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Website: www.jorthodsci.org
DOI: 10.4103/jos.JOS_84_20

A Study of Dentofacial Morphology in Yemeni Adults with Normal Occlusions a cross sectional prospective study

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Abstract:

OBJECTIVE: The purpose of this study was to describe the dentofacial morphology of Yemeni adults.

MATERIALS AND METHODS: The lateral cephalograms of 100 Yemeni adults (50 males, 50 females) were included in the study. All subjects were born to Yemeni parents and grandparents. They all had Class I occlusions with minor or no crowding, well-aligned upper and lower dental arches, good facial harmony, all teeth present except third molars, and no history of orthodontic therapy or maxillofacial surgery. Five angular and eighteen linear measurements were analyzed to determine the soft tissue, skeletal, and dental features. The differences for each measurement between Yemeni males and females were calculated using unpaired *t*-tests.

RESULTS: Significant sexual and racial differences were found for three linear parameters in the skeletal analysis, one angle, and four linear dental measurements, and for all soft tissue linear parameters. Yemeni adults showed a tendency to a facial pattern of Class II, convex profile, reduced prominence of chin, increased lower facial height, and a clockwise rotation of the mandibular plane angle.

CONCLUSION: Yemeni adults have different dentofacial parameters when compared to other racial standards, and these differences could aid in diagnosis and treatment planning.

Keywords:

Cephalometrics, dentofacial morphology, ethnic norms

Introduction

Cephalometric normative values are a well-accepted diagnostic tool in orthodontic treatment planning.^[1] These values are used to recognize the patient's deviation from the normal pattern; thus, a sufficient description of the hard and soft tissue pattern associated with a given malocclusion is essential, especially in patients whose treatment plan includes functional orthopedics or orthognathic surgery.^[2,3]

Different cephalometric studies have been conducted to establish norms for various

ethnic and racial groups.^[4-21] From all these studies, it can be concluded that there are a lot of variations in dentofacial relationships between different ethnic and racial groups. As a result, it is essential to evaluate the cephalometric measurements of every patient according to his or her racial group.

A comprehensive Yemeni cephalometric database is still lacking, and the two cephalometric studies conducted on the Yemeni population^[22,23] were inadequate to describe the overall aspects of dentofacial morphology for Yemenis. Al-Gunaid,^[22] performed a study on males only and developed norms limited to soft tissue structures, while Daer,^[23] developed cephalometric norms mostly perceived from Harvold's analysis.

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How to cite this article: Al-Yousefi AA, Al-Motareb F, Daer A, Al-Labani MA. A Study of Dentofacial Morphology in Yemeni Adults with Normal Occlusions a cross sectional prospective study. J Orthodont Sci 2021;10:19.

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Submitted: 29-Dec-2020
Revised: 03-Feb-2021
Accepted: 25-Feb-2021
Published: 15-Oct-2021

Consequently, the current data of cephalometric norms for the Yemeni population are insufficient, to determine cephalometric standards useful in diagnosis and treatment planning of orthodontic problems and orthognathic surgery for Yemeni adults; and with the increasing number of Yemeni patients looking for specialized treatment from orthodontists and maxillofacial surgeons, it has become indispensable to determine what is considered a good-balanced or pleasing face for the Yemeni population. Hence, the objective of our study was to develop soft tissue, skeletal, and dental cephalometric values for Yemeni adults to be used as a diagnostic tool for orthodontic treatment planning, especially in patients who may need orthognathic surgery or functional jaw orthopedics.

Materials and Methods

This was a cross-sectional study involving (50 males and 50 females), from the student of the Faculty of Dentistry, Sana'a University, Sana'a, Yemen. The interviews and clinical examinations were conducted by the first author to ensure that all participants have fulfilled the following inclusion criteria: Yemeni parents and grandparents, Class I occlusions with minor or no crowding, well-aligned upper and lower dental arches, good facial harmony, normal overbite and overjet, all teeth present except the third molars, and no history of previous orthodontic treatment.

Ethical approval was obtained from the Ethical Committee of the Medical Research (ECA/SU/FD1) at the Faculty of Dentistry, and all contributors had signed the consent form after explaining the nature and purpose of the radiographs. Each subject was seated in the radiographic unit (PaX-Fle × 3D P2, Ver. 1.0.0, Vatech, Korea), and the cephalometric radiograph was taken by a trained radiologist.

Lateral cephalograms of 100 Yemeni adults (50 males, mean age of 23.6 ± 2.1 years and- 50 females, mean age of 21.5 ± 3.1 years) were taken. Their heads were stabilized by a head holder and directed in a natural head position – the true vertical perpendicular to the floor and the true horizontal parallel to the floor.^[24] The radiographs were exposed at 85 kV, 10 mA per second.

Landmarks used in the Study [Figure 1]

The landmarks used in the study were as follows:

Nasion (N), Basion (Ba), Orbital (Or), Porion (Po), Pogonion (Pog), Gnathion (Gn), Menton (Me), Gonion (Go), point A (A), Condylion (Co), Anterior nasal spine (ANS), Posterior nasal spine (PNS), the pterygomaxillary fissure (PTM), Incision superius (Is), Incision inferius (Ii), Subnasale (Sn), Labrale Superius (Ls), Labrale inferius (Li), and Soft tissue Pogonion (Pog'). The definitions of these different landmarks have been stated before by Riolo.^[25]

Cephalometric measurements

From the above-mentioned landmarks, five angular and eighteen linear measurements^[26] were determined to evaluate skeletal [Figure 2], dental [Figure 3], and soft tissue relationships [Figure 4]. These different measurements were described in Table 1.

Reliability of landmarks localization

All cephalometric radiographs were traced by hand using 0.003-mm matte acetate papers. Tracings and measurements were done by one investigator at the Orthodontic Department, Faculty of Dentistry. Twenty radiographs were selected randomly and retraced

Table 1: Different Angular and linear measurements used

Skeletal	
1. Point A-N perp. perpendicular line	Distance from point A to Nasion
2. Pog-N perp. perpendicular line	Distance from Pog to the Nasion
3. F.MPA	The angle between the Frankfort plane and mandibular plane
4. Facial axis angle (F.A.A)	Angle between the basion-nasion plane and foramen rotundum- Gnathion plane
5. M.F.L	Effective midfacial length: distance from condylion to point A
6. Mand.L	Effective mandibular length: distance from condylion to Gnathion
7. L.F.H	Lower facial height: distance from ANS to Menton
Dental	
1. Ui- point A	A From labial surface of the upper incisor to point A
2. Li- A-Pog	From the edge of the lower incisor to a line from point A to Pog
3. Li- MP.A	Angle formed between the long axis of lower incisor and mandibular plane
4. Ui- Pp	From the edge of the upper incisor to the palatal plane
5. Um- Pp	From the mesial cusp of the upper first molar to the palatal plane
6. Li- Mp	From the edge of the lower incisor to the mandibular plane
7. Lm- Mp	From the mesial cusp of the lower first molar to the mandibular plane
Soft tissue	
1. Nasolabial angle	Formed between line tangent to the base of nose and a line tangent to upper lip
2. Ls to Sn-Pog'	Upper lip protrusion: from labrale superius to Sn- Pog' line
3. Li to Sn-Pog'	Lower lip protrusion: from labrale inferius to Sn- Pog' line
4. M.L.S	Mentolabial sulcus: the maximum depth from a line connecting Pog' and the lower lip
5. Point A- Sn	From point A to Subnasale
6. Is- U lip	From incision superioris to the upper lip
7. Ii- L lip	From incision inferioris to the lower lip
8. Pog- Pog'	From hard tissue Pog to soft tissue Pog
9. Z angle	Formed between Frankfort plane and a line connecting Pog' and most protrusive lip point

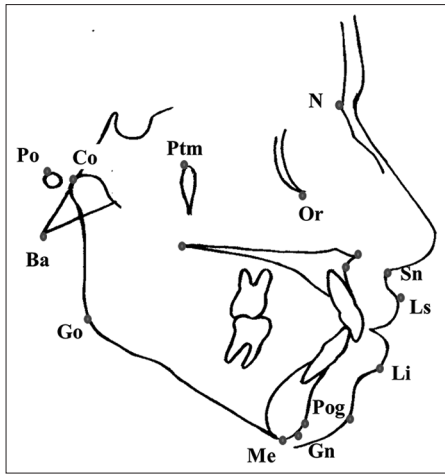


Figure 1: Cephalometric reference points used in the study

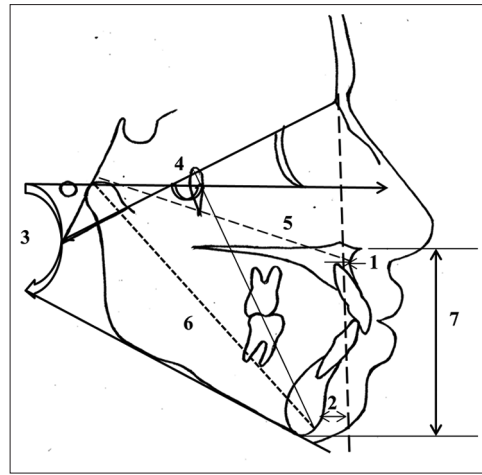


Figure 2: Skeletal angular and linear measurements: 1. Point A- N perp.: From point A to nasion perp. Line (mm), 2. Pog – N perp.: From Pog to the nasion perp. Line (mm), 3. F.MPA°: The angle between Frankfort plane and mandibular plane, 4. F.A.A°: The angle between the basion–nasion plane and foramen rotundum- Gnathion plane, 5. M.F.L: From condylocondylion to point A (mm), 6. Mand.L: From condylocondylion to Gnathion (mm), 7. L.F.H: From ANS to Menton (mm)

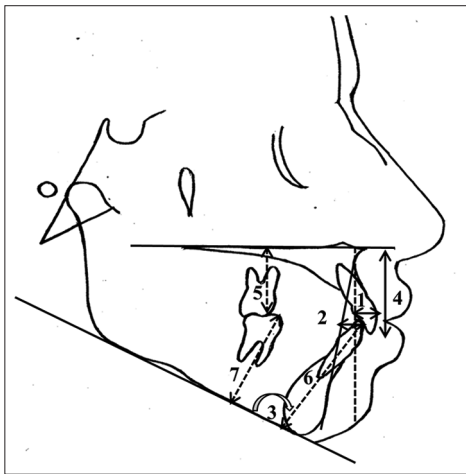


Figure 3: Dental angular and linear measurements: 1. Ui- point A: dimension from the labial surface of the upper incisor to point A (mm), 2. Li- A-Pog: dimension from the edge of the lower incisor to a line from point A to Pog (mm) 3. Li- M.P.A°: the angle between the long axis of the lower incisor and the mandibular plane, 4. Ui- Pp: dimension from the edge of the upper incisor to the palatal plane (mm), 5. Um- Pp: distance from the mesial cusp of the upper first molar to the palatal plane (mm), 6. Li- Mp: dimension from the edge of the lower incisor to the mandibular plane (mm), 7. Lm- Mp: distance from the mesial cusp of the lower first molar to the mandibular plane (mm)

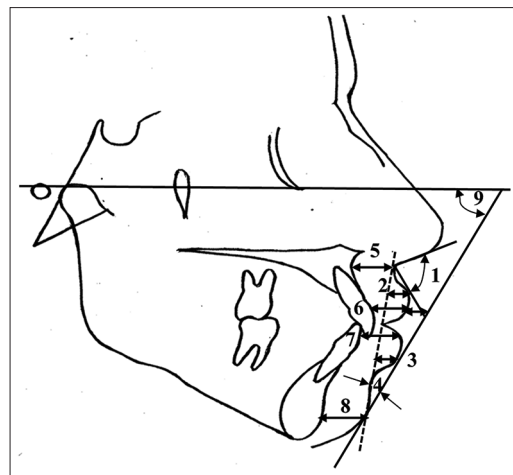


Figure 4: Soft tissue angular and linear measurements: 1. Nasolabial angle: The angle formed between a line tangent to the base of the nose and a line tangent to the upper lip, 2. Ls to Sn-Pog': the distance from labrale superius to Sn- Pog' line (mm), 3. Li to Sn-Pog': the distance from labrale inferius to Sn- Pog' line (mm), 4. M.L.S: The maximum depth from a line connecting Pog' and the lower li (mm) p, 5. Point A- Sn: the distance from point A to Subnasale (mm), 6. Is- U lip: the distance from incision superioris to the upper lip (mm), 7. li- L lip: the dimension from incision inferioris to the lower lip (mm), 8. Pog- Pog': the dimension from hard tissue Pog to soft tissue Pog (mm), 9. Z angle: the angle between Frankfort plane and a line connecting Pog' and the most protrusive lip point

by the same investigator after 2 weeks from the first measurements. Errors in cephalometric tracing were evaluated using Dahlberg's formula.^[27] The errors were from 0.04° to 0.28° for the angular measurements and from 0.02 to 0.36 mm for the linear measurements [Table 2].

The accuracy of landmarks identification was checked by the supervisor. The middle point of the bilateral landmarks was used.

Statistical analysis

Means and standard deviations for all the variables were calculated for each gender using SPSS software (IBM SPSS, V 22.0, Chicago, United States). Unpaired *t*-tests were performed to determine whether significant

cephalometric differences exist between Yemeni males and females.

Results

The descriptive statistics of the twenty-three cephalometric variables used to evaluate the skeletal, dental, and soft-tissue patterns are shown in Table 3 for males and Table 4 for females. Table 5 presents the comparisons between Yemeni males and females.

Table 2: Methodological cephalometric tracing errors

Measurement	Dahlberg's value
Point A- N perp.(mm)	0.026
Pog - N perp.(mm)	0.144
F.MPA (°)	0.046
F.A.A (°)	0.210
M.F.L (mm)	0.364
Mand.L (mm)	0.113
L.F.H (mm)	0.150
Ui- point A (mm)	0.179
Li- A-Pog (mm)	0.079
Li- M.P.A (°)	0.258
Ui- Pp (mm)	0.254
Um- Pp (mm)	0.116
Li- Mp (mm)	0.104
Lm- Mp (mm)	0.138
Nasolabial angle (°)	0.288
Ls to Sn-Pog' (mm)	0.137
Li to Sn-Pog' (mm)	0.070
M.L.S (mm)	0.135
Point A- Sn (mm)	0.084
Is- U lip (mm)	0.110
Ii- L lip (mm)	0.053
Pog- Pog' (mm)	0.099
Z angle (°)	0.103

Table 3: Descriptive statistics for males

Variables	Mean	Std. deviation	Minimum	Maximum
Point A- N perp.(mm)	2.1	1.9	0.00	8.4
Pog - N perp.(mm)	-5.0	4.1	0.00	13.6
F.MPA (°)	27.3	4.4	18.0	37.0
F.A.A (°)	89.2	3.8	80.0	98.0
M.F.L (mm)	103.9	7.4	89.2	122.1
Mand.L (mm)	135.2	6.0	118.6	156.2
L.F.H (mm)	76.9	5.9	66.1	90.3
Ui- point A (mm)	6.5	6.3	2.6	10.5
Li- A-Pog (mm)	4.4	2.1	0.00	8.4
Li- M.P.A (°)	96.4	6.6	84.0	115.0
Ui- Pp (mm)	32.8	3.6	24.7	43.0
Um- Pp (mm)	28.3	3.0	23.1	36.7
Li- Mp (mm)	49.4	3.9	39.6	58.8
Lm- Mp (mm)	37.4	3.8	29.4	48.3
Nasolabial angle (°)	104.5	7.2	76.0	125.0
Ls to Sn-Pog' (mm)	5.3	2.2	0.53	10.5
Li to Sn-Pog' (mm)	4.2	2.0	0.00	8.9
M.L.S (mm)	6.0	1.4	2.1	9.4
Point A- Sn (mm)	18.4	2.8	12.6	25.2
Is- U lip (mm)	12.7	2.6	7.3	21.0
Ii- L lip (mm)	15.0	2.4	9.4	22.0
Pog- Pog' (mm)	13.1	2.8	6.3	18.9
Z angle (°)	75.3	7.4	60.0	95.0

Comparisons between Yemeni males and females

The comparisons between the two groups revealed that in general, the male dentofacial dimensions were larger than those of the females. Skeletally, the male group had a significantly ($P < 0.001$) larger

midfacial length (E.M.L), mandibular length (E. Man.L), and lower facial heights (L.F.H). Dentally, males had a larger lower incisor to mandibular plane angle (Li- MPA°) ($P < 0.01$), in addition to four linear measurements: upper incisor with upper molar to the palatal plane (Ui-Pp, Um-Pp), and lower incisor with lower molar to the mandibular plane (Li-Mp, Lm-Mp) ($P < 0.001$). Furthermore, males had a more protruded upper and lower lips (Ls to Sn-Pog', Li to Sn-Pog'), deeper mentolabial sulcus (M.L.S), larger dimensions of point A to subnasale (point A-Sn) ($P < 0.001$), upper lip to incision superioris (Is-U Lip), lower lip to incision inferioris (Ii- L Lip) ($P < 0.001$) and bony pogonion to soft tissue pogonion (Pog- Pog') ($P < 0.01$).

Discussion

The objective of this study was to describe the dentofacial morphology of Yemeni adults. It was conducted on a group of Yemeni adults who had Class I skeletal and dental relationships, good-balanced faces, and acceptable profiles. The data were analyzed according to gender to obtain more precise and specified normal cephalometric values.

Skeletal analysis

The use of A point, nasion, and B point (ANB) angle is sometimes uncertain,^[28] as it is affected by the anteroposterior position of the nasion and the vertical height of the face, to overcome this subject, McNamara (1984) has introduced the nasion perpendicular line to the Frankfort plane, to be used as a reference line for the evaluation of the position of the maxilla and the mandible relative to the cranial base.

The analysis in our study depends mainly on linear more than angular measurements, to assist in the treatment planning for orthodontic as well as orthognathic surgical cases.

Our data revealed that the maxillary position (point A) is slightly in front of the nasion perpendicular line. The mandibular position in relation to the cranial base, as evaluated by the (Pog-N perp.) and the facial axis angle, confirmed a retruded position on both males and females.

In the male group, the maxilla was more protrusive, whereas the mandible was more retrusive than in females. Thus, considering the skeletal facial convexity, Yemeni males have more convex profiles than females due to the retrognathic mandible rather than the prognathic maxilla. These results were similar to those of the Emirates,^[4] but disagreed with those of the Koreans.^[5]

Table 4: Descriptive statistics for females

Variables	Mean	Std. deviation	Minimum	Maximum
Point A- N perp.(mm)	1.9	1.5	0.00	5.2
Pog - N perp.(mm)	-3.7	3.4	0.00	11.5
F.MPA (°)	27.7	4.3	20.0	37.0
F.A.A (°)	88.8	3.8	79.0	95.0
M.F.L (mm)	96.7	7.6	85.0	120.7
Mand.L (mm)	124.8	6.7	91.3	151.2
L.F.H (mm)	70.5	5.8	58.8	84.0
Ui- point A (mm)	6.1	1.8	2.6	10.5
Li- A-Pog (mm)	4.0	2.2	0.00	9.4
Li- M.P.A (°)	93.1	5.0	85.0	112.0
Ui- Pp (mm)	31.0	3.5	24.1	37.8
Um- Pp (mm)	25.9	2.7	22.0	32.5
Li- Mp (mm)	44.2	4.1	33.6	52.5
Lm- Mp (mm)	33.4	3.9	25.2	47.2
Nasolabial angle (°)	103.6	8.2	76.0	130.0
Ls to Sn-Pog' (mm)	3.6	1.6	0.53	7.3
Li to Sn-Pog' (mm)	3.3	1.9	0.00	7.3
M.L.S (mm)	5.0	1.4	2.1	9.0
Point A- Sn (mm)	16.0	2.1	11.5	22.0
Is- U lip (mm)	9.9	2.0	6.3	14.7
li- L lip (mm)	12.6	2.3	3.1	18.9
Pog- Pog' (mm)	11.6	2.4	6.3	19.9
Z angle (°)	72.8	6.9	60.0	90.0

Similar findings were also observed among the Kuwaitis by Al-Jame,^[6] who stated a more convex profile due to the decreased chin protuberance and a steeper mandibular plane among adolescent Kuwaitis when compared to other norms.

The bimaxillary growth determined by the maxillary and mandibular positions in the studied sample showed significant gender differences when compared to the growth reported by Ayhan and coworkers among the Turkish.^[7] The averages established in the current study are larger than those reported among Turkish and Puerto Rican Americans.^[8] Furthermore, maxillary and mandibular sagittal lengths were significantly ($P < 0.001$) longer in Yemeni males than females. This jaw enlargement is equivalent to the bigger skulls of males.

Regarding the vertical dimension, Yemeni males had a tendency towards an increased vertical jaw relationship as indicated by significantly ($P < .001$) longer LFH. This concludes that males tend to be more dolichofacial than females. These results were near to those of the Egyptians,^[2] Emirates,^[4] and Koreans,^[5] who had a more tendency to vertical growth pattern (backward

Table 5: The comparison between Yemeni males and females

Variables	Yemeni males		Yemeni females		Significance
	Mean	SD	Mean	SD	
Skeletal relationship					
Point A- N perpendicular (mm)	2.1	1.9	1.9	1.5	NS
Pog - N perpendicular (mm)	-5.0	4.1	-3.7	3.4	NS
F.MPA (°)	27.3	4.4	27.7	4.3	NS
F.A.A (°)	89.2	3.8	88.8	3.8	NS
M.F.L (mm)	103.9	7.4	96.7	7.6	***
Mand.L (mm)	135.2	6.0	124.8	6.7	***
L.F.H (mm)	76.9	5.9	70.5	5.8	***
Dental relationship					
Ui- point A (mm)	6.5	6.3	6.1	1.8	NS
Li- A-Pog (mm)	4.4	2.1	4.0	2.2	NS
Li- MP.A (°)	96.4	6.6	93.1	5.0	**
Ui- Pp (mm)	32.8	3.6	31.0	3.5	*
Um- Pp (mm)	28.3	3.0	25.9	2.7	***
Li- Mp (mm)	49.4	3.9	44.2	4.1	***
Lm- Mp (mm)	37.4	3.8	33.4	3.9	***
Soft tissue relationship					
Nasolabial angle (°)	104.5	7.2	103.6	8.2	NS
Ls to Sn-Pog' (mm)	5.3	2.2	3.6	1.6	***
Li to Sn-Pog' (mm)	4.2	2.0	3.3	1.9	*
M.L.S (mm)	6.0	1.4	5.0	1.4	***
Point A- Sn (mm)	18.4	2.8	16.0	2.1	***
IS- U lip (mm)	12.7	2.6	9.9	2.0	***
li- L lip (mm)	15.0	2.4	12.6	2.3	***
Pog- Pog' (mm)	13.1	2.8	11.6	2.4	**
Z angle (°)	75.3	7.4	72.8	6.9	NS

* $P=0.05$, ** $P=0.01$, *** $P=0.001$, NS: Not significant

mandibular rotation) in males more than females, as shown by the increased angle between the Frankfort plane and mandibular plane (F.MPA) and LFH. This tendency toward a backward (clockwise) mandibular growth rotation is indicated by the increased vertical dimension and the reduced chin prominence in Yemenis.

Accordingly, the results of the current study further explained the tendency of males to be more dolichofacial than females. These outcomes also are in accordance with those of Bishara,^[9] who found larger values for males in the skeletal linear parameters describing the anterior and posterior faces of Iowa and Northern Mexico populations.

The differences between males and females were also indicated by Miyajima,^[10] who stated that in the Japanese population, there was a great skeletal difference between genders. Japanese women had a more vertically oriented facial axis angle, larger mandibular plane angles, and smaller midfacial lengths. Our study showed LFH values (males: 76.9 mm and females: 70.5 mm), which were relatively near to those of Daer among Yemeni subjects,^[23] (males: 77.9 mm and females: 69.4 mm).

The F.MPA of Yemeni males was slightly smaller than that of the Iranian males,^[11] whereas in females it was similar to that of the Iranian females.

Yemenis were found to have a larger LFH compared to the Omani sample^[29] and Mexican males^[12]; however, they had smaller LFH than those in the Turkish^[7] and Filipino^[13] females.

Dental analysis

Regarding dental measurements, Yemenis showed no significant gender differences in the position of upper and lower incisors, as indicated by the relationship of the maxillary and mandibular incisors to the A vertical and A-Pog lines, respectively. However, Yemeni males showed a more proclined lower incisors than females as shown by the increased (Li to M.P angle).

This increase in the proclination of lower incisors in Yemeni males could be explained as a compensatory position to the retrognathic mandible, to achieve functional occlusion. This gender dimorphism found between Yemenis, was also found between Omani subjects, who had a proclined lower incisors in females more than males.^[29] In contrast, gender dimorphism was not found in the dental measurements of both Anatolian Turkish and Japanese adults.^[7,10]

The angle measurement (Li- MPLA) in Yemeni females was relatively similar to that of the Iranian females,^[11] whereas it was smaller in Yemeni males (96.4) than that of the Iranian males (98).

The lower incisors in Yemeni adults and the upper incisors in Yemeni females were proclined and tipped forward which indicates dental bimaxillary protrusion. This outcome agrees with the findings of several Saudi studies.^[14,15]

The mean of the lower incisors to A-pogonion (lower incisors protrusion) in Yemenis was more than those of the Caucasians^[25] and Omani adults.^[29] This finding was also close to that reported by Swlerenga,^[12] who found that Mexican American males and females have a significantly more protruded mandibular incisors than those of black Americans or white children.

Considering the vertical measurements, the lower incisor with lower molar to the mandibular plane, and the upper incisor with upper molar to the palatal plane, in Yemeni subjects were similar to those of

the Caucasians.^[10,25] These vertical dental dimensions might be helpful in the determination of which teeth are related more to the discrepancies of the vertical dimension in open or deep bites.

Soft tissue analysis

Generally, the soft tissue followed the hard tissue structures. Nevertheless, despite the retruded chin bone (Pog) in males, their soft tissue chin (Pog') was more protruded than females, this could be due to an increased thickness of the overlying soft tissue. The chin thickness of Yemenis was nearly similar to that of Omani norms.^[29]

With regards to the appearance of the lips, upper and lower lips were more protrusive in Yemeni males than females. These findings were in agreement with the Emirate population.^[4] The lower lip of males was more protrusive, and this could be contributed to the more protruded lower incisors rather than the actual lip thickening.

Our data showed larger nasolabial angles than Saudi^[14] and Omani females,^[29] who had a more protruded lip than the Yemeni subjects of the current study.

Conclusion

- 1 Yemeni adults showed a reduced prominence of chin, an increased lower facial height, and a clockwise rotation of the mandible, resulting in a convex profile and a tendency to Class II facial pattern. Furthermore, Yemeni males exhibited a dental bimaxillary protrusion as indicated by the proclination of the upper and lower incisors
- 2 These cephalometric norms will ensure better diagnosis and treatment planning for Yemeni orthodontic patients.

Financial support and sponsorship

There were no any financial support from any other party.

Conflicts of interest

There are no conflicts of interest.

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