The frontal sinus dimensions in mouth and nasal breathers in Iraqi adult subjects

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ABSTRACT

Background: The frontal sinus area can be used as a diagnostic aid to recognize mouth breather subjects. The aims of this study were to determine the gender difference in each group, to compare the frontal sinus area between mouth breather and nasal breather group, and to verify the presence of correlation between the frontal sinus area and the cephalometric skeletal measurements used in this study.

Materials and Methods: Cephalometric radiographs were taken for 60 adults (30 mouth breathers and 30 nasal breathers) age range (18-25), for each group 15 males and 15 females, in the orthodontic clinic in the college of Dentistry at Baghdad University. The control group (nasal breather) with skeletal class I and ANB angle ranged between 2-4°, and have clinically class I occlusion. The cephalometric measurement for each group were taken, the cephalometric radiographs were analyzed by using AutoCAD 2007 program.

Results and Conclusions: In comparison to nasal breather the mouth breather has larger Gonial angle giving a tendency to posterior rotation with growth of the mandible. The mouth breather has less maxillary length than the nasal breather. No effect of gender in mouth breather on gonial, SNA and SNB angles, no effect of gender in nasal breather on gonial angle, while the other cephalometric measurements were higher in males than females in each group. The mouth breather showed more anteroposterior extent of anterior cranial base; also the mouth breather show an increase in all facial height than the nasal breathers, the frontal sinus area is smaller in mouth breather than in nasal breather. The frontal sinus area showed correlation for both groups (Mouth and nasal breather) with maxillary Length, mandibular length, ramal length, S-N length, TAFH, UAFH, LAFH, TPFH, LPFH, and UPFH. There is only correlation of frontal sinus with the SNA and SNB angles in nasal breather and no significant correlation for both groups with the gonial angle.

Keywords: Frontal sinus, Nasal breather, Mouth breathers. (J Bagh Coll Dentistry 2013; 25(2):155-163).

INTRODUCTION

Paranasal sinuses are filled spaces in the skull. These are subjected to individual variation and their X-ray appearance also depends on the degree of pneumatization. So we have frontal sinus, sphenoidal sinus, ethmoidal air cells, maxillary sinus, and nasopharyngeal space [(1)]. The frontal sinus bud is present at birth in the ethmoid region but is not evident radiographically until the fifth year, when it projects above the orbital rim [(2)]. Rossouw et al have investigated the correlation between the frontal sinus size and mandibular growth prediction in subjects with class I and III malocclusions. They concluded that the frontal sinus is a valuable indicator of excessive mandibular growth [(3)].

Rapid growth of the sinuses continues until the age of 12 years, when they reach nearly adult size [(4)].

In a recent cephalometric investigation that used lateral head films, it was found that the frontal sinus development showed a growth rhythm similar to body height development, with a well-defined pubertal peak [(5)].

Mouth breather subjects had tendency to possess skeletal class II pattern with retruded mandible, more retrognathic facial type and more vertical growth [(6)].

Complete occlusion of one or both nasal passages occurs when unilateral or bilateral choanal atresia is present [(7-9)]. The habit of breathing primarily through the oral cavity is named mouth breathing, which traditionally has been associated with some detrimental dentofacial changes and associated malocclusion [(10)].

The frontal sinus enlargement has not been completely under stood. Individual differences in the growth and desorption processes of the mucosa [(11)], the quality of the frontal bone which is to be pneumatized [(12)], the pressure of growing brain on the internal lamina of the frontal sinus area [(13)], the various pressure and hydrodynamic conditions of the end cranium of affecting the blood supply of the frontal sinus area [(14)], and hereditary factor [(15)].

Few researches were done on Iraqi sample to study the frontal sinus. Al-Bustani studied the frontal sinus and skeletal jaw relation in Iraqi Cl I, Cl II and Cl III individuals [(16)].

The aims of the present cephalometric study were to determine the gender difference in each group mouth and nasal breather, to compare the frontal sinus area between mouth breather and

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nasal breather group, and to correlate the frontal sinus area with other cephalometric skeletal measurements in each group subjects.

MATERIALS AND METHODS

Sample

pretreatment lateral cephalograms were taken of 60 untreated subjects (age 18-25 years old), 30 mouth breather patients (study samples) who was selected from patients who attended the center of ear, nose, throat, head and neck surgery in specialized surgery hospital in Baghdad and 30 adult Class I (control sample) who were selected from patients who attended the orthodontic clinic in the orthodontic department at the college of dentistry, University of Baghdad. The mouth breather group was examined by ENT specialist as having nasal obstruction or habitual mouth breather. The control group was examined by ENT specialist as they were nasal breather, skeletal class I clinically and radio graphically (ANB, 2-4°), they have class I occlusion by Foster method [17-20].

The patients should meet the following criteria, all the sample individuals should have full set of teeth except the wisdoms [21], the entire sample was of Iraqi Arab in origin, all had no previous orthodontic treatment, no previous orthodontic surgery, no history of thumb or digit sucking, no facial deformity and trauma, no any projection errors of radiograph and any other radiographic error such as blurred image, and no history of tonsillectomy or adenoidectomy or any other oral, nose and throat surgery.

- **The instruments include:** Kidney dish, dental mirrors, and sterilizer (Memmert, Germany)
- **The equipment include:** The X-Ray unit (The Planmeca pro Max X-Ray unit) and analyzing Equipment (Dell portable computer and analyzing software (AutoCAD 2007).

Method

Each individual was examined clinically and subjected to the digital true lateral cephalometric radiograph. The individual was positioned within the cephalostat with the sagittal plane of the head vertical, the Frankfort plane horizontal, the teeth were in centric occlusion, and the patient in rest head position. Every lateral cephalometric radiograph was analyzed by AutoCAD program 2007 to calculate the angular, linear, and area measurements. Once the picture was imported to the AutoCAD program, it appeared in the master sheet on which the points and planes were determined, and then the measurements were obtained. The angles were measured directly as they were not affected by magnification while the linear measurement was divided by scale for each picture to overcome the magnification.

Cephalometric landmarks, planes and angles (Figure 1)

Cephalometric landmarks

1. **Point S (Sella):** The midpoint of the hypophysial fossa [1].
2. **Point N (Nasion):** The most anterior point on the nasofrontal suture in the median plane [1].
3. **Point A (Subspinale):** the deepest midline point in the curved bony outline from the base to the alveolar process of the maxilla [1].
4. **Point B (Supramentale):** The most posterior point in the outer contour of the mandibular alveolar process in the median plane [1].
5. **Point Me (Menton):** the most caudal point in the outline of the symphysis [1].
6. **Point Go (Gonion):** A constructed point, the intersection of the lines tangent to the posterior margin of the ascending ramus and the mandibular base [1].
7. **Point ANS (Anterior nasal spine):** It is the tip of the bony anterior nasal spine in the median plane [1].
8. **Point PNS (posterior nasal spine):** This is a constructed radiological point, the intersection of a continuation of the anterior wall of the pterygopalatine fossa and the floor of the nose. It marks the dorsal limit of the maxilla [1].
9. **Point Ar (Articulare):** The point of intersection of the posterior margin of the ascending ramus and the outer margin of the cranial base [1].

Cephalometric planes and linear measurements (Figure 2)

1. **Sella-nasion (SN) plane:** It is the antero posterior extent of anterior cranial base [1,21].
2. **Maxillary base length:** represents the extent of the maxillary base or it is a maxillary base length ANS-PNS [1].
3. **Mandibular base length:** It represents the extent of mandibular base. The distance from gonion to the menton [1].
4. **Ramus length:** This is represented by the distance gonion to articulare [1].
5. **Total anterior facial height (AFH):** It is the shortest distance between nasion and menton [21-23].
6. **Upper anterior facial height (UAFH):** The distance from nasion to anterior nasal spine [21,24,25].

7. **Lower anterior facial height (LAFH):** The shortest distance between anterior nasal spine and menton [1, 22-23].
8. **Total posterior facial height (PFH):** The shortest distance between sella and gonion [22].
9. **Upper posterior facial height (UPFH):** Formed by a line joining sella and posterior nasal spine [26,27].
10. **Lower posterior facial height (LPFH):** Formed by a line joining posterior nasal spine and gonion [27].

Angular measurements (Figure 2):

1. **Gonial angle (Ar-Go-Me):** The angle formed between the posterior border of the ramus and the mandibular plane [1].
2. **SNA angle:** The angle between lines S-N and N-A. It represents the angular antero-posterior position of the maxilla to the anterior cranial base [28, 29].
3. **SNB angle:** The angle between lines S-N and N-B. It is the most commonly used measument for appraising antero-posterior disharmony of the jaw , it represents the antero-posterior position of the mandible in relation to anterior cranial base [28, 29].

The frontal sinus area (mm^2) (Figure 2)

The peripheral border of the frontal sinus was traced [5].

Statistical analysis

All the data of the sample were subjected to computerized statistical analysis using SPSS version 15 (2006) computer program. The statistical analysis included:

1. Descriptive Statistics: Mean, standard deviation (SD), and the statistical table.
2. Inferential statistics: Independent samples- t-test: for the comparison between both groups and gender differences, and Pearson's correlation test to test the correlation between frontal sinus area and the cephalometric variables that are used in this study.

RESULTS AND DISCUSSION

The sample in this study was selected aged between 18 and 25 years old to minimize the effect of any remaining skeletal growth [30], and to get sample with complete frontal sinus growth [4] as the majority of facial growth is usually completed by 16-17 years of age [31].

Table (1) showed the descriptive statistic (mean and SD) in mouth breather group and the gender differences using the t-test, there was no significant difference between male and female in mouth breather group in the mean value of GA , SNA and SNB angles, which indicates that there is no effect of the gender in mouth breather on the direction of the growth of the mandible which represented by GA, and no effect of the gender in mouth breather group on the anteroposterior relation of the maxilla and the mandible to the anterior cranial base, this finding disagrees with Al-Labban [6] who found that the SNAº was higher in males for both mouth breather and nasal breather group than in females. Our result agrees with Watson et al [32] who found that the magnitude of nasal resistance and subject's anterior-posterior skeletal classification were independent from one to other.

Table (2) showed the descriptive statistics (mean and standard deviation) in nasal breather group and the gender difference, there is very high significant gender difference in all cephalometric measurements (except in the Gonial angle), so the mean value of all cephalometric measurement were higher in males than in females due to the fact that males had larger facial dimensions than females[6], the Gonial angle show no significant gender difference indicates that there is no effect of the gender in nasal breather on the direction of the growth of the mandible which represented by the GA.

So the mean value of SNA and SNBº were higher in males of both group than in females this result agrees with Watson et al [32] who found that the magnitude of nasal resistance and subject's anterior-posterior skeletal classification were independent from one to other.

Table (3) showed the comparison between nasal breather and mouth breather group.

Frontal sinus: There is very high significant difference in frontal sinus area measurement between nasal breather and mouth breather group, the mean value of frontal sinus is larger in nasal breather than in mouth breather group, the factors contributing to sinus enlargement have not been completely under stood, however, individual differences in the growth, the quality of the frontal bone, hereditary and hormonal factors have been suggested to be responsible for sinus enlargement [33]. Some earlier studies suggested that increase in thickness in region of Nasion was accounted for by enlargement of the frontal sinus [34]. Baer and Harris [35] interpreted the development of the frontal sinus as process of structural adaptation to the forward and downward growth of the mid face with the forward growth of the external lamina of the frontal bone being essential to keep the contact with the nasal bone and the maxilla. One may logically assume in this research that small frontal sinus area in mouth breather group is may be due to the less amount of air breathed enters the frontal sinus (from the nasal cavity) in mouth breather than that in the nasal breather group. The relationship between mouth breathing and unusual growth is well documented in orthodontic literatures [4,6]. Mouth breathing also causes a weakening of the muscles of facial structure leading to various orthodontic problems [28]. Also, this study found out that the frontal sinus is higher in males of both examined group, than in females, indicating that boys exhibited larger frontal sinus than that in girls (table 1 and 2).

The Gonial angle: The mean value of the gonial angle was higher on mouth breather than in nasal though it never reached the significant level, indicating that mouth breather subjects possessed large gonial angle, leading to more steeper mandibular angle and more tendency to posterior rotation[1]. This result agrees with Al-Labban [6], and supported by Harvold et al [36] who found that lowering the chin for oral respiration gradually resulted in steeper mandibular plane angle and more open gonial angle. Also this finding coincided with Cheng et al [37], who found that the shape and size of the mandible in breathing compromised subjects show significant differences from the control, our finding also agrees with Kesso [21].

The mean value of SNA angle in our research is slightly higher in nasal breather than in mouth breather with no significant difference, this indicates that the nasal breather has slightly more prognathic maxilla relative to the anterior cranial base than the mouth breather group, so the maxilla was more retro-gnathic in the mouth breather group. This result agrees with other researchers Cheng et al [37], Subtently [38], Bresolin et al [39].

The mean value of SNB angle in our research is slightly higher in nasal breather than in mouth breather with no significant difference, this agrees with Ricketts [41] who found that the SNB angle was less in the mouth breather.

The mean value of maxillary length is higher in nasal breather than in mouth breather group with very high significant difference in female group, this finding agrees with Al-Labban[6] who found that this finding is due to bimaxillary retrognathism which is associated with mouth breathing habit. Also this finding agrees with Kesso [21].

The mean value of mandibular length was found to be more in the mouth breather group than in nasal breather with high significant difference in females and no significant difference in males, this may be due to the fact that in mouth breather group the subject open their mouth and drop the mandible down to have adequate breathing through the mouth, this finding agrees with Al-Laban [6], Subtelny, and Subtenly [42] and Gureley [43].

The mean value of ramus length was higher in mouth breather group than in nasal breather group with no significant difference in the male and high significant difference in females.

The mean value of S-N length was found to be higher in mouth breather than in nasal breather, this comes in agreement with Linder-Aronson et al [44] and Solow et al [45], who reported that nasal obstruction can also alter the air way and, subsequently, facial and cranial growth.

The TAFH, UAFH and LAFH, the higher mean value of these measurements in mouth breather group subjects may be due to the fact that the increased mandibular plane and mandibular maxillary angles in mouth breather lead to increase in AFH [1-6] .the mouth breather termed vertical maxillary excess or long face syndrome[6] this finding agrees with Al-Labban[6].

The higher mean value of PFH in mouth breather than that in nasal breathers which means that the nasal breather subjects have smaller posterior facial height, this finding disagrees with Kesso [21] and Al-Labban[6].

Table (4) showed the correlation between frontal sinus and other variable in both groups.

The frontal sinus in mouth and nasal breather group showed a very high significant correlation with facial height(except UPFH in mouth breather group show significant correlation), S-N, ramus length, maxillary length and mandibular length, this finding agrees with Rossuw et al [3], who show a strong correlation between the growth of the mandible and the frontal sinus dimension. The frontal sinus in our research has non-significant correlation with the SNA and SNB angles in mouth breather group, but has a very high significant correlation in nasal breather group this agrees with Bresolin et al [39] who studied both nose and mouth breathers with allergic rhinitis.

The frontal sinus has no significant correlation in our research with the Gonial angle in both mouth breather and nasal breather group, this finding agrees with Prashar et al [46] they found that the poor correlation of frontal sinus with Gonial angle suggested that large frontal sinus may be present with large mandible irrespective of its growth direction, or the form of the mandible, with reference to the relation between body and ramus. Our research of frontal sinus area in nasal and mouth breather group is new in Iraqi population so we might expect more researches on frontal sinus dimension in the future.

The conclusions that can be drawn from this research were:

1. The frontal sinus area is smaller in mouth breather than in nasal breather group, and it is larger in males than females in each group.
2. The frontal sinus in mouth breather and nasal breather group is correlated with the facial height, S-N L, Ramus L, Max L and Mand L. but not correlated in mouth breather with the GA, SNA and SNB angles and not correlated in nasal breather with GA.
3. The mouth breather group has higher GA (giving tendency to posterior rotation with growth of mandible), AFH, PFH, Mandibular length, Ramus length, and S-N length than nasal breather groups.
4. The mouth breather group has less maxillary length than nasal breather group.

Table 1: The means and standard deviation of Mouth breathers

Variables	Gender	Descriptive statistics		Gender difference d.f.=28	
		Mean	S.D.	t-test	p-value
GA	Total	126.94	3.02	-0.33	0.744 (NS)
	Male	126.78	3.78		
	Female	127.13	1.96		
SNA	Total	82.47	2.19	0.70	0.486 (NS)
	Male	82.72	2.05		
	Female	82.19	2.37		
SNB	Total	78.82	1.78	0.80	0.429 (NS)
	Male	79.06	1.89		
	Female	78.56	1.67		
Max. length	Total	49.03	3.37	9.48	0.000 ***
	Male	51.72	1.44		
	Female	46.00	2.06		
Mand. Length	Total	68.12	2.85	3.52	0.001 ***
	Male	69.51	2.76		
	Female	66.55	2.06		
Ramus length	Total	46.19	3.29	6.94	0.000 ***
	Male	48.55	1.77		
	Female	43.52	2.44		
S-N length	Total	67.83	2.43	5.04	0.000 ***
	Male	69.33	2.04		
	Female	66.15	1.58		
TAFH	Total	119.04	7.40	10.20	0.000 ***
	Male	125.06	4.39		
	Female	112.28	2.55		
UAFH	Total	50.79	2.31	6.06	0.000 ***
	Male	52.36	1.72		
	Female	49.03	1.46		
LAFH	Total	68.47	4.15	5.41	0.000 ***
	Male	71.13	3.18		
	Female	65.47	2.88		
TPFH	Total	77.27	5.87	13.83	0.000 ***
	Male	82.32	2.33		
	Female	71.59	2.17		
UPFH	Total	46.98	2.51	2.60	0.014 *
	Male	47.95	2.13		
	Female	45.88	2.51		
LPFH	Total	46.63	3.01	6.92	0.000 ***
	Male	48.80	1.67		
	Female	44.20	2.20		
Frontal sinus area	Total	108.75	18.99	48.09	0.000 ***
	Male	126.27	2.42		
	Female	89.05	2.04		

Table 2: The means and standard deviation of Nasal breather

Variables	Gender	Descriptive statistics		Gender difference d.f.=28	
		Mean	S.D.	t-test	p-value
GA	Total	124.00	1.84	0	1 (NS)
	Male	124.00	2.00		
	Female	124.00	1.73		
SNA	Total	83.55	2.69	3.69	0.001 ***
	Male	85.00	2.50		
	Female	82.00	1.96		
SNB	Total	79.03	2.24	6.02	0.000 ***
	Male	80.63	1.71		
	Female	77.33	1.29		
Max. length	Total	51.31	4.08	6.82	0.000 ***
	Male	54.36	3.25		
	Female	48.06	1.55		
Mand. Length	Total	66.25	2.86	6.43	0.000 ***
	Male	68.34	2.26		
	Female	64.03	1.32		
Ramus length	Total	44.72	4.01	11.09	0.000 ***
	Male	48.16	2.13		
	Female	41.05	1.32		
S-N length	Total	65.34	2.64	6.55	0.000 ***
	Male	67.28	1.78		
	Female	63.26	1.62		
TAFH	Total	110.33	6.56	24.19	0.000 ***
	Male	116.43	1.53		
	Female	103.82	1.36		
UAFH	Total	49.50	2.53	6.06	0.000 ***
	Male	51.31	1.84		
	Female	47.58	1.56		
LAFH	Total	64.52	3.52	12.93	0.000 ***
	Male	67.62	1.01		
	Female	61.22	1.68		
TPFH	Total	74.05	5.29	18.91	0.000 ***
	Male	78.90	1.56		
	Female	68.88	1.38		
UPFH	Total	44.78	2.90	8.14	0.000 ***
	Male	47.08	1.79		
	Female	42.32	1.43		
LPFH	Total	42.91	3.41	9.94	0.000 ***
	Male	45.77	1.88		
	Female	39.87	1.37		
Frontal sinus area	Total	186.32	41.81	66.28	0.000 ***
	Male	226.01	3.67		
	Female	143.99	3.19		

Table 3: Comparison between nasal breather and mouth breather

Variables	Gender	Descriptive statistics				Group difference	
		Nasal Breather		Mouth Breather			
		Mean	S.D.	Mean	S.D.	t-test	p-value
GA	Total	124.00	1.84	126.94	3.02	-4.68	0.000 ***
	Male	124.00	2.00	126.78	3.78	-2.63	0.013 *
	Female	124.00	1.73	127.13	1.96	-4.69	0.000 ***
SNA	Total	83.55	2.69	82.47	2.19	1.78	0.081 (NS)
	Male	85.00	2.50	82.72	2.05	2.91	0.006 **
	Female	82.00	1.96	82.19	2.37	-0.24	0.813 (NS)
SNB	Total	79.03	2.24	78.82	1.78	0.42	0.678 (NS)
	Male	80.63	1.71	79.06	1.89	2.53	0.017 *
	Female	77.33	1.29	78.56	1.67	-2.28	0.030 *
Max. length	Total	51.31	4.08	49.03	3.37	2.47	0.016 *
	Male	54.36	3.25	51.72	1.44	3.13	0.004 **
	Female	48.06	1.55	46.00	2.06	-4.03	0.000 ***
Mand. Length	Total	66.25	2.86	68.12	2.85	-2.63	0.011 *
	Male	68.34	2.26	69.51	2.76	-1.35	0.188 (NS)
	Female	64.03	1.32	66.55	2.06	3.13	0.004 **
Ramus length	Total	44.72	4.01	46.19	3.29	-1.62	0.111 (NS)
	Male	48.16	2.13	48.55	1.77	-0.59	0.556 (NS)
	Female	41.05	1.32	43.52	2.44	-3.48	0.002 **
S-N length	Total	65.34	2.64	67.83	2.43	-3.97	0.000 ***
	Male	67.28	1.78	69.33	2.04	-3.10	0.004 **
	Female	63.26	1.62	66.15	1.58	-5.01	0.000 ***
TAFH	Total	110.33	6.56	119.04	7.40	-5.00	0.000 ***
	Male	116.43	1.53	125.06	4.39	-7.46	0.000 ***
	Female	103.82	1.36	112.28	2.55	-11.40	0.000 ***
UAFH	Total	49.50	2.53	50.79	2.31	-2.15	0.036 *
	Male	51.31	1.84	52.36	1.72	-1.73	0.094 (NS)
	Female	47.58	1.56	49.03	1.46	-2.67	0.012 *
LAFH	Total	64.52	3.52	68.47	4.15	-4.11	0.000 ***
	Male	67.62	1.01	71.13	3.18	-4.23	0.000 ***
	Female	61.22	1.68	65.47	2.88	-4.97	0.000 ***
TPFH	Total	74.05	5.29	77.27	5.87	-2.31	0.024 *
	Male	78.90	1.56	82.32	2.33	-4.96	0.000 ***
	Female	68.88	1.38	71.59	2.17	-4.12	0.000 ***
UPFH	Total	44.78	2.90	46.98	2.51	-3.28	0.002 **
	Male	47.08	1.79	47.95	2.13	-1.28	0.208 (NS)
	Female	42.32	1.43	45.88	2.51	-4.82	0.000 ***
LPFH	Total	42.91	3.41	46.63	3.01	-4.67	0.000 ***
	Male	45.77	1.88	48.80	1.67	-4.98	0.000 ***
	Female	39.87	1.37	44.20	2.20	-6.52	0.000 ***
Frontal sinus area	Total	186.32	41.81	108.75	18.99	9.78	0.000 ***
	Male	226.01	3.67	126.27	2.42	94.60	0.000 ***
	Female	143.99	3.19	89.05	2.04	57.50	0.000 ***

Degree of freedom
Total: 58
Males: 28
Females: 28

Table 4: Correlation between frontal sinus area and other variables in both groups

Variables		Frontal sinus area	
		Nasal breather	Mouth breather
GA	r	0.023	-0.041
	p	0.900 (NS)	0.818 (NS)
SNA	r	0.588	0.102
	p	0.000 ***	0.567 (NS)
SNB	r	0.761	0.119
	p	0.000 ***	0.503 (NS)
Max. length	r	0.799	0.857
	p	0.000 ***	0.000 ***
Mand. length	r	0.758	0.492
	p	0.000 ***	0.003 **
Ramus length	r	0.894	0.773
	p	0.000 ***	0.000 ***
S-N length	r	0.769	0.681
	p	0.000 ***	0.000 ***
TAFH	r	0.969	0.860
	p	0.000 ***	0.000 ***
UAFH	r	0.733	0.727
	p	0.000 ***	0.000 ***
LAFH	r	0.922	0.666
	p	0.000 ***	0.000 ***
TPFH	r	0.954	0.909
	p	0.000 ***	0.000 ***
UPFH	r	0.826	0.402
	p	0.000 ***	0.018 *
LPFH	r	0.865	0.749
	p	0.000 ***	0.000 ***

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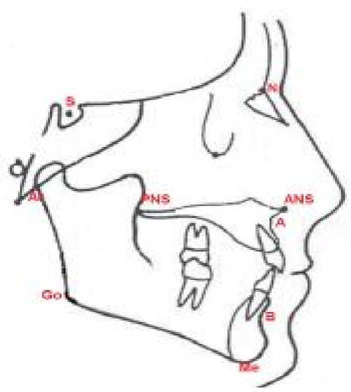

Figure 1: Cephalometric landmarks

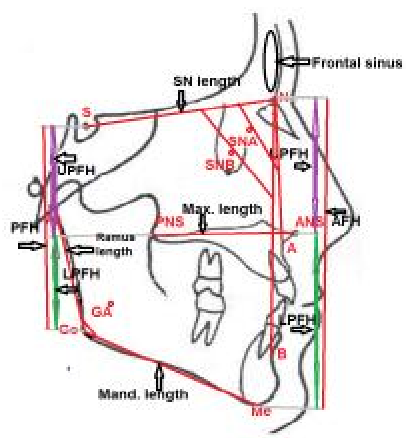

Figure 2: Cephalometric measurements