Original Article

Analysis of frontal sinus in various malocclusions

ABSTRACT

Aims: The study aims to investigate the normal dimensions of the frontal sinus and determine the role of the frontal sinus in various skeletal malocclusions and also to analyze the relationship between the length of the mandible and frontal sinus dimension.

Materials and Methods: A total of 120 lateral cephalograms were selected according to the criteria and were grouped mainly into three groups: Group 1 – Class I ($n = 40$), Group 2 – Class II ($n = 40$), and Group 3 – Class III ($n = 40$). These were traced and analyzed by recording the linear measurements such as maximum width, maximum height, area of frontal sinus region, and the length of the mandible. To compare the difference between the skeletal classes, one-way ANOVA test was performed followed by *post hoc* with Sidak and Bonferroni statistical tests.

Results: There was no such significant difference in the measurements of maximum width, height, and area of frontal sinus region of classes I, II, and III.

Conclusions: After analyzing the linear dimensions, we found out that there is a significant difference in height, width, and area of the frontal sinus region with respect to classes I, II, and III. Therefore, we can say that the frontal sinus plays a significant role in depicting skeletal malocclusions.

Keywords: ANOVA test, frontal sinus, frontal sinus dimensions, lateral cephalograms, malocclusions

INTRODUCTION

A lateral cephalogram is a profile X-ray of the skull and soft tissues and is used to assess the relation of the teeth in the jaws, the relation of the jaws to the skull, and the relation of the soft tissues to the teeth and jaws. Since Broadbent introduced radiography in the year 1931, it has been used primarily for orthodontic diagnosis and treatment.[1,2] From ages, various anatomical landmarks of lateral cephalogram have been used for assessment of different malocclusion and its treatment planning.[3] The landmarks used in this study are paranasal sinus. Paranasal sinus is a group of four paired air-filled spaces that surround the nasal cavity. The four paranasal sinuses present in the human body are: the maxillary sinus, frontal sinus, ethmoidal sinus, and sphenoidal sinuses. We have used the frontal sinus in this study, as it can be easily identified in the lateral cephalogram.[2,4-7] 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 the frontal sinus can be crucial for diagnosing and treating various malocclusions. It is widely used in forensic science due to its irregular shape and individual characteristics making it unique for individuals the same as fingerprints.[8] Thus, we decided to analyze whether the frontal sinus plays any role in various skeletal malocclusions and if it has any effect on the length of the mandible.

MATERIALS AND METHODS

A total of 120 lateral cephalograms were selected according

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to the criteria mentioned below and were grouped mainly into three groups: Group 1 – Class I (n = 40), Group 2 – Class II (n = 40), and Group 3 – Class III (n = 40). All cephalograms were of the same dimension, magnification, and printed from the same machine. The ethical approval was obtained from the Institutional Ethical Committee. Being a retrospective study, the patients were informed that their lateral cephalograms will be used for further studies, and the consent was obtained during that time.

Criteria for selection of the cephalograms are as follows:

- Participant should be healthy with no systemic diseases, signs of trauma, or a congenital disease
- Participant should not have any paranasal sinuses pathology. Participant should show no sign of previous orthodontic treatment
- Participant should be between the age group of 16–30 years
  - All Class I malocclusion patients had an ANB value between 1° and 4°
  - All Class II malocclusion patients had an amplitude of ANB value >4°
  - All Class III malocclusion patients had an amplitude of ANB value <1°.

Table 1: Cephalometric points to be traced on the cephalogram

	Measurements
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 the 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 [Figure 1]
Point Sl	Lowest point on the peripheral borders of the frontal sinus [Figure 1]

Table 2: Linear measurements to be traced on the cephalogram

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

Method

- Cephalograms were grouped mainly into three groups: Group 1 – Class I (n = 40), Group 2 – Class II (n = 40), and Group 3 – Class III (n = 40)
- All lateral cephalograms were taken by skilled and experienced technicians in a standard natural head position as recommended by Broadbent
- The ethical approval was obtained from the institutional ethical committee. Being a retrospective study, the patients were informed that their lateral cephalograms will be used for further studies and consent was obtained during that time
- The cephalograms were manually traced by a single researcher with the help of a 0.5-mm thick lead pencil and a millimeter scale for the planes on orthodontic tracing paper
- For the linear measurements, a millimeter precision digital vernier caliper for the registration of the reading
- Beside routine anatomical designs, the cephalometric points traced are given in Table 1 and linear measurements taken are given in Table 2
- The frontal sinus area was calculated by superimposing

Table 3: ANOVA test to measure *P* value

	Class	Number of cases	Mean	SD	df	*F*	*P*
Frontal sinus width	Class I	18	12.67	2.79	2, 117	5.49	0.005
	Class II	90	12.31	3.51			
	Class III	12	15.83	3.97			
Frontal sinus height	Class I	18	31.33	8.17	2 , 117	1.01	0.365
	Class II	90	30.39	7.17			
	Class III	12	33.58	8.47			
Frontal sinus area	Class I	18	250.5	96.99	2 , 117	3.37	0.038
	Class II	90	234.23	98.13			
	Class III	12	316.92	150.67			
Frontal sinus area	Class I	18	250.5	96.99	2 , 117	3.37	0.038
	Class II	90	234.23	98.13			
	Class III	12	316.92	150.67			
Length of mandible	Class I	18	110.67	7.78	2 , 117	5.75	0.004
	Class II	90	108.66	9.18			
	Class III	12	118.17	10.99			

SD: Standard deviation

Table 4: Bonferroni and Sidak methods were used for *post hoc* analysis

Multiple comparisons								
Dependent Variable				**Mean difference (I-J)**	**Std. Error**	***P***	**95% Confidence Interval**	
							Lower Bound	**Upper Bound**
Frontal_Sinus_Width	Bonferroni	1	2	0.361	0.894	1	-1.81	2.53
			3	-3.167*	1.29	0.047	-6.3	-0.03
		2	1	-0.361	0.894	1	-2.53	1.81
			3	-3.528*	1.064	0.004	-6.11	-0.94
	Sidak	1	2	0.361	0.894	0.969	-1.8	2.53
			3	-3.167*	1.29	0.046	-6.29	-0.04
		2	1	-0.361	0.894	0.969	-2.53	1.8
			3	-3.528*	1.064	0.004	-6.11	-0.95
Frontal_Sinus_Height	Bonferroni	1	2	0.944	1.925	1	-3.73	5.62
			3	-2.25	2.778	1	-9	4.5
		2	1	-0.944	1.925	1	-5.62	3.73
			3	-3.194	2.291	0.497	-8.76	2.37
	Sidak	1	2	0.944	1.925	0.947	-3.72	5.61
			3	-2.25	2.778	0.804	-8.98	4.48
		2	1	-0.944	1.925	0.947	-5.61	3.72
			3	-3.194	2.291	0.419	-8.74	2.35
Frontal_Sinus_Area	Bonferroni	1	2	16.267	26.865	1	-48.99	81.52
			3	-66.417	38.776	0.268	-160.6	27.77
		2	1	-16.267	26.865	1	-81.52	48.99
			3	-82.683*	31.976	0.033	-160.35	-5.02
	Sidak	1	2	16.267	26.865	0.906	-48.81	81.34
			3	-66.417	38.776	0.245	-160.35	27.51
		2	1	-16.267	26.865	0.906	-81.34	48.81
			3	-82.683*	31.976	0.032	-160.14	-5.23
Length_of_Mandible	Bonferroni	1	2	2.011	2.37	1	-3.74	7.77
			3	-7.5	3.421	0.091	-15.81	0.81
		2	1	-2.011	2.37	1	-7.77	3.74
			3	-9.511*	2.821	0.003	-16.36	-2.66
	Sidak	1	2	2.011	2.37	0.782	-3.73	7.75
			3	-7.5	3.421	0.088	-15.79	0.79
		2	1	-2.011	2.37	0.782	-7.75	3.73
			3	-9.511*	2.821	0.003	-16.34	-2.68

*The mean difference is significant at the 0.05 level. CI :Confidence limit, SE: Standard error

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 the frontal sinus, it was also counted as full square, whereas squares having less than half of the areas inside the perimeter were excluded from the count.

Statistical analysis

The data were statistically analyzed with SPSS 20 Software (IBM, Chicago, Illinois, USA). Data were subjected to descriptive analysis for the mean and standard deviation of all variables and ranges. One-way ANOVA and a *post hoc* test (Bonferroni and Sidak) were used for multiple comparisons. $P < 0.05$ was considered as the level for statistically significant data [Tables 3 and 4].

RESULTS

The effectively length of the mandible was statistically significant and showed the length of the mandible in the different classes ($P = 0.004$). This shows the variation in length in the different classes. *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 width and area of frontal sinus are statistically significant in Class III patients and hence shows a positive relationship between the length of the mandible and the maximum width and area of the frontal sinus.

DISCUSSION

The frontal sinuses are one of the four pairs of paranasal

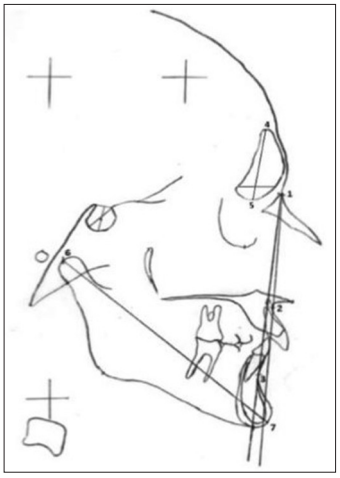

Figure 1: Various cephalometric landmarks that are required for the tracing of lateral cephalogram. (1) Nasion (N), (2) Supspinale (point A), (3) Supramentale (point B), (4) Point Sh (Sh), (5) Point Sl (Sl), (6) Condylion (Co), (7) Gnathion (Gn)

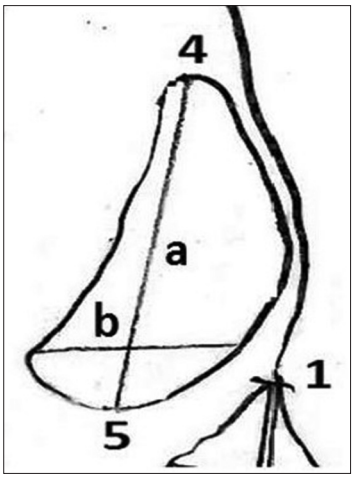

Figure 2: The point described in the figure are as follows: (1) Nasion (*n*), (4) Point Sh (Sh), (5) Point Sl (Sl), Maximum height (a), Maximum width (b)

sinuses that are situated behind the brow ridges. Sinuses are mucosa-lined airspaces within the bones of the face and skull. Each opens into the anterior part of the corresponding middle nasal meatus of the nose through the frontonasal duct which traverses the anterior part of the labyrinth of the ethmoid. The frontal sinus bud is present during the birth in the ethmoidal region, but it is not evident radiographically until the age of 5 years when it projects above the orbital rims.[9] The sinus grows till the age of 12 years. Tanner found that the annual height 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.[10] This suggests that the increase in the sinus size very closely follows a growth trend similar to that of other bones. The development and size of frontal sinus can be crucial for diagnosing and treating various malocclusions. Joffe,[11] Rossouw *et al*.[12] found the frontal sinus enlargement to be associated with prognathic patients. The lateral cephalograms are widely used to study morphologic characteristics of various malocclusions.[13-17] 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 a correlation between dimensions of frontal size with different skeletal patterns.

Apart from this, previously various 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.[18,19] Another study conducted by Ricketts *et al*. cephalometrically analyzed the skeletal growth patterns of 103 patients with Class I and Class III malocclusions to assess abnormal mandibular growth. The results indicate that there is a significant correlation between maxillary length, mandibular length, condylar length, and frontal sinus size on a lateral cephalogram. Thus, the frontal sinus can possibly be used as an additional indicator when one is predicting mandibular growth.

In the present study, manual tracing was used for calculation of the maximum height, maximum width, and frontal sinus area of the 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.[3] 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.

CONCLUSIONS

The maximum width and area of the frontal sinus are statistically significant in Class III patients and hence shows a positive relationship between the length of the mandible and the maximum width and area of the frontal sinus.

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Conflicts of interest

There are no conflicts of interest.

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