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CORRELATION BETWEEN FRONTAL SINUS DIMENSIONS AND CRANIOFACIAL PATTERNS

[1]ANEEQA YAQUB, [2]CH REHAN QAMAR, [3]USMAN ZAHEER, [4]NAAUMAN ZAHEER, [5]JUNAID ISRAR AHMED KHAN

ABSTRACT

The literature indicates variation in different trends found between the frontal sinus dimensions and different sagittal malocclusions. The study aims to correlate the frontal sinus dimensions with sagittal skeletal patterns. Ninety lateral cephalograms of patients aged 16-25 yrs. (both genders) with all three sagittal skeletal classes used. ANB angle is labeled as a critical determinant of skeletal dimension measurement. Subjects were divided into three groups (i.e., Group I with skeletal Class I [ANB = 0-4°], Group II with skeletal Class II [ANB ≥ 5°], and Group III with skeletal Class III [≤ -1°], consisting of 30 patients each). Frontal sinus dimensions were measured and recorded on proforma. In all three sagittal Classes, the sinus height (Sh-Sl) and the sinus width (Sap-Spp) showed a strong positive correlation. Hence, the frontal sinus dimensions cannot accurately predict skeletal sagittal malocclusions. The frontal sinus dimensions are poor indicators of sagittal skeletal malocclusions as it's significantly concurrent.

KEYWORDS: *Frontal sinus, Malocclusion, Sagittal skeletal patterns*

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INTRODUCTION

The prediction of the skeletal jaw patterns is a progressing subject. The efforts to find the indicators that correlate with the maxillary and mandibular growth changes will improve orthodontic diagnosis and treatment planning.[1] Craniofacial patterns are typically classified into vertical and horizontal patterns. Among these, horizontal patterns have a more significant role in developing skeletal malocclusion, which refers to growth and developmental anomalies affecting jaws and teeth, resulting in variations in their position.[2]

One of the sinuses of the skull, the frontal sinus, arises after the frontal bone is aerated. Sinuses proliferate until twelve and stop at sixteen for boys and fourteen for girls. Various craniometric studies show sinus enlargement is closely associated with craniofacial growth. Therefore, differences in frontal sinus size usually depend on the craniofacial pattern. There is evidence that frontal sinus dimensions are multifactorial and related to genetic factors and weather conditions.[3]

The craniofacial structures affect the morphology of the paranasal sinuses.[4] An inverse correlation of frontal sinus size is present with overjet, ANB, and Wit's value, and a direct correlation with mandibular body length SNB angle is seen.[5,6]

In sagittal Class III dimensions, a correlation between craniofacial patterns and frontal sinus height/width is observed (mean 310.50±68.07). At the same time, skeletal Class I (mean 203.33±66.02) and Skeletal Class II (mean 219.07±62.83) cephalograms showed a slightly lower correlation of craniofacial pattern with frontal sinus.[7] Indu et al. state a similar correlation of Class III skeletal dimension with mandibular prognathism and poor to no correlation with Class II and Class I skeletal patterns. [8]

However, Kapasiawala[9] demonstrated statistically insignificant differences in the dimensions of frontal sinus size with Class I (mean height 28.4±6.151, mean

[1] Dr Aneeqa Yaqub (Corresponding Author), BDS, FCPS, University College of Dentistry, The University of Lahore B-440 Askari 10 New Airport Road Lahore Cantt, Lahore Email: aneeqayaqub@yahoo.com Cell: 0321-8979302

[2] Dr Ch Rehan Qamar, BDS, FCPS, CHPE, Professor and Head of Orthodontic Departmetn University College of Dentistry, The University of Lahore, 1km Raiwand Road, Dental Hospital, The University of Lahore Email: rehangamar@live.com Cell: 0345-9219219

[3] Dr Usman Zaheer, BDS, FCPS, CHPE, MOrth RCSED, Assistant Professor Orthodontic Department Lahore Medical and Dental College, Lahore, B440 Askari 10 New Airport Road Lahore Cantt, Lahore Email: usman.zaheer@lmdc.edu.pk Cell: 0321-4440284

[4] Dr Naauman Zaheer, BDS, MPhil, PHD, CHPE, Associate Professor Department of Oral Biology CMH Medical and Dental College, Lahore Pakistan Email: naauman_20@hotmail.com Cell: 0321-4440283

[5] Dr Junaid Israr Ahmed Khan, BDS, FCPS, DDCS, MFDSRCS, CHPH Professor of Orthodontics Department Lahore Medical and Dental College Email: junaid.israr@lmdc.edu.pk Cell: 03224729367

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width 12.55±3.17, mean area 278.75±17.186), Class II (mean height 11.85±3.117, mean width 29.05±6.337, mean area 108.35±10.419), and Class III (Mean height 32±5.849, mean width 13.55±3.426, mean area 285.25±19.183) skeletal patterns.

The literature indicates variation in different trends found between the frontal sinus and different malocclusions. Therefore, the need arises to deduce the correlation between the frontal sinus dimensions and skeletal jaw patterns and the possibility of using the frontal sinus as an indicator for jawbone discrepancy. This finding may enhance our ability to diagnose and treat orthodontic issues.

MATERIALS AND METHODS

A cross-sectional study with the IRB number UCD/ERCA/39, dated August 26, 2020, was done at the University College of Medicine and Dentistry, University of Lahore. The investigation lasted six months (from September 1, 2020, to March 1, 2021), and a sample size of 90 was estimated with a 95% confidence level. The expected correlation is therefore, r = 0.69.10 Non-probability sequential sampling was the sampling method utilized. The study comprised patients with different craniofacial characteristics who were 16 to 25 years old and had fully erupted permanent set of teeth up to the second molars. The craniofacial patterns were divided into three categories: Skeletal Class I (ANB = 0–4°), Skeletal Class II (ANB = 5–5°), and Skeletal Class III (ANB = -1°). The patients excluded were with a history of Orthodontic and Orthopedic treatment, Syndromic or medically compromised patients, Any Paranasal sinus pathology, History of Trauma to the dentofacial region, and TMJ.

The study was carried out after approval on patients aged 16 to 25, reporting to the outpatient Department of Orthodontics. Informed consent was taken, and demographic data were recorded. The lateral Cephalogram of each subject was exposed. All cephalometric radiographs were traced on acetate paper manually. The sagittal skeletal patterns were identified according to the ANB angle. Frontal sinus dimensions were measured in Figure 1 and recorded on proforma per operational definitions.

Frontal Sinus Dimensions

Frontal sinus dimensions will be measured on a lateral Cephalogram involving the following measurements. (Figure. 1)

- Frontal Sinus Height - Determined by the junction of the sinus's highest point (Sh) and sinus's lowest point (Sl).
- Frontal Sinus Width - Determined by a line perpendicular to Sh-Sl, drawn by the junction of the sinus anterior point (Sap) and sinus posterior point (Spp).

The IBM SPSS version 20 software was used for computerized statistical data analysis. Frequencies and percentages were determined for categorical variables, such as gender. Age was one of many qualitative variables with mean and standard deviation. Using Pearson's correlation, correlation coefficients between sinus dimensions and sagittal skeletal patterns were evaluated[10]. Age and gender-based stratification of the data was done. Once stratification was complete, Pearson's correlation was used. Statistical significance was set at $P \leq 0.05$.

RESULTS

The minimum age was calculated from ninety patients as 16 years, and the maximum was 25 years with a mean ± standard deviation of 19.87 + 3.17 years. Thirty-three (36.7%) and fifty-seven (63.3%) of the male and female patients, respectively.

Pearson correlation showed a significant correlation between Skeletal pattern (ANB) and Sinus height (Sh-Sl) having p-value = 0.001, and the Sinus height (Sh-Sl) and Sinus Width (Sap-Spp, Sh-Sl) showed a significant positive correlation in all three classes I, II and III subjects (Table 1).

The correlation was significant between Sinus Dimensions (Sinus height (Sh-Sl) and Sinus Width (Sap-Spp)) and age <20 years with respect to all Skeletal Classes, while it was also significant between Sinus dimensions (Sinus height (Sh-Sl) and Sinus Width (Sap-Spp)) and age ≥ 20 years with respect to Skeletal Classes I and III. It was not significant with respect to Skeletal Class II having p-value = 0.097 (Table 2).

The correlation was significant between Sinus Dimensions (Sinus height (Sh-Sl) and Sinus Width (Sap-Spp, Sh-Sl)) and males with respect to Skeletal Class. At the same time, it was also significant between Sinus Dimensions (Sinus height (Sh-Sl) and Sinus Width (Sap-Spp, Sh-Sl)) and females with respect to Skeletal Classes II and III. It was insignificant concerning Skeletal Class I having p-value = 0.915 (Table 3).

DISCUSSION

The peak of the growth spurt is an essential aspect of the evaluation criteria and is vital for treatment planning. Successful treatment depends on the speed at which the treatment is delivered [11]. This study investigates the relationship between frontal sinus morphology and sagittal dimension. Sinus height (Sh-Sl) and sinus width (Sap-Spp) showed a significant positive correlation in classes I, II, and III in all three subjects. Skeletal malformations tremendously impact aesthetic and functional paradigms as their severity needs to be reduced or fully corrected. The frontal sinus

TABLE 1: CORRELATION BETWEEN SINUS HEIGHT (SH-SL) AND SINUS WIDTH (SAP-SPP, SH-SL) WITH RESPECT TO SKELETAL CLASS[10]

Skeletal Class	Sinus	N	Pearson Correlation Coefficient	P-Value
Class I	Sinus height (Sh-Sl)	28	0.656	0.001
	Sinus Width (Sap-Spp, Sh-Sl)			
Class II	Sinus height (Sh-Sl)	28	0.557	0.001
	Sinus Width (Sap-Spp, Sh-Sl)			
Class III	Sinus height (Sh-Sl)	28	0.684	0.001
	Sinus Width (Sap-Spp, Sh-Sl)			

**. Correlation is significant at the 0.01 level (2-tailed).

TABLE 2: STRATIFICATION OF SINUS DIMENSIONS (SINUS HEIGHT (SH-SL) AND SINUS WIDTH (SAP-SPP, SH-SL)) AND AGE WITH RESPECT TO SKELETAL CLASS AGE ≤ 20 YEARS

Skeletal Class	Sinus Dimensions	N	Pearson Correlation Coefficient	P-Value
Class I	Sinus height (Sh-Sl)	16	0.672**	.004
	Sinus Width (Sap-Spp, Sh-Sl)			
Class II	Sinus height (Sh-Sl)	12	.762**	.004
	Sinus Width (Sap-Spp, Sh-Sl)			
Class III	Sinus height (Sh-Sl)	16	.643**	.007
	Sinus Width (Sap-Spp, Sh-Sl)			
Age ≥ 20 years				
Skeletal Class	**Sinus Dimensions**	**N**	**Pearson Correlation Coefficient**	**P-Value**
Class I	Sinus height (Sh-Sl)	12	.852**	.000
	Sinus Width (Sap-Spp, Sh-Sl)			
Class II	Sinus height (Sh-Sl)	20	.381	.097
	Sinus Width (Sap-Spp, Sh-Sl)			
Class III	Sinus height (Sh-Sl)	14	.789**	.001
	Sinus Width (Sap-Spp, Sh-Sl)			

**. Correlation is significant at the 0.01 level (2-tailed).

may not help determine the sagittal skeletal pattern[12].

Aishwarya et al. used cephalometric measurements to analyze sagittal skeletal growth patterns in 120 patients and assessed their association with frontal sinus size[13]. They found a good association between maximum frontal sinus width and area and mandibular length in class III patients and that maximum frontal sinus width and area were significant in class III patients. These results contrast our study in which frontal sinus dimensions were significant in all three skeletal classes. The possible discrepancies in the results may be due to the large sample size and the population of India. Studies also suggested that increased mandibular length correlated well with frontal sinus dimensions, and this may have influenced our study, as the included samples were young. I have.[7,14] Bustani[15] conducted a study investigating the relationship between skeletal jaw dimensions and validation of the frontal sinus, where the weakest relationship was found. Class I subjects had the smallest average frontal sinus width. Further studies contradict our study that the frontal sinus area is most prominent in class III and smallest in class II.[16]

Statistical substantial differences were established by comparing the mandible's maximum width, the frontal sinus's size, and the mandibular length of the skeletal malocclusions. The frontal sinus area and width were most remarkable in Class III and most minor in Class II. A significant difference in frontal sinus measurements was observed between the gender groups. Results might vary depending on different environments or ethnicities in the population.

TABLE 3: STRATIFICATION OF SINUS DIMENSIONS (SINUS HEIGHT (SH-SL) AND SINUS WIDTH (SAP-SPP, SH-SL)) AND GENDER WITH RESPECT TO SKELETAL CLASS MALES

Male				
Skeletal Class	**Sinus Dimensions**	**N**	**Pearson Correlation Coefficient**	**P-Value**
Class I	Sinus height (Sh-Sl)	15	.593*	.020
	Sinus Width (Sap-Spp, Sh-Sl)			
Class II	Sinus height (Sh-Sl)	10	0.883**	.001
	Sinus Width (Sap-Spp, Sh-Sl)			
Class III	Sinus height (Sh-Sl)	8	0.888**	.003
	Sinus Width (Sap-Spp, Sh-Sl)			
Female				
Skeletal Class	**Sinus Dimensions**	**N**	**Pearson Correlation Coefficient**	**P-Value**
Class I	Sinus height (Sh-Sl)	13	.915	.033
	Sinus Width (Sap-Spp, Sh-Sl)			
Class II	Sinus height (Sh-Sl)	13	0.847**	.000
	Sinus Width (Sap-Spp, Sh-Sl)			
Class III	Sinus height (Sh-Sl)	22	0.650**	.001
	Sinus Width (Sap-Spp, Sh-Sl)			

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

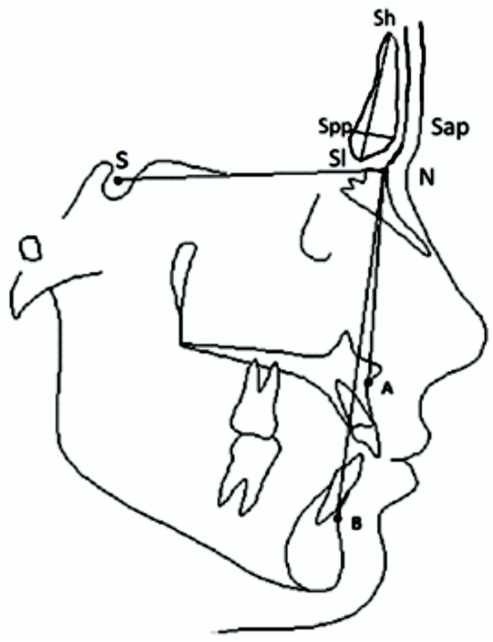

Fig 1: Various cephalometric landmarks that are required for the tracing of lateral cephalogram. 1 Sella (S), 2 Nasion (N), 3Supspinale (point A), (4) Superamentale (point B), (5) Upper frontal sinus point, located in the uppermost region of the frontal sinus (Sh), (6) Lower forntal sinus, located in the lowermost region of the forntal sinus point (SI), (7) Sinus anterior point (Sap), (8) Sinus posterior point (Spp)

Indu et al. evaluated 240 lateral cephalograms to review the reliability of the frontal and maxillary sinuses in assessing different types of skeletal malocclusions, showing a significant correlation between skeletal malocclusion and frontal sinus sizes.[8] According to the results of this study, FSA and large mandibles are associated. Although a significant correlation between maxillary sinuses and some variables could not be established, some showed a positive correlation.

Studies also suggested that increased mandibular length correlated well with frontal sinus dimensions, and this may have influenced our study, as the included samples were young. I have.[7,14] Bustani conducted a study investigating the relationship between skeletal jaw dimensions and validation of the frontal sinus, where the weakest relationship was found. Class I subjects had the smallest average frontal sinus width[15]. Further studies contradict our study that the frontal sinus area is most prominent in class III and smallest in class II.[16]

A study by N. G. Yuksel Asler showed that different cranial structures did not influence the morphology of the frontal sinus. We got the same results. They found that while the human frontal sinus has a constant shape, its dimensions can vary from person to person.[17] Another study by Gamze et al. found no significant correlation between frontal sinus height and various

craniofacial measurements.[18]

Kapasiawala et al in their study, also did not find a significant difference in the frontal sinus maximum area (height and width) based on Class I, Class II, and Class III. Linear measurements of the frontal sinus dimensions (maximum height, maximum width, and area) showed no statistically significant differences between Class I, II, and III (p-values of 0.16, 0.4, and 0.12, respectively), thus confirming the results found in the present study[9]. The current study's findings agree with the study done by Hasan, supporting our results.[19]

In this study, for all the assessments, manual tracing was done. The evidence indicates that manual methods are reliable; they have been used for many years and are the only method for obtaining cephalometric tracings and angular/linear measurements to interpret various cephalometric analyses, treatment planning, skeletal growth, post-treatment evaluation, and research.[20,21] For sorting the sample according to the sagittal skeletal pattern in the present study, the ANB angle was used. Evidence suggested that the ANB angle was the most dependable and valid for evaluating the anterior-posterior relationship of jaws in all sagittal groups. Hence, it may be applied to evaluate the sagittal jaw discrepancy precisely and accurately.[22]

In present study, there are several limitations. The first one is the sample size. We evaluated the results of the present study by looking at patients visiting the outpatient, establishing a smaller sample size than that of the whole population group. Larger sample sizes could provide better clarification of the results.

Secondly, cephalograms are paramount for evaluating frontal sinuses since newer diagnostic aids like cone beam computed tomography are technique-sensitive and expensive, particularly in developing countries. The lateral cephalograms were manually traced on acetate paper in the present study. The main limitation of this technique is that it requires more time and is subjected to a greater degree of operator error. Although the radiographic film was initially stable, it deteriorated after some time, resulting in a loss of image quality. So user-friendly and time-saving characteristics of computerized tracking and digital software can be used to obtain better results.

CONCLUSION

1. The study concludes positive correlation exists between frontal sinus dimensions and the three craniofacial patterns in the sagittal plane.
2. Male patients correlate highly with sinus height and width.
3. The individuals with age 16-21 years show substantial variation.
4. The increase in skeletal height with width showed a significant association.

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CONTRIBUTIONS BY AUTHORS

1 Aneeqa Yaqub:	Conceptuzlization, data curation writing, original draft preparation
2 Ch Rehan Qamar:	Writing review, editing, visulization supervision, formal analysis
3 Usman Zaheer:	Project administration, resources, software validation, data interpretation
4 Naauman Zaheer:	Methodology, investigation, data interpretation
5 Junaid Israr Ahmed Khan:	Methodology, investigation, data interpretation