Pharyngeal airway volume and its relationship to the facial morphology in nasal breathing and mouth breathing subjects (A comparative computerized tomography study)

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ABSTRACT

Background: The value of lateral cephalometric radiographs to evaluate the pharyngeal airway is limited because it provided 2-dimensional (2D) images of complex 3-dimensional (3D) anatomic structures. Three dimensional analyses of the airway volumes are required to understand oral and pharyngeal adaptations in mouth breathing and nasal breathing subjects. The aim of this study was to measure the pharyngeal airway volume and the size of the face, then compare between pharyngeal airway volume in mouth breathing and nasal breathing subjects and find the gender difference in each group, also to study the relation between pharyngeal airway volume and the size of the face.

Material and Methods: Fifty patients including 28 males and 22 females with an age ranged between 18-35 years suffered from clinical symptoms of nasal obstruction and mouth breathing was detected by otolaryngologist and sent to be imaged by Brilliance™ 64, Philips multi-detector computed tomography. Twenty normal subjects (10 males and 10 females) were selected as control. Angular and linear variables were measured in addition to the size of the face and the pharyngeal airway volume.

Results: A statistically significant relationship between the pharyngeal airway volume and the mode of respiration and between pharyngeal airway volume and genders were detected. The pharyngeal airway volume was larger in nasal breathers than in mouth breathers and it was larger in males than in females. The size of the face was larger in males than females.

Conclusion: CT volumetric images provide more reliable and accurate information for measurement of the pharyngeal airway volume, so the changes in the pharyngeal airway volume can be studied before and after surgery and this will aid in selection of the best treatment option in addition to control the relapse after orthodontic treatment with mouth breathing patients.

Keyword: Pharyngeal airway volume, size of the face, mouth breathing, computerized tomography. (J Bagh Coll Dentistry 2014; 26(3):98-107).

INTRODUCTION

After more than a century of conjecture and heated argument, the orthodontic relevance of nasal obstruction and its assumed effect on facial growth continues to be debated. Oral respiration disrupts those muscle forces exerted by tongue, cheek and lips upon the maxillary arch. The main characteristics of the respiratory obstruction syndrome are mouth breathing, open-bite, cross-bite, excessive anterior face height, incompetent lip posture, excessive appearance of maxillary anterior teeth, narrow external nares and "V" shaped maxillary arch [1].

Cone-Beam Computed Tomography (CBCT) was developed in the 1990 as an evolutionary process resulting from the demand for 3-dimensional (3D) information obtained by conventional computed tomography (CT) scans [2].

The upper airway analysis, orthodontic and orthognathic surgical planning for patients with significant facial asymmetry has been increasingly performed based on 3D volumes [3-6].

Most previous studies of the pharyngeal airway, head posture, malocclusion, as well as facial morphology have been carried out using a two dimensional lateral cephalograms [7,8] .

Superimposition of the left and right images in the 2D plane projection of a three-dimensional (3D) structure leads to errors and the left-to-right width of the upper airway is not visible in 2D film. For these reasons, it is difficult to obtain precise volume of the pharyngeal airway and to reproduce the soft tissue structures accurately from lateral cephalograms alone [9,10].

CBCT provides 3D-reconstructed image from multiple sequential planar projection images. It is possible to visualize sites of interest by adjusting the image orientation and rotation. CBCT has different gray-level intensities that allow visualization of soft tissue as well as hard tissue with different tissue densities. It also allows visualization of internal anatomic structures such as the airway independently by eliminating external structures [11,12]. Furthermore, CBCT allows linear, angular, and planar as well as volumetric analyses [13].

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MATERIALS AND METHODS

Sample

The sample is composed of CT images for Iraqi adult patients who were attending Al-Sader medical city in Al-Najaf governorate- ENT department from March 2013 till August 2013.

Only 50 subjects out of 427 individuals (28 males and 22 females with an age ranged between 18-35years were selected when met a special criteria. They sent by otolaryngologist specialist with a special sending request to the Al-Furat center for neuromedicine science / Computerized Tomography department because of clinical symptoms of nasal obstruction and mouth breathing to be imaged by high resolution computerized tomography scanning of the paranasal sinuses that extended to hyoid bone to visualize pharyngeal air way space.

The control group was 20 subjects out of 98 in the same age group and also had been examined and identified by the otolaryngologist specialist in Al-Sader medical city as having no nasal obstruction, All the control group had class I molar relationship according to Angle's classification and class I canine relationship. Also they were class I skeletally through the clinical examination was determined by two fingers method [14].

Method

Each patient attained to the otolaryngology consultant clinic examined by the otolaryngologist specialist to include or exclude any nasal obstruction. This was done by the same otolaryngologist specialist by using head mirror, speculum and flexible nasofibroscopy.

The orthodontist asked each subject about name, age, origin, nationality, occupation, address, past medical history, family history and past dental history. Each patient from the control group was examined to diagnose the skeletal relationship of the upper and lower jaws and the molar and canine relationship. Each patient had a written request with appropriate clinical history. The patients were informed about the study and consent to participate in this study was taken. The chronological age was determined accurately by the period from the birth date to the radiographic exposure date. All these information were documented in formulated case sheet, then a clinical examination was executed to confirm the special sample criteria.

Mouth or nose breathing is recorded subjectively by holding a cold dental mirror in front of the nose and mouth as the patient sits in relaxed position to observe a misting pattern on a cold surface of dental mirror [15]. Then the patients were sent with a written request to the CT scan department to taking CT scan image. During that, the subject was asked to swallow to bring the dentitions into maximum interdigitation, informed not to move his head to either side and to cut breathing and swallowing during the acquisition to minimize measurement errors.

After that, a topogram and a lateral view of the head show the vertex to the 4th cervical vertebrae was obtained and followed by selecting the desired scan range of the sinuses.

Angular Measurements

The following angular measurements were done on 2D cephalogram [16]:

- SNA: Anteroposterior position of maxilla in relation to the anterior cranial base.
- SNB: Anteroposterior position of mandible in relation to the anterior cranial base.
- ANB: Relative anteroposterior position of the maxilla to the mandible.
- Saddle angle (N-S-Ar): The Angle between the anterior &posterior cranial base.

Size of the Face

The size of the face was established from the P-A and lateral synthetic cephalograms as a rectangular prism encompassing the facial bones. (A) with edges as cube, (B) the bizygomatic width projected on x-axis, (C) the N-Me distance projected on the y-axis and (D) the Ba-ANS distance projected on the z-axis [18] (Figure1).

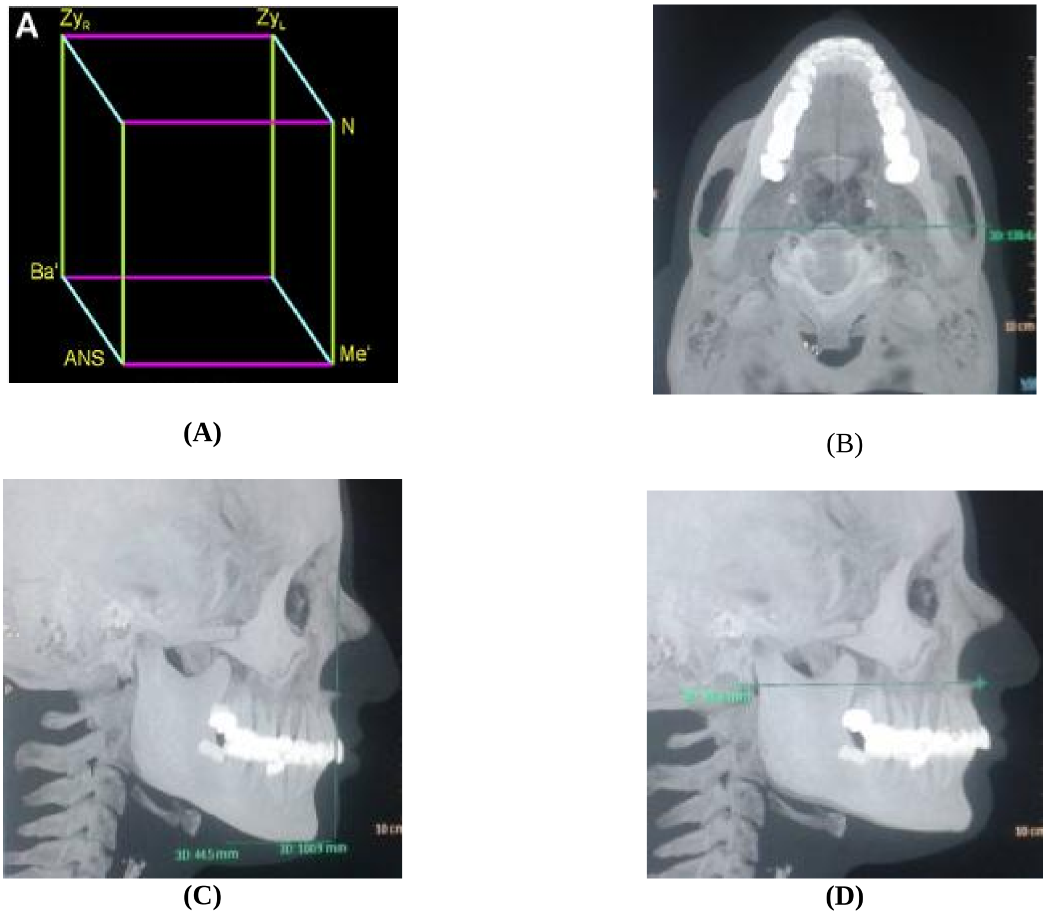

Figure 1: Establishment the size of the face

Three dimensional Model of the pharyngeal Airway volume

The limits for airway analysis are [4]:

- Anterior: a vertical plane through posterior nasal spine perpendicular to the sagittal plane at the lowest border of the vomer.
- Posterior: the posterior wall of the pharynx.
- Lateral: the lateral walls of the pharynx, including the full extensions of the lateral projections.
- Lower: a plane tangent to the most caudal medial projection of the third cervical vertebra perpendicular to the sagittal plane.
- Upper: the highest point of the nasopharynx, coinciding with the posterior choanae and consistent with the anterior limit.

Once segmented, airways were refined to obtain the true shape of the airway by eliminating the projections that did not belong to the airway then the volumes were measured in cm^3 with the measuring tool (Figure 2).

Figure 2: Three dimensional Model of the pharyngeal Airway volume

RESULTS

Angular measurements

The mean differences between males and females nasal breather subjects expressed significant difference in SNA and SNB, female higher than male (Table 1).

There are No significant correlation between Pharyngeal Airway volume & the angular measurements in both groups and gender except in female mouth breather that show significant correlation in SNA and ANB angle (Table 6).

Linear measurements

The mean differences between males and females nasal breather subjects expressed significant differences between genders in Bi-zygomatic width, Ba-ANS ,N-Me and UAFH, male higher than female (Table 1) .

The mean differences between males and females mouth breather subjects expressed significant differences between genders in Bi-zygomatic width, Ba-ANS, N-Me, UAFH and LAFH, male higher than female (Table 2).

The mean differences between nasal and mouth breather male subjects expressed significant differences in N-Me and LAFH, Mouth breather higher than Nasal breather, (Table 3).

The mean differences between nasal and mouth breather female subjects expressed significant differences in LAFH, Mouth breather higher than Nasal breather (Table 4).

The mean differences between nasal and mouth breather total sample expressed significant differences between two groups in N-Me, UAFH and LAFH. It was shown that mouth breathers are higher than nasal breather in N-me and LAFH and nasal breathers are higher than mouth breathers in UAFH, (Table 5).

There are significant correlation between Pharyngeal Airway & the linear measurements in both groups and gender (Table 6).

Size of the face

The mean differences between males and females nasal breather subjects expressed highly significant differences between genders in the size of the face, male higher than female (Table 1) .

The mean differences between males and females mouth breather subjects expressed highly significant differences between genders in the size of the face, male higher than female (Table 2).

The mean differences between nasal and mouth breather male subjects expressed significant differences in the size of the face, Mouth breather higher than Nasal breather (Table 3).

There are significant correlation between pharyngeal airway & size of the face in male nasal and mouth breather and in the total sample (Table 6).

Pharyngeal Air way Volume

The mean differences between males and females nasal breather subjects expressed highly significant differences in Pharyngeal Air way Volume, male higher than female (Table 1) .

The mean differences between males and females mouth breather subjects expressed significant differences between genders in Pharyngeal Air way Volume, male higher than female (Table 2).

The mean differences between nasal and mouth breather male subjects expressed significant differences in Pharyngeal Air way volume Nasal breather higher than Mouth breather (Table 3)

The mean differences between nasal and mouth breather female subjects expressed significant differences in Pharyngeal Air way volume, Nasal breather higher than Mouth breather (Table 4).

The mean differences between nasal & mouth breather total sample expressed significant differences in Pharyngeal Air way volume, Nasal breather higher than Mouth breather (Table 5).

DISCUSSION

Angular measurements

For the SNA and SNB angles, the female nasal breathers had a higher value than male nasal breathers. The SNA angle was highly significant at $P < 0.006$ and the SNB angle was significant at $P < 0.029$. The possible difference in the mean of SNA between males and females is the more anterior position of point N in males than females. The anterior position of point N in males was reported by previous studies [17,18].

The results expressed no significant genders differences in mouth breathers also there were no significant differences between nasal and mouth breathers. This result is in agreement with previous studies that concern with the relationship between facial prognathism and respiratory resistance and found no correlation between nasal respiratory resistance and SNA or SNB angles [19,20]. Since the maxilla is a fixed bone and attached to two cranial bones (frontal and ethmoid bones) and seven facial bones (nasal, zygoma, lacrimal, inferior turbinate, palate, vomer and it fellow on the opposite side). The effect of muscular imbalance on the maxilla is decreased [21].

The result disagrees with the finding of Sassouni *et al.* study that found the reduction in airway space will be associated with retrognathic maxilla [22].

The result showed no significant differences between genders in ANB angle in nasal breather

& mouth breather group. This comes in agreement with Trask *et al.* study [23]. Also the result is in agreement with a Solow *et al.* study that found no significant correlation between airway adequacy and maxillary prognathism [24].

On the other hand, the reduction of the nasopharyngeal airway has no effect on the sagittal jaw relationship. This result agrees with previous studies [19,25,26]. The most probable explanation is that reduced nasopharyngeal airway and the possible subsequent mouth breathing affect both jaw, thus the ANB angle is not affected. But the result disagrees with Ung *et al.* who found that ANB angle had a higher value in the nasally obstructed sample than the normal group [27].

Regarding the saddle angle, there was no significant gender difference in nasal and mouth breathers; this result agrees with Ali [28] and Al-Sahaf [29].

Linear measurements

Males and females nasal breather and mouth breather results expressed significant gender differences in Bi-zygomatic width, Ba-ANS, N-Me, UAFH and LAFH being males higher than females. These results indicated that the males possessed larger facial dimensions than females. This finding was supported by Al-Sahaf who found significant gender differences in all dimensional measurement and in all skeletal classes [29].

There are significant differences between nasal breather & mouth breather group in N-Me, UAFH and LAFH, Nasal breather higher than Mouth breather in UAFH, Mouth breather higher than Nasal breather in N-Me and LAFH.

For the facial height the results showed that for the UAFH for the nasal breather group had a higher mean than mouth breather groups in which it was significant at $P < 0.002$ for the comparison between nasal breather and mouth breather group; this comes in agreement with Kesso that found the UAFH for the nasal breather group had a higher mean than the mouth breather group [30]. But this result disagreement with Trask *et al.* who found no difference in upper facial height between long faces and control subjects [31]

For the LAFH and total AFH, the mean was higher for the mouth breather group than in the nasal breather group. This may be due to the backward rotation of the mandible [31,32].

On the other hand, the present result comes in agreement with Kesso, Tourne and Zain Al-Abedin who found an increase in the lower facial height [30,33,34]

The higher mean value of these measurements in mouth breather group subjects is more than that in nasal breather group may be due to the fact that the increased mandibular plane and maxilla-mandibular planes angles in mouth breathing subject lead to increase in AFH and LFH [16].

The finding of this study disagrees with Martin *et al.* who reported that a lack of a consistent relationship between nasal resistance and dentofacial morphology [35].

Theoretically, the maintenance of vital pharyngeal airway necessitates lowering of the tongue, the soft palate and the mandible. This brings for the dorsal rotation of the mandible or at least ramus resulting in increasing anterior facial height [36]. The prolonged buccal respiration is followed by increase in extrusion of the posterior teeth causing increased anterior facial height [37].

Size of the face

The size of the face was established as a rectangular prism encompassing the facial bones. The average size of the face was statistically significantly larger in the males than in the females. The size of the face was significantly correlated with gender. These result come in agreement with Al-Sahaf, Trenouth et al. and Genecov et al. [29,38,39].

Pharyngeal airway volume was significantly correlated with face size. Subjects with larger faces would be expected to have larger airway volumes and this comes in agreement with Gruer *et al.* [4].

Pharyngeal air way volume

There was significant gender difference in both groups being males had higher mean values than females. Linder-Aronson and Leighton and Martin *et al.* found sexual dimorphism during growth of the posterior wall of the pharynx [40,41].

Airway volume differed significantly for male and female being the female volume smaller which came in agreement with Gruer *et al.* [4].

The mean volume of the pharyngeal airway in males, females and total sample was higher in nasal breathers than mouth breathers. The mean of the pharyngeal airway volume in nasal breather was 20.4 cm^3 and the mean of the pharyngeal airway volume in mouth breather was 15.9 cm^3. This result comes in agreement with Vandana *et al.* [42].

It is quite likely that 3-D images of the airway will allow an improved evaluation of sites of airway obstruction and an improved understanding of the physiologic response to pharyngeal stenosis. It already is possible to use the cranial base surface to superimpose 3-D models for different time points within the same patient, so that changes in airway volume and orientation relative to this stable reference can be studied before and after surgery [43].

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Table 1: Descriptive statistics and genders difference in nasal breathers group

Variables		Genders	Descriptive statistics				Gender difference	
			N	**Mean**	**S.D.**	**S.E.**	**t-test**	**p-value**
Angular measurements (°)	**SNA**	Males	10	83.70	1.25	0.40	-3.111	0.006 (HS)
		Females	10	85.90	1.85	0.59		
		Total	20	84.80	1.91	0.43		
	SNB	Males	10	80.80	1.75	0.55	-2.368	0.029 (S)
		Females	10	82.60	1.65	0.52		
		Total	20	81.70	1.89	0.42		
	ANB	Males	10	2.90	0.88	0.28	-1.144	0.268 (NS)
		Females	10	3.30	0.67	0.21		
		Total	20	3.10	0.79	0.18		
	Saddle angle	Males	10	119	3.65	1.15	0	1 (NS)
		Females	10	119	4.71	1.49		
		Total	20	119	4.10	0.92		
Linear measurements (mm.)	**Bi-zygomatic width**	Males	10	126.74	5.97	1.89	3.251	0.004 (HS)
		Females	10	119.32	4.06	1.28		
		Total	20	123.03	6.26	1.40		
	Ba-ANS	Males	10	98.63	4.89	1.55	2.606	0.018 (S)
		Females	10	93.03	4.72	1.49		
		Total	20	95.83	5.49	1.23		
	N-Me	Males	10	115.50	6.19	1.96	2.383	0.028 (S)
		Females	10	109.11	5.79	1.83		
		Total	20	112.31	6.69	1.50		
	UAFH	Males	10	56.49	3.30	1.04	2.742	0.013 (S)
		Females	10	52.95	2.40	0.76		
		Total	20	54.72	3.35	0.75		
	LAFH	Males	10	59.01	3.39	1.07	1.803	0.088 (NS)
		Females	10	56.16	3.67	1.16		
		Total	20	57.59	3.74	0.84		
Size (cm^3)	**Size of the face**	Males	10	1450.93	188.11	59.49	3.230	0.005 (HS)
		Females	10	1213.82	136.01	43.01		
		Total	20	1332.38	200.79	44.89		
Volume (cm^3)	**PA**	Males	10	22.49	2.88	0.91	4.436	0.000 (HS)
		Females	10	18.30	0.77	0.24		
		Total	20	20.40	2.97	0.67		

Table 2: Descriptive statistics and genders difference in mouth breathers group

Variables		Genders	Descriptive statistics				Gender difference	
			N	Mean	S.D.	S.E.	t-test	p-value
Angular measurements (°)	SNA	Males	28	85.68	3.01	0.57	0.634	0.529 (NS)
		Females	22	85.14	3.00	0.64		
		Total	50	85.44	2.98	0.42		
	SNB	Males	28	81.86	3.03	0.57	-0.067	0.947 (NS)
		Females	22	81.91	2.31	0.49		
		Total	50	81.88	2.71	0.38		
	ANB	Males	28	3.82	2.92	0.55	0.687	0.495 (NS)
		Females	22	3.23	3.18	0.68		
		Total	50	3.56	3.02	0.43		
	Saddle angle	Males	28	118.04	4.44	0.84	0.444	0.659 (NS)
		Females	22	117.50	3.96	0.84		
		Total	50	117.80	4.20	0.59		
Linear measurements (mm.)	Bi-zygomatic width	Males	28	128.87	6.11	1.15	5.882	0.000 (HS)
		Females	22	119.44	4.94	1.05		
		Total	50	124.72	7.31	1.03		
	Ba-ANS	Males	28	100.15	4.90	0.93	8.009	0.000 (HS)
		Females	22	88.87	5.00	1.07		
		Total	50	95.19	7.48	1.06		
	N-Me	Males	28	123.93	8.21	1.55	5.550	0.000 (HS)
		Females	22	112.33	6.03	1.29		
		Total	50	118.83	9.30	1.32		
	UAFH	Males	28	53.08	4.18	0.79	3.854	0.000 (HS)
		Females	22	49.14	2.64	0.56		
		Total	50	51.34	4.07	0.58		
	LAFH	Males	28	70.86	6.55	1.24	4.464	0.000 (HS)
		Females	22	63.17	5.33	1.14		
		Total	50	67.47	7.12	1.01		
Size (cm^3)	Size of the face	Males	28	1599.85	151.32	28.59	9.533	0.000 (HS)
		Females	22	1196.23	145.06	30.93		
		Total	50	1422.26	250.19	35.38		
Volume (cm^3)	PA	Males	28	17.40	5.61	1.06	2.614	0.012 (S)
		Females	22	14.04	2.45	0.52		
		Total	50	15.92	4.77	0.67		

Table 3: Descriptive statistics and group difference in male group

Variables		Groups	Descriptive statistics				Group difference	
			N	Mean	S.D.	S.E.	t-test	p-value
Angular measurements (°)	SNA	NB	10	83.70	1.25	0.40	-2.005	0.052 (NS)
		MB	28	85.68	3.01	0.57		
	SNB	NB	10	80.80	1.75	0.55	-1.038	0.306 (NS)
		MB	28	81.86	3.03	0.57		
	ANB	NB	10	2.90	0.88	0.28	-0.975	0.336 (NS)
		MB	28	3.82	2.92	0.55		
	Saddle angle	NB	10	119.00	3.65	1.15	0.615	0.543 (NS)
		MB	28	118.04	4.44	0.84		
Linear measurements (mm.)	Bi-zygomatic width	NB	10	126.74	5.97	1.89	-0.953	0.347 (NS)
		MB	28	128.87	6.11	1.15		
	Ba-ANS	NB	10	98.63	4.89	1.55	-0.842	0.405 (NS)
		MB	28	100.15	4.90	0.93		
	N-Me	NB	10	115.50	6.19	1.96	-2.952	0.006 (HS)
		MB	28	123.93	8.21	1.55		
	UAFH	NB	10	56.49	3.30	1.04	2.327	0.026 (S)
		MB	28	53.08	4.18	0.79		
	LAFH	NB	10	59.01	3.39	1.07	-5.435	0.000 (HS)
		MB	28	70.86	6.55	1.24		
Size (cm^3)	Size of the face	NB	10	1450.93	188.11	59.49	-2.506	0.017 (S)
		MB	28	1599.85	151.32	28.59		
Volume (cm^3)	PA	NB	10	22.49	2.88	0.91	2.727	0.010 (HS)
		MB	28	17.40	5.61	1.06		

Table 4: Descriptive statistics and group difference in female group

Variables		Groups	Descriptive statistics				Group difference	
			N	Mean	S.D.	S.E.	t-test	p-value
Angular measurements (°)	SNA	NB	10	85.90	1.85	0.59	0.740	0.465 (NS)
		MB	22	85.14	3.00	0.64		
	SNB	NB	10	82.60	1.65	0.52	0.850	0.402 (NS)
		MB	22	81.91	2.31	0.49		
	ANB	NB	10	3.30	0.67	0.21	0.071	0.944 (NS)
		MB	22	3.23	3.18	0.68		
	Saddle angle	NB	10	119.00	4.71	1.49	0.936	0.357 (NS)
		MB	22	117.50	3.96	0.84		
Linear measurements (mm.)	Bi-zygomatic width	NB	10	119.32	4.06	1.28	-0.068	0.947 (NS)
		MB	22	119.44	4.94	1.05		
	Ba-ANS	NB	10	93.03	4.72	1.49	2.221	0.034 (S)
		MB	22	88.87	5.00	1.07		
	N-Me	NB	10	109.11	5.79	1.83	-1.417	0.167 (NS)
		MB	22	112.33	6.03	1.29		
	UAFH	NB	10	52.95	2.40	0.76	3.886	0.001 (HS)
		MB	22	49.14	2.64	0.56		
	LAFH	NB	10	56.16	3.67	1.16	-3.753	0.001 (HS)
		MB	22	63.17	5.33	1.14		
Size (cm^3)	Size of the face	NB	10	1213.82	136.01	43.01	0.324	0.748 (NS)
		MB	22	1196.23	145.06	30.93		
Volume (cm^3)	PA	NB	10	18.30	0.77	0.24	5.337	0.000 (HS)
		MB	22	14.04	2.45	0.52		

Table 5: Descriptive statistics and group difference in total sample

Variables		Groups	Descriptive statistics N	Mean	S.D.	S.E.	Group difference t-test	p-value
Angular measurements (º)	SNA	NB	20	84.80	1.91	0.43	-0.887	0.378 (NS)
		MB	50	85.44	2.98	0.42		
	SNB	NB	20	81.70	1.89	0.42	-0.271	0.787 (NS)
		MB	50	81.88	2.71	0.38		
	ANB	NB	20	3.10	0.79	0.18	-0.670	0.505 (NS)
		MB	50	3.56	3.02	0.43		
	Saddle angle	NB	20	119.00	4.10	0.92	1.086	0.281 (NS)
		MB	50	117.80	4.20	0.59		
Linear measurements (mm.)	Bi-zygomatic width	NB	20	123.03	6.26	1.40	-0.910	0.366 (NS)
		MB	50	124.72	7.31	1.03		
	Ba-ANS	NB	20	95.83	5.49	1.23	0.349	0.728 (NS)
		MB	50	95.19	7.48	1.06		
	N-Me	NB	20	112.31	6.69	1.50	-2.849	0.006 (HS)
		MB	50	118.83	9.30	1.32		
	UAFH	NB	20	54.72	3.35	0.75	3.290	0.002 (HS)
		MB	50	51.34	4.07	0.58		
	LAFH	NB	20	57.59	3.74	0.84	-5.879	0.000 (HS)
		MB	50	67.47	7.12	1.01		
Size (cm^3)	Size of the face	NB	20	1332.38	200.79	44.89	-1.431	0.157 (NS)
		MB	50	1422.26	250.19	35.38		
Volume (cm^3)	PA	NB	20	20.40	2.97	0.67	3.894	0.000 (HS)
		MB	50	15.92	4.77	0.67		

Table 6: Correlation between PA and other variables in both groups and genders

Variables			NB Males	NB Females	NB Total	MB Males	MB Females	MB Total
Angular measurements (º)	SNA	r	0.156	0.317	-0.342	-0.359	0.509	-0.090
		p-value	0.667 (NS)	0.372 (NS)	0.140 (NS)	0.061 (NS)	0.016 (S)	0.536 (NS)
	SNB	r	0.312	0.383	-0.179	-0.053	-0.093	-0.059
		p-value	0.380 (NS)	0.274 (NS)	0.451 (NS)	0.790 (NS)	0.681 (NS)	0.684 (NS)
	ANB	r	-0.401	-0.064	-0.399	-0.315	0.547	-0.036
		p-value	0.251(NS)	0.861(NS)	0.081 (NS)	0.103 (NS)	0.008 (HS)	0.806 (NS)
	Saddle angle	r	-0.188	-0.213	-0.107	-0.095	0.177	-0.006
		p-value	0.603 (NS)	0.555 (NS)	0.654 (NS)	0.630 (NS)	0.432 (NS)	0.967 (NS)
Linear measurements (mm.)	Bi-zygomatic width	r	0.971	0.484	0.903	0.402	-0.129	0.427
		p-value	0.000 (HS)	0.157 (NS)	0.000 (HS)	0.034 (S)	0.567 (NS)	0.002 (HS)
	Ba-ANS	r	0.626	0.558	0.694	0.113	0.490	0.387
		p-value	0.053 (NS)	0.094 (NS)	0.001 (HS)	0.568 (NS)	0.021(S)	0.006 (HS)
	N-Me	r	0.761	-0.147	0.661	0.232	0.134	0.373
		p-value	0.011 (S)	0.685 (NS)	0.001 (HS)	0.235 (NS)	0.552 (NS)	0.008 (HS)
	UAFH	r	0.546	-0.172	0.625	0.311	0.570	0.460
		p-value	0.103 (NS)	0.636 (NS)	0.003 (HS)	0.108 (NS)	0.006 (HS)	0.001 (HS)
	LAFH	r	0.858	-0.120	0.625	0.092	-0.130	0.224
		p-value	0.002 (HS)	0.741 (NS)	0.003 (HS)	0.643 (NS)	0.565 (NS)	0.117 (NS)
Size (cm^3)	Size of the face	r	0.880	0.349	0.846	0.407	0.238	0.476
		p-value	0.001 (HS)	0.323 (NS)	0.000 (HS)	0.032 (S)	0.286 (NS)	0.000 (HS)

$P > 0.05$ Non-significant , $0.05 \geq P > 0.01$ Significant , $P \leq 0.01$ Highly significant