ASSESSMENT OF FRONTAL AND MAXILLARY SINUS AREA IN VARIOUS SKELETAL MALOCCLUSIONS AND THEIR CORRELATION WITH OTHER CRANIOFACIAL PATTERNS-A LATERAL CEPHALOMETRIC STUDY.

A dissertation submitted

in partial fulfilment of the requirements

for the degree of

MASTER OF DENTAL SURGERY

BRANCH – V

ORTHODONTICS AND DENTOFACIAL ORTHOPAEDICS

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

CHENNAI – 600 032

2016 – 2019

DECLARATION BY THE CANDIDATE

I hereby declare that this dissertation titled **"Assessment of frontal and maxillary sinus area in various skeletal malocclusions and their correlation with other craniofacial patterns-a cephalometric study"** is a bonafide and genuine research work carried out by me under the guidance of **Dr. K.S.PREMKUMAR, M.D.S., Professor, Head of the Department,** Department Of Orthodontics & Dentofacial Orthopaedics, Best Dental Science College, Madurai – 625104.

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"No one who achieves success does so without acknowledging the help of others. The wise and confident acknowledge this help with gratitude."

– Alfred North Whitehead

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DECLARATION

TITLE OF DISSERTATION	**ASSESSMENT OF FRONTAL AND MAXILLARY SINUS AREA IN VARIOUS SKELETAL MALOCCLUSIONS AND THEIR CORRELATION WITH OTHER CRANIOFACIAL PATTERNS-A CEPHALOMETRIC STUDY**
PLACE OF STUDY	**BEST DENTAL SCIENCE COLLEGE, MADURAI – 625104.**
DURATION OF THE COURSE	**3 YEARS**
NAME OF THE GUIDE	**Dr.K.S.PREMKUMAR, M.D.S**
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(Dr.A.ANDIAPPAN)

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This agreement herein after the "Agreement" is entered into on this day 31 Dec 2018, 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

Mr **Dr.K.S.PREMKUMAR, M.D.S** aged 45 years working as **Principal, Professor and HOD** in Department of Orthodontics & Dentofacial Orthopaedics at the College, having residence address at Madurai (herein after referred to as the 'Principal Investigator').

And

Mr. Dr.A.ANDIAPPAN aged 26 years currently studying as **Post Graduate student** in Department of Orthodontics & Dentofacial Orthopaedics, Best Dental College, Madurai- 625104 (herein after referred to as the 'PG/Research student and co-investigator')

Whereas the PG/Research student as part of his curriculum undertakes to research on **"ASSESSMENT OF FRONTAL AND MAXILLARY SINUS AREA IN VARIOUS SKELETAL MALOCCLUSIONS AND THEIR CORRELATION WITH OTHER CRANIOFACIAL PATTERNS-A CEPHALOMETRIC STUDY"** for which purpose PG/Principal Investigator shall act as Principal Investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG/Research student as to the extent possible as a Co-investigator.

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Student Guide

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ABSTRACT

AIM : To determine the correlation between the area of frontal sinus and maxillary sinus with other craniofacial patterns

MATERIALS AND METHODS: The total of 96 subjects were collected from the patients who came to the Department of Orthodontics and Dentofacial Orthopaedics for treatment of their malocclusion. Of all the patients those who were subjected to prescription of lateral cephalogram and those who satisfy the inclusion criteria were taken as subjects.Among those chosen subjects who already had their own radiograph were not exposed twice; rather the existing radiograph were used. The subjects lateral cephalograms were traced and divided into three groups based on their ANB angle and certains craniofacial patterns were assessed followed by evaluation of FSA and MSA by graphical method. Obtained craniofacial patterns were correlated with evaluated FSA and MSA values.

RESULTS: The results showed significant correlation of frontal sinus area with SNB of Class II which has the ‘p’ value of 0.037 and weak Pearson’s correlation coefficient of 0.127. The correlation with Pearson’s correlation coefficient showed significant correlation of maxillary sinus area with CO-A of class II skeletal malocclusion which has the ‘p’ value of 0.044 and Pearson’s correlation coefficient of 0.571.

CONCLUSION: It was concluded that certain parameters in Class II malocclusion seems to have a significant positive correlation with both frontal and maxillary sinus area which aids in assessment of Class II skeletal malocclusion whereas Class I and Class III doesn’t show any significant correlation.

LIST OF ABBREVIATION

SL.NO	ABBREVIATIONS	MEANING
1.	MP3	MIDDLE PHALYNX OF THIRD FINGER
2.	GI	FOREHEAD
3.	NaS	ANTERIOR CRANIALBASE
4.	CT	COMPUTED TOMOGRAPHY
5.	FUNC	FUNCTIONAL APPLIANCE
6.	RME	RAPID MAXILLARY
7.	MSL	MAXILLARY SINUS LENGTH
8.	MSH	MAXILLARY SINUS HEIGHT
9.	CBCT	CONE BEAM COMPUTED TOMOGRAPHY
10.	NHP	NATURAL HEAD POSTION
11.	N	NASION
12.	S	SELLA
13.	A	POINT A OR SUBSPINALE
14.	B	POINT B OR SUPRAMENTALE
15.	Gn	GNATHION

SL.NO	ABBREVIATIONS	MEANING
16.	Go	GONION
17.	Me	MENTON
18.	Ar	ARTICULARE
19.	Cd	CONDYLION
20.	Or	ORBITALE
21.	ANS	ANTERIOR NASAL SPINE
22.	Ba	BASION
23.	Ptm	PTERYGOMAXILLARY FISSURE
24.	Pog	POGONION
25.	Po	PORION
26.	N’	SOFT TISSUE NASION
27.	FAA	FACIAL AXIS ANGLE
27.	CO-A	EFFECTIVE MIDFACIAL LENGTH
28.	CO-Gn	EFFECTICE LENGTH OF MANDIBULAR BODY
29.	FSA	FRONTAL SINUS AREA
30.	MSA	MAXILLARY SINUS AREA

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INTRODUCTION

Lateral cephalograms have become an essential diagnostic tool in assessment and treatment planning and have become part and parcel of orthodontic treatment planning. Various anatomical landmarks can be seen in a lateral cephalogram that can be used in assessment of malocclusion.[1-4] Paranasal sinuses are one of such anatomical landmarks seen in lateral cephalogram radiograph as they can be easily assessed and does not provide duplicate information.[5]

There are 4 pairs of anatomical paranasal sinuses such as Maxillary Sinus, Frontal Sinus, Ethmoidal Sinus and Sphenoidal Sinus. Of these maxillary and frontal sinuses are seen in lateral cephalogram in maximum number of patients.[6]

Various studies have been done to hypothesis the effect of growth and development of these sinuses in various skeletal malocclusions.[7] Paranasal sinuses follows the growth pattern as same that of the bones.[8]

During third month of fetal development maxillary sinus starts developing from the ethmoidal infundibulum.After birth maxillary sinus continues to extend both laterally and inferiorly during rapid growth periods from birth to 3 years and from 7 to 12 years of age. Maxillary sinus that lies in close proximity to the maxillary posterior teeth may differ in different skeletal malocclusion.[9]

The bud of frontal sinus is present during birth and not seen projecting above thr orbital rim radiographically until 5th year and rapid growth continues until 12 years and reaches plateau at 16 years in males and 14 in females. In relation to frontal sinus, enlarged sinus is seen in prognathic cases and growth pattern of sinuses follows the same as the corresponding bone.

Till date, research has been done to relate paranasal sinus with Class III malocclusions or to predict growth through the use of dry skull panoramic radiography, cone-beam computed tomography, magnetic resonance and lateral cephalogram but rarely discussed aspect is which paranasal sinus of mid face better assessed the skeletal malocclusion. Hence, the aims and objective of the study are

- To evaluate the dimensions and area of the frontal and maxillary sinus in different types of skeletal malocclusion.
- To determine the correlation between the area and dimensions of frontal sinus with other craniofacial patterns.
- To determine the correlation between the area and dimensions of maxillary sinus with other craniofacial patterns.

AIM:

- To determine the correlation between the area of frontal sinus and maxillary sinus with other craniofacial patterns.

OBJECTIVES:

- To evaluate the area of frontal sinus in various skeletal malocclusions
- To evaluate the area of maxillary sinus in various skeletal malocclusions
- To evaluate the correlation between two areas evaluated with other craniofacial patterns.

REVIEW OF LITERATURE

P.E. Rossouw et al in 1991 analysed about the skeletal growth patterns of 103 subjects with Class I and III malocclusions cephalometrically to assess the abnormal mandibular growth. The surface area (2 mm) of the frontal sinus was assessed by a Summagraphics decoder linked to a microcomputer. Their results indicated that there was a significant correlation between maxillary length, mandibular length, symphysis width, condylar length, and frontal sinus size on a lateral cephalogram thus they had concluded that the frontal sinus can possibly be used as an additional indicator when one is predicting mandibular growth[10].

Atchison KA et al in 1991 conducted a study to determine the amount of diagnostic and treatment planning information gained by orthodontists when pretreatment radiographs are added to a set of orthodontic records. Thirty-nine orthodontists evaluated six test cases and formulated a diagnosis and treatment plan. Information was collected about the participants' certainty with their diagnoses and treatment plans, the impact of the radiographs, the number and type of radiographs that were selected, and the difficulty of each case. Results showed that orthodontists were approximately 75% confident of their diagnosis before reviewing any radiograph. There were 741 radiographs ordered, of which 192 produced changes to the diagnostic process. The lateral cephalometric radiograph was the most productive. Panoramic and full-mouth series were productive but provided largely duplicative information.[1]

Huisamettin Oktay in 1992 in his study, he investigated about the maxillary sinus areas on orthopantomographs of 103 male and 86 female subjects either with ideal occlusions or with malocclusions. In which he found that malocclusions and sex factors have no effect on the size of the maxillary sinuses and that sex is a significant factor only in Angle Class II malocclusions. And thus he concluded that the female subjects with Angle Class II malocclusions have larger maxillary sinuses than the male subjects and the other groups of female subjects.[6]

Scuderi AJ et al in 1993 analyzed CT and MR imaging of the paranasal sinuses in infants and children which revealed a spectrum of findings associated with the normal pneumatization process, both inside the sinus cavities and in the adjacent marrow spaces. These normal findings must be understood and recognized so that CT scans and MR images may be accurately interpreted. If such normal developmental radiologic findings are not appreciated, misinterpretation may occur and lead to inappropriate treatment. The normal process of pneumatization for each paranasal sinus group will be described from the first stages of the process to its completion. CT scans and MR images will illustrate the range of normal radiologic findings associated with the developmental process, with emphasis placed on the types of findings that, although normal, create potential interpretive difficulties.[11]

Sabine Ruf and Hans Pancherz in 1996 studied about the development of the frontal sinus in relation to somatic and skeletal maturity in 26 male subjects aged 9-22 years by means of longitudinal data obtained from lateral head films, handwrist radiographs and body height growth curves. These were grouped together and analysed in a cross-sectional manner. The results of this study revealed that the final size of the frontal sinus varied considerably. They also found that 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 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).[12]

Jean Delaire in 1997 stated that normal development of the maxilla results not only from movements of its constituent skeletal units and bony apposition-resorption superficially, but also from the specific development of the antero-lateral regions. In Class III cases, correction of the skeletal dysmorphosis requires not only that the maxilla is in a correct position (in relation to the mandible) and that the correct occlusion is achieved, but also that there is good development of the exo-peri-premaxilla. This requires normalization of muscular posture (labio-mental, lingual, velo-pharyngeal) and of orofacial functions (nasal ventilation, swallowing, mastication). Postero-anterior traction using an orthopaedic mask can only accomplish part of the treatment of Class III. The action must always be complimented by other therapy aimed at correcting the underdevelopment of the antero-lateral regions. Facemask therapy is not only simple sagittal distraction, but is truly a method for treatment of Class III which is well understood and achieves excellent results. Taking into account the great diversity of anatomical forms of Class III malocclusion, it is not surprising that extra-oral postero-anterior traction gives widely varying results. The quality, however, depends principally on the method used. Orthodontists must not hesitate to call for the assistance of a surgeon each time the functional treatment is insufficient, particularly in cleft patients where the results depend more on surgical procedures, both primary and secondary, than on dentofacial orthopaedics.[13]

Ted Rothstein et al in 2000 analysed the craniofacial and dentofacial skeletal characteristics associated with Angle's Class II, Division 1 malocclusion. They included 613 lateral head radiographs comprising 2 series: (1) 278 films of children with "normal" occlusion and (2) 335 films of children with Class II, Division 1 malocclusion. Each series was subdivided into 6 samples (3 female and 3 male; skeletal ages 10, 12, 14, [±6 months]), representing children with chronological ages ranging from 8.5 to 15.5 years. In all 6 intergroup comparisons, it was found that: (1) the mandible and its dentition is similar to the controls in size, form, and position except for the position of the lower incisors in males; (2) the forehead (Gl), anteriorcranial base (Nas), maxilla (A) and dentition (molars and incisors) are protrusive (mesial positioned), with an increased frontal bone thickness at the level of the sinus, and a larger A-P maxilla, the palate of which is inclined superiorly at its anterior half; (3) no vertical dysplasia was evident; (4) the cranial base angle is larger, as are the anterior and posterior sections that compose it, but it is not related to mandibular position; (5) angular indexes of maxillary and mandibular position that included point Nasion are highly misleading indicators of maxillary and mandibular size and position. Hence from this study they concluded that enlarged sinuses may contribute to the cause of Class II, Division 1 malocclusion.[14]

Throckmorton GS et al in 2001 in this study determined whether patients with greater surgical changes, and presumably greater normalization of their skeletal morphology, showed greater increases in their maximum voluntary bite forces after orthognathic surgery. A total of 104 adult patients (32 males and 72 females) treated with 1 of 8 different orthognathic surgical procedures were examined. Patients' presurgical and postsurgical morphologic and biomechanical measurements were taken from lateral cephalograms. Measurements known to be related to maximum bite force were used in the analysis. Patients' presurgical and postsurgical maximum bite forces were measured at 8 tooth positions (ie, right and left incisors, canines, premolars and molars). Presurgical and postsurgical morphology and biomechanics variables were strongly correlated with each other, suggesting that orthognathic surgery produced relatively little change in patients' overall craniofacial form. Maximum voluntary bite forces were primarily correlated with variables relating to jaw size-both before and after surgery. No correlations were noted between the increases in maximum voluntary bite forces and surgically produced changes in skeletal morphology and the biomechanics variables.Factors other than surgically produced changes in skeletal morphology are responsible for increases in maximum voluntary bite force after orthognathic surgery.[15]

Kwak H H et al in 2004 said that knowledge of the relationship between the root apex and the inferior wall of the maxillary sinus are crucial for diagnosing and treating a sinus pathosis as well as in assisting in dental implantation. Therefore, identifying the proximity between the root apex and the inferior wall of the sinus and clarifying the cortical thickness of the inferior wall of the sinus is essential for determining the topography of a spreading dental infection into the maxillary sinus. Accordingly, knowledge of the topography between the root apex and the inferior wall of maxillary sinus is important for diagnosing and planning dental implantation, endodontic procedures, and orthodontic treatment. This study was undertaken to clarify the morphological and clinical characteristics of the maxillary sinus, particularly the inferior wall of the sinus in Koreans, and to identify the relationship between the inferior wall of the maxillary sinus and the roots of the maxillary teeth. Twenty-four sides of the maxillae of hemi-sectioned Korean heads were used in this study. All specimens were decalcificated and sectioned coronally. On the sectioned specimens, 21 items were measured using an image analyzing system. The distances between the each root apex and the inferior wall of the maxillary sinus were measured. The distance from the root apex to the inferior wall of the sinus was the shortest in the second molar area and the longest in the first premolar area. The thickness of the cortical plate of the inferior wall of the maxillary sinus was thinnest in the first premolar area but it was thickest in the second premolar area. The vertical relationship between the inferior wall and the roots of the maxillary molars was classified into five types. Type I (the inferior wall of the sinus located above the level connecting the buccal and lingual root apices) dominated (54.5% in the first molar area, 52.4% in the second molar area). The horizontal relationship between the inferior wall of the sinus and the root apex was classified into three types. Type 2 (the alveolar recess of the inferior wall of the sinus was located between the buccal and lingual roots) was most common (80% in the first and second molar area). Overall, this study demonstrated the many anatomical characteristics and determined the relationships between the maxillary sinus and their surrounding structures. These findings may have an impact on the clinical management of patients.[7]

Ishii T et al in 2004 illustrated that the interalveolar septum between the upper first molar and the second premolar of the separated human maxillary bone was three-dimensionally observed by micro CT to evaluate the appropriate mini-screw type implant placement position by considering the relationship between the tooth roots and the maxillary sinus. After taking micro CTs of 5 human maxillary bones, horizontally sectioned images of the interalveolar septum area 2, 4, 6, 8, 10, and 12 mm deep from the crest of the alveolar ridge were reconstructed by three-dimensional reconstruction software. The bucco-lingual and mesio-distal lengths and area in each sectioned interalveolar septum were measured using digital image measurement software. Using the results, the interalveolar septum area between the upper first molar and the second premolar approximately 6-8 mm deep from the alveolar crest in the tooth root apical direction was determined to be the safest position for mini-screw implantation. Furthermore, lateral implantation from the palatal side was deduced to be the safest approach.[16]

Fatu. C et al in 2006 investigated the development of the frontal sinus size during life, we studied the planar morphometry in 60 frontal radiographs of patients of different age and gender. A professional software (Bersoft Image 4.02) was used to measure the frontal area of the right and left frontal sinuses on radiographic images. A frontal sinus was already evident in 4-year-old children. Unilateral or bilateral absence of the frontal sinus was seen in 5% of cases. The size of the sinusal area increases up to 19-year-old patients, synchronous with general craniofacial growth. In adults, individual differences in size and shape occurred in relation to environmental factors. In some elderly patients, osseous resorption led to an enlargement of the frontal sinus that might complicate surgical procedures performed in this area.[17]

Emirzeoglu M et al in 2007 said that the size and shape of paranasal sinuses are especially relevant when considering endoscopic sinus surgery. For this reason, the size of the paranasal sinuses has been the subject of many studies, none of which has used stereological methods to estimate the volume. In the present stereological study, we estimated the volume of paranasal sinuses of normal males and females. They used a combination of the Cavalieri principle and computer tomography scans taken from 39 male and 38 female patients to estimate the volumes of frontal, maxillary, ethmoidal and sphenoidal sinuses. The mean volumes of frontal, maxillary, ethmoidal and sphenoidal sinuses were estimated bilaterally, producing mean volumes of 11.6+/-0.8, 35.9+/-1.3, 11.8+/-0.4 and 13.6+/-0.7 cm, respectively. When the correlations between estimated volumes were analyzed statistically a positive relation was found for the paranasal sinuses. The size of the sinuses tends to decrease with age.The findings of the study using the stereological methods could provide data for the evaluation of normal and pathological volumes of the paranasal sinuses.[18]

Nijkamp PG et al in 2008 assessed the influence of cephalometrics in orthodontic treatment planning of individual patients. Diagnostic records of 48 subjects (24 males and 24 females aged 11–14 years) were divided in two stratified groups and assigned to one of two combinations: A, dental casts only, and B, dental casts, cephalometric radiographs, and analysis. The records were presented to 10 orthodontic postgraduates and four orthodontists for formulation of orthodontic treatment plans containing a dichotomous decision regarding the use of a functional appliance (FUNC), rapid maxillary expansion (RME), and extraction (EXTR). The combination of FUNC + RME + EXTR was used as the basis of the outcome measure. Agreement on orthodontic treatment planning using all possible comparisons of diagnostic records of individual patients (AB, AA, and BB) was assessed and overall proportions of agreement (OPA) were calculated for orthodontic postgraduates and orthodontists separately.Median OPA were 0.60 (AB), 0.65 (AA), and 0.60 (BB) for orthodontic postgraduates and 0.50 (AB), 0.75 (AA), and 0.50 (BB) for orthodontists. Irrespective of the level of experience, neither consistency of orthodontic treatment planning between both combinations of diagnostic records showed a statistically significant difference ($P > 0.05$) using Wilcoxon signed rank test nor did consistencies and agreement of orthodontic treatment planning after the addition of cephalometrics. It appears that cephalometrics are not required for orthodontic treatment planning, as they did not influence treatment decisions.[2]

Toshiya Endo et al in 2009 investigated about the maxillary sinus size in different malocclusion groups and the association between maxillary sinus size and dentofacial morphology by the use of lateral cephalometric radiographs. In their research total of 120 lateral cephalograms were used. These radiographs were derived from subjects with skeletal class I, class II, and class III malocclusions, classified on the basis of the A-N-B angle. Each malocclusion group consisted of 20 boys and 20 girls ranging in age from 12 to 16 years. Two linear measurements and three area measurements were made to evaluate maxillary sinus size, and four angular and eight linear measurements were made to evaluate dentofacial morphology. The results of their research showed that there was no significant differences in the size of maxillary sinuses between the different classes of skeletal malocclusion or between sexes and the maxillary sinus measurements were significantly correlated with several dentofacial morphological measurements. They suggested that the orthodontist that when formulating an orthodontic treatment plan, orthodontists should take into consideration the fact that the patients 12 to 16 years old with large cranial bases and nasomaxillary complexes tend to have larger maxillary sinuses, but there is no significant association between maxillary sinus size and the A-N-B angle denoting the sagittal skeletal jaw relationship.[19]

Anil Prashar et al in 2012 assessed the size of frontal sinus in different craniofacial patterns and to assess its correlation with excessive or deficient mandibular growth. Results of the study showed that the mean value of Frontal Sinus area was significantly higher in skeletal Class III as compared to Skeletal Class I and Skeletal Class II and there was no significant difference in the Frontal Sinus Area in vertical craniofacial groups. Positive correlations, in spite of variable significant values in different skeletal classes, were found with effective maxillary length, effective mandibular length, symphysis width and condylar length. Therefore they had concluded that Frontal Sinus Area tended to be larger in individuals having skeletal Class III malocclusion as compared to skeletal Class I and Class II malocclusions and Large Frontal Sinuses were associated with large mandibles, irrespective of their positional relationship to the cranial base and growth direction.[20]

Yessenia Valverde et al in 2012 investigated about the correlation between the enlargement of the frontal sinus and the body height peak in Angle Class III patients, and whether a sinus peak would serve as an indicator of growth maturity. They selected 20 Class III female patients were selected. Records of body height and serial lateral cephalograms taken for orthodontic treatment from 7 to 17 years old were used. Tracings of the radiographs were analyzed and the sinus growth was determined. The result obtained showed that the frontal sinus enlargement was closely related to body height. One year after the body height peak occurred, the frontal sinus also reached a peak that coincided with the maximum amount of sinus width enlargement. The frontal sinus growth peak velocity was about 1.02mm/yr. Nevertheless, there was a small remaining growth one year after the sinus peak in few cases. Thus they concluded that because of the close relationship between the body height growth and the enlargement of frontal sinus during puberty, the frontal sinus development could be used as an indicator of growth maturity.[21]

Prado FB et al in 2012 evaluated cephalometrically the pharyngeal airway space and frontal and sphenoid sinus changes after maxillomandibular advancement counterclockwise rotation for class II anterior open bite malocclusion.The study included 49 patients (98 lateral teleradiographs; 36 females and 13 males) who were analysed in the pre-operative (1 week before surgery) and post-operative (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 evaluated, as well as the dimensions of the frontal and sphenoid sinuses. The differences between the two operative times were evaluated by Student's *t*-test. All measurements showed excellent reproducibility for the intraclass correlation coefficient (ICC > 0.9; $p < 0.0001$). There was an increase in the measurements TB-PhW1 and UP-PhW2 and a decrease in the dimensions of the frontal and sphenoid sinuses after orthognathic surgery.The morphology of the superior and inferior pharyngeal airway space and frontal and sphenoid sinuses changes after 6 months of maxillomandibular advancement counter clockwise rotation for class II anterior open bite malocclusion.[22]

Albarakati SF et al in 2012 aimed to assess the reliability and reproducibility of angular and linear measurements of conventional and digital cephalometric methods.A total of 13 landmarks and 16 skeletal and dental parameters were defined and measured on pre-treatment cephalometric radiographs of 30 patients. The conventional and digital tracings and measurements were performed twice by the same examiner with a 6 week interval between measurements. The reliability within the method was determined using Pearson's correlation coefficient (r^2). The reproducibility between methods was calculated by paired *t*-test. The level of statistical significance was set at $p < 0.05$.All measurements for each method were above 0.90 r^2 (strong correlation) except maxillary length, which had a correlation of 0.82 for conventional tracing. Significant differences between the two methods were observed in most angular and linear measurements except for ANB angle ($p = 0.5$), angle of convexity ($p = 0.09$), anterior cranial base ($p = 0.3$) and the lower anterior facial height ($p = 0.6$).In general, both methods of conventional and digital cephalometric analysis are highly reliable. Although the reproducibility of the two methods showed some statistically significant differences, most differences were not clinically significant.[4]

Devereux L et al in 2012 investigated whether lateral cephalometric radiographs influence orthodontic treatment planning. It aimed to compare the odds of a change in treatment plan in three groups of orthodontists who treatment planned six cases on two occasions, T1 and T2, with the provision of a lateral cephalometric radiograph being varied.The records of 6 orthodontic patients were copied onto compact discs and sent to the 199 participating orthodontists. The orthodontists were allocated to 3 groups, A, B, and C. Clinicians in group A were given all records except the lateral cephalometric radiographs at the T1 and T2 planning sessions. Clinicians in group B were given all records except the lateral cephalometric radiograph at T1 and all records including the lateral cephalometric radiograph and tracing at T2. Clinicians in group C were given all records including the lateral cephalometric radiographs and tracings at T1 and T2. All participants were sent records at T1; those who returned the treatment-planning questionnaire were sent the second set of records and questionnaire at T2, 8 weeks later. Invitations to participate were distributed to all specialist orthodontists who were members of the British Orthodontic Society (n = 950). Of these, 199 orthodontists agreed to take part, a response rate of 21%. Of the 199 who agreed to participate, 149 completed the first treatment-planning questionnaire (T1), for a response rate of 75%. Of the 149 who completed that questionaire, 114 completed the second treatment-planning questionnaire (T2), for a 77% response rate.The availability of a lateral cephalometric radiograph and its tracing did not make a significant difference to any treatment-planning decisions, with the exception of the decision to extract or not between groups B and C for all 6 patients combined, and between groups B and C and groups B and A for patient 4 (Class I incisor relationship on a Class II skeletal base).For most treatment-planning decisions in these 6 patients, the availability of a lateral cephalometric radiograph and its tracing did not make a significant difference to the treatment decisions. For 1 patient, there was a significant change in the extraction decision when a lateral cephalometric radiograph was provided. This highlights the uncertainty surrounding the necessity for lateral cephalometric radiographs in treatment planning. Further research in this area is encouraged to resolve this dichotomy.[3]

Durao, A.R et al in 2013 evaluated the available scientific literature and existing evidence for the validation of using lateral cephalometric imaging for orthodontic treatment planning. The secondary objective was to determine the accuracy and reliability of this technique. In this study they did not attempt to evaluate the value of this radiographic technique for other purposes. A literature search was performed using specific keywords on electronic databases: Ovid MEDLINE, Scopus and Web of Science. Two reviewers selected relevant articles, corresponding to predetermined inclusion criteria. The electronic search was followed by a hand search of the reference lists of relevant papers. Two reviewers assessed the level of evidence of relevant publications as high, moderate or low. Based on this, the evidence grade for diagnostic efficacy was rated as strong, moderately strong, limited or insufficient. The initial search revealed 784 articles listed in MEDLINE (Ovid), 1,034 in Scopus and 264 articles in the Web of Science. Only 17 articles met the inclusion criteria and were selected for qualitative synthesis. In this study results showed seven studies on the role of cephalometry in orthodontic treatment planning, eight concerning cephalometric measurements and landmark identification and two on cephalometric analysis. They concluded that it is surprising that, not withstanding the 968 articles published in peer-reviewed journals, scientific evidence on the usefulness of this radiographic technique in orthodontics is still lacking, with contradictory results.[5]

Sarabjeet Singh et al in 2013 checked the validity of new geometric intersection point Ms, evaluating cephalometerically the spatial position of maxillary sinus and assess any correlation between the spatial position of maxillary sinus and sagittal dysplasias. A total of 20 lateral cephalograms were used, of both sexes, ranging in age from 18-25 years. These radiographs were from subjects, classified into Class I and Class II on the bases of ANB and Ao-Bo. Maxillary sinus was carefully analyzed and measured in linear dimensions of length and width and its spatial position was calculated by using a new geometric intersection point Ms, created by the intersection of the linear measurements, in relation to the anterior cranial base. The length, height and Ms-Msy of maxillary sinus was measured and compared in both the groups. In this study the mean of maxillary sinus length (MSL) and height (MSH) was 43.2 ± SD 3.2mm and 41.2 ± SD 3.8mm, respectively for Class I (p value=0.595) and 44.2 ± SD 4.9mm and 43.0 ± SD 3.4mm, respectively for Class II (p value=0.283). The intersection point Ms depicting centre of maxillary sinus from x-axis (Ms-Msx) was same for both the groups. Mean for Ms-Msy, was 37.3 ± SD 5.7 for Class I and 37.8 ± SD 1.9 for Class II (p value=0.796). Thus the results showed no statistical significant difference between both the groups. Thus they concluded that this new point can contribute in calculating the spatial position of sinus and be an effective measure to study the convexity and concavity of the midface. They also there was no significant spatial position change of maxillary sinus with variation in ANB and Ao-Bo (sagittal). Regarding vertical parameters, Ms may have significant correlation with the various malocclusions.[23]

Arkan Muslim Abdulkareem Al-Azzawi in 2013 evaluated the effect of malocclusion in skeletal Class III on maxillary sinus dimensions ,80 Iraqi subjects have been chosen, lateral cephalometric radiograph had been taken for each examined subject, then samples has been divided into two groups according to SNA and ANB angle. The first group included 40 subjects which composed of 20 males and 20 females who had Class I skeletal malocclusion, the second group included 40 subjects which composed of 20 males and 20 females who had class III skeletal malocclusion. He had analysed the radiograph to determine the measurements of maxillary sinus area by means of computer and Auto Cad program version 2008,from the results it had been found that maxillary sinus area were larger in male than females in both skeletal classes.[24]

Atılım Akkurt et al in 2013 compared the maxillary sinus (MS) volumes of the patients' with and without posterior crossbite (PCB). They included 2 groups of patients for whom CBCT scans were taken (1) 50 patients (mean age: 14.39±1.32 years)without posterior crossbite (NCB); (2) 24 patients (mean age: 14.15±1.53 years) with PCB.The volume calculation was done with using Dolphin 11.0 (Dolphin Imaging, Chatsworth, Calif, USA) software, and values were compared for the differences between the right and left maxillary sinus volume of each group. They found no significant differences were observed between right and left maxillary sinus volume for each group ($p > .05$). Right, left and mean maxillary sinus volume calculated from PCB group was found significantly lower than those calculated from NCB group ($p < .01$). They concluded that right, left and mean MS volumes of PCB patients' were significantly lower than NCB individuals.[25]

Iman I. Al-Sheakli et al in 2013 studied whether the frontal sinus area can be used as a diagnostic aid to recognize mouth breather subjects. Hence they aimed to determine the gender difference in each group, to compare the frontal sinus area between mouth breather and nasal breather group, and to verify the presence of correlation between the frontal sinus area and the cephalometric skeletal measurements. In this study Cephalometric radiographs were taken for 60 adults which was divided into 2 groups (30 mouth breathers and 30 nasal breathers) within the age group of (18-25years) and each group comprises of 15 males and 15 females. The control group (nasal breather) with skeletal class I and ANB angle ranged between 2-4º, and have dental Class I occlusion. The cephalometric measurement for each group were taken, the cephalometric radiographs were analyzed by using AutoCAD 2007 program. The results showed that in comparison to nasal breather the mouth breather has larger Gonial angle giving a tendency to posterior rotation with growth of the mandible. They also found that mouth breathers had less maxillary length than the nasal breather. No effect of gender in mouth breather on gonial, SNA and SNB angles, no effect of gender in nasal breather on gonial angle, while the other cephalometric measurements were higher in males than females in each group. The mouth breather showed more anteroposterior extent of anterior cranial base; also the mouth breather show an increase in all facial height than the nasal breathers, the frontal sinus area is smaller in mouth breather than in nasal breather. The frontal sinus area showed correlation for both groups (Mouth and nasal breather) with maxillary Length, mandibular length, ramal length, S-N length, TAFH, UAFH, LAFH, TPFH, LPFH, and UPFH. There is only correlation of frontal sinus with the SNA and SNB angles in nasal breather and no significant correlation for both groups with the gonial angle.[26]

Tatjana yutoviu et al in 2014 investigated the cranial base morphology, including the frontal facial part in patients with mandibular prognathism, to clarify a certain ambiguities, in opposing viewspoints in the literature. Cephalometric radiographies of 60 male patients 18–35 yearsof age , with no previous orthodontic treatment were analysed on the basis of dental and skeletal relations of jaws and teeth, the patients were divided into two groups: the group P (patients with mandibular prognathism) and the group E (the control group or eugnathic patients). A total of 15 cephalometric parametres related to the cranial base, frontal part of the face and sagittal intermaxillary relationships were measured and analyzed. The results of this study showed that cranial base dimensions and the angle do not play a significant role in the development of mandibular prognathism. Inter relationship analysis indicated a statistically significant negative correlation between the cranial base angle (NSAr) and the angles of maxillary (SNA) and mandibular (SNB) prognathism, as well as a positive correlation between the angle of inclination of the ramus to the cranial base (GoArNS) and the angle of sagittal intermaxillary relationships (ANB). Sella turcica dimensions, its width and depth, as well as the nasal bone length were significantly increased in the patients with mandibular prognathism, while the other analyzed frontal part dimensions of the face were not changed by the malocclusion in comparison with the eugnathic patients. Thus they concluded that the impact of the cranial base and the frontal part of the face on the development of profile in patients with mandibular prognathism is much smaller, but certainly more complex, so that morphogenetic tests of the maxillomandibular complex should be included in further assessment of this impact.[27]

Sertac Aksakalli et al in 2015 studied about the relationship between the frequency of sinus findings and patient's skeletal malocclusion classification. They had taken 105 CBCT scans and divided into 3 groups according to skeletal classification. Two experienced observers reviewed the CBCT images and recorded all maxillary sinus findings. The patients' skeletal malocclusion, the thickness of the Schneiderian membrane, and the pathologic sinus findings were evaluated. The sinus findings were classified into 4 groups: 0 = no finding, 1 = mucosal thickening, 2 = partial opacification with liquid accumulation, and 3 = total opacification. The results of the study showed that there was no statistical correlation between the skeletal malocclusion and pathological sinus findings. However, there were significant differences in the Schneiderian membrane thicknesses between the groups. Thus they have concluded that the Schneiderian membrane thickness was significantly different for Class II and Class III patients. There was no relationship between pathological sinus findings and skeletal malocclusions.[28]

Antoine Daraze in 2015 evaluated the maxillary sinus dimensions by using lateral cephalograms for treatment planning, sex determination and forensics purposes in Lebanese population. He studied about 115 lateral cephalograms of healthy young Lebanese male and female adults, age ranged from 22 to 26 to investigate the maxillary sinus size in different gender and sagittal skeletal classes, and its distribution within vertical facial types. The researchers used five measurements to assess the maxillary sinus size: two linear and three areas. The results of this study showed that all measures of maxillary sinus size displayed significant gender differences. When subjects were categorized into Class I, II and III only the lower sinus area differed significantly between the three groups. From the results he concluded that Class II hyperdivergent subgroup subjects were found to have significantly greater sinus length, total sinus area and upper sinus area when the assessment was based on ANB angle.[29]

Indu Dhiman in 2015 evaluated the reliability of frontal sinus with that of maxillary sinus in the assessment of different types of skeletal malocclusions. The sample for the study comprised of 240 patients (120 males and 120 females) with age of the subjects ranging from 16 to 25 years divided into skeletal Class I, II, and III on the basis of ANB angle cephalometrically (each 40 patients). Linear and angular cephalometric measurements were assessed and correlate with maxillary and frontal sinus size, which is obtained through AutoCAD program. The results showed a significant correlation of frontal sinus with skeletal malocclusion ($P < 0.05$) as compared to the maxillary sinus. Thus the researcher concluded that (1) Frontal sinus is more reliable as compared to maxillary sinus in depicting skeletal malocclusion. (2) Frontal sinus area larger in skeletal Class III malocclusion as compared to skeletal Class I and Class II malocclusion. (3) There is no significant variation in maxillary sinus area in males and females whereas frontal sinus shows significant variations in both males and females in different skeletal malocclusions.[30]

Nishi N. Kapasiawala et al in 2016 compared the relationship of the frontal sinus with the different skeletal malocclusion and association between the length of the mandible and the dimensions of the frontal sinus. The researcher selected 60 pretreatment digital lateral cephalograms according to the criteria and grouped into 3 groups, group 1: Class I (n=20), group 2: Class II (n=20) and group 3: Class III(n=20). Lateral cephalograms were traced and analysed on the basis of frontal sinus i.e. the following linear measurements were recorded: maximum height, maximum width, area of frontal sinus region and the length of the mandible. In this research 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. Hence they concluded as they had observed there was no significant difference between maximum height, width and area of frontal sinus with respect to Class I, Class II and Class III. Hence, they concluded that frontal sinus was not so reliable in depicting skeletal malocclusions.[31]

Azita Tehranchi in 2017 studied about the unique pattern of pneumatization of the frontal sinus as a component of craniofacial structure that would influence the skeletal growth pattern and possibility of using it as a growth predictor. A total of 144 subjects (78 females and 66 males) with a mean age of 19.26 ± 4.66 years were included in this study. Posterior-anterior and lateral cephalograms (LCs) were used to measure the frontal sinus dimensions.to analyse the skeletal growth pattern and relations of craniofacial structures using variables for sagittal and vertical analyses. The results showed that SN- FH and SNA angles had significant associations with frontal sinus dimensions in all enrolled subjects ($P < 0.05$). 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 ($P < 0.05$). Thus the researcher concluded that the larger size of frontal sinus was associated with reduced inclination of the anterior cranial base, increased anterior facial height (in males), and increased gonial angle (in females) in the study population.[32]

Mariya Qadir and Dr. Mohammad Mushtaq in 2017 studies about the relation of size of maxillary sinus and malocclusion .In this study 90 cephalograms were classified into three saggital classes based on ANB. The sample was also divided into a male group and a female group. Size of maxillary sinus was assessed manually in all the radiographs and was related statistically using one way ANOVA test to all the three malocclusion classes. No significant association was observed between all maxillary sinus size parameters except maxillary sinus length in males only. All the measurements in this study were found to be greater in males than in females. No relation was observed between maxillary sinus size and malocclusion in saggital dimension. They had concluded that males had comparatively larger sinuses as compared to females.[33]

Omar T. Said et al in 2017 conducted a study to determine the relationship between anterior occlusion and frontal sinus size. The patient database at the Eastman Institute for Oral Health, University of Rochester, was searched for male patients older than 15 years and females older than 13 years of age. In this study after applying inclusion and exclusion criteria, participants photos and lateral cephalometric and posteroanterior radiographs were examined then classified into a control class I group (n¼20, 15.7 6 2.7 years) and eight malocclusion groups (n¼136, 16.1 6 2.1 years). The frontal sinus area on the lateral cephalometric radiograph and on the posteroanterior radiograph were measured and compared between groups. One-way analysis of variance demonstrated a significant difference among all nine groups (P¼.0001). Pairwise comparison showed a significant difference between the class I group and all other malocclusion groups (P , .05) except the edge-to-edge group for both radiographs and except the bimaxillary protrusion group for the lateral cephalometric radiographs. Linear regression analyses with stepwise model selection demonstrated that anterior cranial base, mandibular plane angle, and upper incisor inclination commonly have a significant effect on frontal sinus size. The conclusion of this study was that the frontal sinus size could be used as an indicator of harmonious anterior occlusion. There were no differences among the subgroups of each skeletal malocclusion. The anterior cranial base, facial height, and maxillary incisor inclination appear to have a significant effect on frontal sinus size. [34]

Ahuja S et al in 2018 assessed the reliability of frontal sinus with different variables in predicting different skeletal jaw relations. In this study120 orthodontic patients of age group 18 years to 30 years and above who came for orthodontic treatment were assessed by using pre-treatment records. After taking radiographs, frontal sinus, maxillary sinus and cephalometric landmarks were traced and further divided into three groups depending of ANB angles. A statically significant correlation was found between frontal sinus with skeletal malocclusion P < 0.05) in all the groups. Class III malocclusion showed the largest frontal sinus area when compared to skeletal Class I and Class II malocclusion. There was significant clinical correlation in varitiaons of maxillary sinus obtained on comparison between males and females. As frontal sinus area was larger in class III and significantly correlating with mandibular length, symphysial width, it is more reliable as compared to maxillary sinus in predicting skeletal relations.[35]

MATERIALS AND METHODS

The subjects were collected from the patients who came to the Department of Orthodontics and Dentofacial Orthopaedics for treatment of their malocclusion. Of all the patients those who were subjected to prescription of lateral cephalogram and those who satisfy the inclusion criteria were takes as subjects.

Among those chosen subjects who already had their own radiograph were not exposed twice; rather the existing radiograph were used.

The study was approved by the Institutional Ethical Committee and Review Board (Date: 22/09/2016). All the individuals included in the study satisfied inclusion criteria. Consent forms including the outline proposed research and privacy terms were distributed to all chosen subjects.

INCLUSION CRITERIA

- Patients of age between 16-25 years.
- No history of previous orthodontic treatment.
- Fully erupted permanent dentition except 3rd molar
- Symmetrical faces
- No Para-nasal sinuses pathology
- No apparent facial disharmony or cleft lip and palate
- Radiographs of good quality which had clearest reproduction of paranasal sinuses (frontal and maxillary sinus).
- No prosthetic replacement of teeth.

EXCLUSION CRITERIA

- Patients undergone orthodontic treatment.
- Any missing tooth/teeth except III molar.
- Any impacted or unerupted permanent tooth.
- Radiograph with ill-defined sinus margins.

ARMAMENTARIUM FOR CLINICAL EVALUATION:

- Mouth mirror
- Explorer

ARMAMENTARIUM FOR RADIOGRAPHIC EVALUATION:

- Radiographic machine : X- mind Pano D +.
- Digital lateral cephalogram.
- Trimax printer.

ARMAMENTARIUM FOR TRACING:

- Lateral cephalogram.
- Acetate tracing paper – 0.003 Matte finish.
- Staedtler mars micro – 0.3 mm HB lead pencil.
- Geometry Box – (Scale, Protractor, Setsquares, Erasers, Sharpener).
- Illuminator.
- Transparent standard graph sheet.
- Calculator.

A Pre-structured proforma was used to collect the relevant information and record cephalometric measurements for each subject. The selected individuals were examined clinically and re-evaluated to check the criteria. Then patients were sent to the department of oral Medicine and Radiology, Best Dental Science College and Hospital and digital lateral cephalograms were taken. Cephalograms were checked to ensure that all the subjects were met with the above mentioned criteria.

The cephalograms of the patients were obtained by positioning the patient's head in cephalostat with the teeth in maximum intercuspation with relaxed lips in order to maintain standardization of radiograph with the Frankfort horizontal plane parallel to the floor and ensured that (NHP) natural head position this obtained by positioning the ear rods and forehead positioning knobs. Distance from the tube to the patient was standardized at 5 feet. Radiographic apparatus was X– Mind pano D+. The tube voltage was 73 kV and scanning time was set at 15 seconds.

Obtained lateral cephalograms from the subjects were traced and a total of 96 subjects were obtained based on the sample size calculation. Based on the ANB angle the subjects were divided into three groups i.e. ANB angle between 2° and 4° (skeletal Class I), ANB >4° (skeletal Class II),ANB <2° (skeletal Class III).

Tracing was done with a 0.3 mm HB lead pencil on acetate matte tracing paper. To eliminate intra- operator error, each cephalogram was traced twice by the same operator and the mean of the two measurements were taken. Only the tracings that correspond with an accuracy of at least 1 mm or 1° were used. The mean values were rounded off to half a degree or half a millimetre and in tracing bilateral anatomic structures a mid-line was used between right and left to eliminate errors during exposure of X-ray film.

The outline of the frontal and maxillary sinus were traced and area of the corresponding were calculated by superimposing a transparent standard graph sheet over the traced lateral cephalogram and the number of squares within the inner border of the sinus outline were counted to get the cross sectional area of the sinus in square millimetres. When less than half of the square was not within the outline the square was not counted in whereas if more than half of the square was within the outline the square was counted to calculate the area.

LANDMARKS USED:

1. N – (NASION) The most anterior point of the nasofrontal sutures in the median plane.
2. S – (SELLA) The geometic centre of the pituitary fossa.
3. A – (POINT A OR SUBSPINALE) The deepest midline point in the curved bony outline from the base to alveolar process of the maxilla.
4. B – (POINT B OR SUPRAMENTALE) Most posterior midline point in the concavity of the mandible between the most superior point on the alveolar bone overlying the mandibular incisors and Pog.
5. Gn – (GNATHION) the most anterior and inferior point of the bony chin. It is constructed by intersecting a line drawn perpendicularly to the line connecting Me and Pog with the bony outline.
6. Go – (GONION) a constructed point, the intersection of the lines tagent to the posterior margin of the ascending ramus and the mandibular base.
7. Me – (MENTON) most caudal point in the outline of the symphysis
8. Ar – (ARTICULARE) the point of intersection of the posterior margin of the ascending ramus and the outer margin of the cranial base.
9. Cd – (CONDYLION) most superior point on the head of the condyle.
10. Or – (ORBITALE) lower most point of the orbit in the radiograph.
11. ANS – (ANTERIOR NASAL SPINE) point ANS is the tip of the bony anterior nasal spine , in the median plane.

12. Ba – (BASION) lower point on the anterior margin of the foramen magnum in the median plane.
13. Ptm - (PTERYGOMAXILLARY FISSURE) the contour of the fissure projected onto the palatal plane. The anterior wall represents the maxillary tuberosity outline, the posterior wall the anterior curve of the pterygoid process.
14. Pog – (POGONION) the most anterior point on the chin.
15. Po – (PORION) the most superiorly positioned point of the external auditory meatus located by using the ear rods of the cephalostat.
16. N' – (SOFT TISSUE NASION) is located at the point of maximum convexity between the nose and forehead.

PARAMETERS:

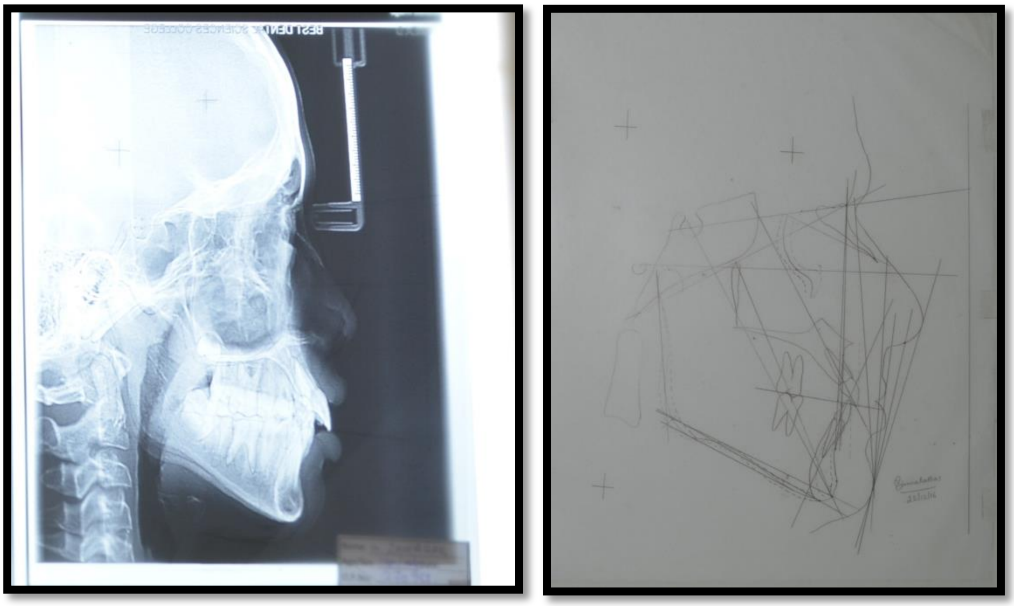
1. SNA (angle) – the angle formed between the S - N line to POINT A. It denotes the anteroposterior position of maxilla relative to cranial base.
2. SNB (angle) – the angle formed between the S- N line to POINT B. It denotes the anteroposterior position of mandible relative to cranial base.
3. ANB(angle) – the angle formed between N-A line and N-B line. It denotes the skeletal base
4. Facial axis (angle)- the angle formed between the Ba – N plane and the plane from the foramen rotundum (Pt) to Gn.
5. CO – A (mm) – effective midfacial length is measured from the condylion to point A.
6. CO – GN (mm) –the effective length of the mandible is measured from condylion to gnathion.

Fig.1 Radiographic apparatus with OPG machine and Cephalostat.

Fig.2 Shows the kV and exposure time

Fig.3 Armamentarium used in tracing

Fig.4 Lateral cephalogram with tracing



STATISTICAL ANALYSIS

All statistical analysis were carried out using the Statistical Package for Social Sciences (SPSS) version 25. Mean and standard deviation was calculated for groups. Pearson's correlation was used to find the correlation between frontal sinus area with other craniofacial patterns as well as maxillary sinus with other craniofacial patterns. p-value of less than 0.05 was considered as statistically significant difference.

RESULTS

The present study was conducted to determine the correlation between the area of frontal sinus and maxillary sinus with other craniofacial patterns based on values obtained from lateral cephalograms.

A total of 96 individuals satisfying the selection criteria were selected.32 samples in each group of skeletal malocclusion such as Class I, Class II and Class III based on the ANB angle.

PARAMETERS:

1) **SNA:**

The mean value of SNA angle for Class I was 81.50, Class II was 83.19 and Class III was 74.89. On comparing between each Class the mean value of SNA was more in Class II than other as in most Class II cases have a prognathic maxilla and very less in class III corresponding to retrognathic maxilla.

2) **SNB:**

The mean value of SNB angle for Class I was 79.03, Class II was 76.06 and Class III was 76.88. On comparing between each Class the mean value of SNB was less in Class II than other as in Class II cases may have retrognathic mandible and Class III also have a relatively less mean value of SNB corresponding to less SNA in Class III

3) **ANB:**

The mean value of ANB angle for Class I was 2.50, Class II was 6.13 and Class III was -1.94. On comparing between each Class the mean value of ANB was more in Class II as they may have prognathic maxilla or retrognathic mandible or both hence maxilla-mandibular discrepancy was more and in case of Class III it was negative as Class III mostly includes relatively prognathic mandible than maxilla.

4) **FACIAL AXIS:**

The mean value of facial axis angle for Class I was 89.08, Class II was 90.25 and Class III was 90.88. On comparing between each Class the mean value of facial axis was more in Class III than others.

5) **Co – A:**

The mean value of Co – A distance for Class I was 83.62 , Class II was 88.34 and Class III was 78.84. On comparing between each Class the mean value of Co-A distance was highest in Class II as effective maxillary length would be more in relative prognathc maxillary cases and lowest in Class III as effective maxillary length would be less because of relatively retrognathic maxilla.

6) **Co – Gn:**

The mean value of Co –Gn distance for Class I was 105.94 , Class II was 103.84 and Class III was 106.28. On comparing between each Class the mean value of Co-Gn distance was highest in Class III as effective mandibular length would be more in relative prognathic mandibular cases and lowest in Class II as effective mandibular length would be less because of relatively retrognathic mandible.

7) **FSA(FRONTAL SINUS AREA):**

The mean value of frontal sinus area for Class I was 196.94 mm^2 , Class II was 272.59 mm^2 and Class III was 388.31 mm^2. On comparing between each Class the mean value of FSA highest in Class III and least in Class I.

8) **MSA(MAXILLARYSINUSAREA):**

The mean value of maxillary sinus area for Class I was 1728.063 mm^2 , Class II was 1285.87 mm^2 and Class III was 1244.63 mm^2. On comparing between each Class the mean value of MSA was highest in Class I and least in Class II

CORRELATION OF CRANIOFACIAL PATTERNS WITH FSA:

On checking the correlation with Pearson's correlation coefficient showed significant correlation of frontal sinus area with SNA of Class II which has the 'p' value of 0.045 and strong Pearson's correlation coefficient of 0.90.

It also showed significant correlation of frontal sinus area with SNB of Class II which has the 'p' value of 0.037 and weak Pearson's correlation coefficient of 0.127.

Other parameters in Class I, Class II and Class II skeletal malocclusion don't exhibit a significant correlation with the frontal sinus area.

CORRELATION OF CRANIOFACIAL PATTERNS WITH MSA:

On checking the correlation with Pearson's correlation coefficient showed significant correlation of maxillary sinus area with CO-A of class II skeletal malocclusion which has the 'p' value of 0.044 and Pearson's correlation coefficient of 0.571.

Other parameters in Class I, Class II and Class III skeletal malocclusion don't exhibit a significant correlation with the maxillary sinus area.

Table 1: Mean values of the Parameters in various study groups.

Parameters	Mean values		
	Class I	**Class II**	**Class III**
SNA	81.50	83.19	74.94
SNB	79.03	76.06	76.88
ANB	2.50	6.13	-1.94
CO-A(mm)	83.62	88.34	78.84
CO-Gn(mm)	105.94	103.84	106.28
Facial Axis Angle	89.88	90.25	90.88
FSA($mm^{2)}$	196.94	272.59	388.31
MSA($mm^{2)}$	1728.063	1285.87	1244.63

Table 2: Correlation between the frontal sinus area and skeletal parameters in various study groups.

Parameters	'p'value	Correlation coefficient
SNA		
CLASS I	0.391	0.195
CLASS II	0.045*	0.90
CLASS III	0.723	-0.065
SNB		
CLASS I	0.305	0.187
CLASS II	0.037*	0.127
CLASS III	0.448	0.024
ANB		
CLASS I	0.266	-0.115
CLASS II	0.288	-0.103
CLASS III	0.197	0.014
CO-A(mm)		
CLASS I	0.061	0.319
CLASS II	0.302	0.095
CLASS III	0.192	-0.159
CO-Gn(mm)		
CLASS I	0.063	0.286
CLASS II	0.378	0.057
CLASS III	0.406	-0.044
FAA		
CLASS I	0.467	0.015
CLASS II	0.472	0.013
CLASS III	0.462	0.018

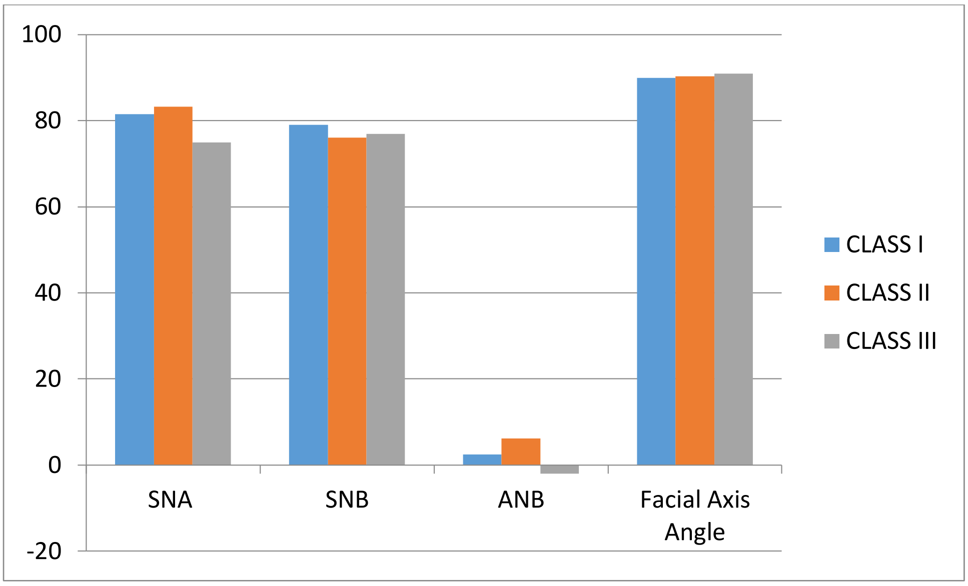
***significant correlation**

Table 3: Correlation between the maxillary sinus area and skeletal parameters in various study groups.

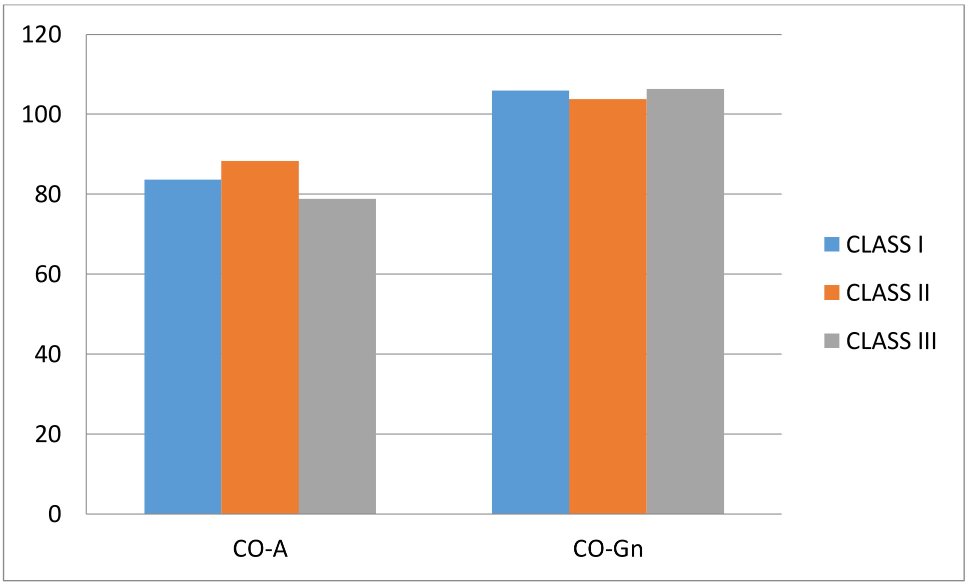
Parameters	**‘p’value**	**Correlation coefficient**
SNA		
CLASS I	0.203	-0.152
CLASS II	0.492	-0.100
CLASS III	0.196	0.156
SNB	0.257	-0.120
CLASS I		
CLASS II	0.492	0.004
CLASS III	0.078	0.256
ANB		
CLASS I	0.272	-0.111
CLASS II	0.067	-0.307
CLASS III	0.133	-0.203
CO-A(mm)		
CLASS I	0.435	0.030
CLASS II	0.044*	0.571
CLASS III	0.310	0.091
CO-Gn(mm)		
CLASS I	0.458	0.020
CLASS II	0.177	-0.170
CLASS III	0.339	0.076
FAA		
CLASS I	0.352	0.070
CLASS II	0.162	0.180
CLASS III	0.424	-0.035

***significant correlation**

Graph -1: Mean values angular parameters in various study groups

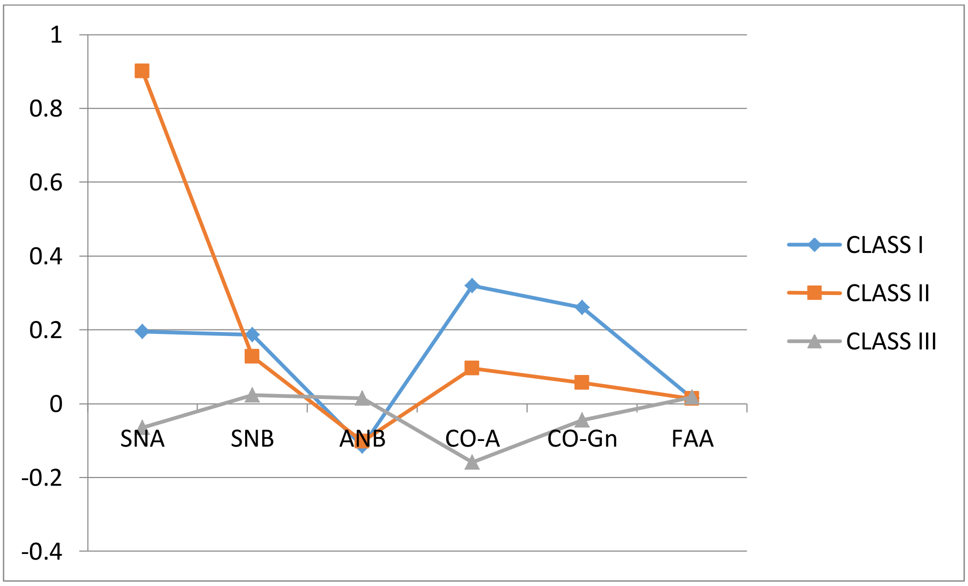


Graph -2: Mean value of linear measurements in various study groups

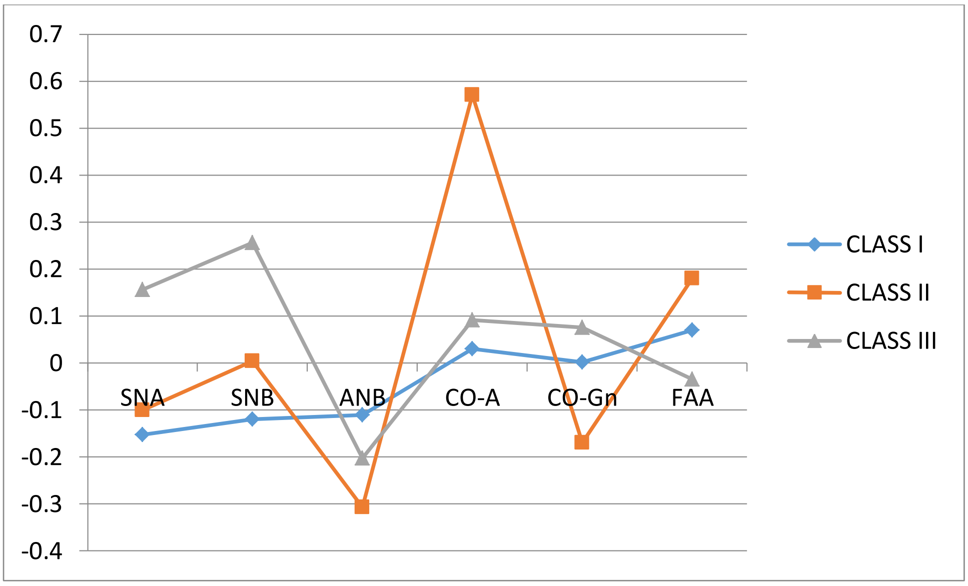


Graph-3: Mean value area of MSA and FSA in various study groups

Graph-4: Correlation between the frontal sinus area and skeletal parameters in various study groups.



Graph -5: Correlation between the maxillary sinus area and skeletal parameters in various study groups.



DISCUSSION

Lateral cephalogram has become an essential orthodontic record and have been most commonly used for appropriate diagnosis and proper treatment planning. Malocclusion has been interpreted to be unfavorable deviations from the norms, and their morphologic characteristics have been studied extensively by analysis of the lateral cephalograms.

A better understanding of the craniofacial complex and the effects of occlusion on its shape could provide indicators of normal occlusion and harmonious maxillo-mandibular relationships.

The human skeleton is a well-balanced dynamic system that responds to different mechanical stresses. Despite technological advances and the intense research studies conducted in the past, the functions and morphology of some structures are still a mystery

Various anatomical landmarks can be seen in a lateral cephalogram that can be used in assessment of malocclusion. Paranasal sinuses are one of such anatomical landmarks seen in lateral cephalogram radiograph as they can be easily assessed and does not provide duplicate information.[5]

Galen referred sinuses to “porosity” of the bones of head way back in AD 130-210. Leonardo Da Vinci (1452–1519), recognized maxillary antrum and frontal sinus as separate functional components in his classical sections of head, with maxillary sinus being called as “cavity of bone supporting the cheek”. Later in 1651 it was Highmore who gave a detailed picture of maxillary antrum and hence was called “antrum of Highmore”.[36] In later half of nineteenth century Zuckerkandl [37]presented description of paranasal sinuses in a more systematic and detailed way paving the way for efficient diagnosis and treatment.

The paranasal sinuses are actually bony cavities at the beginning of upper airway. Embryologically they are developed from various elevations and depressions in the lateral nasal wall at around eighth week of intrauterine life[38]. Each sinus is named after the bone in which it develops.[38, 39] Paranasal sinuses are group of four paired air-filled spaces that surround the nasal cavity. The four paranasal sinuses present in human body are: maxillary sinus, frontal sinus, ethmoidal sinus, sphenoidal sinuses.

They occupy a significant amount of space in the cranium and have long been of interest in studies to determine their function and factors affecting their morphology and size. Multiple functions have been suggested for the paranasal sinuses. A summary by Rae et al.[40] included respiratory function, thermoregulation, and trauma protection as a means to decrease skull weight and many more.

Preuschoft et al[41] reported that paranasal sinuses have been developed in response to the biomechanical necessities of the skull architecture. Thus, of importance are the magnitude and the direction of the forces of mastication, which are major contributing mechanical stress inducers. These processes affect the degree of pneumatization.

The frontal sinuses are the paranasal sinuses which are superior to the eyes, in the frontal bone part of the forehead. The development and size of frontal sinus can be crucial for diagnosing and treating various malocclusions. The origin of frontal sinus is from anterior ethmoidal cells during birth. The frontal sinus bud is present during the birth in ethmoidal region but it is not evident radiographically until the age of 5 year the orbital rims.[42] It migrates into the frontal bone at the end of the first year of life[43.] Tanner found that the annual height (stature) increments in children reached a plateau at 16 years in boys and 14 years in girls, and it was thought that these, too, were the ages at which frontal sinus enlargement .This suggests that the increase in the sinus size very closely follows a growth trend similar to that of other bones.[8]

Several finite element studies demonstrated the distribution of masticatory stress throughout the human skull.[44,45].These high magnitude stresses flow from the dental arches along the medial periphery of the orbits, defined by Toldt in 1914 as ‘‘nasal pillars’’. These stresses reach the frontal sinus through the nasal septum between them as a consequence of stress distribution in the midline.

Subsequently Throckmorton et al.[15] proved that more favorable transmission of stresses along the craniofacial skeleton occurs after orthognathic surgery which provides a more harmonious maxillomandibular relationship in case of skeletal discrepancy.

In addition to this Prado et al.[22] reported the reduction of the frontal sinus size after 6 months after correction of a Class II open bite malocclusion using maxillomandibular advancement with counterclockwise rotation. The authors concluded the change in size as an adaption to stresses induced by a more favorable occlusion.

Maxillary sinus is largest paranasal sinus and first to develop in intrauterine life[46]. It is pyramidal in shape and is related to pterygomaxillary and infratemporal fossa[39]. Floor of maxillary sinus is formed by alveolar process of maxilla [47,48,49,50] and it shares a close anatomic and functional relationship with posterior maxillary teeth.[51, 52].

Its development starts at the 3rd month of fetal development from the infundibulum of the ethmoid bone.[11]After birth, it continues to expand laterally during the two growth spurt periods (from birth to 3 years of age and from 7 to 12 years).[53]

This close relation with posterior maxillary teeth plays a very important role in orthodontic treatment planning [7] e.g. in deciding mesialization of second molar when first molar is absent. In this case due to absence of first molar, maxillary sinus might have moved inferiorly into the alveolar process at that place and thus making mesialization of second molar difficult due to close proximity of cortical sinus wall with second molar roots. With the advent of temporary anchorage devices study of maxillary sinus became more important to prevent complications such as sinus perforation and injury to roots [16]

Different studies have been done to investigate paranasal sinus development in patients by lateral cephalograms. Many researches has been done to relate paranasal sinus with Class III malocclusions or to predict growth through the use of dry skull, panoramic radiography, cone-beam computed tomography, magnetic resonance and lateral cephalogram but rarely discussed aspect is which paranasal sinus of mid face better assessed the skeletal malocclusion.

The present research was done to determine the correlation between the area of frontal sinus and maxillary sinus with other craniofacial patterns and the results obtained were the mean value of frontal sinus area for Class I was 196.94 mm^2, Class II was 272.59 mm^2 and Class III was 388.31 mm^2. On comparing between each Class the mean value of FSA was highest in Class III and least in Class I. The mean value of maxillary sinus area for Class I was 1728.063 mm^2 , Class II was 1285.87 mm^2 and Class III was 1244.63 mm^2. On comparing between each Class the mean value of MSA was highest in Class I and least in Class III.

Endo et al. found that maxillary sinus measurements show no significant difference between different skeletal classes in each gender.[19] Emirzeoglu et al. showed a significant difference in the volume of maxillary sinus between male and female, mainly due to the fact the male exhibit higher and wider maxillary sinus than female.[18]

Oktay found that malocclusion and sex factor had no effect on maxillary sinus size and that sex was a significant factor only in angle Class II malocclusion.[6] Joffe found frontal sinus enlargement to be associated with prognathic subjects.[54]

In a similar study reported by Rossouw et al. (1991) they had only compared the area of the frontal sinus in between adult skeletal Class III and adult skeletal Class I growth pattern cases but did not study the Class II growth pattern cases.[10]

No study has been done in different types of skeletal malocclusions to evaluate the correlation of paranasal sinuses with the skeletal pattern. Hence the present research was done to determine the correlation between the area of frontal sinus and maxillary sinus with other craniofacial patterns such as facial axis angle, effective maxillary length and effective mandibular length.

In the present research FSA was found to be larger in skeletal Class III malocclusion. Skeletal Class III and Class II malocclusion are the extreme variations of the facial developmental process, depicting excessive and deficient mandibular growth respectively, so it was logical to look for a significant difference between the two malocclusions, which was shown by the present study.

Though the FSA increased with mandibular prognathism as in skeletal Class III cases, It was not found to decrease in skeletal Class II malocclusion as compared to skeletal Class I malocclusion. The findings of the present study were also in accordance with those of Rossouw et al. (1991).[10] They demonstrated that a larger FSA was associated with excessive mandibular growth, as in case of skeletal Class III malocclusion.

In our study, the FSA shows the significant correlation with SNA and SNB in skeletal Class II malocclusion as shown in Table 2. The reason may be due to the increase in the thickness of the Nasion that was accounted for the enlargement of the frontal sinus

In the present research MSA was more in skeletal Class I malocclusion as compared to skeletal Class II and Class III malocclusion but whereas in a study by Dhiman, et al reported that the MSA tend to be larger in patients with Class II malocclusion than in those with Class I or Class III malocclusion.[30]It was found that though MSA is more in skeletal Class I malocclusion patients but it significantly shows positive correlation with the effective maxillary length in Class II malocclusion as patients with Class II tend to have large maxillary as corresponding to which the maxillary sinus may be large.

Though frontal sinus and maxillary sinus do not show significant relation some variables shows positive correlation.

LIMITATION

The limitations of this study are as follows:

- Use of two dimensional lateral cephalograms for assessment of a three dimensional parameter.
- Limited sample size
- No gender stratification.

SUMMARY AND CONCLUSION

The present research was to determine the correlation between the area of frontal sinus and maxillary sinus with other craniofacial patterns.-a lateral cephalometric study.

96 samples were selected for the study by the inclusive criteria. The lateral were taken and traced, parameters were analysed and correlation was found with each skeletal malocclusions

From the results of the study following conclusions are drawn:

- SNA was more in Class II than other as in most Class II cases have a prognathic maxilla and very less in class III corresponding to retrognathic maxilla.
- SNB was less in Class II than other as in Class II cases may have retrognathic mandible and Class III also have a relatively less mean value of SNB corresponding to less SNA in Class III
- ANB was more in Class II as they may have prognathic maxilla or retrognathic mandible or both hence maxilla-mandibular discrepancy was more and in case of class III it was negative as Class mostly includes relatively prognathic mandible than maxilla.
- Co-A distance was highest in Class II as effective maxillary length would be more in relative prognathc maxillary cases and lowest in Class III as effective maxillary length would be less because of relatively retrognathic maxilla.
- Co-Gn distance was highest in Class III as effective mandibular length would be more in relative prognathc mandibular cases and lowest in Class II as effective mandibular length would be less because of relatively retrognathic mandible.
- FSA highest in Class III and least in Class I.
- MSA highest in Class I and least in Class III
- Significant correlation of frontal sinus area with SNA and SNB of Class II

- Significant correlation of maxillary sinus area with CO-A of Class II skeletal malocclusion

Hence, from the present research it was concluded that certain parameters in Class II malocclusion seems to have a significant positive correlation with both frontal and maxillary sinus area which aids in assessment of Class II skeletal malocclusion whereas Class I and Class III doesn’t show any significant correlation.

RECOMMENDATIONS

The future scopes of this study with recommendations are as follows

- Use of three dimensional techniques for better diagnosis and assessment of parameters
- Conduct the research on a large sample.
- Divide samples based on gender.

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AFFLIATED TO THE TAMILNADU Dr. M.G.R MEDICAL UNIVERSITY, CHENNAI)

IRB/IEC Reference No: 2016-STU-BrV-ANN-15

'roject title: Assessment of frontal and maxillary sinus area in various skeletal malocclusions and their correlation with other craniofacial patterns- A cephalometric study

Principal Investigator: Dr. A. Andiappan, PG student

Review: New/Revised/Expedited

Date of Review: 27/09/2016

Date of previous review, if revised application:

Decision of the IEC/IRB:

- Provisional approval to conduct the study is being given
- The results of this study, along with summary are to be submitted for obtaining final approval

Recommended time period: one year (28-09-17)

PRINCIPAL
BEST DENTAL S... COLLEGE
...DURAI-625104

Signature of Member Secretary

ETHICS COMMITTEE SIGN BDSC

INSTITUTIONAL REVIEW BOARD SIGN. DATE BDSC

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**

PROFORMA

Case No:

Date:

Name: **Age/ Sex:**

Address:

Questionnaire:

1. **Have you undergone any orthodontic treatment?**

2. **Have you replaced any tooth?**

3. **Do you have any missing tooth?**