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RESEARCH ARTICLE

COMPARATIVE ANALYSIS OF DIMENSION OF FRONTAL SINUS WITH DIFFERENT SKELETAL PATTERNS

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ABSTRACT

Objective: The aim of the study was to investigate the normalcy of the dimensions of frontal sinus and compare the relationship of the frontal sinus with the different skeletal malocclusion and also to find a relationship between the length of the mandible and the dimensions of the frontal sinus.
Materials and Methods: A total of 60 pretreatment digital lateral cephalograms were selected according to the criteria and grouped into 3 groups, group 1: Class I (n=20), group 2: Class II (n=20) and group 3: Class III(n=20). Lateral cephalograms were traced and analysed on basis of frontal sinus i.e. the following linear measurements were recorded: maximum height, maximum width, area of frontal sinus region and the length of the mandible.
Statistical Analysis: One-way ANOVA test was performed to compare the difference between the skeletal classes. Multiple comparison test was performed with post hoc with Bonferoni and Sidak statistical tests were performed.
Results: The linear measurements of maximum height, maximum width, area of frontal sinus region showed statistically insignificant differences in Class I, Class II, and Class III (p-vaule=0.16, 0.4 and 0.12 respectively).
Conclusion: We observed there is a no significant difference between maximum height, width and area of frontal sinus with respect to Class I, Class II and Class III. Hence, we can say frontal sinus is not so reliable in depicting skeletal malocclusions.

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INTRODUCTION

A lateral cephalometric radiograph is a standardized, reproducible radiograph used primarily for orthodontic diagnosis and treatment planning since the introduction of radiography by Broadbent in 1931 (Albarakati *et al.,* 2012; Devereux *et al.,* 2011; Nijkamp *et al.,* 2008; Atchison *et al.,* 1991). Various anatomical landmarks of lateral cephalogram are used for assessment of different malocclusion and its treatment planning (Endo *et al.,* 2010; Salehi *et al.,* 2012). The landmarks used in this study are paranasal sinus, because they can be easily accessed by radiographic methods especially by lateral cephalogram as it does not provide duplicate information (Durão *et al.,* 2013). Paranasal sinuses are a group of four paired air-filled spaces that surround the nasal cavity. The four paranasal sinuses present in human body are: maxillary sinus, frontal sinus, ethmoidal sinus, sphenoidal sinuses. The frontal sinus is used in this study as it can be easily identified in lateral cephalogram of most of the patients. It is present in frontal bone and it is widely used in forensic science due to its irregular shape and individual characteristics making it unique for each individual same as fingerprints (Kullman *et al.,* 1990). Thus, we decided to investigate the relation between frontal sinus and different skeletal malocclusions.

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MATERIALS AND METHODS

60 pretreatment digital lateral cephalograms were selected on the criteria as mentioned below. All cephalograms were of the same dimension, magnification and printed from the same machine. Criteria for selection of the Cephalograms are as follows:

- Subject should be healthy with no systemic diseases, signs of trauma or a congenital disease.
- Subject should not have any paranasal sinuses pathology.
- Subject should show no sign of previous orthodontic treatment.
- Subject should be between the age group of 16years to 30years.

Table 1. Cephalometric Points

Point A	the deepest midline point on the premaxilla between the anterior nasal spine and prosthion.
Point B	the most posterior point in the concavity between the infradentale and pogonion.
N (nasion)	the anterior limit of the frontonasal suture.
Co	the most posterior and superior point on the condyle of mandible.
Gn (gnathion)	the most anterior and inferior point on the symphysis of mandible.
Point Sh	highest point on the peripheral borders of the frontal sinus.(fig 1)
Point Sl	lowest point on the peripheral borders of the frontal sinus(fig 1)

Table 2. Linear Mesurements

Co-Gn	the effective length of the mandible.(fig 1)
Maximum height of frontal sinus (a)	A line connecting Sh to Sl is drawn to measure the maximum height of frontal sinus.(fig 2)
Width of frontal sinus (b)	Perpendicular to above line, a line was drawn to measure the maximal width of frontal sinus. (fig 2)

Table 3. ANOVA to measure p value

		df	Mean square	F	P value	Significance
Maximum heigth of frontal sinus	Between the groups	2	73.817	1.856	0.166	Non significant
	Within the groups	57	39.774			
	Total	59				
Maximum width of frontal sinus	Between the groups	2	218.064	0.879	0.421	Non significant
	Within the groups	57	248.116			
	Total	59				
Frontal sinus area	Between the groups	2	18104.617	2.139	0.127	Non significant
	Within the groups	57	8464.066			
	Total	59				
Effective length of mandible	Between the groups	2	313.817	3.738	0.03	Significant
	Within the groups	57	83.949			
	Total	59				

Table 4. Mean value and standard deviation for Class I

	N	Minimum	Maximum	Mean	Std Deviation
Maximum heigth of frontal sinus	20	16	36	28.4	6.151
Maximum width of frontal sinus	20	6	18	12.55	3.17
Frontal sinus area	20	260	327	278.75	17.186
Effective length of mandible	20	95	131	112.05	9.501

- All Class I malocclusion patients had an ANB value between 1° to 4°.
- All Class II malocclusion patients had an amplitude of ANB value more 4°.
- All Class III malocclusion patients had an amplitude of ANB value less than 1°

Method

Cephalograms were categorised into 3 major groups on Group 1: Class I malocclusion, Group 2: Class II malocclusion, Group 3: Class III malocclusion. All Lateral cephalograms were taken by skilled and experienced technicians in a standard natural head position as recommended by Broadbent et al[1,2,3,4] The cephalograms were manually traced by a single researcher with the help of a 0.5mm thick lead pencil and a millimetre scale for the planes on Orthodontic tracing paper. For the linear measurements a millimetre precision digital vernier calliper for the registration of the reading. They were again evaluated by a second researcher and the arithmetical mean of these readings were taken as the standard value for statistical evaluation and assessment. Beside routine anatomical designs the Cephalometric points traced are given in table 1 and linear measurements taken are given in table 2. During tracing of bilateral anatomic structure, a line was used midway between right and left sides to allow the consideration that all the structures were in midline and it also helped in eliminating errors caused by improper positioning during exposure of X-ray film.

The frontal sinus area was calculated by superimposing the frontal sinus drawn acetate paper over a standard graph paper sheet and counting the number of squares present within the inner outline of frontal sinus. It was measured as square millimeters. When more than half area of the square was within the perimeter of frontal sinus, it was also counted as full square, where as squares having less than half of the areas inside the perimeter were excluded from the count.

Statistical Methods

The data was statistically analysed with SPSS 20 Software (IBM). Data was subjected to descriptive analysis for mean and standard deviation of all variables and ranges. One-way ANOVA (random effective analysis of variance) and a post hoc test (Bonferroni and Sidak) was used for multiple comparisons. $P<0.05$ was considered as the level for statistically significant data.

RESULTS

The linear measurements with the arithmetic mean and standard deviations are tabulated in Table 3. This sets the normalcy of the size of the frontal sinus and can be used for further analysis and reference standard for further studies.The effectively length of the mandible was statistically significant and shows the length of the mandible in the different classes. (p-value= 0.03) This shows the variation in length in the different classes.

Table 5. Mean value and standard deviation for Class II

	N	Minimum	Maximum	Mean	Std Deviation
Maximum heigth of frontal sinus	20	7	19	11.85	3.117
Maximum width of frontal sinus	20	16	40	29.05	6.337
Frontal sinus area	20	93	129	108.35	10.419
Effective length of mandible	20	93	125	107.2	9.22

Table 6. Mean value and standard deviation for Class III

	N	Minimum	Maximum	Mean	Std Deviation
Maximum heigth of frontal sinus	20	23	42	32	5.849
Maximum width of frontal sinus	20	8	18	13.55	3.426
Frontal sinus area	20	250	322	285.25	19.183
Effective length of mandible	20	108	132	115.05	8.751

Table 7. Bonferroni and Sidak methods were used for post hoc analysis

Dependent variable		(I) type	(J) type	P value
Maximum heigth of frontal sinus	Bonferroni	Class I	Class II	1
			Class III	0.593
		Class II	Class I	1
			Class III	0.196
		Class III	Class I	0.593
			Class II	0.196
	Sidak	Class I	Class II	0.919
			Class III	0.483
		Class II	Class I	0.919
			Class III	0.183
		Class III	Class I	0.483
			Class II	0.183
Maximum width of frontal sinus	Bonferroni	Class I	Class II	0.571
			Class III	1
		Class II	Class I	0.571
			Class III	1
		Class III	Class I	1
			Class II	1
	Sidak	Class I	Class II	0.469
			Class III	0.864
		Class II	Class I	0.469
			Class III	0.9
		Class III	Class I	0.864
			Class II	0.9

Table 8. Bonferroni and Sidak methods were used for post hoc analysis (table 7 continued)

Dependent variable		(I) type	(J) type	P value
Frontal sinus area	Bonferroni	Class I	Class II	0.848
			Class III	0.989
		Class II	Class I	0.848
			Class III	0.13
		Class III	Class I	0.989
			Class II	0.13
	Sidak	Class I	Class II	0.631
			Class III	0.699
		Class II	Class I	0.631
			Class III	0.124
		Class III	Class I	0.699
			Class II	0.124
Effective Length of mandible	Bonferroni	Class I	Class II	0.299
			Class III	0.915
		Class II	Class I	0.299
			Class III	0.027
		Class III	Class I	0.915
			Class II	0.027
	Sidak	Class I	Class II	0.27
			Class III	0.664
		Class II	Class I	0.27
			Class III	0.026
		Class III	Class I	0.664
			Class II	0.026

Figure 1. Various cephalometric landmarks that are required for the tracing of lateral cephalogram. 1: Nasion (N), 2: Supspinale (point A), 3: Supramentale (point B), 4: Point Sh (Sh), 5: Point Sl (Sl), 6: Condylion (Co), 7: Gnathion (Gn).

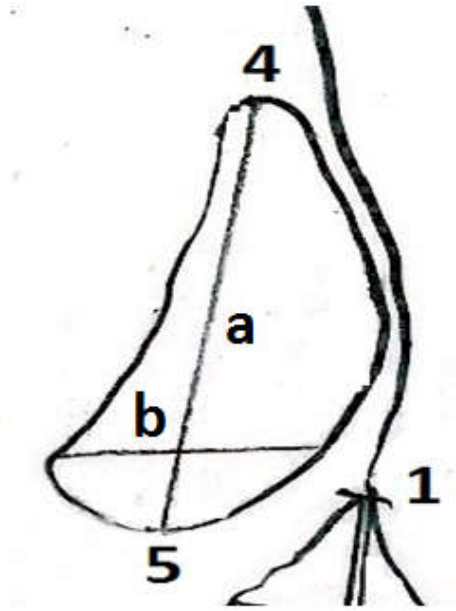

Figure 2. The point describe in the figure are as followed:- 1: Nasion (N) 4: Point Sh (Sh), 5: Point Sl (Sl), Maximum height(a), Maximum width(b).

Post-hoc analysis shows that the effective length of the mandible is highest in Class III and is the shortest in Class II. This signifies the correlation of the mandible with the different classes. The maximum height, maximum width and area of frontal sinus are not statistically significant in Class I, Class II and Class III subjects and showed no correlation between the length of the mandible and the maximum height, maximum width and area of frontal sinus. (p-value=>0.05) .

DISCUSSION

The frontal sinuses are the paranasal sinuses which are superior to the eyes, in the frontal bone, which forms the hard part of the forehead. The development and size of frontal sinus can be crucial for diagnosing and treating various malocclusions. The origin of frontal sinus is from anterior ethmoidal cells during birth. The frontal sinus bud is present during the birth in ethmoidal region but it is not evident radiographically until the age of 5 years when it projects above the orbital rims (Harris *et al.,* 1987). It migrates into the frontal bone at the end of the first year of life (Brown *et al.,* 1984). The sinus grows till the age of 12 years. Tanner found that the annual height (stature) increments in children reached a plateau at 16 years in boys and 14 years in girls, and it was thought that these, too, were the ages at which frontal sinus enlargement ceased (Tanner, 1962). This suggests that the increase in the sinus size very closely follows a growth trend similar to that of other bones. Joffe, Rossouw et al found frontal sinus enlargement to be associated with prognathic subjects (Joffe, 1964; Rossouw *et al.,* 1991). The lateral cephalograms are widely used to study morphologic characteristics of various malocclusions. The present study was carried out to analyze the correlation of frontal sinus with different skeletal pattern. According to the results, we can state that there is no correlation between dimensions of frontal size with different skeletal pattern.

Although our result state there is no correlation previously studies have been carried out and it was suggested that acromegaly is associated with prominent frontal sinus and overgrowth of the jawbone, and one usually finds a class III-type prognathic mandible in these cases (Shafer, Hine, Levy, 1974) (Ruf and Pancherz, 1996). Joffe (1964)found Frontal Sinus enlargement to be associated with prognathic subjects (Joffe, 1964). In a similar study reported by Rossouw *et al*. (1991) they had only compared the area of the frontal sinus in between adult skeletal Class III and adult skeletal Class I growth pattern cases but did not study the Class II growth pattern cases. Ruf and Pancherz(1996) suggested that the somatic maturity stage may be predicted rather accurately by analyzing Frontal Sinus development on pre-existing lateral head cephalograms (Ruf and Pancherz, 1996). The ANB Angle (Steiner, 1953) is still widely accepted as an indicator of maxillo-mandibular harmony (Jacobson, 1975). Therefore , it was used to ascertain its correlation with the Frontal Sinus Area. In the present study, manual tracing was used for calculation of the maximum height, maximum width and frontal sinus area of frontal sinus. Although in some studies the digital method was used to measure these factors, the manual technique has accuracy similar to that of digital technique in this regard (Axelsson *et al.,* 2004). Thus, considering its affordability, the manual technique was used. It seems that further investigations in several centers with larger sample sizes can increase the accuracy of the obtained data and standards.

Conclusion

- The importance of the frontal sinus is established and the normalcy is set by statistical analysis and the standard values are given for the dimensions of the frontal sinus which may be used for further analysis and references.

- The maximum height, maximum width and area of frontal sinus do not correlate with the effective length of mandible and also with the three skeletal types.

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