



Relationship between frontal sinus morphology and cervical vertebral maturation for the assessment of skeletal maturity in Chhattisgarh population: an *In vitro* Cephalometric study.

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ABSTRACT

The aims of this study were to evaluate the relationship between frontal sinus morphology and cervical vertebral maturation for the assessment of skeletal maturity and to determine its validity in assessing the different stages of the adolescent growth spurt. A total of 60 lateral cephalograms of subjects aged between 8 and 21 years were included in the study. Based on the cervical maturation stages, the subjects were divided into 6 groups with 1:1 male to female ratio. The frontal sinus index and the cervical stages were evaluated on the same radiograph. Frontal sinus index was compared with different cervical stages by ANOVA and frontal sinus index values between adjacent cervical stages were compared for each sex by Tukey's post hoc test. The correlation between the cervical stages and the sinus index were assessed by Pearson's correlation test. The height and width of the frontal sinus were significantly larger in the male subjects than in the female. A significant difference was found in the frontal sinus height in males at different cervical stages and for frontal sinus width in females. No significant difference in the frontal sinus index at different cervical stages was found. Frontal sinus morphology cannot be used as a reliable sole indicator for the appraisal of skeletal maturity in patients.

Keywords: frontal sinus, the lateral cephalogram, cervical vertebral maturation

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INTRODUCTION

Human growth and development, from the infancy to puberty, involves dynamic changes in shape and size. Assessment of growth potential during the growth spurt has a significant effect on the process of orthodontic diagnosis and treatment planning to predict the treatment outcome and stability of treatment [1,2]. Various methods have been proposed to evaluate a patient's developmental status. However, most of them lacked precision and failed to give a reliable estimate of skeletal maturity. Amongst the various methods to assess growth by visualization of ossification events, hand wrist radiographs are the oldest and reliable methods [3,4]. The main drawback associated with them is the need of additional radiograph, thereby increasing radiation exposure to the patient². Researchers took a step further when they eliminated the need for additional radiographs using the cervical vertebrae [5,6] seen in the lateral cephalogram for growth assessment.

In past few decades, lateral cephalograms taken routinely for orthodontic diagnosis had been used to assess skeletal maturation by assessing morphologic changes in bodies of cervical width of frontal sinus. Ruf and Pancherz [7] stated that the frontal sinus growth is correlated with somatic maturity. Moreover, limited studies have evaluated the association of frontal sinus growth and skeletal maturity. A previous study revealed that the frontal sinus area expands up to the age of 19 years, and this growth is associated with general craniofacial growth and general skeletal maturity [10]. Many studies are available on the frontal sinus growth; but studies on the correlation of frontal sinus and other growth patterns are limited [1]. The aims of this study were to evaluate the relationship between frontal sinus morphology and cervical vertebral maturation for the assessment of skeletal maturity and to determine its validity in assessing the different stages of the adolescent growth spurt.

MATERIAL AND METHODS

- Standardized pretreatment lateral cephalograms of 60 subjects with aged 18- 21 years were collected from Department of Oral Medicine and Radiology from various institutions of Chhattisgarh for this study.
 - Total sample was uniformly divided into 6 cervical stages having equal numbers of males and females.
 - Patient with age group of 18-21 years of age and subjects with good quality standardized pretreatment lateral cephalograms were included in the study.
 - Subjects with history of sinus- related pathologies; any craniofacial anomaly, syndrome, trauma, or surgery involving the frontal sinus or the cervical vertebrae; any systemic disease affecting growth and development were excluded from study.
- Cephalograms were traced on to a 0.003 inch acetate paper using a 0.5 mm lead pencil under same illumination.

Assessment of frontal sinus as seen on the lateral cephalogram

- On the lateral cephalogram, frontal sinus analysis was performed. Each radiograph was manually traced on a 0.003 inch lacquered polyester acetate paper using a 0.5 inch lead pencil, by a single operator.
- The cephalogram was oriented with the nasion-sella line horizontally.
- The peripheral border of the frontal sinus as seen on the lateral cephalogram was traced.
- The highest (SH) and lowest (SL) points of sinus extension were marked.
- The maximum height was obtained by connecting these points. The maximum width of sinus was assessed perpendicular to this interconnecting line.
- The ratio between the frontal sinus height and width was calculated for each patient and was regarded as the sinus index.



Fig 1 :Assessment of the frontal sinus as seen on lateral cephalogram. (S -Sella, N -Nasion, SH - Highest point on the frontal sinus, SL -Lowest point on the frontal sinus, A -Maximum height of the sinus, B -Maximum sinus width perpendicular to the SH-SL line)

Assessment of skeletal maturation using cervical vertebrae as an indicator

- The maturation of cervical vertebrae was also evaluated on the same lateral cephalograms using the Baccetti's⁶ method.
- Accordingly, the maturation of cervical vertebrae was divided into 6 stages based on the shape of C1, C2 and C3 cervical vertebra.

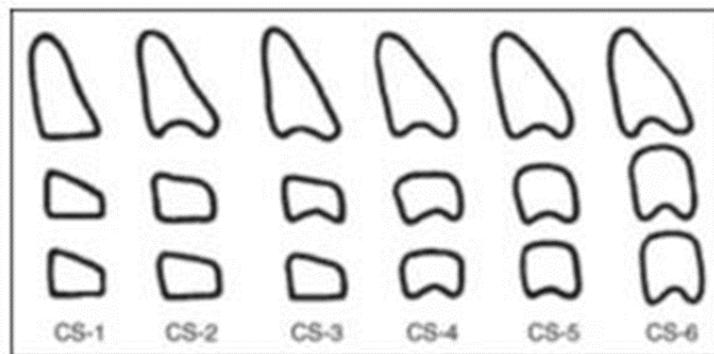


Fig 2: Cervical vertebral maturation stages according to the method of Baccetti⁶et al,

CS 1: the inferior borders of the bodies of all cervical vertebrae are flat; the superior borders are tapered from posterior to anterior;

CS 2, a concavity develops in the inferior border of the second vertebrae; the anterior vertical height of the bodies increases;

CS 3, a concavity develops in the inferior border of the third vertebrae; 1 vertical body has a trapezoidal or wedge shape;

CS 4, a concavity develops in the inferior border of the fourth vertebrae; concavities in the lower border of the fifth and sixth vertebrae are beginning to develop; the bodies of all cervical vertebrae are rectangular;

CS 5, concavities are well defined in the lower borders of the bodies of all cervical vertebrae; the bodies are nearly square, and the spaces between the bodies are reduced;

CS 6, all concavities have deepened; the vertebral bodies are now higher than they are wide.

RESULTS

The independent sample t-test was used to compare frontal sinus measurements in both sexes.

- Comparisons between frontal sinus measurements among the different cervical stages were made using the ANOVA test.
- Tukey's post hoc test was used to determine the correlation between frontal sinus measurements and cervical stages in the sexes.

A P value of ≤ 0.05 was considered statistically significant.

Table 1: Comparison of frontal sinus measurements

Variables	Gender comparison				t-value	p-value
	Male		Female			
	Mean	SD	Mean	SD		
Frontal sinus height	25.36	8.79	22.8	4.02	1.41	0.45 (n.s)
Frontal sinus width	9.76	2.848	7.83	2.245	2.91	0.005 (s)
Index	2.62	0.695	3.06	0.704	2.41	0.01 (s)

Table 1 shows that the frontal sinus height, width and index were compared between the sexes, which showed that a significant difference with males having greater sinus heights & widths, & females having greater values of sinus index.

Table 2: Comparison of frontal sinus measurements at the different cervical stages

Statistical test: ANOVA; (p<0.05- significant, CI=95%), n.s- not significant, s-significant

Variables	Gender	CS I	CS II	CS III	CS IV	CSV	CSVI	p-value
Frontal sinus height	Male	19.0±4.94	21.6±7.63	27.2±2.5	22.60±5.85	26.60±5.85	35.20±14.04	0.04 (s)
	Female	19.2±4.14	21.8±1.30	25.4±5.17	22.8±5.5	24.0±2.2	23.6±2.60	0.21 (n.s)
Frontal sinus width	Male	9.40±4.2	9.40±3.5	8.6±1.1	9.0±1.87	10.4±2.4	11.8±3.03	0.55 (n.s)
	Female	5.4±0.54	7.20±1.48	8.4±2.4	7.2±2.2	8.6±2.19	10.2±1.30	0.009 (s)
Frontal sinus index	Male	2.2±0.88	2.28±0.42	3.16±2.54	2.54±0.61	2.56±0.35	2.98±1.02	0.241 (n.s)
	Female	3.54±0.88	3.08±0.56	3.08±0.54	3.30±0.92	3.06±0.36	2.32±0.39	0.114 (n.s)

Table 2 shows that a significant difference were found in frontal sinus height in males at different cervical stages & for frontal sinus width in females at different stages were found. No significant difference in the frontal sinus index at different cervical stages were found.

Table 3: Comparison of frontal sinus index between adjacent cervical stages (CS)

Variables	Gender	CS I- CS II	CS II - CS III	CS III - CS IV	CS IV- CS V	CSV - CS VI
Frontal sinus index	Male	0.27 (n.s)	0.32 (n.s)	0.68 (n.s)	1.00 (n.s)	0.91 (n.s)
	Female	0.87 (n.s)	1.00 (n.s)	0.99 (n.s)	0.99 (n.s)	0.48 (n.s)

Statistical test: Tukey's post hoc test (p<0.05- significant, CI=95%), n.s- not significant, s-significant

Table 3 shows no significant difference was found between the frontal sinus index & adjacent cervical stages.

Table 4: Correlation between frontal sinus measurements and cervical stages

Variable	Sex	Correlation with cervical stages	
		Correlation	p-value
Frontal sinus height	Male	0.51	0.004 (s)
	Female	0.32	0.008 (s)
Frontal sinus width	Male	0.26	0.15 (n.s)
	Female	0.59	0.001 (s)
Index	Male	0.28	0.15 (n.s)
	Female	-4.01	0.02 (s)

Statistical test: Pearson's correlation; (p<0.05- significant, CI=95%), n.s- not significant, s-significant.

Table 4 shows significant correlation between frontal sinus height and cervical stages in both males and females. No significant correlation was found between frontal sinus width and cervical stages in males where as significant correlation was found in females. Similarly a weak negative correlation was found between frontal sinus index and cervical stages in female subjects, whereas no correlation was found in male subjects.

DISCUSSION

Many studies have been conducted using CVMI and MP3 stages to assess skeletal maturation but literature on use of Frontal sinus as a skeletal maturity indicators is limited. Hence, it was decided to compare Frontal sinus as a skeletal maturity indicators with CVMI stages. The frontal sinus, which are located between the external and internal cortical layers of the frontal bone, are anatomically called pneumatic cavities [4]. Ruf and Pancherz [7], have shown that the enlargement in the width of the frontal sinus can be considered as one of the skeletal maturity indicators in males. A number of indicators have been documented in the literature to assess skeletal growth. Abdel-Kader, proposed MP3 radiograph alone on a dental film in order to reduce radiation exposure [6-8]. However, the method suggested by them requires at least two cephalograms taken at intervals 1 or 2 years apart. By their own admission, two such cephalograms are seldom available at the beginning of treatment. The present study; however, is conducted in both males and females using a single cephalogram available at the beginning of treatment alone. The maximum height of the frontal sinus along with the maximum width was taken into consideration, and the sinus index was calculated and compared to the cervical vertebrae maturation stage of each individual [8,9]

The results of our study reveal that prediction potential using this cross-sectional sinus index technique is low. The height and width of the frontal sinus were significantly larger in the male subjects than in the female. A significant difference was found in the frontal sinus height in males at different cervical stages and for frontal sinus width in females. The Tukey's post hoc test showed that the values of the sinus index were comparable between any 2 adjacent cervical stages. No significant difference in the frontal sinus index at different cervical stages was found [10].

CONCLUSION

- Frontal sinus morphology cannot be used as a reliable sole indicator for the appraisal of skeletal maturity in patients.
- A significant correlation was noted between the frontal sinus height and width and CVM stage in both males and females, which had an increasing pattern. However, no significant correlation was noted between the frontal sinus index and the CVM stage.
- Hence, evaluation of the CVM stage remains the standard method for assessment of skeletal maturity in patients undergoing orthodontic treatment.
- Longitudinal studies using three-dimensional radiographic modalities are required to precisely assess the sinus growth and its correlation with the CVM and skeletal maturity.

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