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Research Article

Does Maxillary Sinus have any Influence on the Skeletal Class or Facial Type?

Hiba Gmati[1]*, Mariem Nasfi[1], Mounira Rtibi[1], Ines Methioub[1], Anissa El Yemni Zinelabidine[2] and Abdellatif Boughzela[2]

[1]*Resident in Orthodontics, Department of Dentistry, Farhat Hached Hospital, Sousse, Tunisia*

[2]*Professor in Orthodontics, Department of Dentistry, Farhat Hached Hospital, Sousse, Tunisia*

***Corresponding Author:** Hiba Gmati, Resident in Orthodontics, Department of Dentistry, Farhat Hached Hospital, Sousse, Tunisia.

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Abstract

Introduction: Maxillary sinuses are very important cavities of the face. Their relationship with some teeth allows to suggest that maxillary sinus development may affect skeletal malocclusions and vertical facial types.

Aim: To determine the relationship between maxillary sinus size, vertical facial types, and different skeletal classes for both genders in a Tunisian population.

Materials and Methods: A retrospective study on 60 lateral cephalograms of Tunisian males and females aged between 12 and 29 years was performed. They were classified into three groups based on ANB, FMA, and GOGN-SN angles.

Five measurements were used to assess the maxillary sinus size: two linear and three areas. They were calculated manually in all the radiographs. ANOVA test was used to determine the relationship between the different measurements.

Results: All measurements were found to be greater in males than in females. No significant association was observed for both skeletal classes and facial types.

Conclusion: No relation was observed between maxillary sinus size, skeletal classes and facial types.

Keywords: Lateral Cephalograms; Maxillary Sinus; Skeletal Classes; Vertical Facial Types

Introduction

The maxillary sinus is the largest of the four paranasal maxillary sinuses [7]. It is a cavity or a space filled with air in the body of the maxilla [13]. It begins to develop at about 12 weeks of fetal life, arising by lateral invagination of the mucous membrane of the middle nasal meatus, forming a slit-like space. Development of the maxillary sinus begins at the ethmoidal infundibulum in the third month of fetal life [16]. After birth, it continues to extend both laterally and inferiorly. It expands not only downwards but also forwards and backwards from its original invagination during the rapid growth period, from birth to three years of age and from seven to twelve years of age [9]. The Floor of the maxillary sinus is formed by the alveolar process of the maxilla and it shares a close anatomic and functional relationship with posterior maxillary teeth [14]. It is related to the teeth roots in variable degrees; either between the roots of adjacent teeth and the roots of the same tooth or elevated in spots to accommodate the roots apices and the roots occasionally protruding into the maxillary sinus cavity. This close relationship allows us to suggest that maxillary sinus development might affect skeletal malocclusions and vertical facial types.

Purpose of the Study

The purpose of this study was to investigate on lateral cephalograms the relationship between maxillary sinus size, vertical facial types and different skeletal classes for both genders in a Tunisian population.

Materials and Methods

The sample of the study was collected from patients who presented to the Department of Orthodontics at Farhat Hached University Hospital in Sousse. Sixty Tunisian patients were included. The inclusion criteria were as follows: Tunisian origin, age range between 12 and 29 years, no history of abnormal habits (mouth breathing), no apparent facial disharmony or cleft lip and palate, no history of orthodontic, facial, orthopedic or surgical treatment, having fully-erupted permanent dentition with the exception of third molars, presenting no tooth decay, no missing teeth, no asymmetrical faces, having no associated syndromes and no maxillary sinus pathology.

Lateral standardized cephalograms were taken by a single operator using the same X-ray device.

Cephalometric analysis

Lateral cephalograms of the involved subjects were traced and measured by a single investigator.

Definitions of the cephalometric points used in the measurement:

1. S (Sella): The mid point of the hypophysial fossa.
2. N (Nasion): The most anterior point on the naso-frontal suture in the median plane.
3. A (sub spinal): The deepest midline point on the premaxilla between the anterior nasal spine and the prosthion.
4. B (Supra mental): The deepest midline point on the mandible between the infra dental and the Pogonion.
5. ANS (Anterior nasal spine): It is the tip of the bony anterior nasal spine in the median plane.
6. PNS (Posterior nasal spine): It is a constructed radiological point: The intersection of a continuation of the anterior wall of the pterygo-palatin fossa and the floor of the nose. It marks the dorsal limit of the maxilla.
7. An: The most anterior point of the maxillary sinus.
8. An′: The orthogonal projection of A to the x-axis.
9. Po: The most posterior point of the maxillary sinus.
10. Po: The orthogonal projection of Po onto the x- axis.
11. Su: the most superior point of the maxillary sinus.
12. Su′: the orthogonal projection of Su onto the y-axis.
13. In: The most inferior point of the maxillary sinus.
14. In′: the orthogonal projection of In into the y-axis [6,8,15].

Definitions of the cephalometric planes used in the measurement:

1. The S-N plane (Sella-Nasion): It is the anterior posterior extent of the anterior cranial base [15].
2. The Frankfort horizontal plane (FH): It is a horizontal plane running between the portion and the orbital [15].
3. The palatal plane or the Maxillary plane (Max. P.): The line joining ANS and PNS [15].
4. N-A line: Formed by a line joining the Nasion and point A [12].
5. N-B line: Formed by a line joining the Nasion and point B [12].
6. x-axis: Horizontal plane, parallel to the Frankfort plane passing through the Sella.
7. y-axis: Vertical plane, perpendicular to the Frankfort plane passing through the Sella.

Method of measurement

The linear and area measurements of the maxillary sinuses were performed using the method of Toshiya., *et al* [8]:

1. Maxillary sinus length (M.S.L) (mm): This line extends from An- to Po-
2. Maxillary sinus height (M.S.H) (mm): This line extends from Su- to In-
3. Upper maxillary sinus area (UMSA) (mm^2): It is defined by the surface of the maxillary sinus portion above the maxillary plane, extending horizontally from the anterior nasal spine (ANS)to the posterior nasal spine (PNS).
4. Lower maxillary sinus area (LMSA) (mm^2): It represents the lower area of the Maxillary sinus below the palatal plane.

5. Total maxillary sinus area (TMSA) (mm^2): It represents the summation of the upper and lower maxillary sinus areas using standard cephalometric reference points, planes, variables and measurements (Figure 1) according to Kwak., *et al.* [12].

The reference points, planes and variables used are shown in figure 1.

Figure 1: Cephalometric landmarks, planes and variables [12].

Then, the sample was divided into three groups based on the ANB angle:

1. ANB angle between 0 - 4 degrees (skeletal class I).
2. ANB greater than 4 degrees (skeletal class II).
3. ANB less than 0 degrees (skeletal class III).

It was also divided into 3 groups on the basis of the FMA and GOGN SN angles:

1. FMA angle between 25 - 30 degrees and GoGn/Sn angle between 32 - 37 degrees (normodivergent/mesocephalic).
2. FMA angle greater than 30 degrees and GoGn/Sn greater than 37 degrees (hyperdivergent/dolichocephalic).
3. FMA angle less than 25 degrees and GoGn/Sn less than 32 degrees (hypodivergent/brachycephalic).

Statistical analysis

All statistical analyses were performed with SPSS 22.0 software.

Chi-square test was used to assess the differences between the maxillary sinus size measurements depending on gender. One-way ANOVA test was used to assess the association significance between the maxillary sinus size measurements, three malocclusion groups and three facial biotype groups in the male, female and merged samples.

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.

Results

The sample involved 21 male subjects and 39 female subjects (Figure 2).

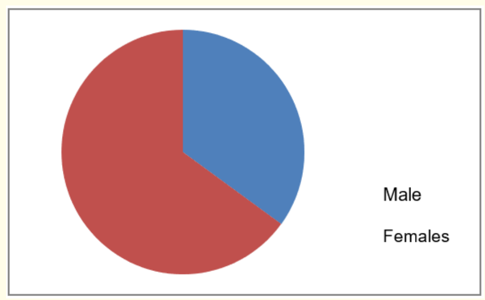

Figure 2: Distribution of the sample according to gender.

The mean age was 16 years (yrs) 8 months (mths) for male subjects and 16 years 9 months for female subjects (Table 1).

Sex	Mean age	SD
Males	16yrs 8mths	4.1
Females	16yrs 9mths	3.7

Table 1: Mean age of the sample.

Results depending on the skeletal class

Skeletal class	Males	Females	Total
Cl I	7	15	22
Cl II	10	19	29
Cl III	4	5	9
Total	21	39	60

Table 2: Distribution of the sample according to the skeletal class.

Statistical analysis showed the following mean values for:

Maxillary sinus height

Skeletal class	Males (mm)	Females (mm)
Cl I	40.714	41.8
Cl II	44	41.052
Cl III	47.5	40

Maxillary sinus width

Skeletal class	Males (mm)	Females (mm)
Cl I	46	43,466
Cl II	45.2	43.21
Cl III	42.5	43.2

Maxillary sinus upper area

Skeletal class	Males (mm^2)	Females (mm^2)
Cl I	1559.266	1523.857
Cl II	1537.8	1519.789
CIII	1736.25	1452.4

Maxillary sinus lower area

Skeletal class	Males (mm^2)	Females (mm^2)
Cl I	196	126.266
Cl II	248	145.263
CIII	93	138.4

Maxillary sinus total area

Skeletal class	Males (mm^2)	Females (mm^2)
Cl I	1881.486	3113.54
Cl II	2000.8	1796.263
CIII	2015.75	1741.8

The mean maxillary height was found to be highest in the skeletal class III group and the skeletal class I group in the male and female samples, respectively.

The mean maxillary width was found to be highest in the skeletal class I group in the male, female and overall samples.

The upper maxillary sinus area was found to be greatest in the skeletal class III group and in the skeletal class I group in the male sample, and the female and overall samples, respectively.

The lower maxillary sinus area was found to be maximal in the skeletal class I group and the skeletal class III group in the male population and the female sample, respectively.

The total maxillary sinus area was found to be maximal in the skeletal class III group, the skeletal class I group, and the skeletal class II group in the male, female, and overall samples, respectively.

All these observations were statistically non-significant using one-way ANOVA test (Table 3-5).

Parameter	Class I	SD	Class II	SD	Class III	SD	Anova test (p-value)
MSH (mm)	40.7143	3.77334	44	5.05525	47.5	8.2664	0.153
MSL (mm)	46	3.95811	45.2	3.08401	42.5	4.20317	0.310
UMSA (mm^2)	1523.8571	224.18031	1537.8	184.99117	1736.25	436.07367	0.189
LMSA (mm^2)	196	156.10680	248	139.5638	93	82.01626	0.375
TMSA (mm^2)	1881.4286	311.35342	2000.80	344.11490	2015.75	371.91968	0.734

Table 3: Descriptive statistics and ANOVA for males.

Parameter	Class I	SD	Class II	SD	Class III	SD	Anova Test (p- value)
MSH (mm)	41.8	4.12657	41.0526	7.49425	40	4.74342	0.840
MSL (mm)	43.4667	3.02056	43.2105	4.32793	43.2	3.89872	0.979
UMSA (mm^2)	1559.2667	193.59769	1519.7895	391.83976	1452.4000	257.93080	0.8
LMSA (mm^2)	126.2667	78.59523	145.2632	99.96046	138.4000	50.54503	0.822
TMSA (mm^2)	1812.0000	173.20384	1796.2632	476.89748	1741.8000	338.61955	0.935

Table 4: Descriptive statistics and ANOVA for females.

Parameter	Class I	SD	Class II	S D	Class III	SD	Anova test p-value
MSH (mm)	41.4545	3.96085	42.0690	6.80825	43.3333	7.24569	0.731
MSL (mm)	44.2727	3.46660	43.8966	4.00308	42.8889	3.78961	0.654
UMSA (mm^2)	1578.5556	199.07476	1526	331.32914	1548	356.30749	0.890
LMSA (mm^2)	148.4545	110.3901	180.8621	123.19953	118.2222	66.12446	0.293
TMSA (mm^2)	1834.0909	220.8906	1866.7931	440.5188	1863.5556	360.6245	0.942

Table 5: Descriptive statistics and ANOVA for the overall sample.

Results depending on facial biotypes

Facial type	Males	Females	Total
Hypodivergent	4	4	8
Normodivergent	6	15	21
Hyperdivergent	11	20	31
Total	21	39	60

Table 6: Distribution according to facial types.

Statistical analysis showed the following mean values for:

Maxillary sinus height

Facial type	Males (mm)	Females (mm)
Hypodivergent	43.5	39
Normodivergent	39.333	41.533
Hyperdivergent	45.909	41.285

Maxillary sinus length

Facial type	Males (mm)	Females (mm)
Hypodivergent	46.25	42.33
Normodivergent	43.5	44.33
Hyperdivergent	45.27	42.71

Upper maxillary sinus area

Facial type	Males (mm^2)	Females (mm^2)
Hypodivergent	1631.75	1462.66
Normodivergent	1417.166	1573.66
Hyperdivergent	1736.25	1452.4

Maxillary sinus lower area

Facial type	Males (mm^2)	Females (mm^2)
Hypodivergent	172.5	65.33
Normodivergent	177.166	127.06
Hyperdivergent	225.09	154.47

Maxillary sinus total area

Facial type	Males (mm^2)	Females (mm^2)
Hypodivergent	2021.5	1645.66
Normodivergent	1723	1839
Hyperdivergent	2074.27	1784.95 mm^2

The mean maxillary sinus width was found to be highest in the hypodivergent male group, the overall samples, as well as the normodivergent female group.

The mean maxillary height was found to be highest in the hyperdivergent group and the normodivergent group in the male and the overall samples and the female sample, respectively.

The upper maxillary sinus area was found to be greatest in the hyperdivergent group in the male and the female samples.

The lower maxillary sinus area was found to be maximal in the hyperdivergent group in the male, female and overall samples.

The total maxillary sinus area was found to be maxim al in the hyperdivergent and the normodivergent groups in the male and the overall samples, and the female sample, respectively.

All these observations were statistically non-significant using one-way ANOVA test (Table 7-9).

	Normo	SD	Hypo	SD	Hyper	SD	ANOVA
MSH	39.333	4.589	43.5	3.316	45.909	5.787	0.065
MSL	43.5	4.183	46.25	4.193	45.272	2.337	0.484
UMSA	141.7166	223.714	1631.75	218.471	1632727	269.023	0.229
LMSA	177.166	134.316	172.5	131.071	225.0909	160.095	0.748
TMSA	1723	345.076	2021.5	330.306	2074.272	267.612	0.093

Table 7: Descriptive statistics and ANOVA for males.

	Normo	SD	Hypo	SD	Hyper	SD	ANOVA
MSH	41.533	3.226	39	4	41.2857	7.6101	0.803
MSL	44.333	2.636	42.333	2.081	42.714	4.440	0.401
UMSA	1573.666	166.242	1462.666	124.343	1501.619	395.0722	0.744
LMSA	127.066	61.272	65.333	32.578	330	154.476	0.209
TMSA	1839.8	162.334	1645.666	94.001	1784.952	474.615	0.697

Table 8: Descriptive statistics and ANOVA for females.

	Normo	SD	Hypo	SD	Hyper	SD	ANOVA
MSH	40.9048	3.686	41.5714	4.0766	42.8750	7.29	0.492
MSL	44.0952	3.0643	44.5714	3.823	43.5938	4.195	0.787
UMSA	1528.9524	192.741	1559.2857	192.839	1546.6875	357.836	0.964
LMSA	141.3810	87.613	126.5714	110.566	178.7500	126.224	0.360
TMSA	1806.4286	226.140	1860.4286	312.816	1884.4063	433.5	0.744

Table 9: Descriptive statistics and ANOVA for the overall sample.

The Chi-square test showed no significant differences between the two genders with regard to all the measurements. However, all the mean values of the maxillary sinus length, height and areas were higher in males than in females for all the skeletal classes and facial biotypes (Table 10).

	MSL	MSH	UMSA	LMSA	TMSA
Females	43.3077	41.2051	1526.3333	137.0769	1795.3333
Males	44.9524	43.5714	1570.9524	208.9500	1963.8571
Chi square test	0.736	0.453	0.621	0.415	0.499

Table 10: Variation of maxillary sinus dimensions according to gender.

Discussion

No significant differences between genders, skeletal classes or facial types were found with regard to Maxillary sinus size.

All the measurements determining maxillary sinus size were found to be greater in males than in females, which is in line with the results of other authors [8,10,11,14]. However, some studies have reported a significant difference between the two genders [3,4,7].

The upper and lower maxillary sinus areas were found to be greater in the skeletal class I group than in the skeletal class III group in the overall sample.

The total maxillary sinus area was found to be greater in the skeletal class II group in the overall sample.

Hyperdivergent subjects were found to have greater maxillary sinus dimensions.

Although these differences were not statistically significant, they could be explained by the fact that the maxillary sinus is located in different positions of the maxilla body.

Alberti reported that a small and narrow maxillary sinus with a concave anterior wall gives rise to a dish face, and that a large maxillary sinus with a convex anterior wall gives rise to a rounded face [2].

Study Limitations

Lateral cephalograms are routinely used in orthodontic practice. They permit total visualization of the maxillary sinus. However, they are limited to only two dimensions, leaving the horizontal dimension unexplored. To overcome this limitation, computed tomography, which is a very advantageous imaging, is used.

The patients' age, which is an important factor influencing maxillary sinus dimensions, was not considered in our study.

Conclusion

To summarize, no significant association was found between maxillary sinus size and skeletal classes, or facial biotypes.

Our results may be useful when mini implants for anchorage is included in orthodontic treatment to avoid maxillary sinus perforation, or in case of orthognathic surgeries to prevent alteration of the maxillary sinus when its contour is within the cutting limit.

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Volume 5 Issue 8 August 2021