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Maxillary sinus size and malocclusion: Is there any relation?

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Abstract

Introduction: There are conflicting evidences available in literature regarding relation of size of maxillary sinus and malocclusion, hence this study was aimed at finding the relation between the two. This will greatly aid in orthodontic diagnosis and treatment planning.

Materials and methods: 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.

Results: No significant association was observed between all maxillary sinus size parameters except maxillary sinus length in males only. All the measurements were found to be greater in males than in females.

Conclusions: No relation was observed between maxillary sinus size and malocclusion in saggital dimension. Males had comparatively larger sinuses as compared to females.

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

1. Introduction

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" [1]. In later half of nineteenth century Zuckerkandl [2] presented description of paranasal sinuses in a more systematic and detailed way paving the way for efficient diagnosis and treatment. The invention of computed tomography (CT) further encanced the knowledge that had been developed more than 100 years ago.

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 [3]. Each sinus is named after the bone in which it develops [4, 5].

Maxillary sinus is largest paranasal sinus and first to develop in intrauterine life [6]. It is pyramidal in shape and is related to pterygomaxillary and infratemporal fossa [5]. Floor of maxillary sinus is formed by alveolar process of maxilla [7, 8, 9, 10] and it shares a close anatomic and functional relationship with posterior maxillary teeth [11, 12].

This close relation with posterior maxillary teeth plays a very important role in orthodontic treatment planning [13]. 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 [14].

Various factors like age [15, 16], sex [17] do influence the relative size of maxillary sinus. Literature is highly varied when it comes to relation of maxillary sinus size with malocclusion. Some studies conclude that there is no relation between the two [18, 19] and some showed partial association between the two [20].

The techniques for measurement of maxillary sinus size presented in the literature are different ranging from cadaveric skulls [21], dry skulls [19], orthopantamographs [18], computed tomography [22] to magnetic resonance imaging [16]. Cephalograms form the basis of orthodontic diagnosis and treatment planning. Not many studies have reported maxillary sinus measurement from lateral cephalograms [23].

Keeping these factors in mind this study was aimed at measurement of maxillary sinus size from lateral cephalograms and correlating it to malocclusions in a saggital plane.

2. Materials and methods

The study was carried out on the patients received in the Out-Patient Department of the Department of Orthodontics & Dentofacial Orthopaedics, Government Dental College & Hospital, Srinagar. The sample for this study consisted of 90 subjects which included 43 males and 47 females. Those subjects between the age group of 15-35 years, 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 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 [24]. The cephalograms 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. The procedure was approved by the ethical committee of the institution and a written consent was obtained from each participant. Lateral cephalogram was traced upon an A4 size acetate paper with a 2B or 3HB 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 are shown in Figure 1.

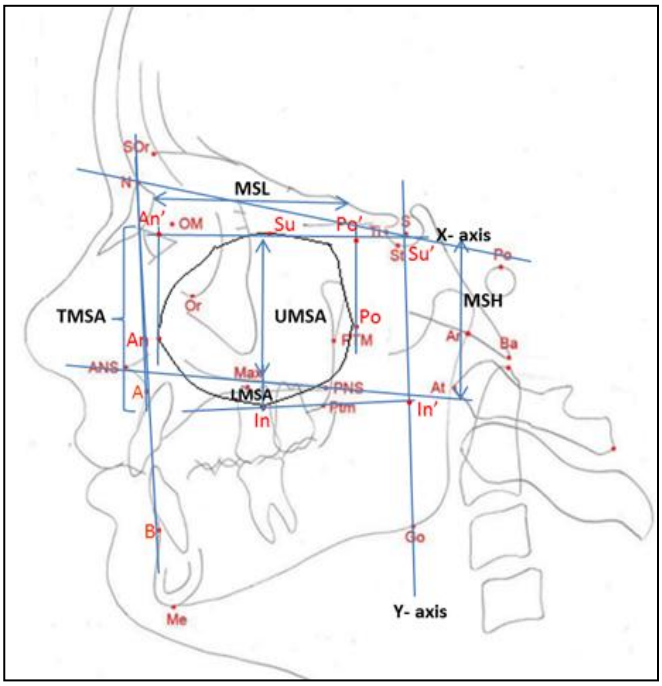

Fig 1: Cephalometric landmarks, planes and variables

Definition of landmarks

1. **Point An:** The most anterior point of anterior wall of maxillary sinus [20].
2. **Point An':** Point projected vertically from An to the x-axis [20].
3. **Point Po:** Posterior most point of maxillary sinus [20].
4. **Point Po':** Point projected vertically from Po to the x-axis [20].
5. **Point Su:** Superior most point of maxillary sinus [20].
6. **Point Su':** Point projected vertically from Su to the y-axis [20].
7. **Point In:** Inferior most point of maxillary sinus [20].
8. **Point In':** Point projected vertically from In to the y-axis [20].
9. **Point ANS:** The most anterior point of the bony hard palate in the mid-sagittal plane [25].
10. **Point PNS:** The most posterior point of the bony hard palate in the mid-sagittal plane [25].
11. **Point A (Subspinale):** The most posterior midline point in the concavity between the anterior nasal spine and the prosthion [26].
12. **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 [26].
13. **Point S (Sella):** The midpoint of the hypophysial fossa [25].
14. **Point N. (Nasion):** The most anterior point on the naso-frontal suture in the median plane [25].

Definition of Planes

1. S-N plane (Sella-Nasion): it is the anterior posterior extent of anterior cranial base [25].
2. Maxillary plane (Max. P.): A line joining between ANS and PNS [25].
3. N- A line: Formed by a line joining Nasion and point A [27].
4. N- B line: Formed by a line joining Nasion and point B [27].
5. Y-axis line: Paralell to vertical edge of radiograph taken in NHP (natural head position) [24]. 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 [24]. 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 commonly used measurement for appraising antero-posterior disharmony of the jaws [28].
2. **Maxillary sinus length (M.S.L**): this line extend from An' to the Po' [20].
3. **Maxillary sinus height (M.S.H**): this line extend from Su' to the In' [20].
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) [20].
5. **Lower maxillary sinus area (LMSA):** which represents lower area of Maxillary sinus from palatal plane [20].
6. **Total maxillary sinus area (TMSA):** which represents difference of total maxillary sinus area and lower maxillary sinus area [20].

All male and female subjects were divided into three groups based on ANB as follows:
Class I: ANB (1-4)^0
Class II: ANB > 4^0
Class III: ANB < 1^0

In males 17 were Class I, 16 were Class II and 10 were Class III. In females 19 were Class I17 were Class II and 11 were Class III. 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.

2.1 Statistical analysis

Statistics consisted of descriptive statistics including mean values for both male and female groups. Also descriptive statistics were calculated for merged sample were calculated. All the groups were subjected to one way ANOVA test to assess the significance of association between maxillary size measurements and three malocclusion groups in male sample, female sample and merged sample.

In the statistical evaluation, the following levels of significance were used:
P>0.05 Non-significant
0.05 ≥ *P*>0.01* Significant
0.01 ≥ *P*>0.001** Highly significant
P≤0.001*** Very highly significant

3. Results

Table 1: Desciptive statistics and ANOVA for males

Parameter	Class I	SD	Class II	SD	Class III	SD	ANOVA (P-Value)
MSH(mm)	43.1	4.3	42.7	5.1	44.2	4.6	0.726
MSL (mm)	42.9	2.3	44.2	2.5	42	2.2	0.0688*
UMSA (mm^2)	1708.69	220.7	1759.14	236.1	1723.9	213.2	0.808
LMSA (mm^2)	140.3	100.2	128.2	90.1	132.5	104.4	0.937
TMSA (mm^2)	1848.99	279.2	1887.34	269.3	1856.4	214.9	0.909

Table 2: Desciptive statistics and ANOVA for females

Parameter	Class I	SD	Class II	SD	Class III	SD	ANOVA (P-Value)
MSH (mm)	38.9	4.9	39.1	4.5	38.8	2.9	0.982
MSL (mm)	40	2.9	39.8	2.3	39.7	2.6	0.950
UMSA (mm^2)	1425.2	114.9	1416.58	129.8	1408.06	130.1	0.944
LMSA (mm^2)	130.8	87.1	139.6	99.2	132.3	70.1	0.953
TMSA (mm^2)	1556	170.4	1556.18	185.2	1540.36	171.5	0.967

Table 3: Desciptive statistics and ANOVA for overall sample

Parameter	Class I	SD	Class II	SD	Class III	SD	ANOVA (P-Value)
MSH (mm)	41	4.6	40.9	4.8	41.5	3.75	0.884
MSL (mm)	41.45	2.6	42	2.4	40.85	2.4	0.253
UMSA (mm^2)	1566.94	167.8	1587.86	182.95	1565.98	171.65	0.856
LMSA (mm^2)	135.55	93.65	133.9	94.65	132.4	87.25	0.992
TMSA (mm^2)	1702.49	224.8	1721.76	227.25	1698.38	193.2	0.908

It can be observed that mean maxillary length is highest in Class II group in males, females and overall sample. Mean maxillary height is highest in Class III group in males and and Class II in females. In overall sample it was observed to be highest in Class III group. Upper maxillary sinus area was found to be greatest in Class II group in males and in overall sample. Lower maxillary sinus area was found to be maximum in in Class I group in males, Class II group in females and almost equal in all three groups in overall sample. The total maxillary sinus area was found to be maximum in Class II group in males, females and overall sample. All these observations except maxillary sinus height in Class II group in males were statistically non-significant.

4. Discussion

The upper maxillary sinus area is more in Class I group than in Class III group in females and overall sample. Though this difference is not statistically significant it can be explained on the basis of role of maxillary sinus in development of Class III, as is evident in studies conducted by various authors [29, 30, 31].This study shows that there is no statistically significant difference for most of the variables in different malocclusion classes which is in partial agreement with a sudy conducted by Oktay [18]. MSH was more in Class III group than Class I and Class II group in the overall sample. This difference is not statistically significant but is in agreement with a study conducted by Urabi [32]. MSL was maximum for Class II group in and this difference was significant in males showing that maxillary sinus length had an impact on saggital jaw position in males. This is in disagreement to other studies [20, 32] which did not show any association between the two. The mean value of TMSA is maximum in Class II group as is proved by other studies conducted by Oktay [18] and Urabi [32] who found maximum values in Class II group in females and males respectively.
Also in this study it is observed that all the measurements determining maxillary sinus size were greater in males as compared to females as is supported by other authors [15, 17, 33]. Hopkins [34] and Dibbets [35] have concluded that males have larger cranial bases hence do have larger maxillary sinuses. This can beexplained on the fact that maxillary sinus is located in maxilla and contributes to development to growth

and development of mid face [7]. This can also explain partially increased values of TMSA in Class II group as is evident in this study. A small maxillary sinus leads to a dish face and a larger one results in a round face. A decreased value of LMSA in Class III group can be explained either on basis of maxillary deficiency which turn prevents the descent of PNS and hence a steeper palatal plane.

4.1 Study limitations, advantages and future directions

This is a study conducted in two dimensions only and maxillary sinus is a three dimensional structure and hence some errors do creep in. Boundaries of maxillary sinus can be superimposed by other structures making the identification difficult and also the association of floor of maxillary sinus with roots of posterior teeth is difficult to assess in cases where maxillary sinus has descended deeply into the intraalveolar region. The use of computed tomography is advantageous in this context but often leads to addition of time consuming and costly steps to orthodontic treatment. Lateral cephalograms have the advantage of being routinely used in orthodontic practice and can also be used quite easily in the clinic. Hence it can be advantageous to use lateral cephalograms in routine assessment of maxillary sinus and limit use of computed tomography to special situations like studying relation of floor of maxillary sinus and roots of posterior teeth in case temporary anchorage devices have to be used in those regions.

Also this study has not considered the factor of age which has shown to effect the size of maxillary sinus. Further studies considering this factor need to be conducted.

5. Conclusion

1. Maxillary sinus length is significantly larger in Class II group in males.
2. Overall maxillary sinus size does not vary significantly with different saggital malocclusion classes.
3. Males showed larger maxillary sinus measurements than females.

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