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Original Research Article

Sexual Dimorphism of Maxillary Sinus: A Morphometric Analysis using Computed Tomography

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ABSTRACT:

Introduction: Gender determination is the important aspect of forensic science. Most of the bones used for sex determination are badly disfigured and found in incomplete state, thus bones recovered intact are used. Maxillary sinus being recovered intact can be used for gender determination by measuring maxillary sinus dimension through computed tomography (CT). The aim of this study was to assess sexual dimorphism using morphometric maxillary sinus measurements through CT scan. **Methods:** This analytical cross-sectional study included CT scan images of 80 patients (40 males and 40 females). Maxillary sinus mediolateral (ML), superoinferior (SI), anteroposterior (AP) linear dimensions and volume were measured. All the measured parameters were then subjected to Student's t-test to determine mean difference between males and females and discriminative statistical analysis to determine gender. **Results:** The mean value of maxillary sinus length, width, height and volume in males on both right and left sides were (3.80±0.175, 3.74±0.209) cm, (2.57±0.317, 2.51±0.295) cm, (3.55±0.338, 3.5±0.286) cm and (17.49±3.909, 16.54±3.274) cm^3 respectively and in females (3.67±0.250, 3.64±0.256) cm, (2.37±0.297, 2.34±0.3222) cm, (3.29±0.280, 3.23±0.254) cm and (14.42±2.935, 13.81±2.779) cm^3 respectively. The discriminative analysis showed that the accuracy of maxillary sinus measurements was 72.5% in females and 75% ofmales (overall accuracy = 73.8%). **Conclusion:** The maxillary sinus measurements are valuable guide for sex determination with relatively good accuracy rate.

Keywords: **Computed Tomography, Maxillary Sinus, Sex Determination**

INTRODUCTION

Sex determination of skeletal remains is one of the major concerns in forensic anthropology, apart from age, race and stature.[1]There are various situations like mass disaster, road traffic accidents, fire, air crashes where it becomes very difficult to identify the individual and also to investigate the criminal cases. Thus, depending upon the uniqueness of anatomical structure, forensic anthropology can be used to identify the unknown deceased person.

It becomes impossible to use the conventional skeletal bones for sex determination because most of the skeleton of unknown human remains are either fragmented or recovered in incomplete state.[2,3] Thus, bones like maxillary sinus which are reported to get recovered intact even in case of severe destruction of skull and other skeletal bones are used.[2]

Maxillary sinuses are the largest paranasal sinus, located in maxillary bone bilaterally. They are the first paranasal sinus to develop, appearing at the end of second embryonic month and maturing at about 20 years of age. They are usually stable after

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second decade of life and radiographic images can provide necessary measurements for morphometric forensic analysis.[4]

CT scan is considered gold standard method to evaluate sinonasal cavities as they provide accurate dimension assessment owing to anatomic complexity of paranasal sinuses.[5] The size and shape of maxillary sinus differ among individuals, between genders, and in various populations. CT measurements of the length, width, height and volume of maxillary sinus can be used for gender determination.[5]

The aim of this study was to evaluate sexual dimorphism using maxillary sinus mediolateral (ML), superoinferior (SI), and anteroposterior (AP) linear dimensions and volume through CT scan.

METHODS:

The present analytical cross-sectional study was carried out in the Department of Radiodiagnosis, Lumbini Medical College and Teaching Hospital, Palpa. The sample size was calculated using the formula $n= 2SD^2(Z_{\alpha/2}+Z_{\beta})^2/d^2$ for comparing two means using mean and standard deviation. where, $\alpha= 0.05$, $\beta=0.02$. Mean and standard deviation taken from previous similar study were mean1=36.9, mean2=39.3, SD1=3.8, SD2=3.8.[6]

Ethical clearance (IRC-LMC 018-A/19) was obtained from institutional review committee.

A total of 80 patients including 40 males and 40 females were selected from March, 2019 to December, 2019 who underwent CT examination for other medical problems not related to the maxillary sinus. Patients ranging from 20-70 years undergoing CT scan who were free from sinus pathology were included. Patients with history of facial trauma, sinus surgery, cleft palate, supernumerary tooth, missing tooth, periapical infections, periodontal infections and with developmental maxillofacial anomaly were excluded.

After obtaining the informed consent, the patients were examined on Siemens Somatom Scope 16 slice spiral computed tomography scanner. Maxillary sinus dimensions (Length, Width and Height) measurements were done directly on computer on DICOM (Digital Imaging and Communications in Medicine) images using electronic calliper inbuilt in DICOM viewer software by one observer who was blind to the sex of patients. In order to evaluate intra examiner error and reliability, 10 randomly selected CT images were retracted by same observer at the interval of 10 days and interclass correlation coefficients were calculated for each parameter. The greatest dimension was taken after going through different slices in coronal and sagittal sections.

- The length was determined on axial reconstructed image, the longest distance antero-posteriorly from the most anterior point to the most posterior point. (Fig. 1)
- Estimation of height was done on coronal reconstructed images, the longest distance from the lowest point of the sinus floor to the highest point on sinus roof. (Fig. 2)
- The width was obtained on axial reconstructed images, the longest distance perpendicular to medial wall of the sinus to the outermost point of lateral wall of the lateral process of the maxillary sinus. (Fig. 1)
- The volume of maxillary sinus was calculated using the formula: Height x width x length x 0.5.[7]

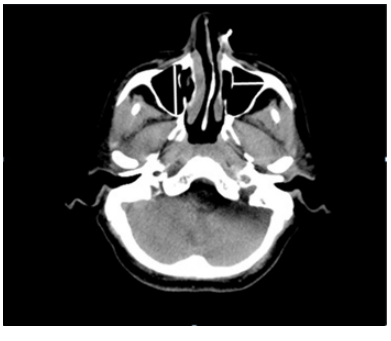

Fig. 1: vertical line shows the length of maxillary sinus; horizonatal line shows the width of maxillary sinus.

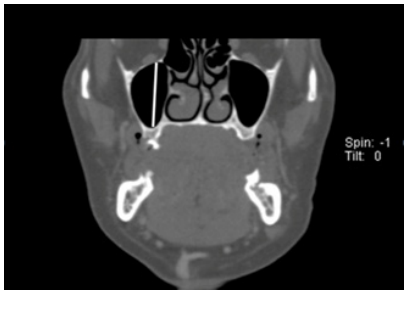

Fig.2: vertical line denotes the height of maxillary sinus.

Statistical methods

The data of maxillary sinus dimensions and volume were entered to Microsoft excel spreadsheet and imported to Statistical Package for Social Sciences (SPSS™) software version 20 for analysis. The Student's t-test was used to determine mean difference of different parameters between males and females.All the measured parameters data was then subjected to discriminant statistical analysis to determine gender. The p value was considered significant when it was< 0.05.

RESULTS:

The present study evaluated CT scans of 80 patients, with equal distribution among males and females. Among males, 13.75% belonged to the age group 31-40 whereas, in females 15% of CT scans belonged to 41-50 years age group.

Maxillary sinus length

The mean values of maxillary sinus length for both right and left side of males were greater in males (3.80±0.175, 3.74±0.209) cm than females (3.67±0.250, 3.64±0.256)cm respectively, with statistically significant difference of sexual dimorphism in only right side (p-value = 0.009) (Table 1)

Maxillary sinus width

The mean value of maxillary sinus width on right and left side of male group was 2.57±0.317 cm and 2.51±0.295 cm respectively. Female group had significantly lower values for both sides (2.37±0.297, 2.34±0.3222) cm with p values of 0.004 for right side and 0.016 for left side.

Maxillary sinus height

The mean value of maxillary sinus height in male group for both right and left sides (3.55±0.338, 3.5±0.286) cm was significantly larger than that of female group (3.29±0.280, 3.23±0.254) cm respectively with the p-values of <0.001 on both sides.

Maxillary sinus volume

The volume of maxillary sinus was significantly greater in males than that of females for right and left sides with p-values of <0.001 on both sides. Mean volume in right and left side for male was (17.49±3.909, 16.54±3.274) cm^3 whereas that for female group was (14.42±2.935, 13.81±2.779) cm^3respectively.

Table 1. Gender differences using right maxillary sinus dimension (N=80)

Parameter	Gender	Mean±SD	p-value
Length (cm)	Male Female	3.80±0.17 3.67±0.25	0.009
Width (cm)	Male Female	2.57±0.31 2.37±0.29	0.004
Height (cm)	Male Female	3.55±0.33 3.29±0.28	<0.001
Volume (cm^3)	Male Female	17.49±3.90 14.42±2.93	<0.001

Table 2. Gender differences using left maxillary sinus dimension (N=80)

Parameter	Gender	Mean±SD	p-value
Length (cm)	Male Female	3.74±0.20 3.64±0.25	0.052
Width (cm)	Male Female	2.51±0.29 2.34±0.32	0.016
Height (cm)	Male Female	3.50±0.28 3.23±0.25	<0.001
Volume (cm^3)	Male Female	16.54±3.27 13.81±2.77	<0.001

The discriminant analysis showed that right maxillary sinus volume was best discriminate parameter that was 80% of female and 62.5% of male (overall accuracy of 71.2%).

Combining both right and left maxillary sinus measurements, overall classification accuracy was improved to 75% for male and 72.5% for female (overall accuracy of 73.8%)

DISCUSSION:

Sex determination is a key step in forensic science to identify unknown person skeletal remnants. Different body parts like pelvis, skull, long bones with an epiphysis and a metaphysis, paranasal sinus, mastoid process and foramen magnum have been used for gender determination. Maxillary sinus being relatively intact among other skeletal remnants can become useful in most difficult times for forensic experts. As maxillary sinus is a complex structure, diagnostic modality like Cone Beam Computed Tomography (CBCT), Magnetic Resonance Imaging (MRI) and CT scan

Table 3. Discriminant analysis using right or left maxillary sinus measurement to distinguish between males and females

Parameters	Wilks lambda	Predicted male percent	Predicted female percent	Predicted overall percent
Right maxillary sinus length	0.916	75%	75%	75%
Left maxillary sinus length	0.952	70%	67.5%	68.8%
Right maxillary sinus width	0.901	55%	72.5%	63.8%
Left maxillary sinus width	0.928	52.5%	67.5%	60%
Right maxillary sinus height	0.852	72.5%	55%	63.8%
Left maxillary sinus height	0.797	75%	60%	67.5%
Right maxillary sinus volume	0.832	62.5%	80%	71.2%
Left maxillary sinus volume	0.828	70%	75%	72.5%

Table 4. Discriminant analysis using alone right or left maxillary sinus measurements to distinguish between males and females

	Wilks lambda	Predicted male percent	Predicted female percent	Predicted overall percent
Right maxillary sinus measurements*	0.803	67.5%	62.5%	65%
Left maxillary sinus measurements*	0.754	72.5%	75%	73.8%

*Right maxillary sinus measurements include length, width, height and volume.
*Left maxillary sinus measurements include length, width, height and volume.

Table 5. Discriminant analysis using both right and left maxillary sinus measurements to distinguish between males and females

	Wilks lambda	Predicted male percent	Predicted female percent	Predicted overall percent
Right maxillary sinus measurements*				
Left maxillary sinus measurements*	0.707	75%	72.5%	73.8%

*Right maxillary sinus measurements include length, width, height and volume.
*Left maxillary sinus measurements include length, width, height and volume.

are used to evaluate the true anatomy of maxillary sinus.[8] However, due to high cost of MRI and limited availability of CBCT in the western region of Nepal, CT scan was used to determine gender in this study. This study highlights the use of various sinus dimension measurement through analysis of CT scan as a method for sex determination. The review article by Xavier et al. concluded that maxillary sinus provides important information in forensic and allows for sex determination.[9]

In this study, except for left maxillary sinus length, overall mean dimension of other parameters was statistically greater among males, which is consistent with numerous other researches .[2,4,10] The reason for greater dimension is possibly due to sex specific differences like bigger body size, larger, robust cranial and postcranial skeleton in males.

The volume of maxillary sinus among males was significantly larger than females with higher percentage of sexual dimorphism in our study. Kanthemet al., Kawariet al., Fernandes and Sahlstrand-Johnson et al. in their study found that mean volume of maxillary sinus were significantly larger in males than in females.The larger dimension and volume of maxillary sinus in males is comparable to many previous studies, and thus can be used for gender determination.[7,11,12,13]

Based on our data, the right maxillary sinus volume was the best discriminate parameter with 80% prediction of female and 62.5% of male with overall accuracy of 71.2%. Apart from volume, right maxillary sinus length showed the prediction of 75% for both males and females. Kanthemet al.[11] concluded that volume of right maxillary sinus can be used as accurate diagnostic parameter for sex determination. Similarly, previous studies by Urooge et al., Sharma et al. and Uthman et al. mentioned left width, AP dimension and height as the best discriminative parameter respectively.[6,8,14]

The overall accuracy rate in terms of determining sex by using all the parameters was 73.8% (75% of males and 72.5% of females). The results are similar to those presented in a study by Uthman et al., Attia et al., Tekeet al. with overall accuracy of 71.6%, 69.9%, and 69.3% respectively. [6,15,16] Even greater overall accuracy rate was seen in the study performed by S. Dangoreet al. (86%), Prabhat et al. (83.3%) and Bangiet al. (88%). [2,5,17] The reason for this variation is likely due to factors such as different ethnicity, race, environment, genetic factors, differences in body morphology, stature etc. Past infections, pneumatization process of maxillary sinus in different age groups, apposition and resorption process in the maxillary sinus also may influence the overall result.

Gender determination using anthropometry has few limitations. Since, the study was population specific and carried in patients from western region of Nepal, the discriminate functions cannot be generalized for the general population of Nepal.

CONCLUSION:

Although most of the bones are recovered incomplete or fragmented, maxillary sinus is reported to remain intact in victims who are incinerated. CTscan is considered one of the excellent modalities to view complex anatomy of maxillary sinus. The results in this study showed that anatomic variation exists between genders. Maxillary sinus dimension and volume measured using CT can be used to determine sex if cranium of unknown origin is found.

Conflict of Interest:

The authors declare that no competing interests exist.

Financial disclosure:

No funds were available.

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