



# Osteometric Assessment of the Mastoids for Gender Determination: A Retrospective CBCT Study

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## Abstract

**Aim:** The aim of the study is to characterize the mastoid process in terms of its size and to assess the reliability of the mastoid's, morphometric parameters in determining the gender of the subject.

**Materials and Methods:** This retrospective study consists of 100 Adult CBCT (Cone Beam Computed Tomography) images of 25 males and 25 females, who were listed for Implant retained Prosthesis. Radiographic measurements of the length, width and height of left and right mastoids were accurately characterized using customized software. Age group of 15 years to 60 years were included and Images with gross artifacts; Images that did not show anatomic details of the base or the lateral sides of the mastoid were excluded.

**Result:** This study showed significant difference between mastoid process of males and females. Statistics revealed highly significant value for mastoid length, width and height ( $p < 0.01$ ). This study revealed that the mastoid process could be used a reliable indicator for gender determination.

**Keywords:** Mastoid process; Mastoid length; Mastoid width; Mastoid height; Sexual dimorphism; Gender identification

## Introduction

Gender determination of an individual using the remains of human skeleton had been an interest among the anthropologists. Osteometric studies using individual bones exhibiting sexual dimorphism has been reported among different ethnic groups [1]. One of the pivotal features considered in anthropological analysis for identification of an individual is the Gender [2]. The studies for sex determination are based on the dimorphism between the genders that is present in the majority of human bones [3]. In cases of mutilated body, it is difficult to identify the bones [4]. Pelvis and skull are the reliable structures for osteometric assessment [2,5]. Sex is best assessed from the pelvis but it is very often damaged [6]. Skull is required more frequently for gender interpretation in medico legal cases [7,8]. In such scenario mastoid plays a vital role in determining the gender of an individual. It is the most dimorphic part of the skull. Next to the pelvic bone mastoid bone is the second best region of the skeleton for this purpose. Due to its compact nature and its protected position in the skull, the petrous bone makes itself the second bone next to pelvis to identify gender which remains intact even in old age [9]. Mastoid process is conical and the prominence projects from the under surface of mastoid portion of temporal bone, located just behind the external acoustic meatus and is lateral to the styloid process [10]. It has been reported that morphological characters of mastoid process are valuable in recognizing a gender [11-13]. As Hoshi had already suggested when skulls were placed on flat surface, the male skulls rest on the mastoid processes, while the female skulls rest on the occipital condyles or other portions of the skull [3,14]. Radiography usage in mass disaster identification is of supreme importance as it was described in the Noronic fire [12].

## Aim and Objectives

The present study aims to assess the measurement of mastoid process as it has maximum sex discriminatory power among all skull variables and to determine the gender from the CBCT images among Indian population. The variables measured are:

1. Mastoid Length
2. Mastoid Width
3. Mastoid Height

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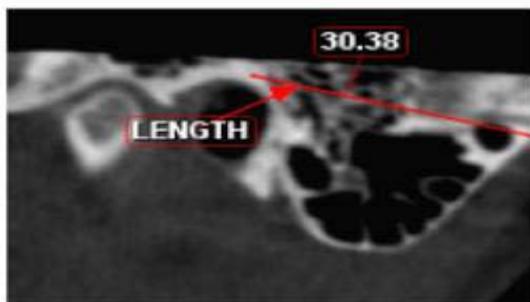


Figure 1: Sagittal view.

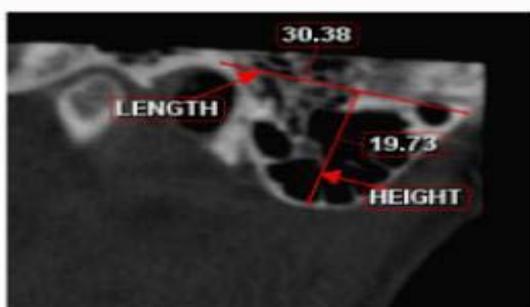


Figure 2: Sagittal view.

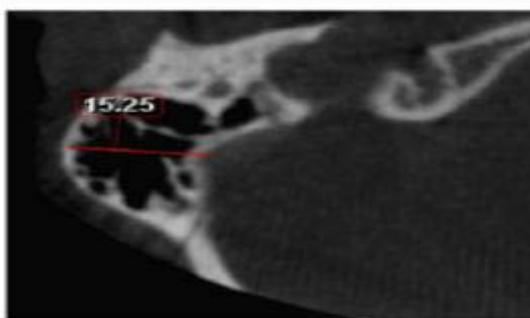


Figure 3: Axial view.

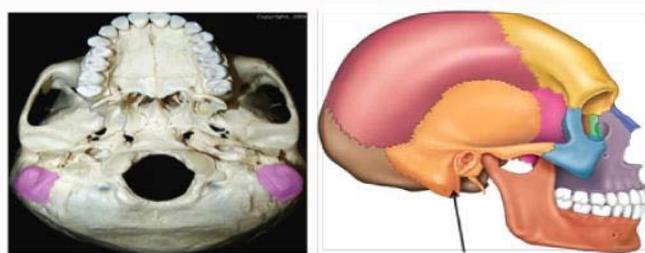


Figure 4: Mastoid Process.

**Mastoid process**

- Length: Length is measured from the posterior end of mastoidea to the mastoidale (Figure 1).
- Height: Height is measured by drawing a perpendicular line from the centric point of length to the tip of the mastoid process (Figure 2).
- Width: Width is measured from the most prominent point on the lateral and medial aspect of the mastoid (Figure 3).

**Results**

The collected data were analysed with IBM, SPSS statistics software 23.0 Version. The mean & S.D were used for continuous variables. To find the significant difference between the bivariate samples in Independent groups the unpaired sample t-test was used (Figure 4). In the above statistical tool the probability value of 0.01 was considered as significant.

**Males:** The mean mastoid length of males (Right-28.95 mm, Left-28.96 mm) (Figure 5A); Height of males (Right-20.13 mm, Left-19.46 mm) (Figure 5B); Width of males (Right-15.12 mm, Left-15.25 mm) (Figure 5C).

**Females:** The mean mastoid length of females (Right -24.55 mm, Left-24.58 mm) (Figure 5A); Height of females (Right-17.30 mm, Left-17.33 mm) (Figure 5B); Width of females (Right-17.27 mm, Left-17.35 mm) (Figure 5C).

**Discussion**

From the present study the statistical analysis of P value is highly significant and it can be concluded that, the Mastoid Length,

**Materials and Methods**

This retrospective study consists of 50 Adult CBCT images (100 Mastoid Process) of 25 males and 25 females which included left and right mastoid process. This study was done using Planmeca mid promax 3D machine and images were analyzed using Planmeca Romexis software.

Radiographic measurements of the Length,Width & Height of Left and Right mastoids were accurately measured using customized software.

**Inclusion criteria**

- Age group of 15 years to 60 years.
- Both Males and Females.

**Exclusion criteria**

- Images with gross artifacts.
- Images that did not show any anatomic details of the base or the lateral sides of the mastoid.

Table 1: T-Test.

Gender	N	Mean	Std. Deviation	Std. Error Mean	
RIGHT L	Male	25	28.956	1.07224	0.21445
	Female	25	24.5556	0.98375	0.19675
LEFT L	Male	25	28.9672	1.11498	0.223
	Female	25	24.588	0.95861	0.19172
RIGHT H	Male	25	20.13	0.93132	0.18626
	Female	25	17.3008	0.69045	0.13809
LEFT H	Male	25	19.4668	3.73303	0.74661
	Female	25	17.3392	0.658	0.1316
RIGHT W	Male	25	15.1224	0.59597	0.11919
	Female	25	17.2712	0.56125	0.11225
LEFT W	Male	25	15.2576	0.5549	0.11098
	Female	25	17.358	0.55627	0.11125

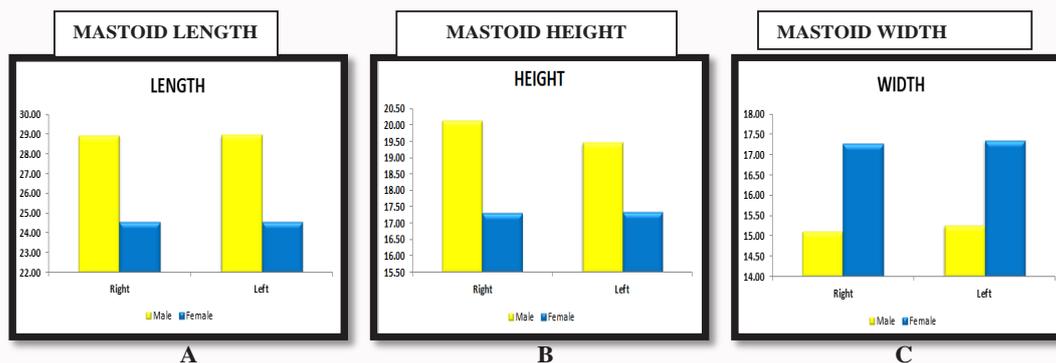


Figure 5: Male and female Mastoid Lengths.

Height and Width is a reliable indicator for sexual dimorphism. All other studies conducted on mastoid for gender determination were done on dry skull obtained from cadavers of known gender and the osteometric measurements were carried out using vernier calliper and 3D reconstructed skull model and this was the first study done on CBCT imaging. Sex classification is more precise in pelvic remains than the skull complete pelvic bone is not available for analysis. Perhaps skull is the second prime region of the skeleton to determine gender. During a mass disaster or breakout of war, where gender determination of a massive population is back breaking and lingering, sex determination using mastoid process could be reliable and alacritous. In the skull, the robust and tough mastoid bone makes it resistant to physical damage. For two reasons, the mastoid region is favourable for sex determination, the compact structure of the petrous portion and its protected position at the base of the skull. So it remains intact in skeletons of very old age. Even though skull is fragmented, the mastoid stays intact. From the size of mastoid, sex can be identified i.e. a larger mastoid suggests male sex and a smaller mastoid suggests female sex [4]. The mastoid process is most resistant to damage, due to its anatomic position at the base of skull has made the mastoids a focus of researcher's interest and encouraged them considering this bone as a prime morphometric trait in their studies of gender identification of human skeletal remains. The results obtained in this study proves that all the measures taken for male subjects were higher than the measurements taken for females, indicating that sex determination can be made by cranial measurements, as described by Ginay & Altinkok and Kemkes & Gobel [2,15,16]. Mastoid length and height are greater in males compared to females, whereas mastoid width is greater in females compared to males. Sumati and Patnaik has worked on mastoid process of North Indian skulls and this happens to be the second study on South Indian population next to das (2012) and the present study was the first study to be attempted on CBCT mode of imaging [5,17]. In this study, the mean mastoid length of males (right-28.95 mm, left-28.96 mm); height of males (right-20.13 mm, left-19.46 mm); width of males (right-15.12 mm, left-15.25 mm) (Table 1). The mean mastoid length of females (right-24.55 mm, left-24.58 mm); height of females (right-17.30 mm, left-17.33 mm); width of females (right-17.27 mm, left-17.35 mm).

According to the study conducted by Amin et al., [11] 3D reconstructed CBCT, Male mastoid length was 30.96 mm, Male mastoid height was 21.60 mm, Male mastoid width was 15.97 mm and Female mastoid length was 24.59 mm, Female mastoid height was 17.30 mm, Female mastoid width was 17.27 mm which was in accordance with our study.

According to the study conducted by verma et al., [10] on dry skull, Male mastoid length was 28.62 mm, Male mastoid height was 21.60 mm, Male mastoid width was 15.39 mm and Female mastoid length was 23.92 mm, Female mastoid height was 17.79 mm, Female mastoid width was 17.36 mm which was in accordance with our study.

## Conclusion

Present study proved statistically that the mastoid length and height is less in females when compared to males and mastoid width is greater in females compared to males. Based on the success in this practical implementation, in future, we aim to determine the volumetric analysis of mastoid process for gender from the human skull imaging (CBCT 3D Image) for the forensic science applications.

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