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Cephalometric Analysis for Gender Determination Using Maxillary Sinus Index in Population of Gujrat, India

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Abstract

Introduction: Humans are sexually dimorphic. Identification of remnants of skeletal and decomposing parts of humans is one of the most difficult skills in forensic medicine. Forensic anthropologists can receive whole or fragmented skeletal remains. But the unique thing is that the maxillary sinus is intact within the skull, so maxillary sinus radiography is being used to identify remains and determine gender.

Materials and Method: A total of 51 adult digital lateral cephalometric radiographs (20 males and 31 females) were included in the study. The maxillary sinus analysis was performed by measuring the height and width of these digital lateral cephalometric radiographs using measurement tools of Sidexis4 software. Maxillary sinus index was calculated, discriminant function analysis performed, and discriminant equation derived for determination of gender.

Results: Comparison of maxillary sinus parameters (height and width) between male and female groups showed statistically insignificant differences in this study. Regression analysis is done and an equation is derived, which will aid in the prediction of gender by substituting the values of specific measurements in the equation.

Keywords: Anthropology, Cephalometric analysis, Gender Determination, Maxillary Sinus

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Introduction

Humans are sexually dimorphic. The identification process of any skeletal remains and decomposing parts of humans is one of the most difficult aspects of forensics. For gender determination in unidentified remains, the foremost choice is the innominate bones, including skull, pelvis, long bones with an epiphysis and a metaphysis, the sella turcica, foramen magnum, length and the height of the head, the distance between the basion and the nasion, the head circumference, the supraorbital edge length, the mastoid process, the mandibular ramus, the height of the mandibular symphysis, the shape and the length of the palate, the circumference of the occipital condyle, sizes of the teeth and paranasal sinuses.[1,2] In maximum cases, like disaster victim identification, the bodies found are not in proper anatomy; often, fragments of the skeletal remains can lead to difficulty in identifying the deceased. But the unique thing is that the maxillary sinus mostly remains intact within the skull so maxillary sinus radiography is being used for identification and is a great tool for gender determination. If we go back to the development of the maxillary sinus, its anatomy shows many variations. Maxillary sinuses are two spaces, filled with air located in the maxillary bone and can be of varied sizes and shapes. The walls are thin in them. We discuss the apex extending inside the zygomatic process and settling in the zygomatic bone. The floor comprises the alveolar process, the first, the second, and the third molars, and the canines' roots may perforate the floor.[3] The pneumatization of the maxillary sinus is different for everyone, and its volume depends upon age.[4] Frontal sinuses are unique to each individual due to their morphological structures, and in forensic science, taking advantage of these features is very important for personal identification.[5-7] The maxillary sinus is one of the paranasal sinuses' largest sinuses.[8] Its development begins at the 3rd month of the fetal development from the infundibulum of the ethmoid bone.[9] After continuation with birth it expands laterally during the two growth spurt periods (from birth to 3 years of age and from 7 to 12 years).[10] However, the mandibular growth remains well after the further ages and outstretch its final dimensions at the age of 20 years in males and 18 years in females.[11] This study is designed to determine the accuracy and reliability of maxillary sinus dimensions as a method for gender identification of unknown persons.

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Material and Methods

A total of 51 lateral cephalograms belonging to both genders (20 males and 31 females) of age group 17–47 years were selected for the study. The radiographs were then stored with

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incorporated patients' details. All radiographs were interpreted, and the maxillary sinuses' height and width were measured using Sidexis4 next-generation software (version 4, Sirona, Germany). The maxillary sinus index (MSI) is calculated as MSI = maxillary sinus width/height (Figure 1). The results obtained were subjected to statistical analysis using SPSS version 20 (statistical package for social sciences) software.

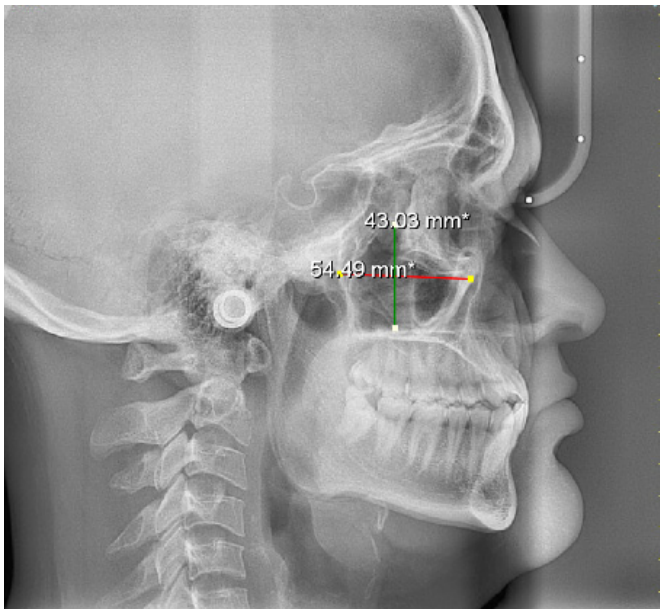

Figure 1: Measurement of the maxillary sinus height and width

The mean values and standard deviation of the maxillary sinus height, width, and MSI in males and females were obtained and tabulated using an independent t-test (Table 1). Significance level was based on p value < 0.05.

Results

Analyzing the obtained data, the result shows that the mean maxillary sinus height is 49.9 mm in males and 50.9 mm in females, and it is statistically insignificant with p value of 0.69. The mean maxillary sinus width is 44.01 mm in males and 44.12 mm in females and it is statistically insignificant with p value of 0.59. The mean MSI is higher in females (1.16) when compared with males (1.13) with an insignificant p-value of 0.244 (Table 2).

Regression analysis is done and an equation is obtained as follows (Table 3):

$$R = 1.217 + 0.338 \times MSI.$$

This equation is provided to calculate "R" which will aid in the prediction of gender by substituting the values of specific measurements (MSI) in the equation. A greater calculated "R" value near to "2" indicates female gender, while "R" value near to "1" indicates male gender.

Discussion

Identification from remains of human skeletons is an important forensic procedure, and determining age and gender is an integral part of identification. The current study is designed

Table 1: Independent Sample Test.

		Levene's Test for Equality of Variances		*t-test for Equality of means*						
									95% Confidence Interval of the Difference	
		F	*Sig.*	*t*	*df*	*Sig. (2-tailed)*	*Mean difference*	*Std. Error Difference*	*Lower*	*Upper*
Length (mm)	Equal Variances assumed	0.152	0.699	-0.696	49	0.490	-1.03306	1.48425	-4.01577	1.94964
	Equal variance not assumed			-0.689	39.357	0.495	-1.03306	1.49891	-4.06403	1.99790
Width	Equal Variances assumed	3.723	0.59	-0.76	49	0.940	-0.1050484	1.3874796	-2.8932930	2.6831962
	Equal variance not assumed			-0.81	47.965	0.936	-0.1050484	1.3011363	-2.7212076	2.5111108
MSI	Equal Variances assumed	1.390	0.244	-0.697	49	0.489	-0.02907	0.04170	-0.11286	0.05473
	Equal variance not assumed			-0.724	45.549	0.473	-0.02907	0.04014	-0.10988	0.05174

Table 2: Group statistics.

Sex		N	Means	Std. Deviation	Std. Error Mean
Length(mm)	Male	20	49.8950	5.31613	1.18872
	Female	31	50.9281	5.08372	0.91306
Width	Male	20	44.018500	3.9436642	0.8818301
	Female	31	44.123548	5.3268443	0.9567295
MSI	Male	20	1.1382	0.12967	0.02899
	Female	31	1.1672	0.15452	0.02775

Table 3: Coefficients

Coefficients[a]						
		Unstandardized Coefficients		*Standardized Coefficients*		
Model		*B*	*Std. Error*	*Beta*	*t*	*Sig.*
1	(Constant)	1.217	.564		2.157	.036
	MSI	.338	.485	.099	.697	.489

a. Dependent Variable: Sex

to analyze gender-based differences in maxillary sinus dimensions. Comparison of maxillary sinus parameters (height and width) between male and female groups showed statistically insignificant differences in this study. A study conducted by Saccucci *et al.* on gender determination using maxillary sinus concluded that no statistical difference was found in maxillary sinus volumes between genders. Their study rejects the hypothesis that maxillary sinus morphology is crucial to determine gender,[12] which supports our study results. Conversely to our study results, Uthman *et al*. concluded that CT images could be used for sex determination and their study proved that the maxillary sinus exhibits anatomic variability with a significant sex difference concerning maxillary sinus width, length, and height and among these parameters, the left maxillary sinus height was the best discriminate variable.[13] Based on the results of Sheikh *et al.*, maxillary sinus height and width exhibit anatomic variability between genders but without any significant difference. The width of the left maxillary sinus can be used as the best discriminate parameter to study sexual dimorphism with an accuracy of 59%.[14] According to Urooge *et al*., the accuracy level for the left maxillary sinus width was 60% in determining gender.[15] Azhar *et al*. showed that maxillary sinus length was the best discriminant parameter with an overall accuracy of 69.81% in the determination of gender.[16] A study was done by Sharma SK *et al*. to measure Maxillary Sinus volume and dimensions by CT scan for gender determination. The difference was statistically significant for sinus anterior-posterior dimension (length) and volume. The Maxillary Sinus length was the best discriminant parameter with an overall accuracy of 69.81%.[17] Maxillary Sinus is the first paranasal sinus to form, and its development has been documented as early as the 17th week of the prenatal period. However, it is after birth that the majority of growth occurs.[18,19] The Maxillary Sinuses are complex anatomical structures with significant variations between individuals.[20] The study of Kim *et al*. on the three-dimensional reconstruction and simulation of maxillary sinus showed that its morphology and size are variable.[21] Morphological variability plays an important role. The differences in growth and development are genetically determined, but the morphological features are also affected by environmental modifications.[22] Paranasal sinuses and pneumatic bones decrease after reaching their maximal size.[23-25] According to Jun *et al*., before the sinus volume declines, the maxillary sinuses of males reach their maximum volume at 21–30 years and women at 11–20 years. The decrease of the maxillary sinus volume may be caused by the loss of bone matrix in the surrounding bones due to aging.[26] Spaeth *et al.* said that the termination of expansion of maxillary sinus is fixed at 17 years of age (same for both sexes).[27] Schatz *et al*. observed that maxillary sinus increases in volume for up to 15 years, afterward maintaining similar volume.[28]

Conclusion

Gender determination is one of the integral aspects of personal identification of an unidentified cadaver, thus narrowing down the diagnosis to be more accurate. Most of the bones conventionally used (skull, pelvis, long bones with an epiphysis and a metaphysis, the sella turcica, foramen magnum, length and the height of the head, the distance between the basion and the nasion, and the distance between the basion and the prosthion, the circumference of the head, the length of the supraorbital edge, the mastoid process, the mandibular ramus, the height of the mandibular symphysis, the shape and the length of the palate, the circumference of the occipital condyle, sizes of the teeth and paranasal sinuses.) are often recovered either in a fragmented and/or decomposed state, especially in catastrophes and mass disasters, making identification difficult. Various authors have reported that zygomatic bones and maxillary sinus remain intact although the skull and other bones may be badly disfigured in incinerated victims.[29,30] Lateral cephalometry, a two-dimensional conventional radiographic technique, is readily available and inexpensive and provides a good assessment of the soft tissue and the hard tissue elements that define the paranasal sinuses and their surrounding structures. Therefore, the morphometric analysis of the maxillary sinus has been proved to be a valuable tool in assessing sexual dimorphism. However, further studies are desirable on large sample size.

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