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Determination of Sex from Mastoid Dimensions among North Indians

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ABSTRACT

Introduction: Sex determination is the keystone of a biological profile and skulls of unknown provenance are best tested for race and sex using different variables. Determination of sex from the skeleton is vital to medico legalinvestigations. The mastoid region is analysed for determination of sex from fragmentary crania in Forensic Anthropology as it is one of the most protected region and resistant to damage due to its anatomical position at the base of the brain.

Objective: The purposeof this study was to determine the existence of sexual dimorphism in the dimensions of mastoid process among North Indians.

Material and Method: Material for the study consisted of 70 adult (above 18 years) human skulls (35 of either sex) of North Indians obtained from Anatomy and Forensic department of SGRDIMSAR, Amritsar. Mastoid measurements (Length, Breadth and A-P diameter) of both the sides were taken in millimeters with the help of sliding Vernier Caliper and size of mastoid process was calculated.

Results: All four mastoidvariables showed significant sexual dimorphism$p<0.001$. Canonical discriminant function Coefficient using stepwise analysis was -3.142 in females and 3.142 in males.In statistical analysis using Canonical Discriminant Functions, Eigen value was 10.015 and Wilks' Lambda was 0.091.

Conclusion: Accuracy of determination of gender using all four variables was 97.1% original and 96.4% cross- validated. Therefore, mastoid process can be used as a tool fordetermination of sex in fragmentary skeletal remains.

Keywords: *Mastoid Process, Forensic anthropology, Sexual dimorphism, North Indians*

INTRODUCTION

In Forensic science, identification of gender by examination of skeleton has been used widely. Skull alone is still widely used for sex determination because all the other human skeletons show variable degree of sexual dimorphism[1][2]. The mastoid process is favourable for sex determination because the petrous frequently survives circumstances that cause skeletal fragmentation[3] and it is less prone to damage due to its safe anatomical position at the base of the skull [4]. So it stays intact even the skull is fragmented and it remains intact in skeletons of very old age. To identify sex in fragmented skullbones, mathematical dimensions of mastoid are used by craniometric techniques . Many studies have been conducted on different populations on sexual dimorphism with respect to the skull. Nagaokaused two parameters on both sides of skull i.e. height and width of mastoid[5]. Paiva& Segre calculated the triangular area between Porion, Mastoidale and Asterion which is then used to identify sex[6]. The present study was undertaken to study the accuracy and reliability of the mastoid process in determination of sex

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of skulls among North Indians from a fragmentary piece of skull by taking different dimensions of the mastoid process and results were analysed statistically.

MATERIAL AND METHOD

Material for the study consisted of 70 adult (above 18 years) human skulls (35 of either sex) of North Indians obtained from Anatomy and Forensic department of SGRDIMSAR, Amritsar. Skulls with metopic bone in the region of craniometric points, diseased and damaged mastoid processes were discarded. Mastoid measurements of both the sides were taken in millimeters with the help of sliding Vernier Caliper (with a least count of 0.01mm). Average of readings of right and left sides were taken and subjected to statistical analysis using SPSS-17.

1. **Mastoid Length:** The length of mastoid is measured from a point on the Frankfurt plane vertically downwards to the tip of the mastoid process[7]. Frankfurt plane is a horizontal plane passing through the upper margin of external acoustic meatus and the lower margin of the orbital opening [8]

   The skull is rested on its right side and the calibrated bar of the caliper is applied just behind the mastoid process, with the fixed flat arm tangent to the upper border of the auditory meatus and pointing (by visual sighting) to the lower border of the orbit. The calibrated bar is perpendicular to the Frankfurt plane of the skull. The measuring arm is adjusted until it is level with the tip of mastoid process, using the base of the skull generally and the opposite mastoid process to control the plane of sighting.

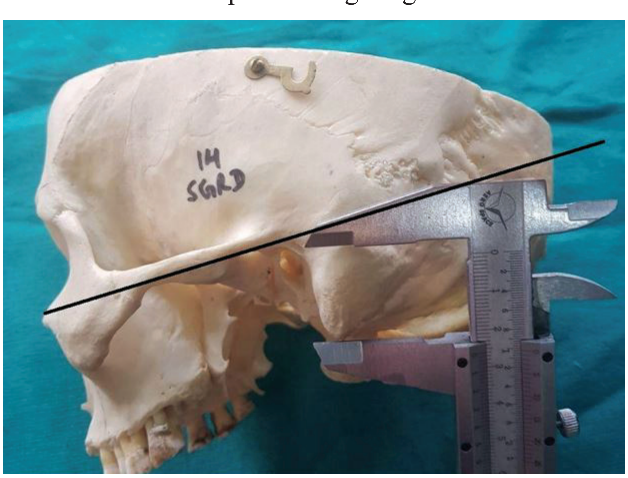

Figure 1: Showing Length of Mastoid Process Using Frankfurt Plane

2. **Mastoid Breadth (Medio- lateral Diameter):** It is taken from the highest part of the medial surface of the mastoid process within the digastric fossa to the most lateral point of the process on the same level[7]

Figure 2: Showing Breadth of Mastoid Process

3. **Mastoid A-P diameter:** It is taken from the lowest point at which the tympanic plate abuts against the anterior surface of the mastoid process to the posterior border of the process on the same level [7]

Figure 3: Showing Antero-Posterior Diameter of Mastoid Process

4. **Mastoid Size [7]:** It was obtained as following

$$\frac{\text{Lenght} \times \text{A-P diameter} \times \text{Breadth}}{100}$$

RESULTS

Table No. I

Variable	Females		Males		P value#
	Mean	SD	Mean	SD	
Mastoid L	22.880	1.093	27.501	1.137	<0.001**
Mastoid B	8.613	0.946	10.636	0.937	<0.001**
AP Diameter	13.520	1.066	16.768	0.956	<0.001**
Size	34.521	10.239	55.291	10.252	<0.001**

#Student 't' test; **p<0.001; Highly significant

Table II: Canonical Discriminant Function Coefficient using stepwise analysis

Variable	Standardized coefficient	Structure Matrix	Unstandardized coefficient	Raw Coefficient (Constant)	Group Coefficient	
					Female	Male
Mastoid L	0.918	0.659	0.823	-34.895	-3.142	3.142
Mastoid B	0.588	0.342	0.625			
AP Diameter	0.688	0.511	0.680			
Size	-0.489	0.323	-0.048			

Table III: Accuracy of determination of gender using all variables

Gender	Correctly classified	Misclassified
Female	68 (97.1%)	2 (2.9%)
Male	68 (97.1%)	2 (2.9%)
Total	136 (97.1%)	4 (2.9%)

Accuracy was 97.1% original

Table IV: Accuracy of determination of gender Cross-validated

Gender	Correctly classified	Misclassified
Female	68 (97.1%)	2 (2.9%)
Male	67 (95.7%)	3 (4.3%)
Total	135 (96.4%)	5 (3.6%)

Accuracy was 96.4% cross-validated

Table V: Stepwise Statistics

Variables Entered/Removed[a,b,c,d]

Step		Wilks' Lambda							
						Exact F			
	Entered	Statistic	df1	df2	df3	Statistic	df1	df2	Sig.
1	Mastoid L	.187	1	1	138.000	601.073	1	138.000	.000
2	AP Diameter	.119	2	1	138.000	507.416	2	137.000	.000
3	Mastoid B	.103	3	1	138.000	394.861	3	136.000	.000
4	Size	.091	4	1	138.000	337.990	4	135.000	.000

At each step, the variable that minimizes the overall Wilks' Lambda is entered.

a. Maximum number of steps is 8.

b. Minimum partial F to enter is 3.84.

c. Maximum partial F to remove is 2.71.

d. F level, tolerance, or VIN insufficient for further computation.

DISCUSSION

Mastoid region has drawn the interest of Forensic experts for its utility in sex determination since long. Larnach and macintosh calculated size of mastoid process and divided it into five grades (very small, small, medium, large or very large).They reported that females have very small to small sized mastoids while males have medium to large sized mastoids[7].

Krogman and Iscan stated that determination of sex, age and race in a collection of 750 skeletons was possible with levels of reliability of 92% using the skull alone and 98% using both pelvis and skull[9]. Bass reported that the skull is probably the second best region of the skeleton to determine the sex[10].

Hoshi classified the mastoid process into three main types based on the direction of the mastoid process in relation to a vertical plane as assessed visually i.e. M-male, N-neutral and F-female. He observed that when skulls were placed on flat surface, the male skulls rest on the mastoid processes while female skulls rest on occipital condyles or other portions of the skull indicating that male skulls have longer mastoid process as compared to female skulls due to whichmale skulls rest on mastoid process[11].

In Cape population[12] the mean mastoid length in male and female skulls was 29.3 mm and 26.5 mm respectively, in Caucasian population28.06mm and 25.21 mm respectively and in Negroes30.32mm and 26.34mm respectively[13]. Passey et al in their study on 70 adult skulls (44 males and 26 females skulls) reported mean mastoid length 29.7mm in males and 24.5mm in female skulls[14].Sumati et al in their study on 60 adult human skulls reported that mean mastoid length was 28.3 mm in males and 23.18mm in female skulls and concluded that subsequent to stepwise discriminant function analysis, mastoid length was found to the best sex determinant[15]. This is in accordance with our study where mastoid mean length in male skulls was 27.501mm and was 22.880mm in female skulls. Our study was further supported by observations of Nagaoka et al [5] on Japanese skulls. They reported larger mastoid length in Japanese male skulls, 49.0$\pm$ 3.47 mm as compare to Japanese female skulls where mastoid length was 47.0 $\pm$2.7 mm suggestive of population differences in measurements of the mastoid process. They concluded that the accuracy of sex classification was more than 80% when single parameter was used and accuracy of 82- 92% was achieved when mastoid height and width were taken together for sex estimation. Sumati et al[15] correctly classified sex in 76.7% crania included in the study while Gupta et al [16] observed an accuracy of 90% for the mastoid process in sexing the crania. Franklin et al[17] reported an accuracy of 68% for mastoid process in sexing of indigenous South African crania .Saini et al [18] utilized eight different measurements on mastoid process and reported an accuracy ranged between 68.1% and 75.4% using each variable in direct discriminant analysis while in step wise analysis , asterion- mastoidale and mastoid breadth provided an accuracy of 87% which is reasonably good for identification in forensic anthropology. Also, the mastoid process was found to be a good discriminator of sex even in condition of severe malnutrition with 87.3% accuracy[19]. The average accuracy by direct method was 85% in males and 80% in females [20], 61% in males and 52% in females [21], In our study, accuracy of determination of gender was 97.1% original and 96.4% cross- validated.

So, compared with the results of other studies, the present study shows that the dimensions of mastoid process measured by anthropometric technique could be of great help in medicolegal investigations and it can be taken as a sex indicator among North Indians

CONCLUSION

The Skull plays a vital role in distinguishing the sex when performing a forensic anthropological analysis. Morphological and morphometric are two basic methods of sexing the human skull. In fragmented skull bone, metric analysis provides greater statistical weight than the morphological analysis. In the skull, the mastoid bone is robust, tough and is located at a protected position at the base of the skull making it favouable for sex determination. By taking the mastoid process measurements carefully and after applying proper statistical analysis, it can be used as one of the bone determinant of sex of fragmentary remains.

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