"RELIABILITY OF FRONTAL SINUS MORPHOLOGY WITH CERVICAL VERTEBRAL MATURATION FOR THE ASSESSMENT OF SKELETAL MATURITY"

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THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY

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I hereby declare that this dissertation titled **"RELIABILITY OF FRONTAL SINUS MORPHOLOGY WITH CERVICAL VERTEBRAL MATURATION FOR THE ASSESSMENT OF SKELETAL MATURITY "** is a bonafide and genuine research work carried out by me under the guidance of **Dr. K.S.PREM KUMAR, M.D.S., Professor, Head of the Department,** Department of Orthodontics and Dentofacial Orthopaedics, Best Dental Science College, Madurai - 625104.

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"Gratitude is the fairest blossom which springs from the soul."

– Henry Ward Beecher

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DECLARATION

TITLE OF THE DISSERTATION	RELIABILITY OF FRONTAL SINUS MORPHOLOGY WITH CERVICAL VERTEBRAL MATURATION FOR THE ASSESSMENT OF SKELETAL MATURITY
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This agreement herein after the "Agreement" is entered into on this day of between the Best Dental Science College represented by its **Principal** having address at Best Dental Science College, Madurai – 625104, (hereafter referred to as, 'the College')

And

Dr. K.S.PREM KUMAR, M.D.S., aged 46 years working as **Professor and Head of the Department** in the Department of Orthodontics & Dentofacial Orthopaedics at the College, having residence address at 2/225 Vignesh Avenue, 2nd street Karupayurani, Opp to Indian Oil Bunk, Madurai-625020 (herein after referred to as the 'Chief Investigator')

And

Dr. J.SYED AAFAQUE aged 25 years currently studying as a **Post Graduate student** in the Department of Orthodontics & Dentofacial Orthopaedics, Best Dental College, Madurai-625104 (hereinafter referred to as the 'PG/Research student')

Whereas the PG/Research student as part of his curriculum undertakes to research on **"RELIABILITY OF FRONTAL SINUS MORPHOLOGY WITH CERVICAL VERTEBRAL MATURATION FOR THE ASSESSMENT OF SKELETAL MATURITY"** for which purpose PG/ Research student shall act as the Principal Investigator and the college shall provide the requisite infrastructure based on the availability and also provide facility to the PG/Research student as to the extent possible as a Co-investigator.

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2.

ABSTRACT

INTRODUCTION

Growth, an expository variable aids the orthodontist in precise diagnosis and treatment planning. Variations in developmental pattern led to the evolution of malocclusion and dentofacial deformities. Developmental status of a patient can be evaluated by several methods but most of them failed to give a reliable estimate of skeletal maturity.

AIM

To evaluate the correlation of frontal sinus morphology with cervical vertebrae stages as a skeletal maturity indicator.

MATERIALS AND METHODS

A total of 180 lateral cephalograms of subjects aged between 8 and 16 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 Kruskal-Wallis test and frontal sinus index values between adjacent cervical stages were compared for each sex by post hoc Dunnett T3 test. The correlation between the cervical stages and the sinus index were assessed by Kendall tau-b values.

RESULTS

There was a significant linear increase and a good statistical correlation of the frontal sinus height and width at each cervical vertebral maturation stages. The index of frontal sinus increases statistically with the cervical vertebral maturation but had a weak correlation with the maturation stage. There was no significant relationship and no significant correlation of frontal sinus height, width and index with gender.

CONCLUSION

Frontal sinus morphology cannot be used as a reliable sole indicator for the appraisal of skeletal maturity in patients.

Key words: Frontal sinus, Cervical vertebral maturation stages, Skeletal indicator.

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INTRODUCTION

Initially, the concept of patient care in dentistry was towards the therapeutic approach. But this concept slowly slided towards preventive as well as interceptive approach. This was made viable through predicting the risk factors of the disease and treating them at the onset. The competent care in dentistry at this current era focuses on the issues related not only to disease and functional disability but also to the patient's own welfare.[1] The appearance of the face and dentition is admitted to have its own effect on human psychosocialhealth.[2]

Malocclusion and Dentofacial deformities evolved due to variations in developmental patterns and should be evaluated against normal development.[3] Growth is a expository variable in orthodontic diagnosis as well as in treatment planning.[4] So the orthodontic treatment encompasses manipulation of skeletal growth along with dental correction.[3] Growth in human body undergoes dynamic changes in size and shape from infancy to maturity. The outcome and stability of treatment planning is influenced by growth potential during the preadolescent or adolescent growth spurt.[5] The growth is assessed through both chronological and skeletal age.

Chronologic age is not a reliable indicator of growth, as it fails to provide a precise diagnosis of the skeletal growth status of a child, because children of same chronologic age will have varied degrees of skeletal maturation.[6] Hence, in order to estimate individual's growth potential, disparate parameters have been used.[5]

Indicators of skeletal age are more vital than the chronological age in respect to the clinical decisions regarding use of either orthopaedic extra oral appliance, functional appliances or orthognathic surgery.[5] Many skeletal maturity indicators have been proposed over the previous decades in order to make the precise diagnosis of the growth.[4] Skeletal maturity can be assessed by inspecting visually the developing bones, mainly of the hand, wrist, and elbow on radiographs.[7,8,9] Though the assessment of maturity through ossification is considered to be reliable, there is an increased risk of radiation exposure.[10] In order to overcome this, Lamparski[11] studied maturation of the cervical vertebrae on lateral cephalogram and reported that cervical vertebral maturation correlated with the skeletal maturation of a child.[12] Currently, the cervical vertebral maturation method is one of the most commonly used method for assessing the growth status of a child. However, it has some limitations which includes the difficulty that occurs while classifying cervical vertebral bodies 3 and 4 either as trapezoidal, rectangular, horizontal, square, rectangular or vertical. Moreover, there is inappropriateness in pubertal growth spurt division into discrete stages to describe a continuous phenomenon.[4]

The limitations of cervical maturation indicators magnetized towards advanced methods, one of which include the frontal sinus maturation which involves assessing the frontal sinus morphological changes occurring during the adolescent growth spurt of a child.[5] The frontal sinuses are paranasal sinuses, which are analysed in cephalometric radiograph. Frontal sinuses are not visible at birth and can be radiographically seen around 4–6 years of age. The height, width and volume of frontal sinuses increases upto 20 years of age.[4]

In 1996, Ruf and Pancherz[13,14] reported that a well-defined pubertal growth spurt was appreciated with the enlargement of the frontal sinus by evaluating the frontal sinus morphology on lateral cephalograms. Hence, frontal sinus can be used to assess the developmental status of a child.

Several studies on the development of the frontal sinus have been reported, but only few studies have investigated the correlation of the frontal sinus with other growth parameters.[5]

The intent of this study was to assess the reliability of frontal sinus morphology, which can be a skeletal maturity indicator by correlating it with the cervical vertebral stages.

AIM

&

OBJECTIVES

AIM

To evaluate the correlation of frontal sinus morphology with cervical vertebrae stages as skeletal maturity indicator.

OBJECTIVES

a. To measure the height and width of frontal sinus.
b. To calculate the height and width ratio (frontal sinus index).
c. To assess the cervical vertebral stages.
d. To correlate the sinus index and the cervical vertebrae stages.

REVIEW OF LITERATURE

Houston (1980), using data from the Harpenden growth study, briefly reported the roles of ossification events, bone stages and bone ages in predicting the pubertal growth spurt. He reported that only little clinical value for predictions made in advance of about more than two years than the average age of peak height velocity (PHV). The practical difficulties of obtaining reliable information about the timings of certain ossification events and PHV precluded their use in most cases despite of their relationship. Certain bone stages indicated that growth completion is nearing. Comparing with carpal age, RUS (Radius, Ulnar and Short bones) age was more closely related to the timing of PHV. Hence, the most convenient and reliable way of estimating the age is estimation of PHV. Assuming that the growth spurt is of the same extent as ossification events or bone age would be misleading and for proper evaluation the appropriate regression equations must be used [10]

Brown WA et al (1984), longitudinally analyzed the enlargement of the frontal sinus among 49 males and 47 females with the first available lateral cephalogram between 2 and 5 years of age. A total of 88 subjects of between age 2 to 5 years and 8 subjects between 6 to 11 years were selected. In addition to the first consecutive cephalograms were taken at yearly intervals. In 28 subjects a last cephalogram was obtained at 24 years or older. Only six subjects out of all, showed the proceeding of the sinus enlargement during the last cephalogram. The enlargement was evaluated by a standardized measurement of the maximum vertical height of the sinus. The median age of appearance of the frontal sinus was 4 ± 1.8 years for the girls and 3 ± 1.5 years for the boys. It enlarged upto 32 X 60 mm in the males and 26 X 60 mm in the females. The median age where the sinus enlargement ceased was 13 ± 7.2 years for girls and 15± 6.8 years for boys. This showed that the enlargement of the frontal sinus, due to osteoclastic activity followed the trend for growth in bone lengths very closely.[15]

Harris A.M.P et al (1987), conducted a study using standardized radiographs among 60 adult black patients which included 30 female and 30 males and were compared with same number of patients from the Cape colored ethnic group. Sinus height, sinus width, perimeter, number of edge loculations, inter-orbital distance and sinus area were included in the study. The frontal sinuses in male were greater in both supero-inferior and mediolateral dimensions and had a greater number of edge loculations. Inter-orbital distance was greater in the black racial group than with Cape colored and sinuses were absent in 6 which accounts for about 7% of blacks and only 1 which accounts for about 7% of Cape colored. The differences between racial groups and sexes were insufficient for definitive identification purposes.[16]

P.E. Rossouw et al (1991), analysed about the skeletal growth patterns cephalometrically for 103 subjects with Class I and III malocclusions to assess the abnormal mandibular growth. The surface area of the frontal sinus was examined by a Summagraphics decoder linked to a microcomputer. Their results indicated that there was a positive correlation between maxillary length, mandibular length, symphysis width, condylar length, and frontal sinus size on a lateral cephalogram. They concluded saying that when one is predicting the mandibular growth, the frontal sinus can be used as an additional indicator.[17]

Sabine Ruf et al (1996), reviewed the possibility of predicting somatic maturity stages by observing the frontal sinus growth. The study was conducted among 53 adolescent boys, and the frontal sinus size development was assessed on lateral head films. The accuracy of the procedure was tested by comparing the prediction stage with that of the longitudinal growth data for body height of the subjects which revealed that the only prediction was whether the pubertal growth peak in height has been passed. The precision of this method was high about approximately 90%. But, the age of body height peak was predicted by the method with lower accuracy of approximately 55%. No significant difference was found between the prediction at 1 and 2 year intervals. The study concluded that the somatic maturity stage may be predicted accurately by analysing the frontal sinus development on pre-existing lateral head films.[13]

Sabine Ruf and Hans Pancherz (1996) studied the development of the frontal sinus in relation to somatic and skeletal maturity by means of longitudinal data obtained from lateral head films, hand wrist radiograph and body height growth curves in 26 male subjects of age 9-22 years. These were grouped together and assessed in a cross-sectional manner. The results revealed that the final size of the frontal sinus varied considerably. They also found that in analogous to body height growth at puberty, the enlargement of the frontal sinus exhibited a similar pattern with a well-defined peak, which on average occurred 1.4 years after the body height peak. From these results they concluded that in comparison with skeletal maturity, 65 per cent of the subjects reached the sinus peak during the hand radiographic stages MP3-G or MP3-H, while the body height peak coincided with an earlier maturity stage (MP3-FG).[14]

Kucukkeles et al (1999) conducted a study to analyse the associations between cervical vertebrae maturation index (CVMI) and skeletal maturation indicators (SMI) to determine the reproducibility of the identifications on the lateral cephalograms and hand-wrist films. The study consisted of 180 untreated subjects (99 girls and 81 boys) aged from 8 to 18 years whose lateral cephalometric and left hand-wrist radiographs were obtained from the files of the Marmara University School of Dentistry, Department of Orthodontics. The results of this study indicated significant relation between cervical vertebrae maturation and hand-wrist skeletal maturation.[18]

Franchi et al (2000), analysed the validity of 6 stages of cervical vertebral maturation as a biologic indicator for skeletal maturity in 15 females and 9 males. From this method they found the greatest increment in mandibular and craniofacial growth during the interval from vertebral stage 3 to vertebral stage 4, when the peak in statural height also occurred. The prevalence rate among the examined subjects who presented with the peak in body height at this interval was 100% for boys and 87% for girls. Ramus height (Co- Go) and S-Gn also showed significant deceleration of growth during the interval CVS 4 to CVS 5 when compared with CVS 3 to CVS 4. Cervical vertebral maturation is an appropriate method for the appraisal of mandibular skeletal maturity and also provides indication concerning treatment timing of mandibular deficiencies in individual patients based on single cephalometric observation and without additional x-ray exposure.[12]

Madhu et al (2003) conducted a study to provide a simple method of skeletal maturity assessment using the developmental stages of the middle phalanx of the third finger (MP3) as seen on an IOPA film taken using a standard dental x-ray machine. The present methods of skeletal maturity assessment like the hand-wrist radiographs or cervical vertebrae radiographs are expensive and required elaborate equipment and accounts for high radiation exposure, especially for growing children. The results of the study showed that this method used was highly reliable and could be used as an alternative to assess the skeletal maturity of growing children.[9]

Gagliardi et al (2004), conducted a longitudinal study to investigate the relationship of frontal sinus development with somatic and skeletal maturation among Aboriginal Australians. The study was conducted among 17 males and 14 females aged between 7 and 18 years using lateral cephalograms and hand wrist radiographs. Growth velocities in frontal sinus height, frontal sinus depth and stature were also calculated for both sexes. The frontal sinus was found to show a well-defined adolescent growth spurt, with its peak velocity which occur after the peak velocity in body height. Females were found to attain peak velocity in sinus height earlier, than males. The sequence of hand–wrist ossification events showed a similar pattern in both sexes, which occurred one year earlier in females. So the author concluded that an adolescent spurt was present in frontal sinus growth and that the spurt tends to occur after statural velocity has peaked.[19]

Canavese et al (2005), reviewed the importance of skeletal age in the evaluation of remaining growth. During puberty, skeletal age is an important tool when performing a lower limb epiphysiodesis or when treating spinal deformities patients. Skeletal age should be assessed together with other clinical and radiological findings such as standing and sitting heights, Risser sign, Tanner stages and annual growth rate. Most current clinical and radiographic markers do not help paediatric orthopaedic surgeons to clearly distinguish maturity levels prior to Risser I. Sauvegrain et al. developed a method to assess skeletal age by using elbow radiographs (AP and lateral projections). Between 11 and 13 years of skeletal age in girls and between 13 and 15 years of skeletal age in boys, the olecranon apophysis is characterised by a clear morphological development. This method is a reliable tool to assess skeletal age during puberty because significant morphological changes in the elbow happen every six months.[8]

Fatu C et al (2006), analysed the development of the frontal sinus size during life. A retrospective study was performed on 60 frontal radiographs of patients of different age and gender among which 36 were females and 24 were males. The planar morphology was studied. The radiographs were digitalized and a professional software was used to measure the frontal area of the right and left frontal sinuses. The results of this study showed that frontal sinus was evident in 4-year-old children. 5% of cases showed unilateral or bilateral absence of the frontal sinus. Upto 19 years of life the pneumatization of sinus increases which is in synchronous with general craniofacial growth and there was no major differences found among the gender. They also stated that in regard to the environmental factors the change in the individual size and shape has occurred. In some elderly patients, osseous resorption led to an enlargement of the frontal sinus that might complicate any surgical procedures performed in this region.[20]

Chin et al (2008), conducted a longitudinal study in order to establish a quantitative cervical vertebral maturation (CVM) system for adolescents with normal occlusion. The study was conducted among 87 children and adolescents from 8 to 18 years old with normal occlusion, who were selected from 901 subjects. Sequential lateral cephalograms and hand-wrist films were taken once in a year for 6 years. The lateral cephalograms of all the individuals were divided into 11 maturation groups according to the Fishman skeletal maturity indicators. The morphologic appearances of the second, third, and fourth cervical vertebrae at 11 developmental stages were analyzed. With 3 morphologic variables, the quantitative CVM system including 4 maturational stages was established. The study concluded that the quantitative assessment of CVM is a simple method to assess the skeletal maturation during adolescence more efficiently and reliably.[21]

Fudalej et al (2010), assessed the effectiveness of the cervical vertebral maturation (CVM) method in order to predict circumpubertal craniofacial growth in the post peak period. The CVM stage was predicted among 51 adolescent boys and 125 adolescent girls on cephalograms taken at post treatment and end of follow-up period. Results showed that boys in CVM stage 3 had significantly more changes than girls. They concluded that CVM method was effective in determining the amount of post peak circumpubertal craniofacial growth.[22]

Ricky W. K. Wong et al (2009), conducted a study to evaluate the validity predicting the skeletal age in the circumpubertal period using the cervical vertebral maturation method as an indicator. It was done by correlating it with the hand-wrist method. Hand-wrist and lateral cephalometric radiographs of 400 Chinese subjects were selected randomly aged from 10 to 15 years for girls and 12 to 17 years for boys. Skeletal ages were assessed using CVM method and the HWM. The study results showed that the CVM was significantly correlated with HWM skeletal age. The study concluded that the CVM serves as valuable indicator of skeletal growth in the circumpubertal period, and also provides information for timing of growth modification.[23]

MałgorzataKuc-Michalska et al (2010), conducted a study to compare and assess the duration of the pubertal growth peak in Class I and Class III individuals. The data consisted of pretreatment lateral cephalometric records of skeletal Class I or Class III subjects, i.e., 93 female and 125 male subjects of white ancestry. The duration of the pubertal peak was calculated from the average chronological age intervals between stages CS3 and CS4 of the CVM in Class I vs Class III group. The study resulted that in skeletal Class I individuals, the pubertal peak had a mean duration of 11 months, whereas in Class III subjects it lasted upto 16 months. They concluded that the growth interval corresponding to the pubertal growth spurt (CS3–CS4) when compared with normal skeletal relationship, was longer in Class III subjects.[24]

Besana et al (2010), reviewed the probability analysis through trait combination is a viable method of categorizing an individual using the frontal sinuses. The research examined the feasibility of discrete trait combinations and superimposition pattern matching. The author concluded that Discrete trait combinations do not have a high enough discriminating power. Only superimposition pattern matching was an effective method of identifying an individual using the frontal sinuses.[25]

Trenton S. Nestman et al (2011), investigated the reproducibility of the individual vertebral patterns. The morphology of cervical vertebrae C2 through C4 from 30 cephalometric radiographs was evaluated using questions based on the CVM method. The study resulted that the inter observer agreement was high for lower borders of C2, C3, and C4; and low for vertebral bodies of C3 and C4. This showed overall poor reproducibility of the CVM method. Thus the study concluded that the CVM method was not appropriate to use as a strict clinical guideline for the timing of orthodontic treatment.[26]

Anil Prashar et al (2012), analyzed the size of frontal sinus in different craniofacial patterns and its relationship with mandibular growth. The study showed that Frontal Sinus area was significantly higher in skeletal Class III than Skeletal Class I and Skeletal Class II. The author concluded that, Frontal Sinus Area was found to be larger in individuals having skeletal Class III malocclusion. Hence, the large Frontal Sinuses were associated with large mandibles, irrespective of their positional relationship to the cranial base and growth direction.[27]

FB Prado et al (2012), studied the changes after maxillomandibular advancement and counter clockwise rotation for class II anterior open bite malocclusion by cephalometrically evaluating the pharyngeal airway space and frontal and sphenoid sinus changes. The study included 49 subjects (98 lateral teleradiographs; 36 females and 13 males) who were analysed in the 1 week before surgery and 6 months after surgery periods. In each lateral teleradiography, the dimensions of the inferior and superior pharyngeal airway space, TB-PhW1 [the point between the posterior aspect of the tongue to the dorsal pharyngeal wall (oropharynx) (TB) and the point on the dorsal pharyngeal wall closest to TB (PhW1)] and UP-PhW2 [and the point between the posterior aspect of the soft palate to the dorsal pharyngeal wall (nasopharynx) (UP) (PhW2)] measurements were measured, as well as the dimensions of the frontal and sphenoid sinuses. After orthognathic surgery there was an increase in the measurements TB-PhW1 and UP-PhW2 and a decrease in the dimensions of the frontal and sphenoid sinuses. The study concluded that there is a morphological changes in the superior and inferior pharyngeal airway space and frontal and sphenoid sinuses after 6 months of maxillomandibular advancement counterclockwise rotation for class II anterior open bite malocclusion.[28]

Yessenia Guevara et al (2013), investigated the correlation between the enlargement of the frontal sinus and the body height peak in Angles Class III patients, as an indicator of growth maturity. In 20 Class III female patients, their body height was measured and serial lateral cephalograms taken for orthodontic treatment from 7 to 17 years old were used. By using the method of Ertük, tracings were analyzed and the sinus growth was determined. The results showed that the frontal sinus enlargement was in close proximity to body height. The author concluded that the frontal sinus development as an indicator of growth maturity.[29]

Prasad et al (2013) did a study to determine correlation of the CVM index with the modified median phalanx index (MP3) as described by Rajagopal and Kansal. A sample of 200 subjects (100 males and 100 females) of Nellore, Indian origin boys aged between 10 to 19 years and girls of 8 to 16 years were selected for the study. The subjects were selected randomly from patients visiting the Departments of Orthodontics and Dentofacial Orthopedics, Pediatric dentistry and Oral medicine and Radiology at Narayana Dental College and Hospital, Nellore. Radiographs of lateral cephalogram and left hand MP3 were taken. There was a good concordance between 6 stages of CVMI (Hassel and Farman) and the 6 stages of MP3 (Rajagopal and Kansal). Physiological maturity was earlier in females than in males when compared to the individuals of opposite sex of same chronological age. They concluded that chronological age cannot be a valid predictor of assessing the skeletal maturity because skeletal maturity is earlier in females. [30]

Patil et al (2013), assessed the reliability of frontal sinus as a skeletal maturity indicator in males and females. Study was conducted on Lateral cephalograms of 75 males and 75 females, both in pre-and post-pubertal stages of development determined by Middle phalanx of the third finger (MP3) radiographs. Lateral cephalograms were analyzed for frontal sinus maturity by estimating the maximum height, width and height to width ratio. The scores imparted were F, FG, G, H, and I. Correlation between different MP3 stages of males and females were determined. The author concluded that the frontal sinus was not a reliable criteria for prediction of skeletal maturity.[4]

Tarvade et al (2015), reviewed Skeletal maturity indicators. The author stated that the biological and histological growth was a composite of morphogenetic and histogenetic changes which occur continuously over a period in response to genetic coding as well as environmental influence. It was one of the most myriad variations and plays an important role in the etiology of malocclusion and also in the evaluation of diagnosis, treatment planning retention and stability of any case. The author also reported that the growth maturation stages were important for proper timing and treatment management, various methods such as skeletal and physiologic/biochemical methods were reliable for the clinical references and the review also suggests that more simplified non-invasive methods can be considered as additional diagnostic tool to avoid exposure to radiation.[7]

Finkel et al (2015), determined the relative influence of genetic and environmental factors on functional aging using the twin analysis. The sample consisted of the 237 twins pairs for whom data were available on both members of the pair. For descriptive purposes, the sample was divided into three age groups: younger (age 27-39 years), middle-aged (age40-59 years), and older (age 60-88 years) twins. Measures of 30 demographic, cognitive, physiological, personality, and behavioural variables were available from 140 monozygotic twin pairs and 97 dizygotic twin pairs ranging in age from 27 to 88 years. The study concluded that the analysis of twin similarity for components of functional age suggested the relative influence of genetic and environmental factors varies greatly for different components of functional aging. In addition, the genetic and shared environmental influences on the three components were common to all three, while the nonshared environmental influences were specific to each component.[6]

Indu Dhiman (2015), evaluated the reliability of frontal sinus with that of maxillary sinus for assessing different types of skeletal malocclusions. The study was conducted on 120 males and 120 females aged from 16 to 25 years and were divided into skeletal Class I, II, and III based on ANB angle (each 40 patients). Linear and angular cephalometric measurements were assessed and correlate with maxillary and frontal sinus size obtained through AutoCAD program. The results showed that a significant correlation of frontal sinus with skeletal malocclusion when compared with the maxillary sinus. The present study concluded that the frontal sinus was more reliable as compared to maxillary sinus in depicting skeletal malocclusion. The frontal sinus area was larger in skeletal Class III malocclusion than skeletal Class I and Class II malocclusion. There is no significant variation in maxillary sinus area in males and females whereas frontal sinus shows significant variations among the gender in different skeletal malocclusions.[31]

Trivedi et al (2016), reviewed on Growth and Growth Studies in Orthodontics and stated that the organization and complexity of growth and development was clearly evident in the changes that take place in the head and face. They stated that Craniofacial growth was a complex process and a thorough understanding of the principles or concepts of growth would enable to meticulously plan the treatment, and also understand the normal variations from abnormalities. They also stated that the basic control of growth, both in magnitude and timing, was located in the genes. The author reviewed various studies which include Bolton-brush growth study, Burlington growth study, Michigan growth study, Iowa child welfare study, Forsyth twin study, Meharry growth study, The Krogman Philadelphia growth study, Denver child growth study, Fels growth study. Various concept have been given by them and they aided the orthodontist to diagnose and assess the case and plan the best treatment plan possible for the patient.[3]

Mahmood et al (2016), evaluated the association between frontal sinus morphology and cervical vertebral maturation for the assessment of skeletal maturity by doing a cross sectional study. It was conducted using the pre-treatment lateral cephalograms of 252 individuals aged 8 to 21 years. The subjects were divided into 6 groups based on the CVM stages. The frontal sinus index was calculated by dividing the frontal sinus height and width, and the cervical stages were evaluated on the same radiograph. The frontal sinus index values were compared at different cervical stages. The study resulted that the height and width of the frontal sinus were significantly larger in the male subjects when compared with the female subjects and a significant association was found between the frontal sinus height and width and cervical stages in both sexes. However, the changes in the frontal sinus index across the different cervical stages were found to be significant only in male subjects. Similarly, a weak negative correlation was found between the sinus index and the cervical stages in male subjects, and no correlation was found in females. Hence the author concluded that the frontal sinus index cannot be used as a reliable maturity indicator.[5]

Nishi N. Kapasiawala et al (2016), conducted a study to compare the relationship of the frontal sinus with the different skeletal malocclusion and also to find the association between the length of the mandible and the dimensions of the frontal sinus. 60 pre-treatment digital lateral cephalograms were selected and grouped into 3 groups based on the type of malocclusion pattern. Lateral cephalograms were traced and the maximum height, maximum width, area of frontal sinus region and the length of the mandible were analysed. The results showed that the linear measurements of maximum height, maximum width, area of frontal sinus region were statistically insignificant in Class I, Class II and

Class III respectively and also no correlation existed between the length of the mandible and the maximum width and area of frontal sinus. So, they concluded that frontal sinus was not reliable in depicting skeletal malocclusion.[32]

Azita Tehranchi et al (2017), in a group of Iranian patients, assessed the relationship between the cephalometric indices and frontal sinus dimensions. This retrospective study was done in 144 subjects (78 females and 66 males) with a mean age of 19.26 ± 4.66 years. In order to measure the frontal sinus dimensions, Posterior-anterior radiographs and lateral cephalograms were used. The skeletal growth pattern and the relations of craniofacial structures were predicted using variables for sagittal and vertical analyses. The results showed that the SN-FH and SNA angles had significant associations with frontal sinus dimensions in all enrolled subjects. In males, the SN-FH, sum of posterior angles, Pal-SN, and Jarabak index were significantly associated with the size of frontal sinus ($P < 0.05$). In females, the associations of SN-FH and gonial angles with frontal sinus dimensions were significant ($P < 0.05$). Hence, they concluded that there was a correlation between frontal sinus dimensions and increased anterior facial height (sum of posterior angles, Pal-SN, and Jarabak index) in males and increased gonial angle in females.[33]

Buyuk et al (2017), studied the morphologic structure of the frontal sinuses using posteroanterior cephalometric radiographs among Turkish adolescents and also correlated the findings between male and female. 148 subjects were divided into two groups (74 males with mean age of 14.55 ± 1.42 years and 74 females with mean age of 14.95 ± 1.80 years). The maximum height and width of the frontal sinus in right and left side, maxillary width, cranial width, nasal width, antegonial width were measured in postero-anterior radiographs. The right and left frontal sinus width, maxillary width, antegonial width, and cranial width were larger in males than females. The right frontal sinus height and width were positively correlated with antegonial width in males. The right and left frontal sinus width were positively correlated with nasal width in females. From the study results they said that the Frontal sinuses were unique in their morphological structure for each individual. So it can also be utilized in forensic science for personal identification.[34]

MATERIALS

&

METHODOLOGY

STUDY DESIGN

The present research was a cross sectional study.

STUDY AREA

The study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Best Dental Science College, Madurai located in Tamil Nadu.

ETHICAL CLEARANCE

The nature and purpose of the study was explained to the Institutional Review Board at Best Dental Science College and Ethical clearance was obtained to conduct the main study (Annexure–I).

INFORMED CONSENT

After explaining the research in detail in a simple and comprehensible language, informed consent was obtained from the research participants / parents. (Annexure -II).

PERMISSION BY THE COLLEGE AUTHORITIES

The prior permission was taken from the Principal and the HOD to conduct the study at the Department of Orthodontics and Dentofacial Orthopaedics.

SOURCE OF DATA

Data were collected from the pre-treatment lateral cephalograms of patients who visited the Department of Orthodontics and Dentofacial Orthopaedics in the period of 2017-2019.

STUDY POPULATION

The study population included patients who had visited the Department of Orthodontics within the age group of 8-16 years in between the time period of 2017-2019.

ELIGIBILITY CRITERIA

INCLUSION CRITERIA

1. Subjects aged between 8 and 16 years.
2. Symmetrical face.
3. Void of frontal sinus pathologies.
4. No apparent facial disharmony due to developmental abnormalities.

EXCLUSION CRITERIA

1. Subjects with a history of any craniofacial anomaly or syndrome.
2. Subjects with a history of trauma or surgery involving the frontal sinus or the cervical vertebrae.
3. Subjects with systemic diseases and syndromes affecting growth and development.
4. Radiographs with ill-defined sinus margins.

SAMPLE SIZE DETERMINATION

The following formula for the sample size n:

$$n = (Z_{\alpha/2}+Z_{\beta})^2 * 2 * \sigma^2 / d^2,$$

where $Z_{\alpha/2}$ is the critical value of the Normal distribution at $\alpha/2$ (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96), Z_{β} is the critical value of the Normal distribution at β (e.g. for a power of 80%, β is 0.2 and the critical value is 0.84), σ^2 is the population variance, and d is the difference you would like to detect.

POPULATION VARIANCE

Calculated as: $\sigma^2 = (1/N)* \sum^{N}_{i=1}(x_i-\mu)^2$,

where, $\mu = (1/N)* \sum^{N}_{i=1}x_i$

When performing significance tests, the sample variance provided an estimate of the population variance which are as follows:

Confidence level	-	95%
Power	-	80%
Hypothesised difference	-	9.5
Population variance	-	100

By using the above formula and parameters, the sample size was derived.

Sample size required for each group was 30

Hence, the total sample size for six groups was 180

BLINDING

It was a single blinded study. The prime investigator was blinded by the key investigator about the age and sex of the study participants.

MATERIALS USED IN THE STUDY

- Lateral cephalogram.
- Acetate Paper (0.003" THICKNESS).
- 0.3mm HB pencil (Steadler).

COLLECTION OF DATA

A Pre-structured Performa was used to collect the relevant information and records of the patients.

Radiographs were taken using X-Mind pano D+ radiographic machine. The tube voltage was 73 kV and scanning time was 15 seconds.

The lateral cephalogram's of the patients were standardized by doing as follows,

- The midsagittal plane was perpendicular to the floor and parallel to the sensor.
- The patient's head was stabilized in the cephalostat with the help of ear rods and forehead positioning knob so that the Frankfort horizontal plane was parallel to the floor.
- The patients were asked to keep the teeth in maximum intercuspation with relaxed lips.

The selected radiographs were examined and re-evaluated to check the criteria.

LANDMARKS USED

SH	Highest point on the frontal sinus
SL	Lowest point on the frontal sinus
A	Line joining SH and SL denoting the maximum frontal sinus height
SPP	Posterior point on the frontal sinus
SAP	Anterior point on the frontal sinus
B	Line joining SPP and SAP denoting the maximum frontal sinus width perpendicular to line A
S	Anatomic center of sella turcica
N	Deepest point in the midline at the frontal suture

CERVICAL VERTEBRAE MATURATION STAGES

Cervical vertebral maturation stages were classified according to Baccetti et al [35] as follows,

CS1	The inferior borders of the bodies of all cervical vertebrae are flat; the superior borders are tapered from posterior to anterior.
CS2	A concavity develops in the inferior border of the second vertebrae; the anterior vertical height of the bodies increases.
CS3	A concavity develops in the inferior border of the third vertebrae; the vertical body has a trapezoidal or wedge shape.
CS4	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.
CS5	All 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.
CS6	All concavities have deepened; the vertebral bodies are now higher than they are wide.

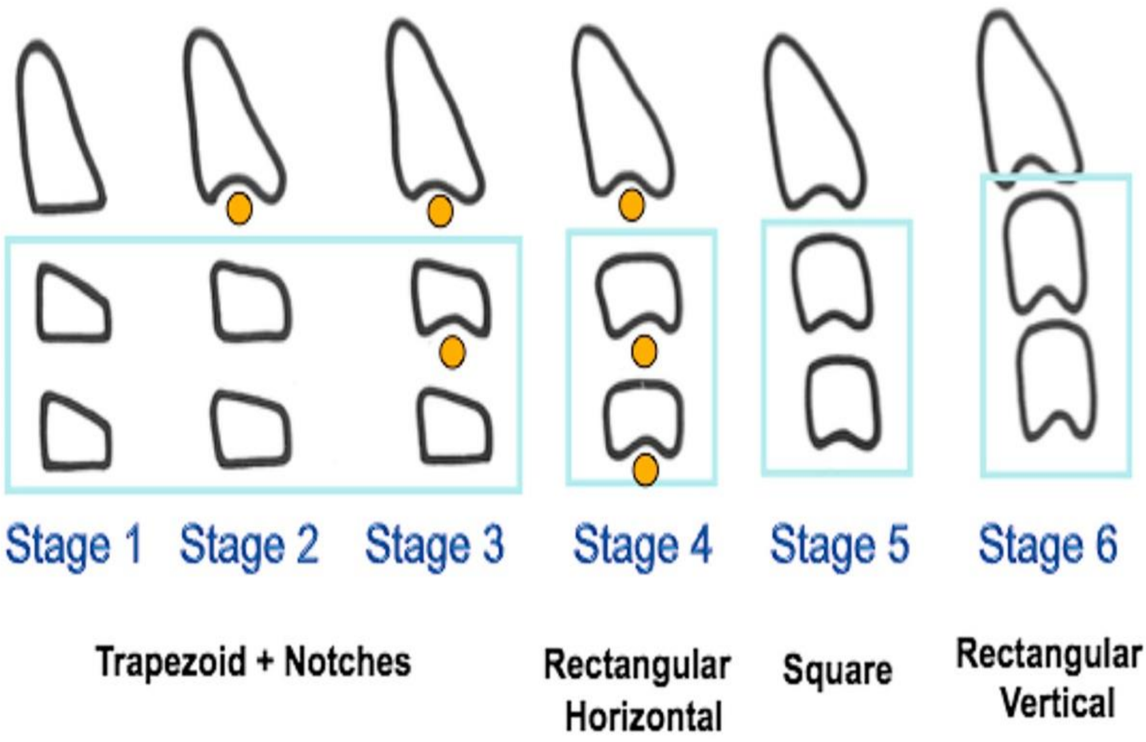

Figure 1 : Cervical Vertebral Maturation Stages

METHODOLOGY

- The obtained lateral cephalograms were oriented with sella nasion line horizontally.
- The cervical vertebrae and the frontal sinus were traced on the same radiograph for all the subjects.
- Following this, cervical maturation stages and frontal sinus index were analysed.

Cervical Vertebral Maturation Stages Analysis:

- The maturation stages were assessed on the lateral cephalograms according to Baccetti et al [35]

- Based on the maturation stages, the subjects were divided into 6 groups.

  GROUP 1: Stage 1 cervical vertebrae maturation.

  GROUP 2: Stage 2 cervical vertebrae maturation.

  GROUP 3: Stage 3 cervical vertebrae maturation.

  GROUP 4: Stage 4 cervical vertebrae maturation.

  GROUP 5: Stage 5 cervical vertebrae maturation.

  GROUP 6: Stage 6 cervical vertebrae maturation.

Frontal Sinus Morphology Analysis:

- The maximum height and width of the frontal sinus were measured in millimeter according to method of Ertuk[36]
- The frontal index was calculated by the formula,

$$\text{Frontal sinus Index} = \frac{\text{Frontal sinus Height}}{\text{Frontal sinus Width}}$$

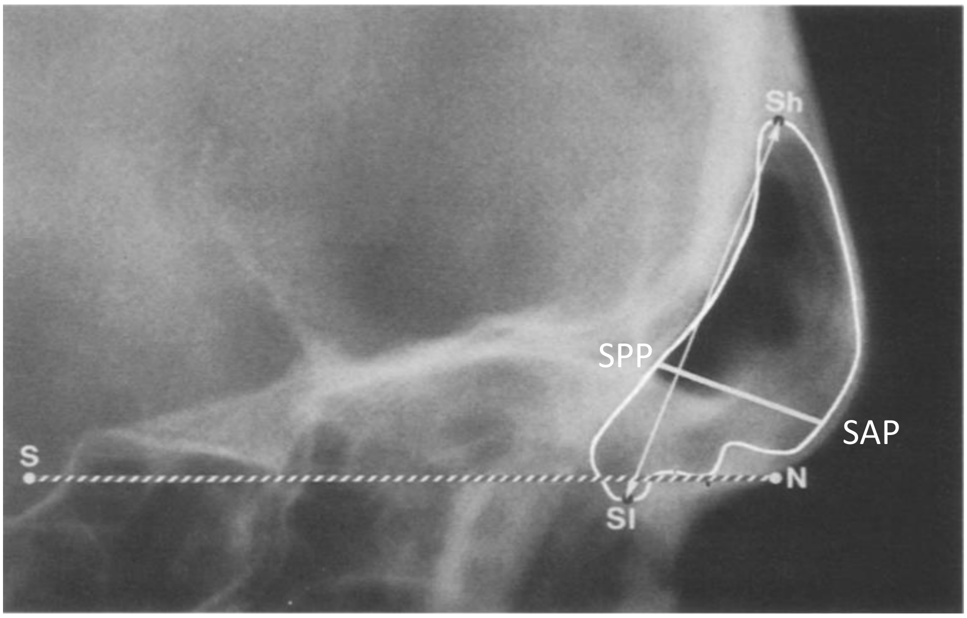

Figure 2 : Assessment of frontal sinus morphology

- To eliminate the intra-operator error, each cephalogram was traced twice on two separate acetate matte tracing paper by the same operator. The frontal sinus index was measured on both and the mean of the two measurements were taken.
- The tracing that showed difference of ≤ 1mm or 1° were considered. The mean values were rounded off to half a degree or half a millimeter.

STATISTICAL ANALYSIS

The collected data were recorded in a Master Chart. Data analysis was done with the help of computer using SPSS software for Windows (SPSS Inc., Chicago, IL, version 23.0 for Windows). The Mann-Whitney U test was used to compare frontal sinus measurements in both the sexes. Comparisons between frontal sinus measurements among the different cervical stages were made using the Kruskal-Wallis test. The Pearson's correlation was used to determine the correlation between frontal sinus measurements and cervical stages in the sexes. p value less than 0.05 was considered statistically significant.

Figure 3 : Materials for tracing

Figure 4 : Lateral cephalogram machine

Figure 5 : Patient positioned for radiograph

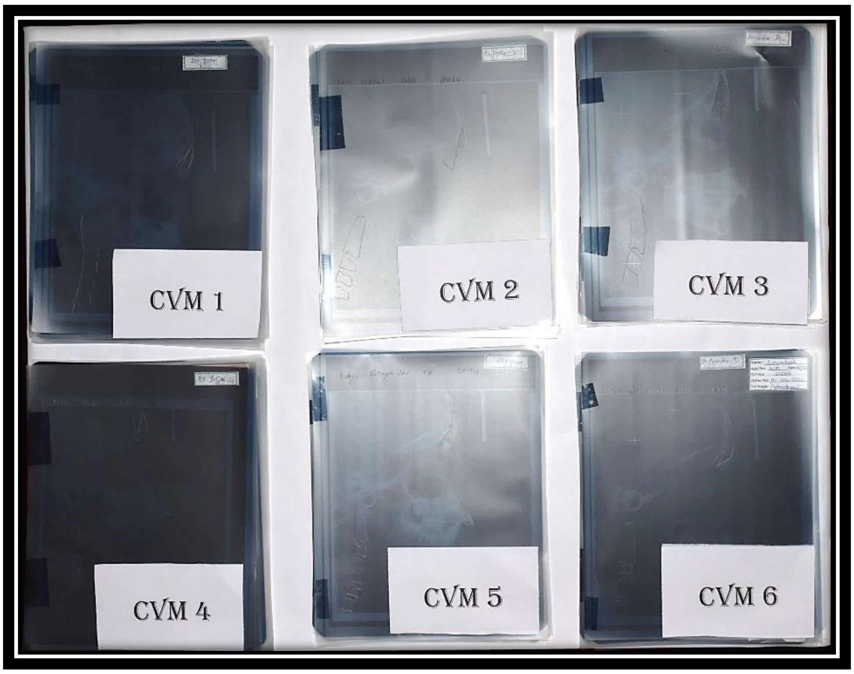

Figure 6 : Radiographs grouped for tracing

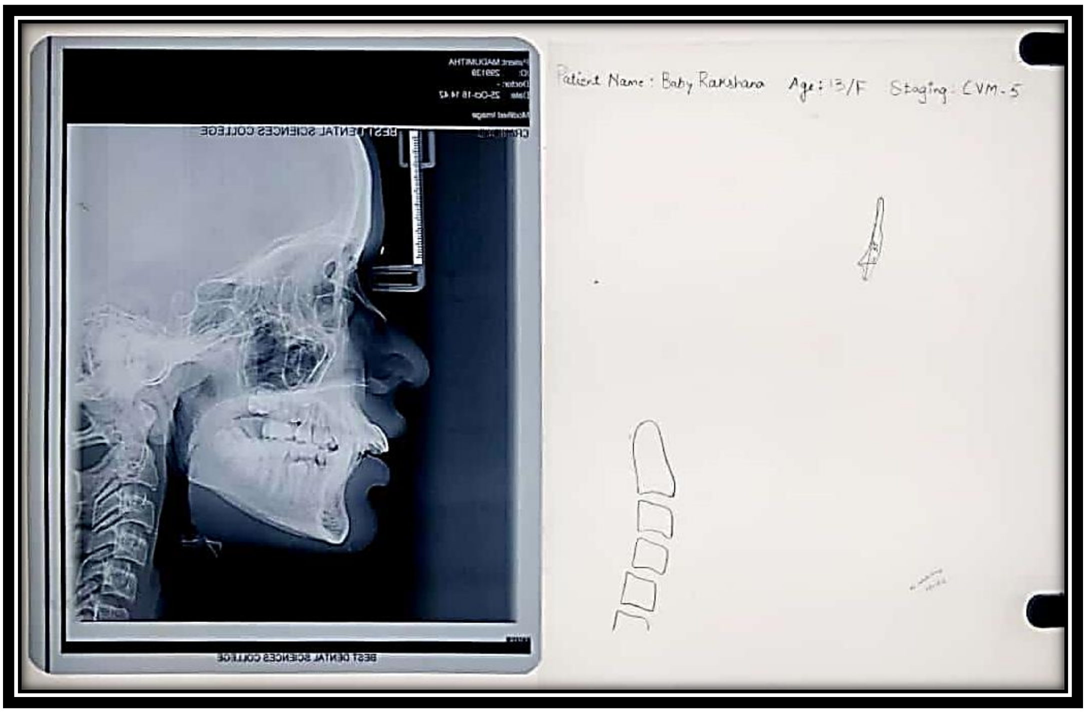

Figure 7 : Traced sheet of the radiograph

RESULTS

In the present study, the frontal sinus height, width, index and the cervical maturation stages were successfully analysed on the same lateral cephalograms of each subject in all the six groups.

STATISTICAL ANALYSIS:

The statistical procedures were carried out in 2 steps—

1) Data compilation and presentation
2) Statistical analysis

The recorded data was compiled and entered into a spreadsheet computer program (Microsoft Excel). Data analysis was done with the help of computer using **Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, version 23.0 for Windows).**

The frequencies, percentages, means and standard deviations were calculated for quantitative variables. 'p' value less than 0.05 denoted a significant relationship in the present study.

TABLE 1: MEAN VALUES OF FRONTAL SINUS HEIGHT AT VARIOUS MATURATION STAGES

	Minimum (mm)	Maximum (mm)	Mean (mm)	Std. Deviation (mm)
FRONTAL SINUS HEIGHT AT CS1	12.00	19.00	15.7667	1.86960
FRONTAL SINUS HEIGHT AT CS2	9.00	29.00	19.6333	3.77362
FRONTAL SINUS HEIGHT AT CS3	17.00	35.00	21.3667	3.34750
FRONTAL SINUS HEIGHT AT CS4	16.00	35.00	26.2667	4.33059
FRONTAL SINUS HEIGHT AT CS5	22.00	35.00	28.9667	3.51826
FRONTAL SINUS HEIGHT AT CS6	24.00	41.00	31.9667	4.41380

Table 1 describes the frontal sinus height in all Cervical Vertebral Maturation Stages. The Mean values of frontal sinus height in CS 1, 2, 3, 4, 5, 6 were 15.766±1.8669, 19.633±3.773, 21.366±3.347, 26.266±4.330, 28.966±3.518, 31.966±4.413 respectively. This shows a linear increase in height of the frontal sinus at each Cervical Vertebral Maturation Stages.

TABLE 2: MEAN VALUES OF FRONTAL SINUS WIDTH AT VARIOUS MATURATION STAGES

	Minimum (mm)	Maximum (mm)	Mean (mm)	Std. Deviation (mm)
FRONTAL SINUS WIDTH AT CS1	5.00	8.00	6.4667	1.04166
FRONTAL SINUS WIDTH AT CS2	5.23	11.00	7.9885	2.48258
FRONTAL SINUS WIDTH AT CS3	6.00	12.00	8.7333	1.22990
FRONTAL SINUS WIDTH AT CS4	6.00	15.00	10.1667	2.10227
FRONTAL SINUS WIDTH AT CS5	6.00	17.00	10.9333	2.63836
FRONTAL SINUS WIDTH AT CS6	7.00	19.00	12.3333	2.53708

Table 2 shows the Mean values of frontal sinus width in all Cervical Vertebral Maturation Stages. The Mean values of frontal sinus width in CS 1, 2, 3, 4, 5, 6 were 6.466±1.041, 7.988±2.482, 8.733±1.229, 10.166±2.102, 10.933±2.638, 12.333 ± 2.537 respectively. This reveals a gradual increase of the frontal sinus width at each Cervical Vertebral Maturation Stages.

TABLE 3: MEAN VALUES OF FRONTAL SINUS INDEX AT VARIOUS MATURATION STAGES

	Minimum (mm)	Maximum (mm)	Mean (mm)	Std. Deviation (mm)
FRONTAL SINUS INDEX AT CS1	1.63	3.80	2.534	0.604
FRONTAL SINUS INDEX AT CS2	1.90	5.00	2.416	0.592
FRONTAL SINUS INDEX AT CS3	1.89	3.50	2.462	0.306
FRONTAL SINUS INDEX AT CS4	2.00	4.33	2.653	0.537
FRONTAL SINUS INDEX AT CS5	1.86	3.83	2.760	0.532
FRONTAL SINUS INDEX AT CS6	2.00	4.57	2.685	0.642

Table 3 describes that the Mean values of the frontal sinus index in CS 1, 2, 3, 4, 5, 6 were 2.534±0.604, 2.416±0.592, 2.462±0.306, 2.653±0.537, 2.760±0.532, 2.685±0.642 respectively. This indicated index of frontal sinus increases with the cervical vertebral maturation.

TABLE 4: MEAN VALUES OF FRONTAL SINUS HEIGHT IN VARIOUS STUDY GROUPS WITH RESPECT TO GENDER

	Gender	N	Mean (mm)	Std.Deviation (mm)	Std.Error Mean (mm)
CS1 FRONTAL SINUS HEIGHT	FEMALE	15	14.8667	1.72654	.44579
	MALE	15	16.6667	1.58865	.41019
CS2 FRONTAL SINUS HEIGHT	FEMALE	15	19.4667	2.89992	.74876
	MALE	15	19.8000	4.58569	1.18402
CS3 FRONTAL SINUS HEIGHT	FEMALE	15	20.6667	1.98806	.51331
	MALE	15	22.0667	4.26726	1.10180
CS4 FRONTAL SINUS HEIGHT	FEMALE	15	26.0667	1.75119	.45216
	MALE	15	26.4667	5.97455	1.54262
CS5 FRONTAL SINUS HEIGHT	FEMALE	15	27.2667	3.51460	.90746
	MALE	15	30.6667	2.66369	.68776
CS6 FRONTAL SINUS HEIGHT	FEMALE	15	32.2000	3.48876	.90079
	MALE	15	31.7333	5.29780	1.36789

GRAPH 1: MEAN VALUES OF FRONTAL SINUS HEIGHT IN VARIOUS STUDY GROUPS WITH RESPECT TO GENDER

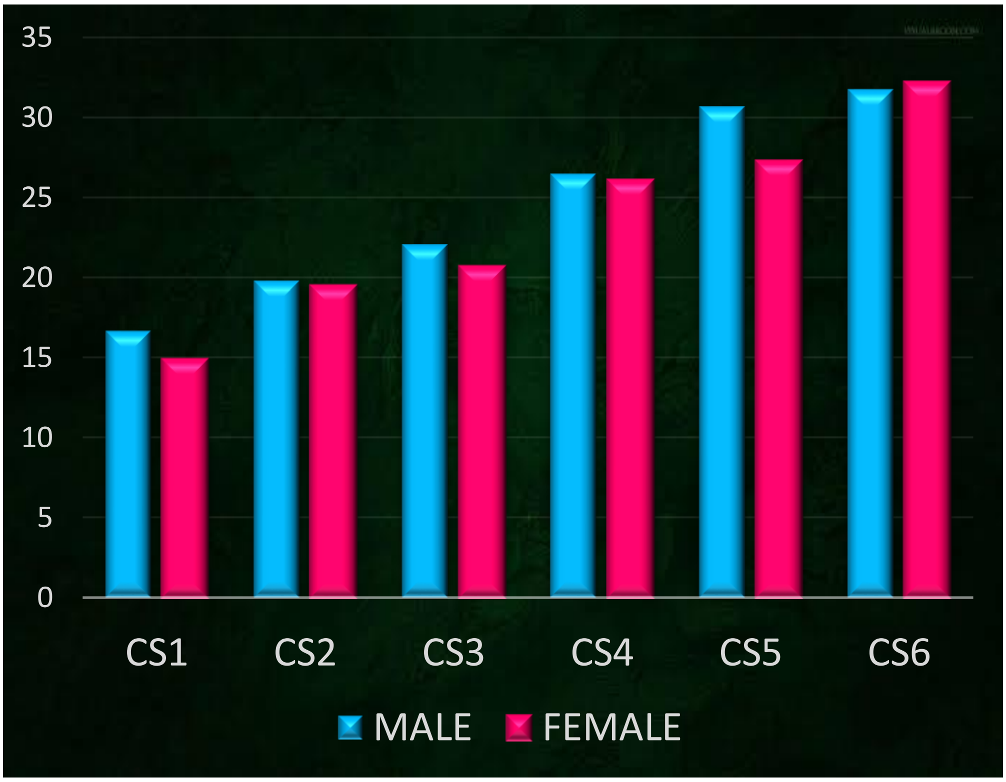

Table 4 and Graph 1 describes the gender wise distribution of the frontal sinus height in all Cervical Vertebral Maturation Stages. The Mean values of frontal sinus height among female subjects in CS1, 2, 3, 4, 5, 6 were 14.866±1.726,19.466±2.899,20.666±1.988, 26.066±1.751, 27.266±3.514, 32.200±3.488 respectively. The Mean values of frontal sinus height among Male subjects in CS1, 2, 3, 4, 5, 6 were 16.666±1.588,19.800±4.585, 22.066±4.267, 26.466±5.974, 30.666±2.663, 31.733±5.297 respectively. This indicates that the frontal sinus height increases at each Cervical Vertebral Maturation Stages in both males and females but the frontal sinus height was more in males when compared to females.

TABLE 5: MEAN VALUES OF FRONTAL SINUS WIDTH IN VARIOUS STUDY GROUPS WITH RESPECT TO GENDER

	Gender	N	Mean (mm)	Std. Deviation (mm)	Std. Error Mean (mm)
CS1 FRONTAL SINUS WIDTH	FEMALE	15	6.8000	1.01419	.26186
	MALE	15	6.1333	.99043	.25573
CS2 FRONTAL SINUS WIDTH	FEMALE	15	8.4000	.98561	.25448
	MALE	15	7.5771	3.38119	.87302
CS3 FRONTAL SINUS WIDTH	FEMALE	15	8.5333	.63994	.16523
	MALE	15	8.9333	1.62422	.41937
CS4 FRONTAL SINUS WIDTH	FEMALE	15	10.2000	2.24245	.57900
	MALE	15	10.1333	2.03072	.52433
CS5 FRONTAL SINUS WIDTH	FEMALE	15	9.9333	2.54858	.65804
	MALE	15	11.9333	2.40436	.62080
CS6 FRONTAL SINUS WIDTH	FEMALE	15	11.2667	2.21897	.57293
	MALE	15	13.4000	2.44365	.63095

GRAPH 2: MEAN VALUES OF FRONTAL SINUS WIDTH IN VARIOUS STUDY GROUPS WITH RESPECT TO GENDER

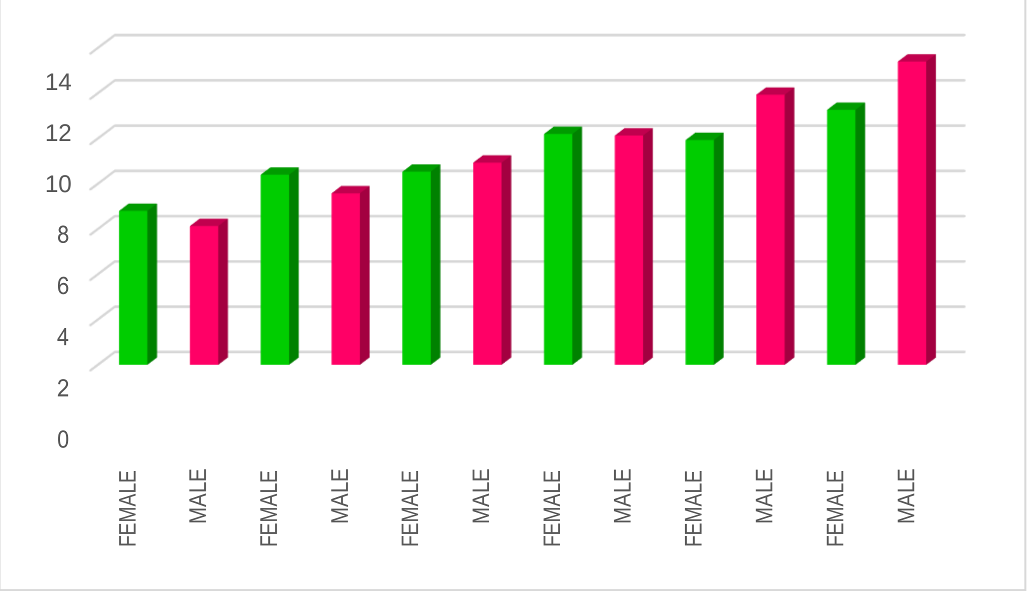

Table 5 and Graph 2 shows Mean values of frontal sinus width among the gender. Mean values of frontal sinus among female subjects in CS 1, 2, 3, 4, 5, 6 were 6.800±1.014, 8.400±0.985, 8.533±0.639, 10.200±2.242, 9.933±2.548, 11.266±2.218 respectively. The Mean values of frontal sinus width among Male subjects were CS 1, 2, 3, 4, 5, 6 were 6.133±0.990, 7.577±3.381, 8.933±1.624, 10.133±2.030, 11.933±2.404, 13.400±2.443 respectively. This shows that the frontal sinus width increases at each Cervical Vertebral Maturation Stages in both males and females. The width of frontal sinus was more in males when compared to females.

TABLE 6: MEAN VALUES OF FRONTAL SINUS INDEX IN VARIOUS STUDY GROUPS WITH RESPECT TO GENDER

	GENDER	N	Mean (mm)	Std. Deviation (mm)	Std. Error Mean (mm)
CS1 FRONTAL SINUS INDEX	FEMALE	15	2.2776	.53584	.13835
	MALE	15	2.7921	.57193	.14767
CS2 FRONTAL SINUS INDEX	FEMALE	15	2.3242	.25273	.06525
	MALE	15	2.5081	.80270	.20726
CS3 FRONTAL SINUS INDEX	FEMALE	15	2.4300	.24477	.06320
	MALE	15	2.4947	.36411	.09401
CS4 FRONTAL SINUS INDEX	FEMALE	15	2.6716	.62886	.16237
	MALE	15	2.6351	.45001	.11619
CS5 FRONTAL SINUS INDEX	FEMALE	15	2.8721	.57758	.14913
	MALE	15	2.6490	.47710	.12319
CS6 FRONTAL SINUS INDEX	FEMALE	15	2.9758	.74170	.19151
	MALE	15	2.3961	.35326	.09121

GRAPH 3: MEAN VALUES OF FRONTAL SINUS INDEX IN VARIOUS STUDY GROUPS WITH RESPECT TO GENDER

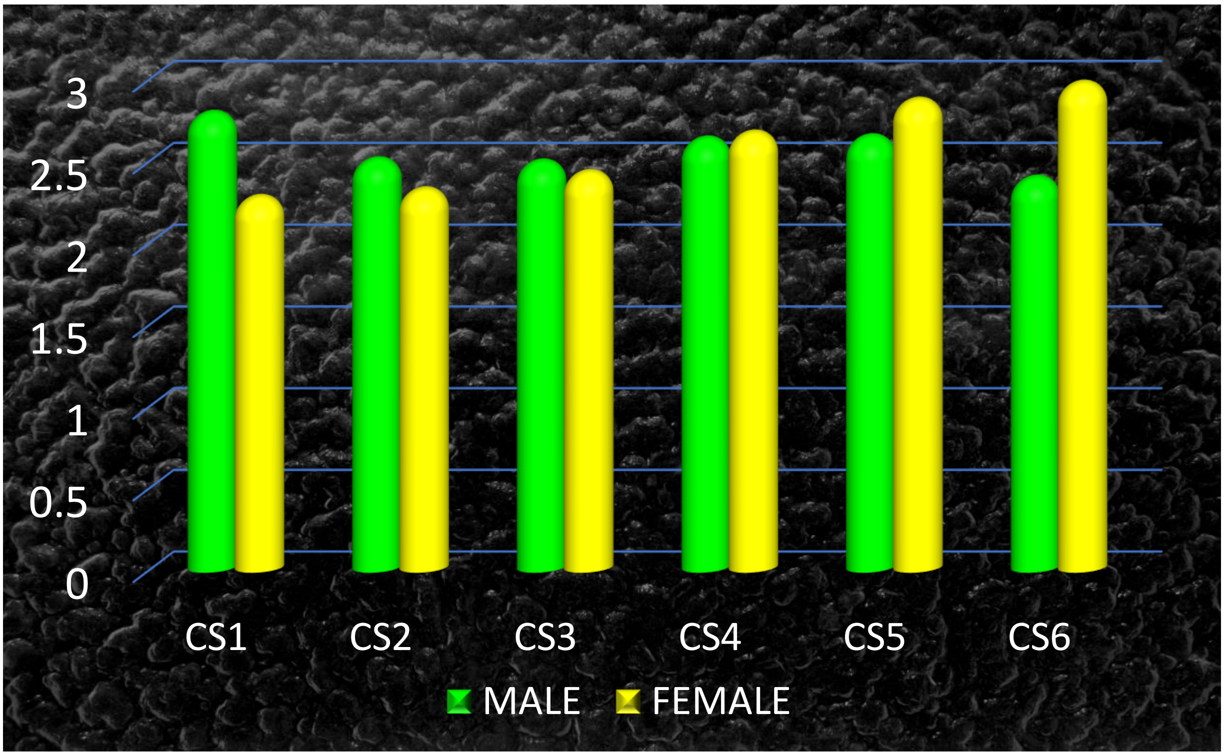

Table 6 and Graph 3 describes the Mean±SD gender wise distribution frontal sinus index in all Cervical vertebral maturation stages. The Mean±SD of frontal sinus index among Female subjects in CS I, II, III, IV, V, VI is 2.277±0.535, 2.234±0.252, 2.430±0.244, 2.671±0.628, 2.872±0.577, 2.975±0.741 respectively. The Mean±SD of frontal sinus index among Male subjects in CS I, II, III, IV, V, VI is 2.792±0.571, 2.508±0.802, 2.494±0.364, 2.635±0.450, 2.649±0.477, 2.396±0.353 respectively. This indicated the variation of frontal sinus index with respect to gender. The frontal sinus index was comparatively higher in males when compared to females.

TABLE 7: NORMALITY OF DISTRIBUTION

	Shapiro-Wilk		
	Statistic	**df**	**Sig.**
FRONTAL SINUS HEIGHT	.979	180	.008
FRONTAL SINUS WIDTH	.971	180	.001
FRONTAL SINUS INDEX	.882	180	.000

Table 7 shows normality of distribution of data among the groups using Shapiro-Wilk test. The p value of fontal sinus height, width and index of frontal sinus was .008, .001 and .000. which indicates the skewed distribution.

TABLE 8: INTERGROUP COMPARISON OF PARAMETERS

	N	**Mean (mm)**	**Std. Deviation (mm)**	**p**
FRONTAL SINUS HEIGHT	180	23.9944	6.65133	.007
FRONTAL SINUS WIDTH	180	9.4370	2.84424	.001
FRONTAL SINUS INDEX	180	2.5855	.55337	.024

GRAPH 4: INTERGROUP COMPARISON OF PARAMETERS

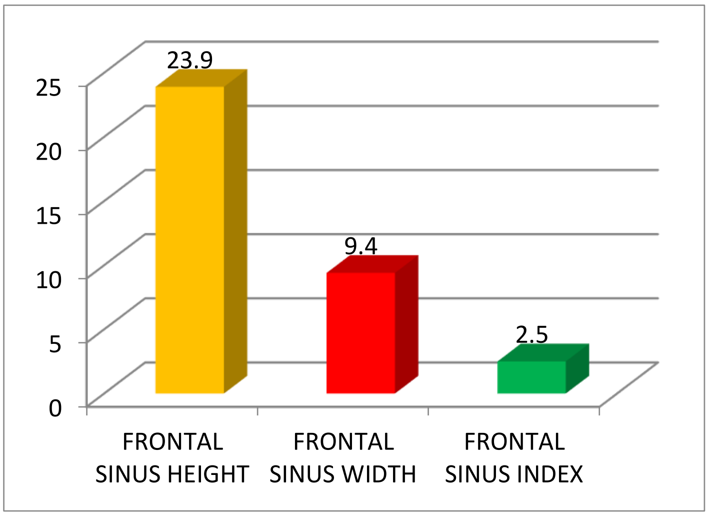

Table 8 and Graph 4 reflects the intergroup comparison of frontal sinus height, width and index using Kruskalwalis test. There was a significant difference of frontal sinus height, width and index among the groups with the p value of 0.007, 0.001 and 0.024 respectively.

TABLE 9: INTERGROUP COMPARISON OF PARAMETERS WITH RESPECT TO GENDER BY KRUSKALWALIS TEST

	N	Mean (mm)	Std. Deviation (mm)	p
FRONTAL SINUS HEIGHT	180	23.9944	6.65133	.286
FRONTAL SINUS WIDTH	180	9.4370	2.84424	.242
FRONTAL SINUS INDEX	180	2.5855	.55337	.941

GRAPH 5: INTERGROUP COMPARISON OF PARAMETERS WITH RESPECT TO GENDER

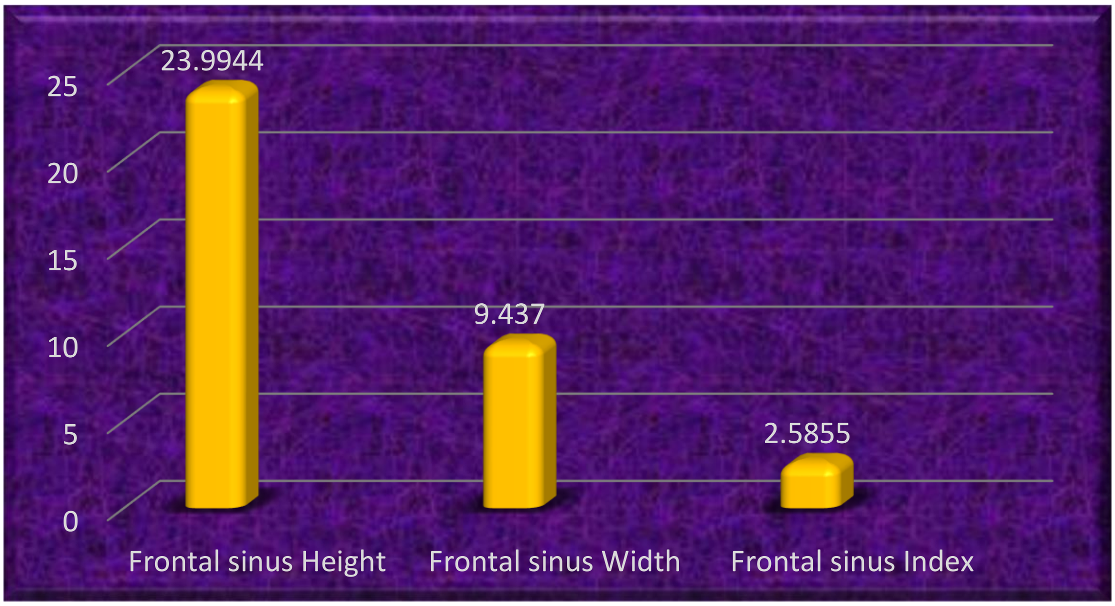

Table 9 and Graph 5 reflects the intergroup comparison of frontal sinus height, width and index with respect to gender. The p value .286,.242 and .941 shows no significant difference of frontal sinus height, width and index with respect to gender respectively.

TABLE 10: CORRELATION OF PARAMETERS WITH CERVICAL VERTEBRAL MATURATION

			FRONTAL SINUS HEIGHT	**FRONTAL SINUS WIDTH**	**FRONTAL SINUS INDEX**
Kendall,s tau_b	CERVICAL VERTEBRAL MATURATION	Correlation Coefficient	.724**	.597**	.150**
		Sig. (2-tailed)	.001	.023	.006

GRAPH 6: CORRELATION OF PARAMETERS WITH CERVICAL VERTEBRAL MATURATION

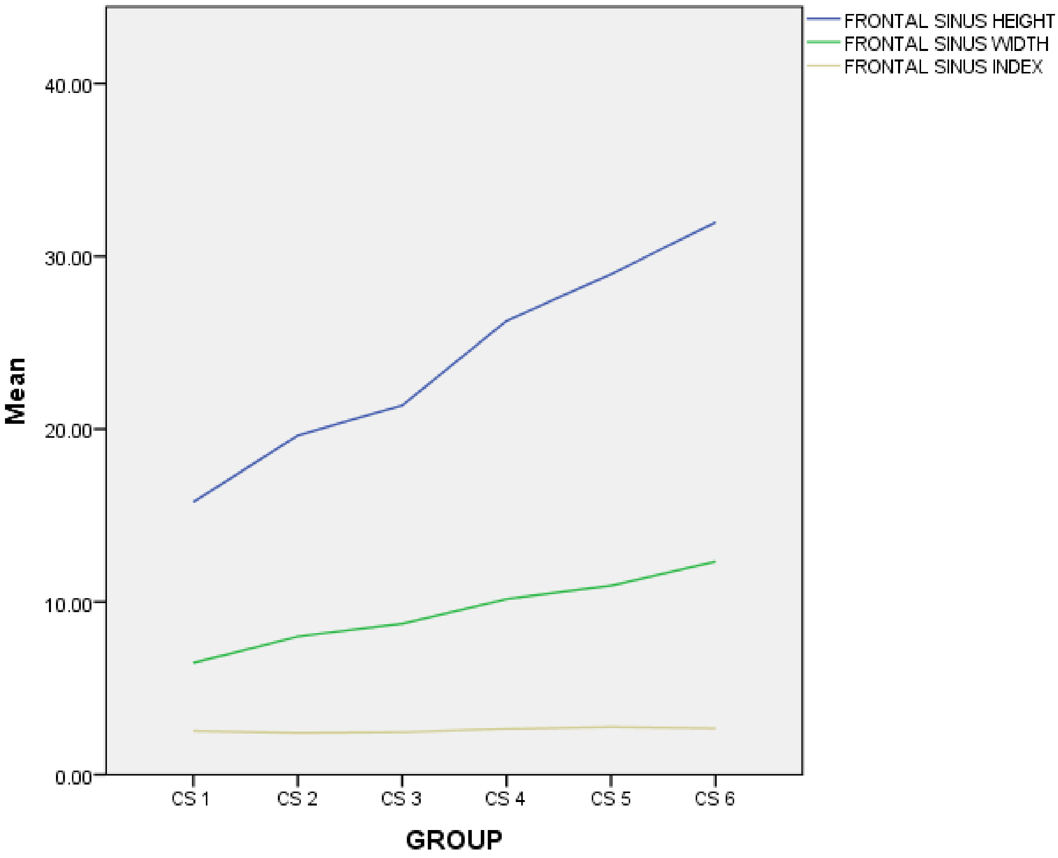

Table 10 and Graph 6 shows the correlation of frontal sinus height, width and index with group. This shows that there was a very high correlation existed between the Cervical Vertebral Maturation Stages and the Frontal Sinus height and width with a Correlation Coefficient of 0.724, 0.597. A weak significant correlation existed between frontal sinus index and Cervical Maturation Stages with a correlation coefficient of .150.

TABLE 11: CORRELATION OF PARAMETERS WITH GENDER

			Group	FRONTAL SINUS HEIGHT	FRONTAL SINUS WIDTH	FRONTAL SINUS INDEX
Kendall's tau_b	GENDER	Correlation Coefficient	.000	.067	.075	-.005
		Sig. (2-tailed)	1.000	.286	.242	.941

GRAPH 7: CORRELATION OF PARAMETERS WITH GENDER

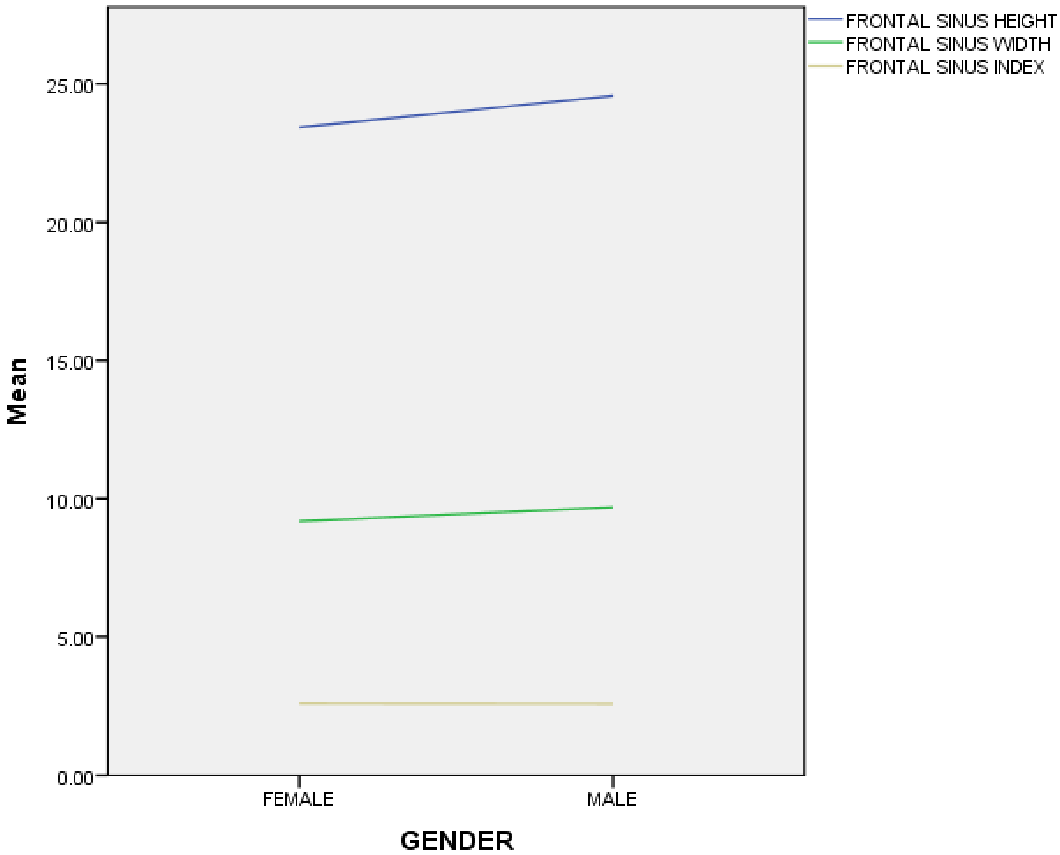

Table 11 and Graph 7 shows the correlation of frontal sinus height, width and index with gender. This shows that there was no correlation existed between Frontal Sinus height, width, index and Gender with the correlation coefficient of 0.000,.067,.075 and p value of 1, .286, .242 and .941.

DISCUSSION

An understanding of growth events is of prime eminence in the practice of orthodontics. Maturational status can have substantial impact on diagnosis, treatment goals, treatment planning and the eventual outcome of orthodontic therapy. Clinical findings regarding the use of functional appliances, extra oral traction forces, extraction versus non-extraction treatment or orthognathic surgeries were mostly based on growth considerations. Prophecy of both the time and the amount of active growth, especially in the craniofacial complex, would be useful to the orthodontist.[7]

Chronological age, skeletal age, physiologic age, and dental age are used to assess the timing of growth spurt. The chronological age is not reliable method for assessing growth spurt. In most of the conditions, skeletal age is assessed to identify the different phases of the growth spurt.

The pubertal growth spurt is important in perception of orthodontics. The somatic growth rate is at its maximum during this growth phase which is 3 – 4 years in females and 4-5 years in males. The girls have an earlier onset of puberty whereas in the boys, late onset is seen. The accelerating phase may last for 2 years on average. After 3-4 years of the end of this growth spurt, the active growth ceases.[7]

A number of methods are available to assess the skeletal maturity of an individual in orthodontic practice. The most accurate method was assessing ossification of bones in hand wrist but this method required additional radiation exposure. In order to overcome this *Lamparski* conducted a study and concluded that the cervical vertebral maturation was correlated with the skeletal maturation of a child. Many studies had showed strong correlation between hand wrist skeletal maturation and cervical vertebrae stages *(Chin et al*[21]*, FloresMir et al*[7]*).* Advances in this was assessing the developmental status through frontal sinus. In accordance with this, *Ruf and Pancherz*[14] analysed the frontal sinus morphology on lateral cephalograms and they reported that the enlargement of the frontal sinus was correlated with the pubertal growth spurt. The height, width and index of the frontal sinus keeps on increasing till 20 years which could be evident radiographically.[5] So, keeping these in mind, the present study was planned to determine the reliability of frontal sinus morphology for the assessment of skeletal maturity with cervical vertebral maturation with cervical vertebral maturation.

Ruf and Pancherz in 1996,[14] evaluated the frontal sinus morphology by correlating with body height. Frontal sinus enlargement was compared with that of epiphysial development of the middle phalanx of the third finger and radius by *Gagliardi et al*[19], *Ruf and Pancherz*[13], *Yessenia Valverde et al*[23]. Not many studies on the reliability of frontal sinus morphology for the assessment of skeletal maturity is available in works of literature. Hence, this study was conducted to determine the correlation between the height, width and index of frontal sinus and cervical maturation stages.

The pneumatization of frontal sinus increases with age. Hence, the height and width of frontal sinus increases gradually in both the sexes. In order to assess the skeletal maturity, the morphological variations of frontal sinus were assessed through index which was calculated by dividing frontal sinus height by width. This method was in accordance with *Mahmood et al, 2016.*[5]

In order to avoid any confounding factors equal ratio of male and female subjects were included in all the six groups. (female 50% and male 50%) The frontal sinus height and width increased in a linear pattern through successive cervical maturation stages. This was similar to the studies by *Mahmood et al, 2016,*[5] *Nishi N. Kapasiawala et al in 2016.*[32] The height of the sinus was greater in males than females except in group 6 which showed increased height in females than males. This was similar to that of the studies by *Mahmood* *et al, 2016,*[5] *Nishi N. Kapasiawala et al in 2016,*[32] but in these studies all male subjects showed increased frontal sinus height. According to *Mahmood et al, 2016,*[5] the width of the frontal sinus is greater in males than females. But in this present study, equal proportion was obtained. Cervical stages 1,2 and 4 in females showed greater frontal sinus width than males.

In the present study, with successive cervical vertebral stages, the frontal sinus height and width of both the sexes and index of females increased in a linear pattern. The result revealed correlation was existed between the frontal sinus height, width, index and the cervical vertebral stages. This was in line with the study conducted by *Hafiz Mahmood et al*[5] which reported a statistically significant increase in height, width and index of frontal sinus.

The present study showed that there was no significant relationship and no significant correlation between the gender and the Cervical Maturation Stages. This study was in accordance with the study conducted by Suleyman Kutalmıs¸ Buyuk et al among 148 Male and Female patients with the mean age of 14 years. It concluded that each individual will have unique frontal sinuses due to their varied morphological structures and there was no significant difference seen among the male and female patients.[34] But the results of the present study was contradictory to the study conducted by *Hafiz Taha Mahmood et al*[5] *and Ajinkya A Patil et al*[4] where a significant difference was among male and female population were observed. The reason for this difference could be the change in the growth pattern among the study participants.

Various studies have been conducted to evaluate the reliability of frontal sinus index and skeletal maturation. Besides, *Yessenia valverde et al*[21] conducted a study among Japanese girls and reported that the frontal sinus enlargement is associated with the increase in body height during puberty which also advocated the use of variations in the frontal sinus morphology could be considered as a reliable maturity indicator in the assessment of child's developmental status. *Gagliardi et al*[19] assessed the association between frontal sinus growth and somatic (body height) as well as skeletal (hand-wrist ossification) maturation. The study was conducted among Aboriginal Australians male and female population and reported a close relationship between frontal sinus growth and hand-wrist ossification. It also emphasized that the frontal sinus could be used as a reliable indicator of skeletal maturation.

In contradict to these studies, the present study showed that the frontal sinus height, width and index were significantly associated with the cervical stages, but, the frontal sinus index failed to characterize the different stages of the adolescent growth spurt. These findings were similar with the study conducted by *Ajinkya A Patil and Revankar.*[4] They evaluated the correlations between the frontal sinus index and the ossification of the middle phalanx of the third finger and failed to find a significant correlation. Thus, they concluded that the frontal sinus index could not be used as a reliable maturity indicator.

In the present study, a significant correlation between the cervical vertebral maturation stages and the frontal sinus maturation was present. But there was no correlation between gender and cervical vertebral maturation stages.

A specific pattern of variation in the frontal sinus index could be found only if the width and height of the frontal sinus increased at different rates. The results of the present study and those of previous studies highlight the fact that the linear increase in the frontal sinus width and height were comparable, which might result in minimum changes in the frontal sinus index values.

SUMMARY

&

CONCLUSION

The present research was a cross sectional study designed to assess and correlate the relationship between the frontal sinus and cervical vertebral maturation stages.

The study was conducted among 180 samples which were selected based on the inclusion and exclusion criteria. Lateral cephalograms were selected, frontal sinus height, width, index and cervical maturation stages were traced, assessed and the correlation between them were analysed.

The results could be summarised as

- There was a significant linear increase and a good statistical correlation of the frontal sinus height at each cervical vertebral maturation stages.
- There was a gradual increase and a good statistical correlation of the frontal sinus width at each cervical vertebral maturation stages.
- The index of frontal sinus increases statistically with the cervical vertebral maturation but had a weak correlation with the maturation stages.
- There was no significant relationship and no significant correlation of frontal sinus height, width and index with gender.

LIMITATIONS
&
RECOMMENDATION

LIMITATIONS

- Use of two dimensional lateral cephalograms for the assessment of three-dimensional parameter.
- Limited sample size.
- Cross sectional design of the study.

RECOMMENDATION

The research explored the comparison and the association of height, width and index of frontal sinus with the cervical vertebral stages. The present study showed a significant relationship between cervical vertebral stages and frontal sinus height, width and index. However further research might aid in strengthening the evidence established in the study. To our knowledge there was hardly a few studies to test the relationship between the frontal sinus maturation and the cervical vertebral stages, the relationship was still not completely established, hence future research to unveil the precise relationship is advocated. Use of the volumetric imaging techniques for the assessment of frontal and other paranasal sinuses and to evaluate their reliability as a tool to assess the different stages of the adolescent growth spurt.

Further longitudinal study design with large sample size is warranted to reliably assess the patient's growth status.

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ANNEXURES

Annexure I

INSTITUTIONAL ETHICAL COMMITTEE

Best Dental Science College and Hospital
Ultra Nagar, Madurai - 625 104.
RECOGNIZED BY DENTAL COUNCIL OF INDIA, NEW DELHI
AFFLIATED TO THE TAMILNADU Dr. M.G.R MEDICAL UNIVERSITY, CHENNAI)

IRB/IEC Reference No: 2018-STU-BrV-JSA-02

Project title: Reliability of Frontal Sinus Morphology with Cervical Vertebral Maturation for the Assessment of Skeletal Maturity

Principal Investigator: Dr. J. Syed Aafaque, PG student

Review: New/Revised/Expedited

Date of Review: 23/02/2018

Date of previous review, if revised application:

Decision of the IEC/IRB:

- Approval to conduct the study is being given

Signature of the Principal
PRINCIPAL
BEST DENTAL SCIENCE COLLEGE
MADURAI-625104

NB:

Inform IRB/IEC immediately in case of any issue(s)/adverse events

Inform IRB/IEC in case of any change of study procedure, site and investigator

This permission is only for the period mentioned above

Annual report to be submitted to IEC/IRB

Members of IEC/IRB have right to monitor the trail with prior intimation

Annexure II

BEST DENTAL SCIENCE COLLEGE MADURAI

CONSENT FORM

STUDY TITLE: "RELIABILITY OF FRONTAL SINUS MORPHOLOGY WITH CERVICAL VERTEBRAE MATURATION FOR THE ASSESSMENT OF SKELETAL MATURITY"

NAME OF THE INVESTIGATOR: Dr. SYED AAFAQUE

PARTICIPANT NAME: R. Vishali

AGE: 12 **SEX:** Female

I R. Vishali have been informed about the details of the study in own language. I have understood the details about the study. I know the possible risks and benefits for me, by taking part in the study. I understand that I can withdraw from the study at any point of time and even then, I will continue to get the medical treatment as usual. I understand that I will not get any payment for taking part in this study. I will not object if the results of this study is getting published in any medical journals, provided my personal identity is not reviewed. I know what I am supposed to do by taking part in this study and I assure that I will give my full co-operation for this study.

R. Vishali

SIGNATURE OF THE PATIENT/ ~~GUARDIAN~~

பெஸ்ட் பல் மருத்துவமனை மதுரை

ஒப்புதல் படிவம்

ஆய்வின் பெயர் : "எலும்புகளின் முதிர்ச்சியை முன்புற சைனஸ் அமைப்பு மற்றும் கர்ப்பப்பை வாய் முதுகெலும்பின் முதிர்ச்சியைக் கொண்டு கண்டறியவும், அதன் நம்பகத்தன்மையை மதுரை மக்கள் தொகையில் கண்டறியவும், ஓர் ஆய்வு".

ஆராய்ச்சியாளரின் பெயர் : Dr. சயீத் அட்பாக்

பங்குபெறுபவர் பெயர்: M. கதிர்

வயது: 7 **பாலினம்:** M

என்னுடைய மகன் / மகள் கதிர் இந்த ஆய்வில் பங்குபெறுவதன் மூலமாக விளையக்கூடிய நன்மையும் தீமையும் நன்றாக அறிந்து கொண்டேன். எந்த நேரத்திலும் இந்த ஆய்விலிருந்து நான் விலகிக்கொள்ளலாம், இருப்பினும் எனக்கான சிகிச்சையை வழக்கம்போல் அளிக்கப்படும் என்பதையும் அறிவேன். என் தனிப்பட்ட அடையாளத்தை தவிர்த்து இந்த ஆய்வின் முடிவை எந்த மருத்துவ இதழிலும் வெளியிடுவதில் எனக்கு எந்த ஆட்சேபனையும் இல்லை எனக்கு எவ்வித சன்மானமும் வாழங்கப்படாது என்பதை முழுமையாக தெரிந்துக்கொண்டேன் நான் இந்த ஆய்வில் முழுமனதோடு பங்கேற்கிறேன் என்பதை தெரிவித்துக் கொள்கிறேன்.

முருகேஷ்

பங்குபெறுபவர்/பெற்றோரின் கையொப்பம்