessarily apply to others.[5,32–41] The present study was undertaken to establish cephalometric norms for a young population of Omanis of Arab descent. Statistically significant differences were observed in comparison to Eastman Standard norms for almost all of the cephalometric variables.[10–27]

With regards to skeletal parameters, the Omani subjects had a significantly smaller SNA angle in comparison to the Eastman Standard norms, suggesting a retro-positioned *maxilla*.[12] In contrast, previous studies conducted to establish cephalometric norms in other Arab populations have shown variations in SNA and SNB angles [Table 4].[2–5,8,38–40,42] Overall, Arab Omanis were found to have a more retruded *maxilla* when compared to the Eastman Standard norms or Egyptian, Saudi, Kuwaiti and Emirati samples; however, they were less retruded than Jordanian, Moroccan and Yemeni samples.[3–5,8,38–40,42] Nevertheless, results from the present study showed no significant difference with Eastman Standard norms regarding the sagittal relationship between the *maxilla* and the mandible (i.e. the ANB angle).[12] Previous studies in Saudi Arabia and Jordan have reported similar findings, while other studies in Kuwait, Saudi Arabia, Morocco and Yemen have reported conflicting findings.[2,3,37–40] Arab Omanis were found to have relatively reduced ANB angles compared to reports for other Arab populations.[2–5,8,38–40,42]

On the other hand, the angle between the palatal and MN planes was significantly higher among the current sample of Omani adults in comparison to Eastman Standard norms.[14] Furthermore, the SN-MP angle was significantly higher among the Omani subjects by 1.57 degrees.[13] It can therefore be concluded that Omanis have slightly more divergent basal planes, as well as a more caudally tipped palatal plane. This is in accordance with a previous study conducted in Saudi Arabia, but in contrast to Hamdan *et al.*'s findings among Jordanian adolescents.[2,3] In the current study, the lower and upper anterior facial heights of the Omani subjects were significantly shorter than those in Eastman Standard norms, by 5.6 mm and 2.6 mm, respectively; moreover, the ratio of lower anterior facial height to upper anterior facial height was significantly lower (-18.1%).[11,15–17] Thus, it seems that Omanis have considerably smaller anterior facial heights, which is in accordance with Hamdan *et al.*'s findings.[3] In addition, the upper PFH and overall PFH of the Omani subjects were significantly shorter, by 12.4 mm and 6.3 mm, respectively, compared to Eastman Standard norms.[13] However, lower PFH was similar to that of Eastman Standard norms.[18] This is in contrast to the findings of Bishara *et al.* and Behbehani *et al.* among Egyptian and Kuwaiti adolescents, respectively.[5,37] The Wits appraisal value for the studied Omani population was also significantly different to that of Eastman Standard norms.[19]

In terms of dental parameters, both the overjet and overbite values for the studied Omani population were significantly lower than those of Eastman Standard norms.[20,21] Moreover, the angles between the UI and MP and the LI and MN were increased by 3.9 and 4.1 degrees, respectively, while the interincisal angle was decreased by 13.8 degrees, suggesting that the Omani subjects had more proclined incisors compared to Eastman Standard norms.[10,13] In addition, Omanis had the greatest degree of incisor proclination compared to other Arab populations, apart from Emiratis.[2–5,8,38–40,42] Protrusion of the LI and the distance between the LI and facial plane was also increased by 1.8 mm and 1.5 mm, respectively.[22,23] This finding is in accordance with other studies of Arab populations which indicated greater proclined incisor relations.[2–5,8,38–40,42] Finally, the LDFH of the Omani subjects was shorter than those of Eastman Standard norms by 2.8 mm.[15,16]

Within soft tissue parameters, both the upper and lower lips were more protrusive in the current Omani sample in comparison to Eastman Standard norms, by 7.9 and 1.2 mm, respectively.[22] Behbehani *et al.* reported similar findings in a Kuwaiti population.[37] In the current study, the nasolabial angle was also significantly more obtuse by 3.6 degrees in comparison to Eastman Standard norms.[22]

Regarding gender differences within the studied Omani population, females had a significantly greater sagittal relationship between the *maxilla* and mandible, as evidenced by their ANB values. This feature was further supported by the females having a more positive Wits appraisal value. These findings suggest that Omani females display a more retrusive mandible, which is in contrast to reported findings from other Arab populations.[3,5,42] In addition, females in the current

Table 4: Comparison of selected cephalometric norms in an adult Omani population (N = 150) with other Arab populations[2–5,8,38–40,42]

Author and year of study	Population	Mean ± SD				
		SNA in degrees	SNB in degrees	ANB in degrees	Wits appraisal in mm	UI-LI in degrees
Current study (2018)	150 Omani adults	81.24 ± 4.40	79.38 ± 4.28	1.90 ± 2.61	-0.59 ± 3.25	121.57 ± 10.98
Hassan (2006)[2]	70 Saudi adults	80.8 ± 4.06	77.5 ± 4.48	3.7 ± 1.522	-	-
Hamdan *et al.* (2001)[3]	65 Jordanian adolescents	80.7 ± 3.67	77.7 ± 3.19	3.0 ± 1.96	-	127.5 ± 7.93
Bishara *et al.* (1990)[5]	90 Egyptian adolescents	82.7 ± 3.6	79.5 ± 3.5	3.2 ± 1.7	-0.1 ± 2.8	124.1 ± 8.4
Al-Jasser (2000)[8]	87 Saudi students	83.6 ± 4.3	81.0 ± 3.7	2.5 ± 2.0	-	124.8 ± 6.9
Al-Jame *et al.* (2006)[4]	162 Kuwaiti adolescents	83.04 ± 3.6	79.44 ± 3.4	3.6 ± 2.16	-0.48 ± 2.36	-
Aldrees (2011)[38]	485 Saudi adults	82.49 ± 4.17	79.55 ± 3.84	2.93 ± 2.31	0.13 ± 2.47	-
Ousehal *et al.* (2012)[39]	71 Moroccan adults	80.59 ± 3.8	77.68 ± 3.55	3.11 ± 1.68	-	-
Daer *et al.* (2016)[40]	194 Yemeni students	80.86 ± 2.54	77.89 ± 2.52	2.97 ± 1.35	-	126.65 ± 7.19
Al Zain *et al.* (2012)[42]	61 Emirati adults	81.7	78.6	3.1	-	118.6

SD = standard deviation; SNA = sella (S)/nasion (N) point A; SNB = SN point B; ANB = A point/N/B point; UI = upper incisor; LI = lower incisor.

study had significantly more proclined LIs compared to males, as expressed by the LI-MN angle; this is in accordance with findings of Bishara *et al*.[5]

This study is subject to certain limitations. As noted earlier, Oman is a heterogenous country and is native to individuals of various ethnicities and races, with Arabs representing only a portion of the total population.[9] Therefore, in order to determine accurate and specific cephalometric norms for the Omani population, a larger sample comprising all of the different tribes existing in the country should be evaluated.

Conclusion

In comparison to Eastman Standard norms, the Arab Omani subjects were found to have a slightly more retrusive *maxilla* and an increased MP-MN angle. Their vertical facial heights were also significantly shorter than those of Eastman Standard norms. The Wits appraisal value for the Omani subjects was also comparatively reduced, nearing zero. In terms of dental parameters, the incisor relations of the Omani subjects were edge-to-edge in nature and the interincisal angle was reduced, suggesting more proclined incisors. With regards to soft tissue parameters, the lips of the Omani subjects were significantly more protrusive and the nasolabial angle more obtuse compared to the Eastman Standard norms. These findings suggest that certain cephalometric parameters, such as slightly more proclined incisors, should be considered acceptable and normal within the Arab Omani population, despite differing from Eastman Standard norms.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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