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Original Article

Measurements of maxillary sinus volume and dimensions by computed tomography scan for gender determination

Suresh K. Sharma [a,*], *Massarat Jehan* [b], *Anil Kumar* [c]

[a] *Associate Professor and Head, Department of Anatomy, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India*

[b] *Resident, Department of Anatomy, Gajra Raja Medical College, Gwalior, Madhya Pradesh, India*

[c] *Consultant Radiologist, Vidya Health Imaging, Gwalior, Madhya Pradesh, India*

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ABSTRACT

Introduction: Humans are sexually dimorphic. Identification of remnants of skeletal and decomposing parts of human is one of the most difficult skills in forensic medicine. Forensic anthropologists often receive an incomplete skeleton, which are recovered fragmented but some bones are often recovered intact e.g. maxilla. However, typical identification methods may be inconclusive, especially when certain extreme post-mortem changes have developed.

The aim of this study is to compare the size and volume of the maxillary sinus between males and females by CT Scan for gender determination.

Materials & methods: 102 cases (61 males & 41 females) were studied from Gwalior region. The sinus measurements were taken from series of CT Head images on DICOM viewing software using inbuilt electronic caliper. Independent sample *t*-test & discriminant function analysis were done using Graph pad prism & Word Excel Sheet windows 2007 version.

Results: The dimensions & volume of the maxillary sinus of male was found to be larger than those of female & this difference was statistically significant ($p < 0.05$) for sinus AP & Volume. 65.16% of males & 68.9% of females were sexed correctly & the overall percentage for sexing maxillary sinuses correctly was 67.03% & sinus AP was the best discriminant parameter with an overall accuracy of 69.81%.

Discussion: We can conclude that CT measurements of maxillary sinus dimensions & volume may be useful for identification of gender in forensic anthropology to some extent when other methods are inconclusive.

* *Corresponding author*. Tel.: +91 9826766889.
E-mail address: drrajsuresh@gmail.com (S.K. Sharma).

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1. Introduction

A primary component of any skeletal analysis is determination of age and sex. Identification of the individual from skeletal remnants and decomposing parts of human is one of the most difficult skills in forensic medicine in spite of rapid progress in various diagnostic methods. Gender and age estimation is considered as an important problem in the identification of unknown skull.[1] Gender determination is an important step in identification in forensic medicine. In most of cases forensic anthropologists receive an incomplete skeleton therefore it is important for alternate areas of the skeleton to be researched for sex estimation. Because most bones that are conventionally used for sex determination (skull, pelvis and long bones etc.) are often recovered either in a fragmented or incomplete state, it has become necessary to use bones that are often recovered intact e.g. the maxilla. It has been reported that maxillary sinus remains intact although the skull and other bones may be badly disfigured in victims who are incinerated and therefore maxillary air sinus can be used for identification.

Next to the pelvis, the skull is the most easily sexed portion of the skeleton, but the determination of sex from the skull is not reliable until after puberty.[2] Skull requires the most frequent sexing in medico legal cases. It appears to be the main reliable bone exhibiting sexually dimorphic traits, because skull has a high resistance to adverse environmental conditions over time, resulting in the greater stability of dimorphic features as compared to other skeletal bony pieces.[3]

Traditionally, radiology has been limited in its applications to forensic medicine in the field of identification. Visual inspection, anatomic measurement and precise measurement of bone dimensions often exceed radiologic contribution, particularly where identification of skeletal remains is required. The most helpful area of the body for comparison radiography is the cranium.[4] Measurements of the maxillary sinuses in computerized tomography (CT) scans can be used for determination of age and gender when other methods are inconclusive.[5,6] Maxillary sinus dimensions measurements are valuable in studying sexual dimorphism. They tend to stabilize after second decade of life and the radiographic images could provide adequate measurements for maxillary sinuses that cannot be approached by other means. Hence, morphometric analysis of maxillary sinuses can assist in gender determination.[7] It has been reported that computerized tomography is a suitable imaging method in the identification of unknown human remains and presents a lot of advantages as compared with conventional radiographs.[8] CT scans are an excellent imaging modality used to evaluate the sino-nasal cavities as they provide three-dimensional information and an accurate assessment of the paranasal air sinuses.

The purpose of the present study was to determine and compare the size and volume of the maxillary sinus, between the left and right, and between the males and females of Gwalior region by CT Scan. This work has importance in identifying the sex of a person in the forensic anthropology and also for criminal investigations.

2. Materials and methods

2.1. Selection criteria

This study was an Observational study in which CT images of 102 adult individuals of Gwalior region, in the age group of 20–60 years of either sex were chosen with 61 males and 41 females, who attended the Vidya Health Imaging, Gwalior for head and paranasal sinuses CT Scan. The cases were collected from January 2012 to January 2013 who had complaints of headache or with suspicion of sinusitis but without pathological findings in maxillary sinuses and no history of trauma and in whom CT Scan was normal as diagnosed by the Radiologists.

2.2. Exclusion criteria

Any Maxillary Sinus radiography with obvious pathology or Trauma, facial asymmetry or septal deviation or who had previously undergone surgical procedures or with cleft palate or ectopic and supernumerary teeth were excluded from the study.

2.3. The materials

All the patients were examined on *Siemens Emotion 16 (16 slice) Multi Detector Spiral Computed Tomography Scanner*. All measurements of maxillary air sinus dimensions (AP, width and height) were done directly on computer on DICOM images using *Electronic Caliper* inbuilt in the DICOM viewer software. The maxillary sinus volumes were calculated manually by using a proven mathematical formula.

2.4. Methodology for measurement of maxillary sinus dimensions

The greatest measurement was taken after going through different slices in coronal and sagittal sections. Parameters measured on right and left maxillary air sinus are as follows:

1 The antero-posterior dimension was measured on Sagittal reconstructed image and was defined as the longest distance antero-posteriorly from the most anterior point to the most posterior point (Fig. 1).
2 The height of sinus was measured on coronal reconstructed image and was defined as the longest distance from the lowest point of the sinus floor to the highest point of the sinus roof (Fig. 2).
3 The transverse distance/width was measured on coronal reconstructed image and was defined as the longest distance perpendicular from the medial wall of the sinus to the outermost point of lateral wall of the lateral process of the maxillary sinus (Fig. 3).
4 Maxillary air sinus volume of each side were calculated manually using the formula: (height × width × AP diameter × 0.52) proven mathematical formula, in which maximum dimensions of maxillary air sinuses were taken which gives the approximate volume of each sinus.

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