European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 07, Issue 10, 2020

Frontal Sinus - A New Horizon Towards Growth Estimation

Dr. Priyank Sudani[1], Dr. Arpita Datta[2], Capt. Dangar Shyam M[3], Dr. Anup K Panda[4], Dr. Jina Jani[5], Dr. Deep D Patel[6]

[1]Post Graduate Student, Department of Paediatrics and Preventive Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India;
[2]Post Graduate Student, Department of Paediatrics and Preventive Dentistry, Institute of Dental Sciences, S'O'A University, Bhubaneswar, Odisha, India;
[3]B.D.S., Dental Officer, 308 Field Hospital, C/O 56 APO, India;
[4]M.D.S., Head of the Department, Department of Paediatrics and Preventive Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India;
[5]M.D.S., Senior Lecturer, Department of Paediatrics and Preventive Dentistry, College of Dental Sciences and Research Centre, Ahmedabad, Gujarat, India;
[6]B.D.S., General Dentist, USA;

[1]Email: priyanksudani55@gmail.com;[2]arpita2d@gmail.com;[3]shyamdangar17@gmail.com ;[4]dranuppanda76@gmail.com;[5]jinajani15@gmail.com;[6]ddeeppatel96@gmail.com

ABSTRACT

BACKGROUND: The human skeleton is a well-balanced dynamic system which responds to different mechanical stresses. The paranasal sinuses occupy a significant amount of space in the cranium which has been a topic of interest in studies to determine their function and factors affecting their morphology and size. The ability to predict the craniofacial growth pattern helps in improving accurately the reliability of treatment planning and long-term success. AIMS: Growth evaluation plays a significant role in the accurate diagnosis and treatment planning of children. This study aimed to correlate the frontal sinus index with anterior and posterior facial heights. The objective was to evaluate the association between frontal sinus morphology, facial heights and sagittal jaw discrepancies for the assessment of growth. METHODS: A total of 50 Lateral cephalograms of the children aged 7-15 years in Ahmedabad were used to measure the frontal sinus dimensions. Correlation between the frontal sinus dimensions, anterior & posterior facial heights and skeletal jaw discrepancies were evaluated and data were statistically analyzed. RESULTS: Very Low Positive Co-relation was found between the sinus index and ANB angle (0.105073974); Very Low Negative Co-relation was found between the sinus index and SN-GoGn angle (-0.148290904); Weak Positive Co-relation was found between sinus index and Lower anterior facial height (0.275691492) and the sinus index and anterior facial height (0.214073235); Medium Positive Co-relation was found between the sinus index and posterior facial height (0.307817304). CONCLUSION: None of the parameters could be significantly correlated with the frontal sinus index. Hence, at this juncture, the use of this indicator as the sole criterion for evaluating the

growth using cross-sectional data is questionable. So, Frontal sinus is not as reliable as a sole criterion for growth evaluation.

KEYWORDS: Frontal sinus, Frontal sinus index, Growth indicators, Growth estimation, Lateral cephalograms, Method of Ertük.

1. INTRODUCTION:

Over a long time, researchers have tried to discover different indicators to predict the skeletal growth in children. According to Malgorzata[1], the classical parameters are body height, weight, menarche period, chronological age, dental age, and skeletal maturity. Skeletal maturity involves the hand wrist bones ossification, cervical vertebral maturation, and also the assessment of the elbow.[2-4] Hand wrist bones ossification has been used as the most accurate method, with the exception that it requires an additional exposure of radiation.[5, 6]

In an attempt to forestall this additional radiation exposure, Lamparski[7] reported that cervical vertebral maturation was correlated to skeletal maturation. Likewise, Ruf and Pancherz[8] analyzed and confirmed that the frontal sinus growth is associated with somatic maturity.

The frontal sinus is an element of the anterior ethmoidal cells that evaginate from the frontal recess on to the frontal bone. These are two irregular cavities that are separated from each other by a thin bony septum. These cavities extends for a variable distance between the 2 tables of the skull and goes in the backward, upward and lateral-ward direction. These are absent at birth but as the child grows, they become evident.[6]

Previous investigations have stipulated that during the 2nd year of life, the vertical growth of the frontal sinus begins which extends laterally to the orbital roof.[9] Furthermore, the frontal sinus is identified around the 5th year, and it's radiographically evident at the age of 8 years, with the appearance of being well expanded at the age of 12.[6, 10] Various studies have stated regarding the area of the frontal sinus that increases up to 19 years of age which grows synchronously with general craniofacial growth and also with general bone growth.[6]

Along-with the reports on the development of the frontal sinus, few studies have investigated the relationship of the frontal sinus with other growth parameters. Brown stated that the main enlargement of the frontal sinus was completed according to the annual height increments in children. A study on Australian aboriginals has also revealed that there is a close relationship between certain hand wrist ossification events and peak growth velocity in stature and frontal sinus dimensions.[11]

For assessing the developmental status of a child, changing morphology of the frontal sinus during the adolescent growth spurt could be considered as a new method. Ruf and Pancherz evaluated frontal sinus morphology on lateral cephalograms and found out a well – defined pubertal growth spurt within the enlargement of the frontal sinus. In the literature, various authors have tried to study more regarding the correlation of the frontal sinus development with the skeletal growth.[12]

ISSN 2515-8260 Volume 07, Issue 10, 2020

The assessment of growth potential during the preadolescent or adolescent growth spurt has considerable influence on diagnosis and treatment planning as well as outcome and stability.[12] so an understanding of growth events is of primary importance in the practice of clinical pediatric dentistry. Considering that most of the previous studies have been carried out, this study aimed to investigate a correlation between the frontal sinus dimensions, anterior & posterior facial heights and skeletal jaw discrepancies in children aged 7-15 years in Ahmedabad.

2. MATERIAL AND METHODS:

Data were collected retrospectively from the pretreatment lateral cephalograms of orthodontic patients visiting the department of orthodontic and Dentofacial orthopedics, College of Dental Sciences and Research Centre, Ahmedabad. This in-vitro study consisted of a total of 50 children aged 7-15 years with good-quality standardized pretreatment lateral cephalograms. During the analysis of the data, some patient's radiographs were excluded if

- The quality of the cephalogram was not good enough to visualize the definition of the borders of the sinus.
- Participants give a history of sinus-related pathologies - any craniofacial anomaly, syndrome, trauma, or surgery involving the frontal sinus or any systemic disease affecting growth and development.

The lateral cephalogram was taken on the Digital Cephalostat machine Carestream CS 8000c calibrated at 70 kV and 10 mA, with exposure time ranging from 0.32 to 0.64 seconds and Kodak film, size 18 x 24 cm, equipped with a Lanex intensifier screen was used with heads positioned in a cephalostat with the Frankfurt plane parallel to the ground.

Evaluation of Lateral Cephalogram

For evaluating all lateral cephalograms, a method by Ertuk and Bonn was used[13]. The tracing of the radiographs was made by hand which was later analyzed. First, the nasion – sella line was oriented for later superimposition. After orienting the S- N line, the frontal sinus was traced by following the areas of high radiopacity as the peripheral areas. The highest point (SH) and also the lowest point (SL) were identified and connected by drawing a line (SH-SL). To calculate the width, a second line perpendicular to the SH-SL line was drawn and also the widest line that was measured from the sinus posterior point (SPP) and the sinus anterior point (SAP) was calculated as the sinus width.

The maximum height and width of the sinus were measured as shown in (Fig 1). The ratio of frontal sinus height to width was calculated for every patient which was regarded as the sinus index. The Shapiro-Wilk test was used to check the normality of the data, which showed a non-normal distribution; hence, nonparametric tests were applied. The Mann-Whitney U test was used to compare measurements of frontal sinus. Along with that anterior and posterior facial heights, SNA angle, SNB angle, ANB angle and SN-GoGn angle were assessed and statistically analyzed.

ISSN 2515-8260 Volume 07, Issue 10, 2020

Error of Method

Lateral cephalograms were evaluated twice by the same researcher with an interval of one week difference. Five subjects were selected randomly and an error in the calculation of the sinus width size was analyzed. The reassessment of sinus width size was defined by re-defining the SH – SL line which was done using Dahlberg Houston's formula (1983). Whenever the error for sinus width size ranges between 0.01 and 0.05, the assessment for the reproducibility of the SH-SL line was considered to be high.

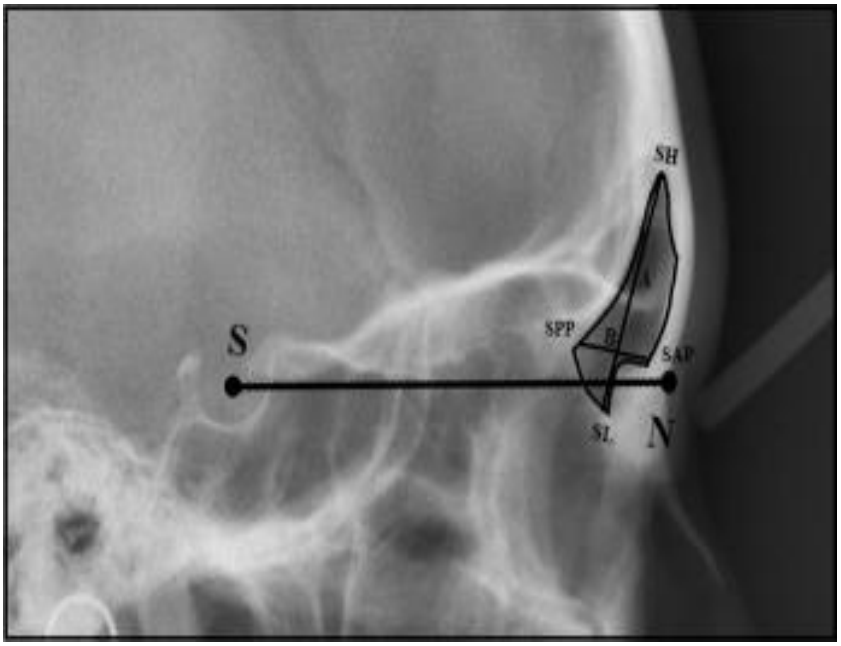

Figure-1: Assessment of the frontal sinus Morphology on a lateral cephalogram using the method by Ertuk (1968).[13]

SH - The highest point on the frontal sinus;
SL - the lowest point on the frontal sinus;
SPP - posterior point on the frontal sinus;
SAP - anterior point on the frontal sinus;
S - Anatomic center of sella turcia;
N - The deepest point in the midline at the frontonasal suture.
A-Line joining SH and SL denoting maximum frontal sinus height;
B - Line joining SPP and SAP denoting the maximum frontal Sinus width perpendicular to line A;

3. RESULTS:

The mean, minimum and maximum frontal sinus height, width, and sinus index obtained from the frontal sinus analysis at the respective age were tabulated in table 1.

Table 2 shows the number and the respective mean ages of male and female patients with mean frontal sinus index, mean frontal sinus height and mean frontal sinus width. The

ISSN 2515-8260 Volume 07, Issue 10, 2020

patients were matched for age and there was no significant difference between the mean age of male and female patients.

Table 3 shows the correlation and values of significance between the frontal sinus index and various parameters. We observe Very Low Positive Co-relation was found between the sinus index and ANB angle (0.105073974); Very Low Negative Co-relation was found between the sinus index and SN-GoGn angle (-0.148290904); Weak significant Positive Co-relation was found between sinus index and Lower anterior facial height (0.275691492) and the sinus index and anterior facial height (0.214073235); Medium Positive Co-relation was found between the sinus index and posterior facial height (0.307817304).

At the end of the observation, the frontal sinus showed an average frontal sinus index of 1.72134, varying from 0.87 to 4.75. However, statistical analysis was carried out on the data to obtain any other implication as detailed below.

Table-1: variations in Frontal Sinus index, Frontal sinus height and Frontal sinus width according to Age.

AGE (YEARS)	**FRONTAL SINUS INDEX**			**FRONTAL SINUS HEIGHT**			**FRONTAL SINUS WIDTH**		
	MEAN	**MIN.**	**MAX.**	**MEAN**	**MIN.**	**MAX.**	**MEAN**	**MIN.**	**MAX.**
7	1.125	1.125	1.125	18	18	18	16	16	16
8	1.435	0.87	2	21.5	18	28	16	12	23
9	1.521	0.94	3	19.4	16	22	14.8	7	20
10	14.0226	1.06	2.84	19.89	13	30	12.11	6	25
11	9.1683	1.19	2.27	28.67	22	39	15.83	12	21
12	10.2063	1.15	2.13	23.63	17	29	16.5	8	22
13	1.6043	1.09	2	23.14	17	31	14.86	10	22
14	2.2063	1.1	4.75	24.75	17	32	13.13	4	20
15	1.52	1.4	1.64	18.5	14	23	12	10	14

Table 2: Mean age, mean frontal sinus index, mean frontal sinus height and mean frontal sinus width of male and female subjects in the study.

GROUP	**NUMBERS**	**MEAN AGE (YRS)**	**MEAN FRONTAL SINUS INDEX**	**MEAN FRONTAL SINUS HEIGHT**	**MEAN FRONTAL SINUS WIDTH**
MALE	**29**	**11.21**	**1.6772**	**23.69**	**14.89**
FEMALE	**21**	**11.62**	**1.7822**	**21.48**	**13.86**
TOTAL	**50**	**11.38**	**1.7213**	**22.76**	**14.46**

ISSN 2515-8260 Volume 07, Issue 10, 2020

Table 3: correlation and values obtained from the frontal sinus index analysis for respective parameters.

RELATION WITH THE SINUS INDEX	CO-RELATION	VALUE
ANB Angle	**Very Low Positive**	**0.105**
SN-GoGn Angle	**Very Low Negative**	**-0.148**
Lower Anterior Facial Height	**Weak Positive**	**0.276**
Anterior Facial Height	**Weak Positive**	**0.214**
Posterior Facial Height	**Weak Positive**	**0.308**

4. DISCUSSION:

Knowing and understanding the relationship between somatic growth, skeletal maturity and the development of the frontal sinus may be of great value for dental treatment. This means that the timing of treatment in cases where it is expected to improve the relationship of the jaws, it is necessary to evaluate the growth spurt. Considering previous investigations about the frontal sinus development, this study was designed to mainly investigate the anterior and posterior facial heights, SNA, SNB, ANB and SN-GoGn angle and correlate this one to frontal sinus index.[10, 11, 14]

The frontal sinus follows craniofacial growth. Its enlargement is stimulated by the brain growth and various hydrodynamic conditions that occur within the endocranium.[6, 15]

During the data analysis, it was found that the frontal sinus was radiographically seen around 8 to 9 years old cephalogram. This finding coincided with previous studies that have confirmed about the frontal sinus that gets detected in radiographs during or around 7 year's old.[16]

A previous study done by Yessenia Valverde et al. (2013)[16] observe the enlargement of the frontal sinus and the relation of this one with the body height. This enlargement was noticeable from 8 years old which continued until the body height peak was reached. It was also noticed that this enlargement was in a forward and upward direction.

According to Yessenia Valverde et al. (2013)[16] the frontal sinus width size in Japanese girls aged 7-17 years were ranged from 10.78 to 13.56 mm which was found to be smaller in contrast to the frontal sinus of Australian aboriginals. They have also found that the frontal sinus growth pattern is similar to body height. It has a peak that occurred 1 year after body height peak and the sinus peak growth velocity was about 1.02 mm/yr. This finding was slightly the same as Ruf's study where the frontal sinus grew at a 1.3mm/yr rate. [10, 16]

The enlargement of the frontal sinus occurred gradually and it seemed that the frontal sinus had a growth pattern that begins at an early age as a round shape, which becomes larger in height and finally its width enhanced. Studies indicate that on reaching the body height peak, in the girls, the frontal sinus becomes wider and the anterior border gets more pronounced. So, the growth pattern of frontal sinus appears to be in an anterosuperior direction. This finding corresponds to that of Gagliardi.[11]

ISSN 2515-8260 Volume 07, Issue 10, 2020

Rossouw[14] stated that patients having large ANB angle had the longest mandible along with the largest frontal sinus. Thus, he concluded that the size of the frontal sinus was one factor that may help the practitioner to determine whether he would be able to attain stability by treating a Class III malocclusion.

Further research is required to investigate more about the frontal sinus development. From previous studies, it had been seen that identifying the specific shape in which the frontal sinus enlargement relates to the growth spurt might be considered a useful indicator for predicting skeletal or somatic maturity. This may be considered as an advantage relevant to the decrease in radiation exposure.[16]

It is necessary to know the leftover growth potential during the period of treatment and the percentage of growth expected at the time of treatment[17]. The results showed that the prediction potential with this cross-sectional sinus index technique is low. Probably the sample size wasn't adequate to reveal a statistical difference if in any respect present.[18]

Ruf and Pancherz[19] have shown that the enlargement in the width of the frontal sinus can be considered as one of the skeletal maturity indicators in males. However, this method requires at least two cephalograms taken at intervals 1 or 2 years apart. In the present study which was conducted in both males and females, only a single cephalogram that was available at the beginning of treatment was taken. Hence that comparison is not possible in the present study, so the maximum height of the frontal sinus along with the maximum width was taken into consideration, and the sinus index was calculated and compared.[18]

Rossouw et al.[14] studied the skeletal growth pattern on 53 adult skeletal Class I and 50 adult skeletal Class III patients in which the surface area of frontal sinus was examined to assess the abnormal mandibular growth and they concluded that for predicting mandibular growth, the frontal sinus can be used as an additional indicator. In contrast, our study checks the validity of the frontal sinus as a growth assessment tool by observing the sinus index.

5. CONCLUSION:

This study has demonstrated that none of the parameters of frontal sinus analysis could be significantly correlated with the frontal sinus index. Hence, at this juncture, the use of this indicator as the sole criterion for evaluating the growth using cross-sectional data is questionable. So, Frontal sinus is not as reliable as a sole criterion for growth evaluation.

KEY POINTS

- Frontal sinus development begins 7-8 years, complete till late adolescence.
- Frontal sinus analysis can be done with the Ertürk method (1968).
- Frontal sinus enlargement in relation to body height (Forward and upward direction).

6. REFERENCES:

[1] Malgorzata M, Tiziano B. Duration of pubertal peak in skeletal Class I and Class III subjects. Angl Orthod. 2010; 80: 54-7.

[2] Fudalej P, Bollen AM. Effectiveness of the cervical vertebral maturation method to predict postpeak circumpubertal growth of craniofacial structures. Am J Orthod Dentofacial Orthop. 2010; 137: 59-65.

[3] Cavanese F, Charles YP, Dimeglio A. Skeletal age assessment from elbow radiographs Review of the literature. Chi Organi Mov. 2008; 92: 1-6.

[4] Chen LL, Min-Xu T, Jiang JH, Zhang XZ, Lin JX. Quantitative cervical vertebral maturation assessment in adolescents with normal occlusion: a mixed longitudinal study. Am J Orthod Dentofacial Orthop. 2008; 134(6): 720.e1-720.e7.

[5] Grave KC, Brown T. Skeletal ossification and the adolescent growth spurt. Am J Orthod. 1976; 69: 611- 19.

[6] Brown WAB, Molleson TI, Chinn S. Enlargement of the frontal sinus. Ann Hum Biol. 1984; 11(3): 221-6.

[7] Lamparski DG. Skeletal age assessment utilizing cervical vertebrae. Am J Orthod. 1975 Apr; 67(4): 458 - 59

[8] Ruf S, Pancherz H. Development of the frontal sinus in relation to somatic and skeletal maturity. A cephalometric roentgenographic study at puberty. Eur J Orthod. 1996; 18: 491-97.

[9] Koppe T, Rae TC, Swindler DR. Influence of craniofacial morphology on primate paranasal pneumatization. Ann Anat. 1999; 181: 77-80.

[10] Ruf S, Pancherz H. Frontal sinus development as an indicator of somatic maturity. Am J Orthod Dentofacial Orthop. 1996; 110: 476-82.

[11] Gagliardi A, Winning T, Kaidonis T. Association of the frontal sinus development with somatic and skeletal maturation in Aboriginal Australians: a longitudinal study. Hum Biol. 2004; 52: 39-52.

[12] Dodmani VR et al. Relation between Frontal Sinus Morphology and the Cervical Vertebral Maturation for the Evaluation of the Skeletal Maturity among Solapur Population: A Cross Sectional Study. J Med Sci clinic Res. 2018. 6.

[13] Ertürk N. Teleroentgen studies on the development of the frontal sinus. Fortschr Kieferorthop. 1968; 29(2): 245-48.

[14] Rossouw PE, Lombard CJ, Harris AM. The frontal sinus and mandibular growth prediction. Am J Orthod Dentofac Orthop. 1991; 100(6): 542-46.

[15] Noetzel H. Ober den einfluf des gehirns auf die formder benachbarten nebenhohlen des schadels, teil 1. Dtsch. Z. Nervenheilkd. 1949; 160: 126-36.

[16] Valverde Y, Watanabe N, Yamaki M, Saito I. The frontal sinus enlargement as an indicator of growth maturity in class III patients – a pilot study. Int J Med Sci Pub Health. 2013; 2(2): 451-5.

[17] Singh S, Sandhu N, Puri T, Gulati R, Kashyap R. A Study of Correlation of Various Growth Indicators with Chronological Age, research article. Int J Clinic Pediatr Dent. 2015 Sept-Dec; 8(3): 190-5.

[18] Patil AA, Revankar AV. Reliability of the frontal sinus index as a maturity indicator. Indian J Dent Res. 2013 Jul-Aug; 24(4): 523.

[19] Ruf S, Pancherz H. Can frontal sinus development be used for the prediction of skeletal maturity at puberty? Acta Odontol Scand. 1996; 54: 229-34.