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Sexual Dimorphism in Mastoid Process Using Discriminant Function Analysis

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Abstract

Background & Aims: Determining sex from the human skeleton and its fragments has very high importance in anthropology, forensic medicine, and human osteology. Petrous temporal bone with the mastoid process is usually preserved in the case of burning, as it has compact structure with protected position at the skull base. Present study aimed to select the best discriminator from all mastoid parameters and to develop an equation for the determination of sex from Western Indian skulls via discriminant function analysis.

Materials & Methods: Present study was carried out on total 160 human adult dry skull bones of known sex (90 male and 70 female) which were collected from the Anatomy Departments of various Medical and Dental Colleges across Gujarat, India. Three mastoid process parameters namely mastoid length, mastoid breadth, and antero-posterior diameters were measured on both the sides using a digital vernier calliper.

Results: All these mastoid variables are statistically highly significant ($p < 0.0001$) for sexual dimorphism; each has a higher value in males than females. When the regression equation was applied, 96.2% of male skulls and 94.6% of female skulls were correctly classified.

Conclusion: Mastoid length has the highest discriminative power among the three variables measured in this study. The knowledge of mastoid process measurements provided by the present study will be helpful in human osteology, anthropology, and forensic science for evaluation of sex from western Indian skulls.

Keywords: Mastoid Process, Sex Determination, Discriminant Function, Skull, Mastoid Length

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Introduction

Determining sex from the human skeleton and its fragments is important in studying human osteology and is perhaps the most important and often the only tool available in forensic science or in anthropology. The pelvis and skull are the two most sexually dimorphic elements in the skeleton (1-4). Many times, for forensic identification, only bony fragments are available instead of whole complete skeletons (5). Petrous temporal bone with the mastoid process is usually preserved in the case of burning, as it has a compact structure with protected position at the skull base (6).

Due to larger muscles inserted into the mastoid process, it is typically more robust in males; this qualitative observation of the mastoid process is typically one feature of the cranium used to determine the sex of a skeletal individual (7).

The Present study aimed to select the best discriminator from all mastoid parameters and to develop an equation for the determination of sex from Western Indian skulls via discriminant function analysis.

Materials & Methods

The Present study was carried out on total 160 human adult dry skull bones of known sex (90 male and 70 female), after ethical clearance from the human ethical committee (Registration No. IRB00008091). The skulls available at the Anatomy Departments of various Medical and Dental Colleges across Gujarat, India were analysed. Those skulls having intact mastoid processes with fully ossified spheno-occipital junction were included in this study. The mastoid process parameters, mastoid length, AP (Antero-posterior) diameter, and mastoid Breadth were measured on both the sides using a digital vernier calliper (Figures 1, 2, and 3).

Fig. 1. Mastoid length measurement

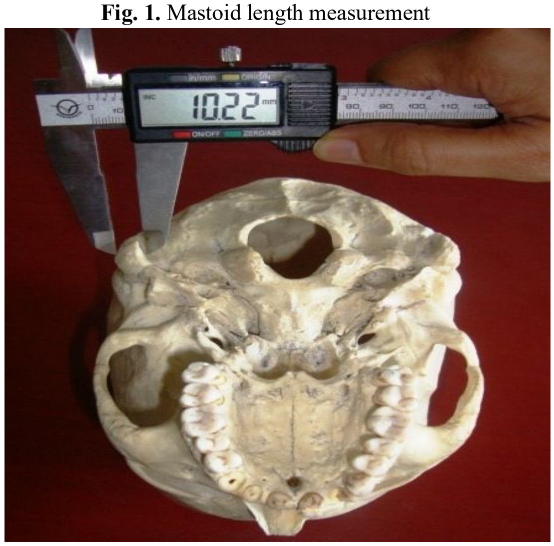

Fig. 2. Mastoid breadth measurement

Fig. 3. A-P diameter of mastoid process measurement

(i) Mastoid Length: Distance measured from the point on the Frankfurt plane (horizontal plane passing from the infraorbital margin to the upper margin of external acoustic meatus (8), vertically downwards up to tip of the mastoid process by digital vernier calliper (9). (Figure 1)

(ii) Mastoid Breadth: Distance measured from the highest part of the medial surface of the mastoid process within mastoid notch to the most lateral point at the same level of the mastoid process by digital vernier calliper (9) (Figure 2).

(iii) Antero-posterior diameter: Distance measured from the lowest point where tympanic plate abuts against the anterior surface of the mastoid process to the posterior border of the process at the same level by digital vernier calliper (9) (Figure 3).

To reduce intra observer error, for all the skull bones, each parameter is measured twice at two different sessions by the same observer and the mean was counted. Data was analysed by SPSS software. After calculating the Mean and SD of the right and left mastoid parameters, Student's t-test was applied and P values were calculated for each parameter. Discriminant function analysis was applied and wilk's lambdas and eigenvalues were obtained. Least wilk's lambda and highest eigenvalue suggest best discriminant power. By applying regression model, constant and coefficient values were calculated for the regression equation. Percentage of correctly classified skull bones were achieved by this equation.

Results

Table 1 shows the comparison between the mastoid variables of males and females; all the mastoid variables are lesser in females than in males.

Table 1. Mean and standard deviation values of parameters

Parameters		Male (90)		Female (70)		T test	P value
		Mean (mm.)	SD	Mean (mm.)	SD		
Mastoid length (L)	R	34.20	2.78	26.38	2.43	18.64	P < 0.0001
	L	34.17	2.69	26.57	2.66	17.80	P < 0.0001
Mastoid Breadth (B)	R	12.05	1.19	9.86	0.91	12.72	P < 0.0001
	L	12.00	1.23	9.88	0.95	11.95	P < 0.0001
AP diameter (APD)	R	17.45	1.09	14.90	1.34	13.19	P < 0.0001
	L	17.32	1.21	14.95	1.49	11.08	P < 0.0001

The difference was statistically highly significant for each variable, suggestive of sexual dimorphism. Table 2 shows wilk's lambda for each variable by discriminant function.

Table 2. Equality test of Group Means

Parameters	Wilk's Lambda	F	df1	df2	Significance
Mastoid Length(mm)	.323	667.86	1	318	.000
Mastoid Breadth (mm)	.510	305.98	1	318	.000
A-P Diameter(mm)	.521	292.87	1	318	.000

Table 3 gives eigenvalues of all the three parameters. Mastoid length has the least wilk's lambda; the highest eigenvalue shows that mastoid length has maximum discriminant ability.

Table 3. Variance of parameters in percentage

Parameters	Eigenvalues		
	Total	Variance Percentage (%)	Cumulative Percentage (%)
Length	2.456	81.87	81.87
Breadth	.306	10.20	92.08
AP Diameter	.238	7.92	100.00

We can derive a formula from Table 4 (regression model) as:

SEX = 4.609446- 0.0652078(Length) - 0.048025(Breadth) - 0.0386547 (AP Diameter)

Table 4. Regression Model

Parameters	Co-Efficient	Standard Error	T test	P>t	95% Confidence	Interval
Mastoid Length (mm)	-.065	.005	-11.66	0.000	-.076	-.054
Mastoid Breadth (mm)	-.048	.016	-3.02	0.003	-.079	-.017
AP Diameter (mm)	-.039	.014	-2.84	0.005	-.065	-.012
_cons	4.609	.144	31.96	0.000	4.326	4.893

On solving the equation, if the answer is more than 1.5, mastoid process and the skull belongs to the male sex and if is less than 1.5, the sex is female. When regression equation was applied, 96.2% of the male skulls and 94.6% of the female skulls were correctly classified.

Discussion

In the present study, authors measured mastoid length, breadth, and AP diameter, and analysed them by discriminant function. Among these three variables, mastoid length has the least wilk's lambda (0.323) and highest eigenvalue (2.456), showing that the mastoid length has maximum discriminant ability. When regression equation was applied to the present study group, 96.2% of the male skulls and 94.6% of the female skulls were correctly classified.

In study of Gupta AD et al., the means for the male mastoid process measurements were 29.23 mm (L), 11.25 mm (B), and 16.55 mm (APD); for the females the means were 22.44 mm (L), 8.60 mm (B), and 12.79 mm (APD) (10). Sumati et al. studied 60 adult human skulls and found that mean for the male mastoid measurements were 28.3 mm (L), 11.46 mm (B), and 17.52 mm

(APD), and for the females were 23.18 mm (L), 8.68 mm (B), and 13.69 mm (APD); they classified 76.7% of the crania samples correctly (11). Chaudhary et al. reported the means for males were 27.50 mm (L), 10.64 mm (B), and mm 16.77 mm (APD); the results for females were 22.88 mm (L), 8.61 mm (B), and 13.52 mm (APD); and they classified 96.4% of them correctly by using mastoid dimensions (12). Sujarittham et al. studied mastoid process; mean for male mastoid measurements were 25.24 mm (L), 11.7 mm (B), and for females were 20.73 mm (L) and 9.78 mm (B) (13). Gupta et al. (9), Sumati et al. (10) and Sujarittham S et al. (13) found the mastoid length as the best discriminator for sex determination from the mastoid process.

Deshmukh et al. (14), Passey et al. (15), and Virupaxi et al. (16) measured mastoid length in skulls of different Indian population and found means of mastoid length as 29.0 (L), 29.7 (B), 30.2 (APD) for male and 27.0 (L), 24.5 (B), and 26.2 (APD) for females, respectively. Various studies outside India like studies of Keen (17) and Giles (18) showed that as compared to female skulls, the mastoid mean length was greater in males irrespective of any race or region. Johnson et al. (19) revealed that the best discriminators for race are not always the best for sex. In the study of Sumati et al. on calcaneum, it was concluded that the sex is best described by a unique discriminant function for each race (20). The regression equation derived in the present study is useful for sex determination of the skull of Western Indian population. The knowledge of mastoid process measurements provided by the present study will be helpful in the human osteology, anthropology, and forensic science for evaluation of sex from Western Indian skulls.

Conclusion

The present study shows that mastoid length, breadth, and AP (antero-posterior) diameter of the mastoid process are statistically highly significant (p<0.0001) for sexual dimorphism from mastoid process. Each variable has higher value in males than females. The mastoid length has the highest discriminative power followed by the mastoid breath and antero-posterior diameter. When regression equation was applied, 96.2% of the male skulls and 94.6% the female skulls were correctly classified. The knowledge of mastoid process measurements provided by the present study will be helpful in the human osteology, anthropology, and forensic science for evaluation of sex from Western Indian skulls.

Acknowledgments

None declared.

Ethical statement

The above-mentioned sampling protocols were approved by the human ethical committee (Registration No. IRB00008091).

Conflict of interest

None declared.

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