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RESEARCH ARTICLE

SEXUAL DIMORPHISM OF MAXILLARY SINUS DIMENSIONS USING THE CBCT IMAGING AMONG SOUTH INDIAN POPULATION

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ABSTRACT

Background: Maxillary sinuses of various species are known to exhibit sexual dimorphism. The maxillary sinus in males is larger in volume than females in contemporary human populations. Hence, an attempt is being made to use the different dimensions of the maxillary sinus in the determination of sex using coronal, axial and sagittal sections of CBCT scan.

Materials and Methods: A total of 175 CBCT scans of bilateral maxillary sinuses of 74 females and 101 males in the age group of 16 to 80 years, were retrospectively selected from the CBCT archives. The dimensions of right and left maxillary sinuses was measured using DICOM software and statistical analysis was done.

Results: Maxillary sinus volume on both sides showed statistically significant results with a higher percentage of sexual dimorphism.

Conclusion: Volume of maxillary sinus can be used as a precise diagnostic parameter for sex determination.

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INTRODUCTION

Determination of gender of an individual from decomposed skeletal remains is an integral and challenging task in forensic medicine. Skeletal remains have been used for sexing the individual as bones of the body are last to perish following death, next to enamel of teeth (Uthman *et al*., 2011). Maxillary sinuses remain intact although the skull and other bones may be badly disfigured in victims who are incinerated and hence can be used for identification (Teke *et al*., 2007). After the pelvis, skull is the most common and easily used portion of the skeleton which can be used for gender determination. It is the main reliable bone exhibiting sexually dimorphic traits, because skull has a high resistance to adverse environmental conditions over time, resulting in greater stability of dimorphic features as compared to other skeletal parts (Sudke and Diwan, 2009). It has been suggested that the maxillary sinuses remain intact in certain cases such as burnt, decomposed, and highly fragmented remains where in they can be used in gender determination when conventional sex indicators are absent. Maxillary sinuses are two air spaces located in the maxillary bone of variable morphology among different individuals. It is the largest of all the paranasal sinuses and is the first to develop at 10 weeks in utero. After birth, it continues to pneumatize into the developing alveolar ridge as the permanent teeth erupt and at 12□13 years of age, the sinus floor is in level with the nasal floor. Pneumatization of the sinus ends at the age 20, with the completion of the eruption of the third molars and the sinus reaches 5 mm inferior to the nasal floor (Sharan and Madjar, 2008). In forensic medicine, radiology has limited applications so far. Visual inspection, anatomic measurement and precise measurement of bone dimensions often exceed radiologic contribution, particularly where identification of skeletal remains are required (Sharma *et al*., 2014). Since maxillary sinuses stabilize after second decade of life, radiographic images could provide adequate measurements that cannot be attained by other means. Cone-beam computed tomography (CBCT) which has now become a benchmark in the field of dentistry is an excellent imaging modality for measuring craniofacial structures, including the complex anatomic structure of maxillary sinuses. Hence, this study was undertaken to determine the gender of an individual using maxillary sinus measurements obtained by CBCT scans among South Indian Population.

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MATERIALS AND METHODS

This study was approved by the institutional ethical committee. After initial screening for adaptability to the inclusion and

exclusion criteria 175 CBCT scans of bilateral maxillary sinuses (74 females and 101 males) were retrospectively selected in the age group of 16 to 80 years (mean age of 40 yrs). The patients with history of maxillofacial trauma, congenital craniofacial abnormalities, orthognathic surgery, facial asymmetry and missing one or more maxillary teeth were excluded from the study. CBCT images with evidence of any maxillary sinus pathology such as mucosal thickening, sinusitis, and odontogenic cyst or tumor were also excluded. CBCT images were obtained using Carestream 9300C CBCT machine using DICOM software with a field of view (FOV) of 17 by 13.5 cm, 90 kVp, 6mA, and exposure time of 10 secs. Two observers, both experienced radiologists blind to the age and sex of patients determined the volume of maxillary sinus by measuring the anteroposterior (AP) dimensions in the sagittal sections, height and transverse diameter of the sinus in coronal section. The height was determined as the maximum distance from the lowest point of the maxillary sinus floor to the upper most point of the roof. For each parameter the greatest distance was considered. Maxillary sinus volume of each side was calculated manually using the mathematically proven formula i.e. height x width x AP diameter x 0.52 (Sharma *et al*., 2014). After measuring all dimensions, statistical analysis was done using SPSS version 15 and the data was subjected to Mann-Whitney U-test and Wilcoxon sign rank test.

RESULTS

The present study compared the volume of maxillary sinus between the genders. Descriptive analysis of various parameters of maxillary sinus for males and females is summarized in Table 1 & 2 respectively. On applying Mann-Whitney U Test and Wilcoxon sign rank test a statistically significant difference was found in all the dimensions of maxillary sinus between males and females suggesting that males have a significant higher volume as compared to females (Table 1).

Table 1. Statistical Analysis

Variables	Male		Female		t value	p value
	Mean	SD	Mean	SD		
Right AP in mm	39.93	5.13	34.01	5.12	7.387	.000*
Right tranverse in mm	35.23	7.28	29.01	6.76	5.629	.000*
Right height in mm	36.16	4.68	30.02	5.15	8.065	.000*
Right vol in cm3	27.77	10.54	16.20	7.60	7.829	.000*
Left AP in mm	38.95	4.90	33.98	4.85	6.529	.000*
Left tranverse in mm	34.53	7.51	28.32	6.63	5.541	.000*
Left height in mm	35.53	4.55	30.00	4.87	7.553	.000*
Left vol in cm3	25.96	9.79	15.70	7.11	7.459	.000*

*Significant at p <0.01

DISCUSSION

Cone Beam Computed Tomography (CBCT) scan is an emerging tool in the field of dentistry used for evaluation and detection of any pathology in head and neck region. Sinus radiography has been used for identification of remains and determination of sex and ancestry. CBCT scans are an excellent imaging modality to provide an accurate assessment of the paranasal sinuses, craniofacial bones, as well as the extent of pneumatization of the sinuses. It provides thorough information not available from standard radiographs and measurements of maxillary sinuses are useful to support gender determination. Sexual dimorphism refers to the systemic difference in the form, either in shape or size between individuals of different sexes but same species. Sexual dimorphism remains a crucial step towards establishment of positive identity of the deceased individual. In addition to maxillary sinus, sexual dimorphism can also be done using other skeletal structures such as foramen magnum, occipital bone and frontal bone. The present study highlights the importance and role of CBCT in gender determination by evaluating maxillary sinus volume among the South Indian population. CBCT provides images that represent a series of contiguous cross-sections like conventional CT (computerized tomography), and the multiplanar sectioning of the reconstructed data set permits unlimited virtual dissections of the specimen without further physical damage providing images of good resolution, with affordability, portability, and simplicity. The post-mortem forensic imaging scans of the specimen can be later compared to any probable ante mortem plain film images. Today because of its widespread applications including implantology, oral and maxillofacial surgeries, temporomandibular joint assessment, endodontics, orthodontics, periodontics, sinus imaging, temporal bone/ lateral skull and skull base studies, it provides the opportunity to use CBCT in forensic medicine. Certain studies on 3D reconstruction, bite-mark analysis, age estimation, person identification and anthropological assessment have been done using CBCT with promising results. In the present study, the dimensions and volume of maxillary sinuses of right and left side were notably larger in males as compared to females revealing higher percentage of sexual dimorphism. The reason for increased volume in males may be because of their increased muscle mass and larger airway to fulfill respiration needs. Since the maxillary sinus occupies the remaining space within nasomaxillary complex it also increases in size (Enlow, 1990). The present study results are consistent with the previous published literature.

Uthman *et al*. studied the accuracy and reliability of maxillary sinus dimension measurement in gender classification through the use of reconstructed helical computed tomography (CT) images among total of 88 patients, found that reconstructed CT image could provide valuable measurements for maxillary sinuses and could be used for sexing when other methods of sexing are not conclusive (Uthman *et al*., 2011). In another study by Uthman *et al*. he also concluded that maxillary sinus height was the best discriminating parameter that could be used to study sexual dimorphism with overall accuracy of 71.6%. In a study done by Jehan *et al*. on 191 subjects (106 males and 85 females) it was found that average sinus AP was significantly higher for males as compared to females. (Jehan *et al*., 2014) Kim *et al*. studied 33 hemi sectioned Korean CT images where he found that all dimensions as well as volume of the sinus was larger in males compared to females as seen in our study. (Teke *et al*., 2007) Another study by Vidya *et al*. concluded that the volume of the maxillary sinuses of both sides was significantly greater in males as compared to female skulls, which is similar to present study. Teke *et al*. in 2007 studied width, length and the height of the maxillary sinus in 127 adult patients by CT and observed that the measurements of the maxillary sinuses of females were smaller than those of males, with 69.4% accuracy in gender determination.

Conclusion

The result of the present study showed that the maxillary sinus exhibits anatomic variability between the genders and can be

used as a valuable parameter in gender determination. CBCT is an excellent imaging modality for evaluating maxillary sinus dimensions in the field of forensic science for its accuracy, reliability and usability.

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