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A cephalometric evaluation of correlation between dimensions of frontal sinus and maxillary sinus in different skeletal patterns

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Abstract

Aim: The aim of the study is to investigate maxillary and frontal Sinuses size in different malocclusion groups and the association between their sizes and dentofacial morphology, also to analyse the relationship between the length of the mandible and the two sinuses using lateral cephalometric radiographs.

Materials And Methods: This study was conducted by assessing 57 cephalograms of patients with age group ranging from 16-30 years of age divided into skeletal Class I, II and III based on ANB angle (19 each group). Maxillary sinus area, frontal sinus area and length of the condyle was measured manually by tracing all the radiographs.

Result: In the present study, on comparison of frontal sinus area (FSA) in different skeletal classes shows skeletal Class III patients have more FSA compared to other skeletal groups. In case of maxillary sinus area (MSA), skeletal Class II patients have large MSA as compared to other groups. Also, positive correlation is found between FSA and MBL with greater total mandibular length in skeletal Class III but MSA shows no significant relation with any variable used in the study.

Conclusion: From orthodontic point of view frontal sinus can be used as one of the reliable parameters as compared to maxillary sinus to assess skeletal malocclusion. Also, there is positive relationship between frontal sinus area and total mandibular length. There is no significant relation between maxillary sinus size and malocclusion in saggital dimension.

Keywords: Maxillary sinus, Frontal sinus, malocclusion, cephalometrics, saggital jaw position

Introduction

Leonardo Da Vinci (1452–1519), recognized maxillary antrum and frontal sinus as separate functional entity in his classical work on sections of head, with maxillary sinus being called as “cavity of bone supporting the cheek”. Highmore in 1651 gave a detailed picture of maxillary sinus which was called “antrum of Highmore” [1]. Zuckerkandl in nineteenth century described paranasal sinuses in a more systematic and detailed way paving the way for efficient diagnosis and treatment [2]. The paranasal sinuses are the bony cavities at the beginning of upper airway which Embryologically developed at around eighth week of intrauterine life from various elevations and depressions in the lateral nasal wall. Of all the sinuses maxillary sinus is largest paranasal sinus and first to develop in intrauterine life. It is pyramidal in shape and is related to pterygomaxillary and infratemporal fossa. Floor of maxillary sinus is formed by alveolar process of maxilla and it shares a close anatomic and functional relationship with posterior maxillary teeth. This close relation with posterior maxillary teeth plays an especially important role in orthodontic treatment planning [3]. By the age of 12–15 years the maxillary sinus grows to its matured size along with the maxillary growth period [4]. The frontal sinus size may be affected by different factors, such as bone density, forces of the masticatory muscles, occlusal relationships, and jaw relation [5]. The frontal sinus, one of the paranasal sinuses, does not exist at birth, and it starts to develop after the age of 2 years. Its development continues until late puberty and is completed at the age of approximately 20 years [6]. Literature has found conflicting evidence about relation of maxillary and frontal sinus with malocclusion. Some studies conclude that there is no relation between the two [7, 8] and some showed partial association between the two [9].

Different techniques for measurement of maxillary sinus size are presented in the literature ranging from cadaveric skulls, Orthopantamographs, computed tomography to magnetic resonance imaging and Cephalograms form the basis of orthodontic diagnosis and treatment planning. There are few studies where both frontal and maxillary sinuses are compared together with different malocclusion classes from lateral cephalograms. A lateral cephalogram, is a portrayal X-ray of the craniofacial structures which is used to assess the relation between jaws, the teeth in the jaws, the skull, and the soft tissues. With the introduction of the cephalometer in 1931 by Broadbent, cephalometric analysis has become a standardized diagnostic method in orthodontic practice.

Keeping all these factors in mind this study was aimed at comparing measurement of frontal and maxillary sinus sizes from lateral cephalograms and correlating it to malocclusion classes in a sagittal plane also to analyse the relationship between the length of the mandible and the two sinuses.

Materials and Method

This was a retrospective study. The study was carried out on patients in the Out-Patient Department of the Department of Orthodontics and Dentofacial Orthopaedics at Bharati Vidyapeeth (Deemed to be) University, Dental College and Hospital, Sangli. The sample for this study consisted of 57 cephalograms of patients with age group ranging from 16-30 years of age divided into skeletal Class I, II and III based on ANB angle (19 each group) as:

- ANB = between 2° and 4° (skeletal Class I)
- ANB >4° (skeletal Class II)
- ANB <2° (skeletal Class III)

The subjects who did not undergo any prior orthodontic treatment and had a full complement of permanent teeth up to 2nd molars were selected for the study. It was ensured that the subjects selected had Symmetrical faces,

no caries or missing teeth, periodontal problem, TMJ abnormality, any associated syndrome and had not undergone any surgery. Lateral standardized cephalograms were taken by a single operator using the same X-ray device and a standardized procedure, with cephalograms being taken in Natural Head Position based on the work of Solow and Tallgren [10]. The good quality cephalograms which had clearest reproduction of paranasal sinuses (frontal and maxillary sinus) were made with the mandible in the intercuspal position with an anode to mid subject distance of 5 feet. Thyroid shield and lead apron were worn by the subject to reduce radiation exposure. To ensure consistent magnification, all the radiographs were made upon standardize lateral radiograph (18*24cm film, Kodak, Germany). The procedure was approved by the ethical committee of the institution and a written consent was obtained from each participant. Lateral cephalograms were traced upon an A4 size acetate paper with a 2B hard lead pencil over well-illuminated viewing screen. The linear measurements were recorded with a measuring scale up to a precision of 0.5 mm. The angular measurements were analysed with a protractor up to a precision of 0.5°.

The reference landmarks, planes and variables used for Maxillary Sinus and Frontal sinus Measurements are shown in Figure 1and 2.

Cephalometric Measurements

Definition of Landmarks

1. Point An: The most anterior point of anterior wall of maxillary sinus [9]
2. Point An': Point projected vertically from An to the x-axis [9]
3. Point Po: Posterior most point of maxillary sinus [9]
4. Point Po': Point projected vertically from Po to the x-axis [9]
5. Point Su: Superior most point of maxillary sinus [9]
6. Point Su': Point projected vertically from Su to the y-axis [9]
7. Point In: Inferior most point of maxillary sinus [9]
8. Point In': Point projected vertically from In to the y-axis [9]
9. Point ANS: The most anterior point of the bony hard palate in the mid-sagittal plane
10. Point PNS: The most posterior point of the bony hard palate in the mid-sagittal plane
11. Point S (Sella): The midpoint of the hypophysial fossa
12. Point N. (Nasion): The most anterior point on the nasofrontal suture in the median plane
13. Point A (Subspinale): The most posterior midline point in the concavity between the anterior nasal spine and the prosthion [10].
14. Point B (Supramentale): The most posterior midline point in the concavity of the mandible between the most superior point on the alveolar bone overlying the lower incisors and pogonion [10].

Definition of Planes

1. S-N plane (Sella-Nasion): it is the anterior posterior extent of anterior cranial base
2. Maxillary plane (Max. P.): A line joining between ANS and PNS
3. N- A line: Formed by a line joining Nasion and point A [3]
4. N- B line: Formed by a line joining Nasion and point B [3]
5. Y-axis line: Paralell to vertical edge of radiograph taken in NHP (natural head position) [10] Drawn through Sella.
6. X- axis line: This was taken as a pure perpendicular plane to the true vertical recorded in the lateral head radiograph [10]. This was drawn through Sella.

Definition of variables

1. ANB Angle: The angle between lines N-A and N-B. It represents the difference between SNA and SNB angles or it may be measured directly as the angle ANB. It is the most used measurement for appraising anteroposterior disharmony of the jaws.
2. Maxillary sinus length (M.S.L): this line extends from An' to the Po' [9]
3. Maxillary sinus height (M.S.H): this line extends from Su' to the In' [9]
4. Upper maxillary sinus area (UMSA): which defined by the area above maxillary plane that constructed from anterior nasal spin (ANS) to posterior nasal spin (PNS) [9]
5. Lower maxillary sinus area (LMSA): which represents lower area of Maxillary sinus from palatal plane [9]
6. Total maxillary sinus area (TMSA): which represents difference of total maxillary sinus area and lower maxillary sinus area [9]

The linear measurements were measured using scale and the areas were measured as follows:

TMSA = MSL x MSH

LMSA = Maximum perpendicular height from palatal plane to lower border of maxillary sinus x maximum width on the palatal plane.

UMSA = TMSA ─ LMSA

Units of measurement were millimeters (mm) for linear measurements and square millimeters (mm^2) for the areas.

The reference landmarks, planes and variables used for Frontal Sinus Measurements are shown in Table 1 and Table 2.

The frontal sinus was traced by following the areas of high radiopacity as the peripheral areas. The peripheral border of the frontal sinus was traced, and the highest (Sh) and lowest (Sl) points of its extensions were marked. Perpendicular to the interconnecting line Sh-Sl, the maximal width of the frontal sinus will be assessed.

Table 1: Cephalometric points to be traced on the cephalogram

1	Point A	The deepest midline point on the premaxilla between the anterior nasal spine and prosthion
2	Point B	The most posterior point in the concavity between the infradentale and pogonion
3	N (nasion)	The anterior limit of the frontonasal suture
4	Co	The most posterior and superior point on the condyle of the mandible
5	Gn (gnathion)	The most anterior and inferior point on the symphysis of mandible
6	Point Sh	Highest point on the peripheral borders of the frontal sinus
7	Point Sl	Lowest point on the peripheral borders of the frontal sinus

Table 2: Linear measurements to be traced on the cephalogram (Measurements in mm)

	Measurements
1. Co-Gn	(The effective length of the mandible)
2. Maximum height of frontal sinus	(A line connecting Sh to Sl is drawn to measure the maximum height of frontal sinus)
3.Width of frontal sinus	(Perpendicular to above line, a line was drawn to measure the maximal width of frontal sinus)

Statistical Analysis

Statistics consisted of descriptive statistics including mean, ranges, and standard deviations. Also, descriptive

statistics were calculated for merged sample. One-way ANOVA and a post hoc test was used for multiple comparisons. $p \leq 0.05$ was considered as the level of significance.

Results

In the present study, on comparison of frontal sinus area (FSA) in different skeletal classes shows skeletal Class III patients have more FSA compared to other skeletal groups. In case of maxillary sinus area (MSA), skeletal Class II patients have large MSA as compared to other groups. Also, it has been found that upper maxillary sinus area is significantly large in case of skeletal Class II cases and lower maxillary sinus area is large in case of skeletal Class III patients. Significant correlation is found between FSA and MBL with greater total mandibular length in skeletal Class III but MSA shows no significant relation with any variable used in the study. [Table 3 and Table 4]

Table 3: Descriptive statistics involving mean, standard deviation, F values and P values of maxillary sinus area parameters.

Parameters	Class I	Class II	Class III	F value	p value
MSL	38.04 ± 3.39	39.05 ± 2.64	37.21 ± 2.10	2.124	0.129
MSH	41.06 ± 3.47	41.58 ± 2.51	40.18 ± 2.55	1.144	0.326
UMSA	1413.84 ± 158.80	1470.04 ± 147.67	1326.26 ± 143.57	4.425	0.017 *
LMSA	145.66 ± 47.85	154.37 ± 42.98	170.03 ± 45.88	1.393	0.257
TMSA	1559.50 ± 169.16	1624.41 ± 154.85	1496.29 ± 136.27	3.287	0.045 *

Table 4: Descriptive statistics of mean, standard deviation, P value and F value of intercomparison group

Parameters	Class I	Class II	Class III	F value	p value
ANB	2.32 ± 1.00	6.47 ± 1.17	-4.00 ± 2.54	179.648	0.001 *
Go-Gn	116.74 ± 3.74	112.11 ± 4.14	124.42 ± 4.73	41.288	0.001 *
FSA	353.66 ± 54.36	396.79 ± 62.05	641.99 ± 145.99	49.028	0.001 *
MSA	1559.50 ± 169.16	1624.41 ± 154.85	1496.29 ± 136.27	3.287	0.045 *

Discussion

Lateral cephalogram have been the essential and most used diagnostic aid for diagnosis as well as evaluation for treatment outcome and routine orthodontic records. Maxillary sinus is the largest of all four paranasal sinus and first to develop during intrauterine life. It is pyramidal in shape and is related to pterygomaxillary and infratemporal fossa. The floor of maxillary sinus is formed by alveolar process of maxilla. It has similar anatomic and functional relationship with posterior maxillary teeth. Due to its close relationship with posterior maxillary teeth, it has paramount role in orthodontic treatment plan.

Frontal sinus is present behind the brow ridge. At birth, the frontal sinus bud is present at ethmoidal region, but gets evident radiographically by the age of 5 years and

grows till the age of 12 years. Bone growth in human body follows same growth pattern as in paranasal sinuses.[11]

According to the study carried by Rossouw et al., the frontal sinus as seen on a lateral cephalogram is a valuable indicator of excessive mandibular growth.[12] Joffe in his studies found that the frontal sinus enlargement is associated with mandibular prognathism.[13] Oktay from his studies concluded that malocclusion and sex factor had no effect on size of maxillary sinus and that sex was a significant factor only in cases of Class II malocclusion.[8] Ricketts et al. conducted a study on 103 patients and cephalometrically analyzed the skeletal growth patterns with Class I and Class III malocclusions to assess abnormal mandibular growth. The result significantly found correlation between FSA and MBL.

In this study, manual tracing was used for calculation of maxillary and frontal sinus area. Although, some studies use digital method to measure these factors, the manual technique has similar accuracy with that of manual technique. Thus, according to the affordability, the manual technique is used.[14]

Conclusion

The conclusion of this cephalometric study is as follows:

1. The total maxillary sinus area is significantly large in skeletal Class II cases.
2. Skeletal Class III cases have larger frontal sinus area as well as total mandibular length, irrespective of growth direction or form of mandible.
3. There is positive relationship between the frontal sinus area and total length of mandible.
4. Overall maxillary sinus area does not vary significantly with different skeletal jaw discrepancies.

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Legend Figures

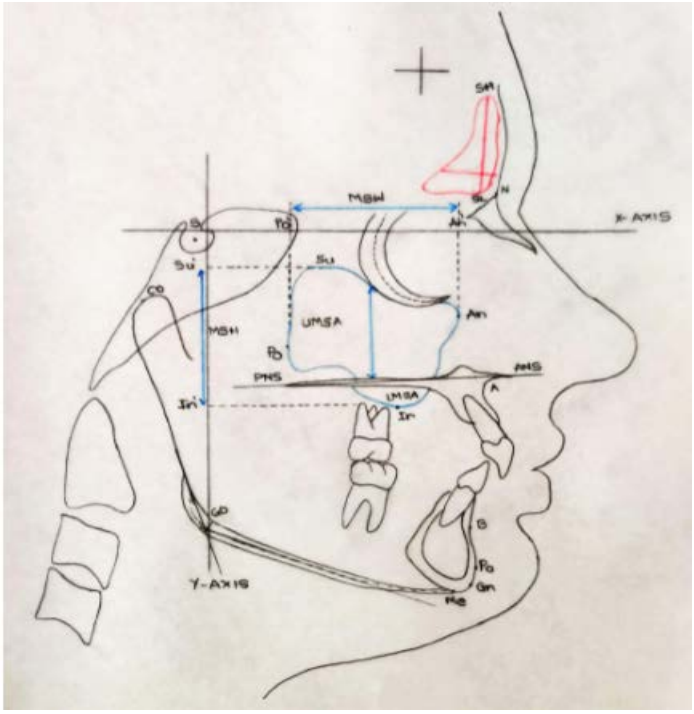

Figure 1: Cephalometric variables

Figure 2: Cephalometric landmarks