Original Article

Indian Journal of Forensic Medicine and Pathology
Volume 17, Number 3, July-September 2024
DOI: https://dx.doi.org/10.21088/ijfmp.0974.3383.17324.5

Determination of Sex Using Mastoid Process

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How to cite this article:
Vishnu Prasad, Thumma Amar, Vedarethinam, *et al.* Determination of Sex Using Mastoid Process. Indian J Forensic Med Pathol.2024;17(3):185-189.

Abstract

Background: Anthropometric studies of bones play a crucial role in establishing identification, especially in fragmented skeletal remains. Mastoid process is acone shaped bony protuberance extending from mastoid region of temporal bone of the skull. It is usually undamaged, because of its unique and secured position. The present study is aimed at evaluating the usefulness of the mastoid length in gender identification.

Material and Methods: 54 dried, and unharmed skulls of identified sex were employed in the study. Out of which 28 were male, 26 were female. The mastoid process length was measured on either side by using a Vernier calliper from Frankfurt's plane.

Results: In male skulls, the mean mastoid length was 29.5 ± 3.65 mm, while in female skulls, it was 24.6 ± 3.55 mm. A statistical analysis indicated that the mastoid length for determining sex has a highly significant p value of less than 0.0001.

Conclusion: The mean mastoid length is significantly less in females than in males. Therefore, it can be considered as a sexual dimorphic feature and is useful in determining sex from fragmented skull.

Keywords: Anthropometry; Sexual dimorphism; Mastoid length.

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Received on: *11-07-2024*

Accepted on: *16-10-2024*

Introduction

Sex determination is most accurate after the complete skeleton is accessible, as this allows for a comprehensive analysis of various anatomical features. When dealing with fragmented remains, identifying sex becomes challenging due to the absence of a single bone characteristic that can perfectly indicate the skeleton's sex.[1] Therefore, in such cases, it is crucial to examine sex-specific traits across multiple bones to achieve an accurate determination. Research focusing on individual bones that exhibit sexual dimorphism, such as the pelvis and skull, has been extensively documented

across various populations in osteometric studies.[2]

The accuracy of sex determination is particularly high when a complete skeleton is subjected to forensic examination. Among the skeletal components, the pelvis is recognized as the maximum consistent indicator for sex determination because of its pronounced sexual dimorphism. The pelvic bones provide clear markers that distinguish between male and female anatomy, such as the shape and size of the pelvic inlet, the size of the sciatic notch, and the overall robustness of the pelvis. However, in forensic contexts, it is common to encounter incomplete and fragmented pelvic remains, which necessitates the examination of other skeletal parts.

The skull is the subsequent greatest slice of the skeleton for determining sex after the pelvis. Forensic examinations frequently involve partial or fragmented skulls, as the skull is often more resistant to environmental and physical damage compared to other bones. Within the skull, the petro us portion of the temporal bone is exceedingly resilient to various types of harm, including thermal damage, due to its dense structure and unique location.[3, 4] This resilience makes the petro us part a valuable component in forensic analyses when other parts of the skull are not intact.

The Mastoid process is another significant feature present in the skull. It is situated at the base of the skull, behind the ear. Examining the mastoid process for gender identification is advantageous because it is situated in a well-protected area, making it less likely to be damaged. The mastoid process exhibits distinct sexually dimorphic traits, with males typically having larger and more prominent mastoids compared to females.[5, 6] This difference in size and robustness provides a useful marker for sex determination.

The present study aims to evaluate the usefulness of the mastoid length in gender identification from fragmented skulls. This research is particularly relevant in forensic contexts where complete skeletal remains are not available, and accurate sex determination is critical for identification purposes. By focusing on the mastoid process, the study seeks to establish reliable criteria that can be applied to fragmented remains, thereby enhancing the exactness and consistency of forensic sex determination procedures.

In addition to the mastoid process, other cranial features can also contribute to sex determination. These include the overall robustness of the skull, the prominence of the brow ridges, the shape of the orbits, and the configuration of the mandibular angle. Each of these features exhibits varying degrees of sexual dimorphism, which can be used in conjunction with the mastoid process to improve the accuracy of sex determination.

Moreover, advancements in imaging technologies, such as CT scans and 3D reconstructions, have significantly enhanced the ability to analyze fragmented remains. These technologies allow for detailed examination of bone morphology and the identification of subtle differences that may not be apparent through traditional visual inspection. By incorporating these technological advancements, forensic scientists can achieve more accurate and reliable results in sex determination from fragmented remains.

While sex determination is most accurate once a broad skeleton is accessible, examining sex-specific traits across multiple bones is essential when dealing with fragmented remains. The pelvis and skull, particularly the mastoid process, provide valuable markers for sex determination due to their pronounced sexual dimorphism and relative resilience to damage. The present study aims to establish reliable criteria for using mastoid process length in sex determination, contributing to the advancement of forensic identification methods.

Materials and Methods

Study Overview

The current study was performed in the Museum at the Department of Forensic Medicine, Vinayaka Missions Medical College, Karaikal. A total of 54 adult human dried skulls (28 male and 26 female) were included for evaluating the role of mastoid length as an anthropometric parameter for sex determination from fragmented skulls. The selected skulls were of known sex and were free from any apparent deformities, fractures, or diseases, ensuring accurate measurements uninfluenced by pathological conditions.

Measurement Technique

Tools and Precision

To measure the dimensions of the mastoid process, a digital Vernier caliper was used. This tool provided precise measurements recorded to the millimeter. Dimensions were measured on both the left and right side of each skull to ensure consistency and accuracy. The average of these measurements was then calculated to obtain a mean mastoid length for each skull, which was used

in the statistical analysis to assess the reliability of mastoid length as a sex determinant.

Observer Consistency

To ensure the accuracy and consistency of the measurements, a single observer, trained in biometric techniques, conducted all measurements, thereby minimizing inter-observer variability.

Detailed Methodology

The methodology for determining the mastoid process length involved specific steps to ensure precision. The measurement was made vertically upwards, following the tip of the mastoid process, to the point where it crossed the Frankfurt plane, a standard anatomical reference line.[7] (fig. 1)

Fig. 1: The Frankfurt's plane is a horizontal plane that extends across the bony orbit's lower margin and the external acoustic meatus's upper margin

Positioning the Skull

The procedure began by positioning the skull on its right side, facing the observer. The skull was aligned tangentially along the upper border of the auditory meatus, in line with the Frankfurt plane.

Using the Vernier Caliper

The fixed arm of the Vernier caliper was then aligned with the deepest point on the edge of the bony orbit, ensuring that the Frankfurt plane of the cranium was perpendicular to the calibrated bar of the caliper. Once the tip of the mastoid process aligned with the measuring arm of the caliper, the reading was recorded. This measurement provided the length of the mastoid process, extending from this anatomical line to the tip of the mastoid. (fig. 2)

Fig. 2: Measurement of Mastoid process Length

Importance of the Mastoid Process

This method of measurement is particularly important because the mastoid process is a robust and relatively well-protected part of the skull, making it less likely to be damaged compared to other cranial features. The mastoid process exhibits sexually dimorphic traits, with males typically having larger and more prominent mastoids than females. By accurately measuring the mastoid process, forensic scientists can make informed determinations about the sex of fragmented skulls, which is crucial in forensic investigations where complete skeletons are not always available.

Mitigating Measurement Errors

Observer Training

The use of a single observer with specialized training ensured that the measurements were consistent and reliable.

Bilateral Measurements

By taking measurements on both sides of each skull and using the mean value, the study accounted for any asymmetry that might exist between the left and right mastoid processes.

RESULTS AND DISCUSSION

The experiments performed in the Museum at the Department of Forensic Medicine, Vinayaka Missions Medical College, Karaikal, revealed significant differences in mastoid process length

among male and female skulls. The mean mastoid length for male skulls was found to be 29.5 mm with a standard deviation of 3.65, whereas the mean mastoid length in female skulls was 24.6 mm, with a standard deviation of 3.55. The P-value was less than 0.0001, indicating a significant difference between the mastoid lengths of the skulls of men and women. (Table 1)

Table 1: Mastoid length measurements in the skulls of male & female skulls

Parameter	Male (n=28)		Female (n=26)		P-value
	Mean Mastoid length	Standard deviation	Mean Mastoid length	Standard deviation	
Mastoid length	29.5 mm	3.65	24.6 mm	3.55	<0.0001 (Highly significant)

Across all the skulls that were analysed, the results consistently showed that the linear length of the mastoid process was shorter in females than in males. This finding aligns with previous research, such as the work of Hoshi H,[8] which categorized skulls based on mastoid process length and observed similar sexual dimorphism. Hoshi's study noted that male skulls tend to rest on the mastoid process when placed on a flat external surface, whereas female skulls tend to rest on the occipital condyles due to shorter mastoid processes.

Comparative studies across different populations also support these findings. Research on the Cape population[9] reported average mastoid lengths of 26.5 mm for females and 29.3 mm for males. In the Caucasian population,[10] the mean mastoid lengths were 25.21 mm in females and 28.06 mm in males. Studies on Negro populations[10] found mean mastoid lengths of 30.32 mm in males and 26.34 mm in females.

Further regional studies, such as those conducted by Sumati and Puranik[11] on Northern Indian skulls, found mean mastoid lengths of 23.18 mm in females and 28.3 mm in males. Passey J *et al.*[7] reported similar results, with mean mastoid lengths of 29.7 mm in males and 24.5 mm in females. Additional research by Song *et al.*[12] in China and by Patil and Mody[13] in India also corroborates these findings, demonstrating the reliability of using mastoid process length as a parameter for gender identification in forensic anthropology.

CONCLUSION

Our study emphasizes the importance of mastoid length, particularly valuable in forensic medicine for decisive sex from skeletal relics. The research demonstrated a statistically significant variance in mastoid length among male and female subjects, supporting the validity of mastoid length as a measure of sexual dimorphism. These findings align with results from other research conducted both internationally and within the Indian population.

The statistically significant difference observed between females and males in mastoid length enhances its forensic applicability. This highlights its potential as a robust parameter in forensic anthropology and medico-legal investigations. The consistent sexual dimorphism in mastoid process length across various populations reinforces its reliability as an indicator for sex determination, making it a valuable tool in scenarios where complete skeletal remains are not available.

This study contributes to the rising evidence supporting the use of mastoid length in forensic contexts. By providing a reliable and statistically validated method for sex determination, it aids forensic practitioners in the accurate identification of unknown individuals, thereby improving the effectiveness of forensic and medico-legal investigations.

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