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RESEARCH ARTICLE

CORRELATION OF PARANASAL SINUSES WITH THE CHRONOLOGICAL AGE IN HIMACHALI POPULATION

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ABSTRACT

Introduction: The precise identification of skeletal maturity with regard to the onset of the pubertal growth spurt has major clinical implications in treatment efficacy and efficiency. Different methods in an attempt to determine the best indicator of maturity have been evaluated. But still researches are being done to assess the maturity of an individual in relation to chronological age. **Aims and objectives:** To evaluate the correlation of maxillary sinus area and frontal sinus area as growth indicator with chronological age to assess the maturity of an individual in Himachali Population. **Material and Methods:** 150 lateral cephalograms of subjects were divided into three groups of 50 each based on chronological age and each group was further subdivided into 2 subgroups of 25 males and 25 females: group I (8-10) years of age), group II(10-12)years of age and group III(12-14)years of age and measurements were recorded ; the chronological age was correlated with the area of maxillary sinus and frontal sinus using SPSS software**. Conclusion:** maxillary sinus was found to be highly correlated with the chronological age.

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INTRODUCTION

Timing is a fundamental part of treatment planning in orthodontics. Initiating treatment in a growing patient at the right time has shown significant favorable effects in the correction of disharmonies in all the three planes of space (Franchi *et al*., 2008). Successful treatment outcome of malocclusion is dependent on time to correct underlying skeletal discrepancy. The ability to predict the magnitude and direction of a patient's facial growth early in life would enable the clinician to modify growth so that the appropriate treatment can be rendered (Kolodziej *et al*., 2002). The clinical importance of evaluating skeletal maturation is an integral part of individual patterns of growth and development (Leonard, 1982). Additional information is necessary to estimate the maturation level of the individual. Such information can be obtained from the dental, skeletal, and pubertal development. By comparing with standards for age and sex, it is possible to assess whether the development of the individual is average, accelerated, or retarded. In orthodontics it is more relevant to evaluate the individual's maturation in relation to his or her own pubertal growth spurt.

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This predicts knowledge of relationships in time between maturation indicators and pubertal growth events. Sexual maturation characteristics, chronologic age and skeletal development are some of the more common means that have been used to identify stages of growth. Determination of maturation and subsequent evaluation of growth potential during preadolescence or adolescence is extremely important.[4] Every skeletal and muscular dimension seems to be involved in the pubertal growth spurt. The pubertal growth spurt is considered to be an advantageous period for certain types of orthodontic treatment and should be taken into account in connection with orthodontic treatment planning (Hagg, 1982). The precise identification of skeletal maturity, with particular regard to the onset of the pubertal growth spurt has major clinical implications in terms of treatment efficacy and efficiency (Giuseppe Perinetti, 2014). It has been long recognized that an individual's chronological age does not correlate well with maturational age. Skeletal age may be retarded or advanced from the actual chronological age. Many authors have attempted to determine the best indicators of the degree of maturity. Several indices have been proposed to identify the skeletal maturation phases. An indicator that can be used to assess the growth status of an individual is the size of frontal sinus. The frontal sinus bud is present at birth in the ethmoidal region but is not evident radiographically until fifth year, when it projects above the orbital rim (Harris, 1987). It is a part of anterior ethmoidal cells which evaginate from the

frontal recess directly to the frontal bone. There are few studies that have investigated the relationship of the frontal sinus with other growth parameters. Frontal sinus development has also been found to show a growth rhythm similar to body height development with a well-defined pubertal peak (Ruf, 1996). The development of maxillary sinus begins at ethmoidal infundibulum in the third month of fetal life. Among the paranasal sinuses maxillary sinus plays an important role in the formation of facial contours. After birth maxillary sinus continues to extend both laterally and inferiorly during the rapid growth period from birth to 3 years of age and from 7 to 12 years of age (Graney, 1993). Therefore, knowledge of the development and size of maxillary sinus may be very important for studying and predicting the growth of an individual. Different authors had reported different methods in an attempt to determine the best indicator of maturity. Every method has its own advantages, disadvantages and limitation over the other method. But still researches were being done to assess the maturity of an individual in relation to chronological age. So the aims and objectives of this study were to evaluate the correlation of maxillary sinus area and frontal sinus area as growth indicator with chronological age to explore the best method to assess the maturity of an individual in Himachali population.

MATERIALS AND METHODS

The present study was conducted on 150 subjects of Himachali ethnic origin who were the residents of Himachal Pradesh from the last two generations. Lateral cephalograms were obtained from the patients who visited the department seeking orthodontic treatment. Following were the inclusion criteria:

Inclusion Criteria

- All the subjects were in growing age.
- No history of bone deformities, bone diseases and major illness in the past.
- Subjects were of Himachal ethnic origin and were residents of Himachal Pradesh from last two generations.
- No congenital or acquired malformation of the skeletal and dental origin.

The 150 subjects were divided into three groups of 50 each based on chronological age and each group was further subdivided into 2 subgroups of 25 males and 25 females.

- **GROUP I:** 8-10 years of age
- **GROUP II:** 10-12years of age
- **GROUP III:** 12-14years of age

All lateral Cephalometric films were placed on transparent cellulose acetate sheet (0.003 inch).All reference points were identified, located and marked. The peripheral borders of maxillary sinus and frontal sinus were traced on each lateral cephalogram, for each patient. All tracings were done by a single investigator to eliminate individual error.

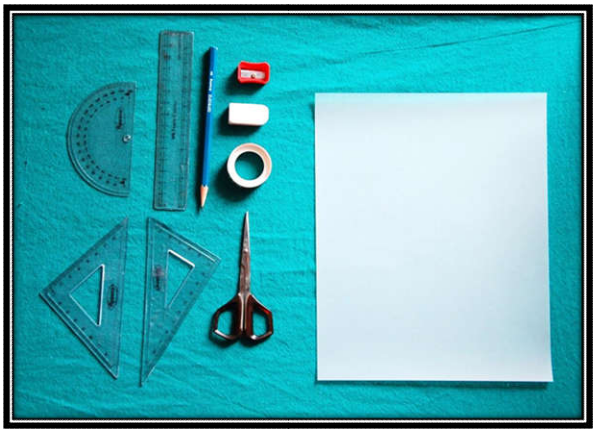
METHOD OF ASSESSMENT

Assessment of Chronological Age: The chronological age was taken as the difference between the day records were taken and date of birth of the patient as told by the patient or by the parent.

Evaluation of Maxillary Sinus Dimensions: The linear and area measurement of maxillary sinus was done using the method of Toshiya *et al*. (2009). (Photograph 1)

Maxillary sinus length (MSL): this line extends from An to the Po. Maxillary sinus height (MSH): this line extends from Su to the In. Total maxillary sinus area (TMSA): this represents summation of upper and lower maxillary sinus area.

Evaluation of Frontal Sinus Dimension: Width of the frontal sinus was measured by the method described by Erturk (1968) in which the lateral head films were obtained with the nasion – sella line horizontally. (Photograph 2) The peripheral borders of the frontal sinus were traced and the highest point (SH) and lowest point (SL) of its extension were marked and connected by drawing a line (SH-SL). Perpendicular to the interconnecting line, the maximum width of the frontal sinus was assessed. After all the measurements were recorded for the subjects then the chronological age for each subject was correlated with the area of maxillary sinus and frontal sinus using SPSS software.



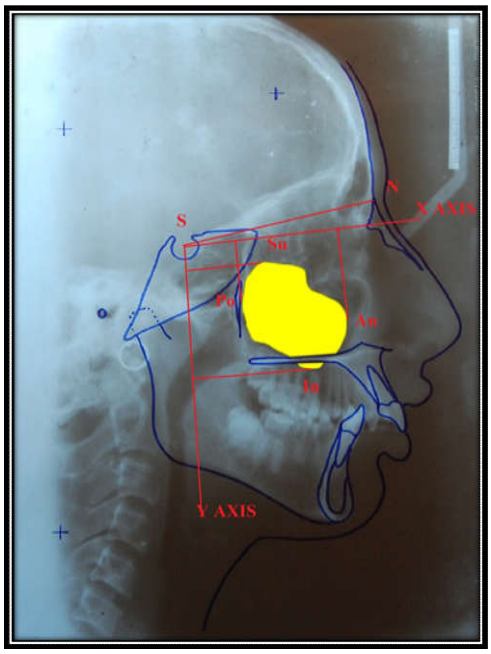
Photograph 1. Armanterium Used For Study

Photograph 2. Lateral cephalogram machine (planmeca x-ray machine model no.2002)

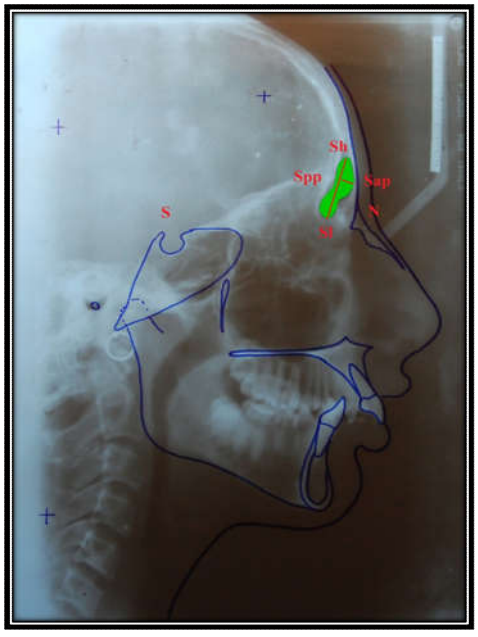
RESULTS

The correlation between them was assessed by using Student's t test and Pearson's correlation coefficient using SPSS software, version 21. Unpaired t- test were done to find the means and standard deviation of chronologic age, area of maxillary sinus and area of frontal sinus.

Photograph 3. Lateral cephalogram cassette used for radiograph



Photograph 4. Lateral Cephalogram Showing Dimensions Of Maxillary Sinus



Photograph 5. Lateral cephalogram showing dimensions of frontal sinus

Table I. Mean frontal sinus area, maxillary sinus area in male and female subjects

GROUP	FRONTAL SINUS	MAXILLARY SINUS
MALE	74.4 ±34.54	533.34 ±101.32
FEMALE	61.45 ±32.52	561.74 ±111.26
TOTAL	67.74 ±34.03	547.54 ±107.00

p<0.05and p<0.01 (significant)*; p<0.01(highly significant) **; p>0.05(not significant)

Table II: Difference between frontal sinus areas, maxillary sinus area among male and female subjects

Group	Mean difference	Standard error	P value
Frontal sinus area	2.51	2.78	0.01*
Maxillary sinus area	1.63	8.74	0.10

p<0.05and p<0.01 (significant)*; p<0.01(highly significant) **; p>0.05(not significant)

Pearson's correlation test was performed to find out the correlation between these parameters. Table I showed the descriptive statistics of the frontal sinus area and maxillary sinus area in male and female subjects. Table II showed the difference between frontal sinus area, maxillary sinus area, among male and female subjects. The difference between the value of frontal sinus area between male and female subjects was found to be statistically significant (p= 0.01). Table III showed the mean and standard deviation of the age, frontal sinus area, and maxillary sinus area in three different age groups among male and female subjects. The area of frontal sinus and maxillary sinus increases with increasing age that is in all the three age groups. Area of both these sinuses was more in males as compared to females. Table IV showed the student t test between the various parameters of age, frontal sinus area, and maxillary sinus area, among three age groups between male and female subjects. Table V showed the correlation of frontal sinus area with other parameters like chronological age, maxillary sinus area. It was found that frontal sinus area was maximum correlated with the maxillary sinus area (p= 0.0001) then with chronological age (p= 0.0005) Table VI showed the correlation of maxillary sinus area with various growth indicators like chronological age, frontal sinus area. It was found that maxillary sinus area was highly correlated with chronological age (p= 0.0001). Positive correlation was also found between maxillary sinus area and the frontal sinus area (p= 0.0001).

DISCUSSION

Growth of human body and face are characterized by variability in growth rate and individual progression towards biological maturity. Variations in the timing of skeletal and facial growth were found to be related to variations in the level of maturational development. Accurate age estimation is considered to be of great importance in dental and medical practices. Correct skeletal maturation estimation provides measures to predict the optimum timing for treatment in orthodontic and orthopedic clinical practice. Thus, optimal timing for dentofacial orthopedics is linked intimately to the periods of accelerated or intense growth that can contribute significantly to the correction of skeletal imbalances in the individual patient. Chronological age is not the perfect indicator and may have little or no role in the assessment of maturational status of a child. Hence, it cannot be considered as an absolute factor for the evaluation of overall growth potential in a child.

Table III. Age, frontal sinus area, maxillary sinus area in three different ages among male and female subjects

PARAMETERS	8-10 years		10-12 years		12-14 years	
	Male	Female	Male	Female	Male	Female
	(N=25)	(N=25)	(N=25)	(N=25)	(N=25)	(N=25)
AGE	9.2±0.86	9.4±0.50	11.72±0.45	11.56±0.50	13.4±0.05	13.4±0.05
FRONTAL SINUS AREA	57.84±24.50	47.24±18.58	77.8±27.50	67.62±31.25	86.48±43.27	69.50±40.28
MAXILLARY SINUS AREA	492.84±66.6	487.00±61.4	513.84±91.2	570.68±122.9	593.36±114.1	626.82±95.3

p<0.05and p<0.01 (significant)*; p<0.01(highly significant) **; p>0.05(not significant)

Table IV. Student t test between the various parameters of age, frontal sinus area, and maxillary sinus area between the three age groups among male and female subjects

PARAMETERS	AGE (YEARS)		FRONTAL SINUS AREA		MAXILLARY SINUS AREA	
AGE GROUPS	t	p		p	t	p
8-10 years	-1.37	0.183	1.40	0.17	0.29	0.77
10-12 years	1.71	0.24	1.26	0.21	-1.74	0.09
12-14 years	0.56	0.57	1.47	0.15	-1.17	0.25

p<0.05and p<0.01 (significant)*; p<0.01(highly significant) **; p>0.05(not significant)

Table V: Pearson's correlation of age, maxillary sinus area with frontal sinus

PARAMETERS	FRONTAL SINUS AREA		
	r	R^2	p
AGE	0.278	0.077	0.0005**
MAXILLARY SINUS AREA	0.387	0.150	0.0001**

p<0.05and p<0.01 (significant)*; p<0.01(highly significant) **; p>0.05(not significant)

Table VI. Pearson's correlation of age, frontal sinus area, with maxillary sinus area

PARAMETERS	MAXILLARY SINUS AREA		
	r	R^2	P
AGE	0.466	0.217	0.0001**
FRONTAL SINUS AREA	0.387	0.150	0.0001**

p<0.05and p<0.01 (significant)*; p<0.01(highly significant) **; p>0.05(not significant)

Table VII: Pearson's correlation of frontal sinus area, maxillary sinus area and with age

PARAMETERS	AGE		
	r	R^2	p
FRONTAL SINUS AREA	0.278	0.077	0.0005**
MAXILLARY SINUS AREA	0.466	0.217	0.0001**

p<0.05and p<0.01 (significant)*; p<0.01(highly significant) **; p>0.05(not significant

Also, more information about the prediction of growth status of a child is given by the skeletal age, secondary sexual characters, and dental age which are estimated from the degree of maturation of various tissues. It is necessary for an orthodontist to know about the residual growth potential left in a child during the course of treatment because of the individual variations in timing, duration and velocity of growth, so the conventional method of growth prediction by chronological age is not desired. Hence various methods have been used to evaluate the skeletal age and maturational status of a child like the cervical vertebrae maturation, dimensions of frontal and maxillary sinus. Development of the frontal sinus shows a rhythm similar to the development of the body, maxillary sinus dimensions shows the effect on the skeletal development of the child. Hence, the study was done to evaluate and assess the relationship of area of frontal sinus, area of maxillary sinus with chronological age, and to assess the correlation if any among all these parameters in Himachali population. In the present study the mean value of frontal sinus area was found out to be (57.84±24.5) in males and (47.24±18.5) in females respectively as shown in (Table II) in group I (8 – 10 year). Also, in the present study the mean value of frontal sinus area was found out to be (77.80±27.5) in males and (67.62±31.2) in females respectively as shown in (Table II) in group II (10– 12 year).

The mean value of frontal sinus area was calculated as (86.48±43.2) in males and (69.50±40.2) in females respectively as shown in (Table II) in group III (12– 14 year). The mean surface area of frontal sinus was found to be highest in group III in both males and females (77.80±27.5) and (67.62±31.2) respectively among all the three groups. Also, the mean surface area of frontal sinus was found to be least in group I which was found out to be (57.84±24.5) in males and (47.24±18.5) in females respectively. The reason for this variation may be due to the growth of the frontal sinus that begins during second year and extends laterally to the orbital floor around fifth year of age, with the appearance of being well expanded at the age of 12- 14 years of age. So, as the age advances the growth of the frontal sinus being more in the vertical direction due to the structural adaptation to the forward and downward growth of the mid face with the forward growth of the external lamina of frontal bone which is essential to keep the contact with the nasal bone and maxilla. This is in acceptance with the study done by Baer and Harris. The present study is in accordance with the study conducted by Dolan who reported that the growth of the sinuses continues until the age of 12 years, when they reach nearly adult size. The results of our study is also in favor of study conducted by Tanner who also found that the annual height increments of frontal sinus were till the age of 14 year after which the

enlargement of the frontal sinuses ceased. This suggests that increase in the size of the frontal sinus follows the trend in growth in bone lengths very closely. Similar results were also found in the study done by Gagliardi A, Winning *et al*. (2004) who proposed that frontal sinus was found to display a well-defined adolescent growth spurt, with its peak velocity occurring after the peak velocity in body height. Also, the mean value of frontal sinus area is more in males as compared to females in all the three groups. This may be attributed to the fact that the morphological differences in the cranium between the two sexes are determined mainly by genetic factors more so by nutritional, hormonal or muscular factors. This explains why frontal sinus is on an average larger in males when compared to females. This is in acceptance with the study conducted by ChetanBelaldavar, Kotrashetti VS *et al*.[17]Also, similar results were found in the study conducted by Quatrehomme G *et al*. (1993) and study done by Patil K *et al*.[19]who also concluded that the dimensions of frontal sinuses were higher in males as compared to females. When the correlation of frontal sinus was studied with various other growth indicators like chronological age, maxillary sinus area it was found that frontal sinus area was correlated to its highest degree with the maxillary sinus area (r=0.387), (p= 0.0001) which is shown in (Table V) which shows highly statistically significant value. The correlation of frontal sinus with chronological age was (r=0.278) (p= 0.0005). In the present study the mean value of maxillary sinus area was found out to be (492.84±66.5) in males and (487.00±61.41) in females respectively as shown in (Table II) in group I (8 – 10 year). Also, in the present study the mean value of maxillary sinus area was found out to be (570.68±122.9) in males and (513.84±91.24) in females respectively as shown in (Table II) in group II (10– 12 year).

The mean value of frontal sinus area was calculated as (626.82±95.3) in males and (593.36±144.2) in females respectively as shown in (Table II) in group III (12– 14 year). The mean surface area maxillary sinus was found to be highest in group III in both males and females (626.82±95.3) and (593.36±144.2) respectively among all the three groups. Also, the mean surface area of maxillary sinus was found to be least in group I which was found out to be (492.84±66.5) in males and (487.00±61.41) in females. The difference may be explained by the fact that the development of maxillary sinus begins at the ethmoidal infundibulum in the third month of fetal life. After birth it continues to extend both laterally and inferiorly during the rapid growth period from birth to 3 years of age and attains its maximum size from 7-12 years of age. This is in acceptance with the study done by Graney, Rice, (1993) and a study conducted by Scuderi AJ, Harnsberger, (1993) who also reported the same. Also in all the three groups it was seen that the dimensions of maxillary sinus were higher in males as compared to females this may be due to the fact that the cranial base dimensions tend to be larger in males than in females and that the patients with larger cranial bases have in turn larger volume of maxillary sinuses. This is in accordance with the study conducted by Dibbets, (1996) and Hopkin *et al*. (1968) Also, Emirzeoglu *et al*. (2007) and Ariji *et al*. (2006) showed a significant difference in the volume of maxillary sinus between male and female subjects, mainly due to the fact that males exhibit higher and wider maxillary sinus as compared to females. Although the differences found between males and females in various groups in our study were not statistically significant. At times in the absence of maxillary first molar over a long period of time, it may make the maxillary sinus to invade the alveolar process of the missing site more inferiorly, thus making the contact of the cortical bone of the maxillary sinus floor with their roots.

Therefore, the knowledge of the development and size of maxillary sinus plays a very crucial role for diagnosing and treating various orthodontic malocclusions. The correlation of maxillary sinus with various other growth indicators like chronological age, frontal sinus area was calculated and it was found that maxillary sinus area was highly correlated with the chronological age (r=0.466), (p= 0.0001) shown in (Table VI) which shows highly statistically significant value. Correlation of maxillary sinus area with frontal sinus area was (r=0.387) (p= 0.0001) which again showed high positive correlation. Cephalometrics provides orthodontists with a large and useful body of descriptive information and the associated methodology can also be applied to the growth changes within the craniofacial complex. The amount of future facial growth is of immense importance, especially in the young children. The necessity for early diagnosis has been particularly stressed when orthopedic treatment is anticipated on either the maxilla or mandible (Rossouw, 1991). Orthodontic treatment of the most dentofacial problems will be affected by the concurrent growth regardless of the appliance mechanics. Therefore, maturational information can also be very valuable in selecting and executing orthodontic retention procedures or facial surgery. Although the use of two-dimensional lateral cephalogram along with little sample size may be the limiting factor, it is statistically demonstrated in this study that among the paranasal sinuses, maxillary sinus is better correlated with the chronological age. Further research would be required to minimize the limiting factor by doing study on large sample size and using three dimensional techniques for a better diagnosis and treatment planning.

Conclusion

Among the paranasal sinuses, maxillary sinus was found to be highly correlated with the chronological age and a positive correlation was found between the frontal sinus and chronological age.

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