Sex Determination from Dimensions of the Maxillary Sinus using Computerized Tomography

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ABSTRACT
Background: *Identification of corpses is a problematic forensic subject in cases of severe injuries, and exacerbated post mortem changes from mass burials and disasters with considerable skeletal remains. Identification of such human remains requires a comparison between ante-mortem and post-mortem evidences from intact, easily recoverable bones like the maxillae.*
Aim of the study: *To determine the accuracy for gender determination by maxillary sinus dimensions.*
Materials and Methods: *130 subjects (79 males and 51 females), between 20 - 80 years, with normal maxillary sinus CT anatomy, from head CT scans carried out at the Radiology Department of the Usmanu Danfodiyo University Teaching Hospital (UDUTH) Sokoto were studied. The anteroposterior and transverse diameters were measured from axial images, while the craniocaudal diameter was measured from coronal and sagittal reformatted images. Using Neusoft Dual Slide Helical CT machine, measurements were taken between the widest points on the sinuses from three-dimensional reconstructed images using V-works 3.0 program.*
Results: *The discriminant analysis showed that the left anteroposterior diameter accurately identified 73 subjects (56%) i.e. (42 males (53.2%) and 31 females (60.8%)), the left craniocaudal diameter accurately identified 55.4% of subjects i.e. 46 males (58.2%) and 26 females (51.0%).*
Conclusion: *Computerized Tomography measurements of maxillary sinus dimensions may be helpful to support gender determination in forensic anthropology in addition to other methods of gender identification in unknown human specimen.*

Keywords: *Maxillary Sinus Dimension, Computerized Tomography, Gender Determination, Sokoto, Nigeria.*

INTRODUCTION

Forensic anthropology is the application of the science of physical anthropology to legal process. It involves the identification of skeletonised badly decomposed or otherwise

unidentified human remains. Identification problems are important for legal and humanitarian reasons as in unraveling criminal cases, problems of inheritance, military casualties, mass burials and disasters with considerable skeletal remains, and an important question to answer in any death investigation is, the identification of the deceased. This requires the need to compare ante-mortem and post-mortem records, as such, the use of bones that are often easily recovered intact like the maxilla, becomes necessary although the skull and other bones may be badly disfigured as in victims who are incinerated (Teke *et al*., 2007; Mohammed and Eman, 2011). The maxillary sinus is the largest of the paranasal sinuses and represents a complex anatomical structure with a significant inter-individual variation (Helmy *et al*., 1969; Sinnatamby, 2005; Koji *et al*., 2009; Uthman *et al.*, 2011). High resolution Computed Tomography (CT) which has become indispensible in the complete evaluation of the maxillary sinus and its lesions (Damman *et al*., 2000), is a valuable, fast and, now widely available imaging modality for three-dimensional evaluation of anatomical structures producing multislice CT technology, voxel sizes with submillimeter resolutions, multiplaner and volumetric reconstructions (Reichs, 1993; Damman *et al*., 2000; Maryam *et al*., 2010). Measurements of the maxillary sinus could be used for sexing when other methods are not convincing (Teke *et al*., 2007), The predictive role of the maxillary sinus in gender determination was reported by Fernandes, (2004), from Nelson R. Mandela School of Medicine, University of Kwa Zulu Natal, South Africa, that the degree of gender accuracy was 79%. From Ankara University School of Medicine, Ankara, Turkey, and the University of Sharjah College of Dentistry, United Arab Emirate, the overall accuracy of maxillary sinus dimensions in gender determination using helical CT was 69.3% (Teke *et al*., 2007) and 73.9% (Uthman *et al*., 2011) respectively, while Attia *et al.*, (2012), from Mansoura University, Egypt, reported an overall accuracy of 69.9%. There is paucity of data on gender determination from maxillary sinus dimensions using CT among Nigerians (Africans) and present findings are the outcome of results obtained from Caucasian subjects. The aim of this study is therefore to compliment their findings and to establish a baseline data for values in our environment.

MATERIALS AND METHODS

This study involved 130 subjects (79 males and 51 females), between 20 - 80 years, with normal maxillary sinus CT anatomy, from head CT scans carried out at the Radiology Department of the Usmanu Danfodiyo University Teaching Hospital (UDUTH) Sokoto, over a period of five years. Head CT Scans were obtained from the local data base of the CT machine and back up compact disc from the CT library. Films were viewed on the computer monitor. Good positioning of images was observed to ensure symmetry or asymmetry of the maxillary sinus. Measurements were made with Neusoft Dual Slide Helical CT machine, (2005 model, 15 cm FOV, 200 mA, 120 kV, scanning at high resolution bone algorithm at 1 second and slice thickness of 5mm), with software that provides a meter rule, with which linear measurements (craniocaudal, anteroposterior and transverse diameters) in millimeters between the widest points on the sinuses were taken from axial, coronal and sagittal reformatted images as described by Mohammed and Eman, (2011) and Sahlstrand *et al.*, (2011). These measurements were performed on three-dimensional reconstructed images using V-works 3.0 program. Data was manually sorted out, tabulated, entered into computer using Microsoft word and Microsoft Excel and the discriminant function analysis was done using Minitab 16.0 statistical package.

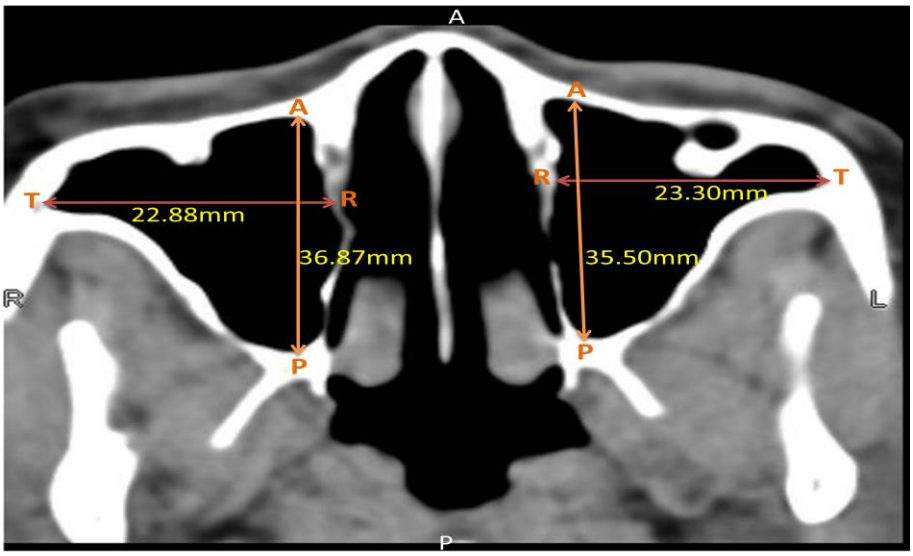

Figure 1. Axial CT of a 23year Old Male Showing Measurements of the Anteroposterior Diameter AP, (R=36.87mm, L=35.50mm), and Transverse Diameter TR, (R=22.88mm, L=23.30mm). R= Right side, L= Left side, A=Anteroior, P=Posterior.

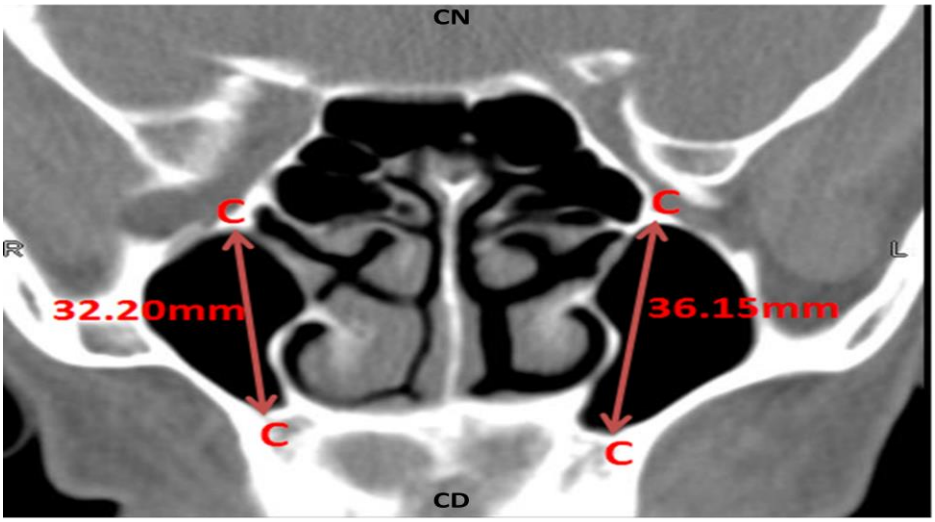

Figure 2.
Coronal CT of a 30 year Old Female Showing Measurements of the Craniocaudal (Height) Diameter CC. The Right CC was 32.20mm while the Left CC was 36.15mm. R= Right side, L= Left side, CN= Cranial end, CD= Caudal end.

RESULTS

In the discriminant analysis for gender identification using all variables of the maxillary sinus, 39 (49.4%) out of 79 males, and 25 females (49%) out of 51 were correctly classified. Thus the overall percentage for accurate gender classification using all the measured variables of the maxillary sinus was 49.2% (64 subjects). With respect to the extent to which each maxillary

sinus variable was exact in identifying a male as male and a female as such; the left anteroposterior diameter gave the highest percentage of 56% (73 subjects), i.e. it correctly identified 42(53.2%) of males and 31(60.8%) of females. The left craniocaudal diameter came close giving 55.4% [46(58.2%) and 26(51.0%) for males and females respectively].

Table 1: Discriminant Function Analysis for Gender Classification Using Maxillary Sinus Dimensions.

Observed Group	Predicted (True) group		Percentage correct
	Males	Females	
Males	39	26	49.4%
Females	40	25	49%
Total correctly classified sex = 64			49.2%

Table 2: Discriminant Function Analysis for Gender Determination by each Variable of the Maxillary Sinus.

Variables		Gender		Total
		Male	Female	
Right Maxillary Sinus	CC	41(51.9%)	26(51.0%)	67(51.5%)
	TR	39(49.4%)	28(54.9%)	67(51.5%)
	AP	42(53.2%)	27(52.9%)	69(53.1%)
Left Maxillary Sinus	CC	46(58.2%)	26(51.0%)	**72(55.4%)**
	TR	40(58.8%)	30(50.6%)	70(53.8%)
	AP	42(53.2%)	31(60.8%)	**73(56.2%)**

CC = Craniocaudal, TR = Transverse, AP = Anteroposterior.

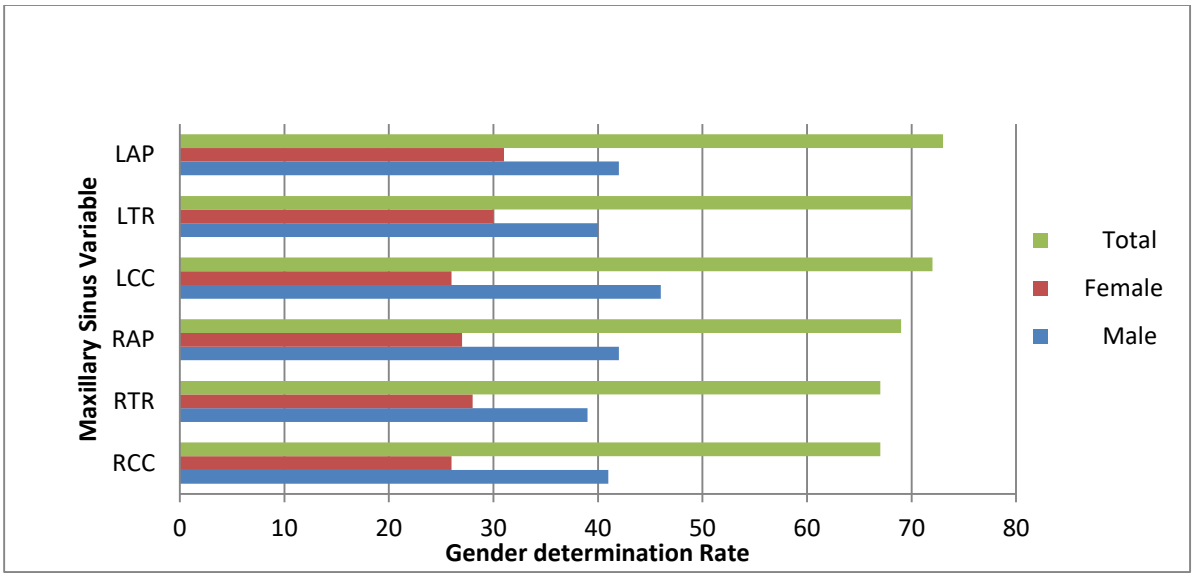

Figure 3. A 3D Bar Graph Indicating the Rate of Gender Determination by Each Variable of the Maxillary Sinus in Both Sexes and in the Total Population.

Table 3: Gender Classification of the Maxillary Sinus by Discriminant Function Analysis of the Left Anteroposterior Diameter of Subjects Used in the Study.

Observed Group		Predicted Group		
		Males	Females	% Correct
Gender	Males	42	20	53.2
	Females	37	31	60.8
Correctly classified gender of subjects = 73			56.2%	

DISCUSSION

In this study, two linear dimensions of the maxillary sinus, namely; the left anteroposterior, and left craniocaudal diameters demonstrated considerable degree of accuracy in gender determination, with an overall predictive accuracy of 56.2% (42 males (53.2%), 31 females (60.8%) and 55.4% (males 46(58.2%) and females 26(51.0%). In a similar study from Ankara, Turkey, different from the result of this study, the ability of the maxillary sinus size to identify gender was 69.3% (69.3% in males and 69.4% in females), according to Teke *et al*., (2007). This results, though with lower values, is comparable to the findings among Egyptians in El-Minia by Mohammed and Eman, (2011), who reported also that two variables; the left craniocaudal diameter and size of the maxillary sinus showed the highest predictive accuracy rate of 70.8% in males and 62.5% in females. Uthman *et al*., (2011), from United Arab Emirate reported that, the craniocaudal diameter was the best discriminant parameter used to study sexual

dimorphism with an overall accuracy of 71.6%; 74.4% of male sinuses and 73.3% of female sinuses were sexed correctly. The results of this study also differs from the findings among Egyptians in Mansoura by Attia *et al.*, (2012), who concluded that the right craniocaudal diameter was the best descriminant variable between genders with an overall accuracy of 69.9% (71.8% for males and 67.6% for females). Our result also differs from a similar study conducted among Indians in Mysore, by Vidya *et al*., (2013), who reported that gender could best be determined from the maxillary sinus by measuring the left transverse diameter and the right sinus volume.

CONCLUSION

Computerized Tomography can provide valuable measurements like the left anteroposterior and left craniocaudal diameters that could be useful to support gender determination through forensic anthropology; however, with a relatively low-accuracy rate of less than 60%.

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