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Original Article

Anatomy Section

Morphometric Study of Maxillary Air Sinus using Computed Tomography

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ABSTRACT

Introduction: Maxillary air sinus is the largest paranasal air sinus. It exhibits dimorphic features and remains intact in victims who are incinerated therefore it can be used for identification of individual and gender determination. CT is most reliable method for measurements of maxillary sinus dimensions and anatomical variations related to it.

Aim: The present study was conducted to find out the volume and maximum Anteroposterior (AP) diameter of the maxillary air sinus and the anatomical variations related to it.

Materials and Methods: CT images of 100 healthy adults were subjected to the measurements of volume and maximum AP diameter of right and left maxillary air sinus using Autocontour software. Student's 't'-test was used to find out significant difference between males and females.

Results: The volume of right and left maxillary sinuses in males were found to be 12.95±4.48 cm^3, 13.26±3.94 cm^3, and in females 10.59±3.37 cm^3, 10.16±2.92 cm^3 respectively. A statistically significant difference was observed between volume of right and left maxillary sinuses in males and females. Maximum AP diameters of right and left maxillary sinuses in males were 37.31±4.62 mm, 37.74±3.59 mm and in females were 36.15±3.92 mm, 35.57±3.50 mm respectively. Statistically significant difference was observed between the maximum AP diameter of males and females for left maxillary sinus.

Conclusion: The results of the present study and knowledge of variations in maxillary sinus as seen in computed tomographic scans will help in identification of individual, sex determination and minimizing risks during surgery.

Keywords: Functional endoscopic sinus surgery, Gender determination, Hypoplasia, Maxillary sinus parameters

INTRODUCTION

Paranasal air sinuses are complex anatomical structures situated within the frontal, maxilla, ethmoid and sphenoid bone and shows a significant inter-individual variation. Maxillary air sinus is the largest paranasal sinus [1]. The maxillary sinus exhibits dimorphic features therefore it can be used for identification of an individual [2]. In forensic medicine identification of individuals from skeletal remains and decomposing parts is one of the most difficult task. For gender determination long bones, bony pelvis and skull are conventionally used [3-5]. Maxillary sinus remains intact in victims who are incinerated, although other bones of skull may be disfigured therefore it can be used for identification of sex of individuals [2,3,6]. The shape and size of maxillary sinus differ between males and females and in various populations [7]. The methods for measuring the dimensions of maxillary sinus have been changed from cadaveric skull measurements to Computed Tomography and Magnetic Resonance Imaging (MRI) with the advances in medical techniques [8-10]. Because of loss in mucosa and other soft tissue in cadavers, the volume measurement of maxillary sinus from cadaveric skull will be larger than the actual size. Measurements of maxillary sinus can be more accurate with CT as craniometric points can be precisely located [11]. Helical CT presents a lot of advantages as compared to other methods such as conventional radiographs [12]. Therefore, the present study was conducted to find out the normal dimensions of the maxillary air sinus and the anatomical variations related to it.

MATERIALS AND METHODS

This was prospective cross-sectional study conducted in Department of Anatomy and Department of Radiodiagnosis, School of Medical Sciences and Research, Sharda University, Noida, India, from 1st July 2016 to 31st January 2017 after approval of Institution ethics committee. CT images of 100 adults (20-80 years) of either sex were obtained out of which 54 were males and 46 were females. CT images of patients with fractures of face and paranasal sinus, chronic sinusitis, sinonasal malignancy, septal deviation, cleft palate, ectopic and supernumerary teeth were excluded from the study. All

the CT-scans were non contrast. All the CT-scan images were obtained through the 128 slice CT scanner (OPTIMA 660, GE Medical System) with the slice thickness of 0.6 mm and images were displayed in all three planes i.e., axial, coronal and sagittal using AW volume share workstation. Images were first subjected to bony alignment of maxillary sinus cavity. Autocontour software was used for the measurement of volume and maximum AP diameter as it gives accurate measurement of irregular structure like maxillary sinus. Volume of maxillary sinuses were obtained from all three views i.e., axial, sagittal and coronal whereas, the maximum AP diameter (longest distance between the most anterior point to the most posterior point) of Right (R) and Left (L) sinuses were measured in axial images.

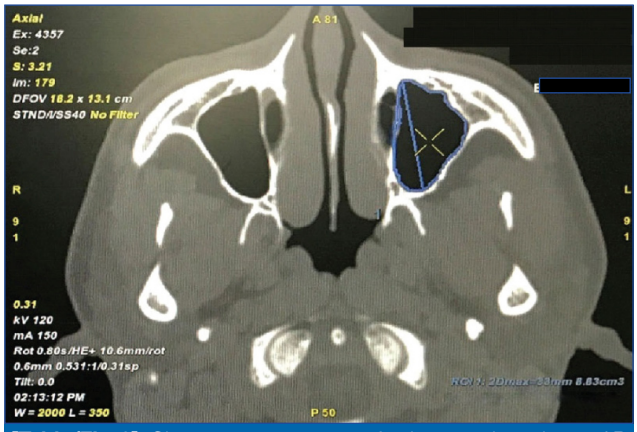
STATISTICAL ANALYSIS

Window Excel sheet version 2007 and IBM SPSS software version 21.0 were used for statistical analysis. Descriptive statistics, namely mean and standard deviation were calculated. Normality of data was analysed by using Kolmogorov-Smirnov test. Independent sample 't'-test was done to assess statistical difference between measured parameters of maxillary sinuses between males and females. Paired 't'-test was used to assess statistical difference between right and left maxillary sinuses.

RESULTS

The volume of maxillary sinuses were found to be larger in males compared to females. The volume of right and left maxillary sinuses in males were found to be 12.95±4.48 cm^3, 13.26±3.94 cm^3 and in females10.59±3.37 cm^3, 10.16±2.92 cm^3 respectively. A statistically significant difference (p=0.004) and (p=0.001) were observed between volume of right and left maxillary sinuses in males and females. The maximum AP diameter of maxillary sinuses were also found to be larger in males than in females. The maximum AP diameter of right and left maxillary sinuses in males were 37.31±4.62 mm, 37.74±3.59 mm and in females were 36.15±3.92 mm, 35.57±3.50 mm respectively [Table/Fig-1,2]. Statistically significant difference was observed between the maximum AP diameter of males and females for left maxillary sinus (p=0.003) where p<0.05 was considered statistically significant [Table/Fig-3].

[Table/Fig-1]: Shows images of maxillary sinus in different views.



[Table/Fig-2]: Shows measurements of volume and maximum AP diameter of maxillary sinus in axial view.

Parameters	Males (Mean±SD)	Females (Mean±SD)	p-value	t-value
Right Sinus Volume	12.95±4.48 cm^3	10.59±3.37 cm^3	0.004*	2.93
Left Sinus Volume	13.26±3.94 cm^3	10.16±2.92 cm^3	0.001*	4.40
Right Maximum AP Diameter	37.31±4.62 mm	36.15±3.92 mm	0.182	1.34
Left Maximum AP Diameter	37.74±3.59 mm	35.57±3.50 mm	0.003*	3.06

[Table/Fig-3]: Shows the volume (cm^3) and maximum AP diameters (mm) of Right (R) and Left (L) maxillary sinus in males (n=54) and females (n=46).
*Statistically significant at p<0.05

In the present study three cases of maxillary sinus hypoplasia were observed [Table/Fig-4]. Hypoplasia of maxillary sinuses were determined by subtracting two standard deviation from normal mean of volume and maximum AP diameter (i.e., mean±2SD). All the hypoplastic sinuses had normal mucosa and were not associated with anomalies of uncinate process.

Parameters of Maxillary sinus	Case 1 (28 years Male)	Case 2 (52 years Male)	Case 3 (52 years Female)
Volume (Right)	5.3 cm^3	1.6 cm^3	3.2
Volume (Left)	3.3 cm^3	1.5 cm^3	4.15
AP Diameter (Right)	29 mm	20 mm	24
AP Diameter (Left)	28 mm	19 mm	27

[Table/Fig-4]: Shows the volume (cm^3) and maximum AP diameters (mm) of hypoplastic maxillary sinuses.

DISCUSSION

CT-scans provide valuable data about the anatomical details of the paranasal sinus. Males usually have larger maxillary sinuses as compared to females [13]. In the present study the volume of maxillary sinuses in males were found to be significantly larger than in females.

Szilvassy J et al., [14] and Sharma SK et al., [3] reported that the left maxillary sinus is larger than the right sinus in both males and females. According to Priner S et al., the volume of right maxillary sinus was higher in males whereas, in females volume of left maxillary sinus was higher [15]. In our study it was observed the volume of left maxillary sinus were higher than right in males whereas, in females the volume of right maxillary sinus were slightly larger than left maxillary sinus.

In the present study the volume of right and left maxillary sinuses were found to be less for both males and females as compared to the other studies [Table/Fig-5].

Study	Dimension	Males	Females
Sharma SK et al., [3] (2014)	Volume	R=15.84±5.857 cm^3 L=16.45±6.143 cm^3	R=13.65±3.926 cm^3 L=14.18±4.672 cm^3
Pirner S et al., [15] (2009)	Volume	R=19.5±6.2 cm^3 L=19.2±6.6 cm^3	R=15.9±5.1 cm^3 L=16.8±4.2 cm^3
Kim HJ et al., [16] (2002)	Volume	18.0±6.2 ml	11.1±3.4 ml
Prabhat M et al., [17] (2016)	Volume	R=16.63±4.54 cm^3 L=15.19±3.94 cm^3	R=11.61±5.15 cm^3 L=10.95±4.98 cm^3
Urooge A et al., [18]	Volume	R=16.74±5.28 cm^3 L=16.58±5.69 cm^3	R=16.89±4.97 cm^3 L=16.59±5.09 cm^3
Present study (2017)	Volume	R=12.95±4.48 cm^3 L=13.26±3.94 cm^3	R=10.59±3.37 cm^3 L=10.16±2.92 cm^3

[Table/Fig-5]: Comparison of volume of maxillary sinus with previous studies.

The AP diameter of maxillary sinuses were found to be more in the present study as compared to the studies done by Sharma SK et al., [3] and less than the studies conducted by Kim HJ et al., [16], Prabhat N et al., [17] and Souza AD et al., [19] [Table/Fig-6].Various factors such as sample size, different ethnic and racial groups, genetic factors, environmental factors, past infections of maxillary sinuses may be responsible for the variations in the dimensions and volume of maxillary sinus in these studies.

Maxillary Sinus Hypoplasia (MSH) is a very uncommon condition. It has been reported that the hypoplastic maxillary sinuses are usually associated with hypoplastic or absence of uncinate process [20,21]. Bolger WE et al., classified MSH into three types i.e., Type I with normal uncinate process, well-defined infundibular passage and mild sinus hypoplasia; Type II with absence or hypoplasia of uncinate process, significant hypoplasia of sinus and ill defined infundibular passage; and Type III with absence of uncinate process, profoundly hypoplastic sinus [21]. In the present study no uncinate process abnormalities were observed in hypoplastic maxillary sinuses which corresponds to Type I MSH. Identification of anomalies of uncinate process in patients with sinus hypoplasia is very important because uncinate process serve as important landmark during Functional Endoscopic Sinus Surgery (FESS).

Study	Dimension	Males	Females
Sharma SK et al., [3] (2014)	AP diameter	R=34.89±3.256 mm L=35.03±3.559 mm	R=33.20±2.943 mm L=33.59±2.915 mm
Kim HJ et al., [16] (2002)	Maximum AP diameter	40.7±4.5 mm	37.4±3.0 mm
Prabhat M et al., [17] (2016)	AP dimension	42.60±3.79 mm	36.00±4.09 mm
Souza AD et al., [19] (2016)	AP diameter	R=38.6±4.5 mm L=39.0±3.6 mm	R=37.2±2.1 mm L=37.1±3.0 mm
Present study (2017)	Maximum AP diameter	R=37.31±4.62 mm L=37.74±3.59 mm	R=36.15±3.92 mm L=35.57±3.50 mm

[Table/Fig-6]: Comparison of maximum AP diameter of maxillary sinus with previous studies.

Similar to the previous studies, the volume and AP diameter of maxillary sinus was found to be more in males compared to females. Volume and maximum AP diameter of normal maxillary sinuses may be useful for gender determination in forensic medicine and criminal investigations when other methods of sexing are not conclusive. It will also help the physician in correlating the clinical and radiological findings for diseases of maxillary sinus and surgical interventions.

LIMITATION

The limitations of the present study are small sample size due to limited duration of the study, restricted accessibility, high radiation exposure to the patients. Further, studies on larger sample size are needed to confirm the finding of the present study.

CONCLUSION

The results of the present study showed that anatomic variability exists between genders. Maximum AP diameter and volume of the maxillary sinus was found to be higher in males as compared to females. Right maxillary sinus volume

and maximum AP diameter were larger than left sinus in males whereas left maxillary sinus volume and maximum AP diameter were larger than right sinus in females. Therefore, knowledge of average volume and maximum AP diameter of maxillary sinus of healthy adults and their variations as seen in CT-scans will help in gender determination. It will also help in minimizing risks during surgery by providing precise information of the surrounding structures.

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