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Morphometric Analysis and Sexual Dimorphism of Mastoid Process for Determination of Sex

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Abstract; Background; to determine the sex the skull and skeletal plays an important role for the archeologists, physical anthropologist, and forensic anthropologist. To gain by using the knowledge of osteology of human anatomy. Due to its anatomical position of mastoid process at basolateral region of skull so it is the most dimorphic bone which it is least damaged. The parameters of mastoid process are larger in males than in females. In present study to determine the sex in unidentified skulls an attempt has been made to evaluate the use of mastoid process measurements. For that to test the accuracy of sex determination using discriminant function analysis. **Material and Method;** this study is carried out in department of anatomy D.Y.Patil Medical college, Kolhapur. A total sample size is 100 adult human dry skulls (50 Male 50 Female) were studied to determine the accuracy of sex of mastoid process. The Mastoid length, antero-posterior diameter, medio-lateral diameter and to calculate the mastoid index. Also the distance between, asterion to mastoidale, asterion to porion, Porion to mastoidale [1] were studied**. Results;** in the present study we observed that, out of seven mastoid variables, six variables are more in males as compare to females. The difference observed for six variables if mastoid process was statistically significance ($p<0.005$). The discriminant function analysis revealed that mastoid process is correctly classified for the sex in 75% of left side skull and 60% of right side skull subjects[1.] And mastoid length, ast-ms, ast-po, po-ms was found to be excellent discriminant function analysis for sex. The present study provides the baseline data for determination of sex of mastoid process of skull.

Key Words; Discriminant Function analysis; Mastoid process; Sex determination.

INTRODUCTION

The mastoid process is located postero-inferorly to the external acoustic meatus and it is prominent breast like projection inferiorly from the mastoid part of temporal bone [1]. It is often a difficult task to determination of sex in fragmented skulls, as no isolated characteristics of any particular bone can perfectly determine the sex of a skeleton. When the complete skeleton is available then highest accuracy in determination of sex is achieved [2]. The pelvic bone and pelvis is best assessed for sex than the skull, but complete and whole pelvis is not always available for analysis [3]. Several studies have been shown that cranium is also an excellent indicator for sexual dimorphism by morphometric analysis. For determination of sex skull is probably the second best region of the skeleton [4]. The measurement of skull is vary significantly in different population of the word. By the size and robustness the dimorphism in skull is based. The mastoid process is the most dimorphic bone of the skull which plays an important and significant role in sexual dimorphism. The mastoid process is most protected and resistant to damage because of its anatomical position at the basolateral region so it is favorable for determination of sex[5.] Commonly mastoid process is larger in males as compare to females. The morphometric study of mastoid process have been employed by pavia and

sergre[6] (2003), Nagoaka[7] (2008), Sumati patnaik[8],(2010), and A D Gupta[9] (2012). Very few studies present on this so considering this entire scenario, present aims to evaluate the use measurements in mastoid process for determination of sex in unidentified human skeleton remains, decomposed and mutilated body. The present study intends to assess the dimorphic reliability of various morphometric parameters of mastoid process by using discriminant function analysis. The observation interpretation and sex discriminating functions obtained will be very useful for Anatomist, anthropologist, and forensic experts in individual homicidal cases, mass disaster, and multiple burials leaving mere charred and mixed incomplete remains to be recovred[10.]

MATERIAL AND METHODS

The present study was conducted in department of Anatomy, D Y Patil Medical College, and Kolhapur. 100 dry adult human skulls (50 Male 50 Female).To determine the validity of variables in mastoid process for sexual dimorphism. The skulls with no deformity, intact mastoid process attached Spheno-occipital junction were included in the study. Deformed and congenital anomaly skulls were excluded from the study. Measurements were taken on mastoid process by using digital Vanier caliper to the nearest millimeter (mm) as per standard anthropological convention. All the measurements were done by single observer to avoid inter-observer error.

Frankfort plane- a horizontal line passing through margin of external acoustic meatus and lower margin of orbital opening. The following measurements were taken on mastoid process of skull.

. Mastoid length: Measured from a point on Frankfort plane vertically downwards to the tip of mastoid process[11] .Facing the skull on one side towards the observer; to fix the one arm of Vernier Caliper on upper border of auditory meatus (fig.1).

. Medio-lateral diameter: Most lateral point of the mastoid process to the highest part of medial surface[11] (Fig.2).

. Antero-posterior diameter- (mastoid breadth): From the posterior border of the external acoustic meatus near its summit to the straight distance of posterior end of incisura mastoidea (PEIM) [11](Fig.3).

. Mastoid process index= Mastoid breadth/ Maximum mastoid lenghtx100

For the further mastoid process measurements the following points were used. Asterion (AST) meeting point of lambdoid, occipitomastoid, and parietomadtoid sutures. Porion: (Po) superior point of external acoustic meatus. Mastoidale: (Ms): is the tip of mastoid process. The points were located and marked. The following reading was measured in millimeter.

- Asterion to Mastoidale (AST-Ms)
- Asterion to Porion (AST-Po)
- Porion To Mastoidale (Po-Ms)

The data obtained was tabulated and analysed using IBM SPSS 21.0.0 version software. Univariate analysis was obtained for all the above parameters by calculating mean, standard deviation and p value. Then discriminant function analysis was performed with each single variable.

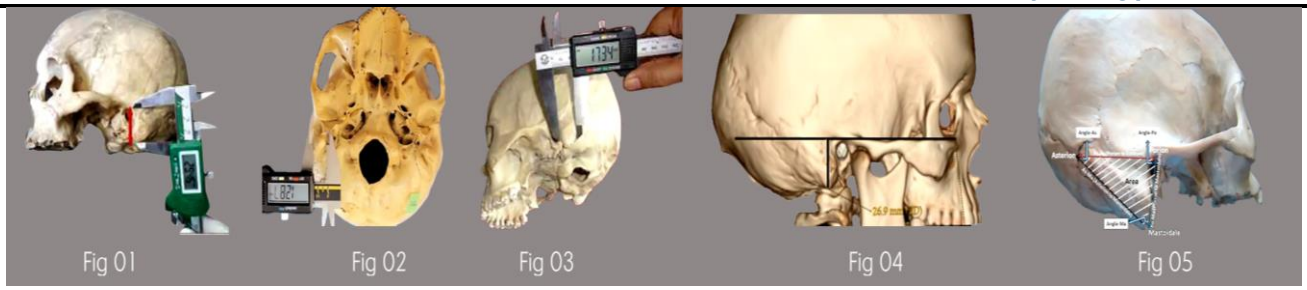

Fig.1. Length of Mastoid process

Fig.2. Medio-lateral Diameter

Fig.3. Antero- posterior Diameter

Fig.4. Frankford's plane

Fig.5.Mastoid triangle

Results: Total 100 dry adult human skulls (50 Male,50 Female) with measurable and intact mastoid process were studied. The univariate analysis revealed that the mean of mastoid variables like mastoid length (37.21), medio-lateral diameter (6.36), antero-posterior diameter (23.19), Ast-Ms (51.27), Ast-po (39.23), and Po-Ms (28.40) were more in males than females and the measurements was statistically significant ($p<0.005$). The mean of mastoid index was found less in males (67.78) than in females (70.98). This difference was statistically significant (table No. 1)

Table no. 1: Descriptive statistics for mastoid measurements (n=100)

Sr. No.	Mastoid variable	Male (n=50) Right side		Female (n=50) Right side		T value	P value	Significance
		Mean	SD	Mean	SD			
1	Mastoid length	37.21	8.72	34.68	7.00	1.6	0.11	NS
2	Medio lateral diameter	6.36	1.84	4.77	2.06	4.07	P<0.001**	Highly significance
3	Antero-posterior diameter	23.19	4.89	21.00	4.33	2.31	0.019**	Highly significance
4	Mastoid index	64.81	15.84	62.11	14.82	0.87	0.38	NS
5	Asterion – mastoidale	51.57	5.25	45.91	4.91	5.26	P<0.001**	Highly significance
6	Asterion-porion	39.23	3.6	37.18	4.61	2.47	0.015*	Significance
7	Porion-mastoidale	28.40	3.25	27.22	4.24	1.55	0.12	NS
8	Mastoid area	539.66	77.12	494.06	106.49	2.43	0.016**	Highly significance

All measurements were in millimeters (mm); * significance;** Highly significane

$P<0.05$ consider statistically significant.

There is significant difference observed in means of male (right side) and Female (right side) By unpaired t-test for APD,MLD,MS,AST-Ms, AST-PO, and MA.($p<0.01$)

P<0.05, value of probability is considered statistically significant at 5%

P<0.01, value of probability is considered statistically significant at 1%

Table no.2

Sr. No.	Mastoid variable	Male (n=50) left side		Female (n=50) left side		T value	P value	Significance
		Mean	SD	Mean	SD			
1	Mastoid length	37.47	9.10	32.87	7.25	2.78	0.003**	Highly Signicicant
2	Medio lateral diameter	6.06	1.44	5.22	2.35	2.16	0.033*	significance
3	Antero-posterior diameter	24.24	4.11	22.23	5.54	2.05	0.04	significance
4	Mastoid index	67.78	17.53	70.98	25.06	0.73	0.46	NS
5	Asterion - mastoidale	50.89	6.79	43.23	8.62	4.93	P,0.001**	Highly significance
6	Asterion-porion	38.65	5.23	37.0	4.05	1.72	0.044*	Significance
7	Porion-mastoidale	27.89	3.89	26.66	3.86	1.58	0.058	NS
8	Mastoid area	513.06	135.69	465.77	112.16	1.88	0.06	NS

All measurements were in millimeters (mm); * significance;** highly significance

P<0.05 consider statistically significant.

There is significant difference observed in means of male (left side) and Female (left side) By unpaired t- test for ML, APD,MLD,MS,AST-Ms, AST-PO, Parameters (p<0.05)

P<0.05, value of probability is considered statistically significant at 5%

P<0.01, value of probability is considered statistically significant at 1%

Those variables follows the normality condition is considered for discriminant analysis.

The discriminant function equation formula derived for the determination of sex is : Y= -9.233+(0.241)x AST-PO, Y= -7.349+ (0.264)x PO-MS ; All variables Y=12.214+(0.208)x AST-PO+(0.153)x PO-MS for right side.

Table no 3

	Wilks lambda	canonical correlation	structure matrix	function centroid value	Average Accuracy
AST-PO	0.941	0.243	1.00	F= - 0.248 M= +0.248	58%
PO-MS	0.976	0.156	1.00	F= - 0.156 M= +0.156	58%
All variable	0.914	0.294	0.815 0.512	F= - 304 M= +0. 304	60%

The discriminant function equation formula derived for the determination of sex is : Y= -6.293+(0.134)x AST-MS on left side

Table no 4

	Wilks lambda	canonical correlation	structure matrix	function centroid value	Average Accuracy
AST-MS	0.809	0.437	1.00	F= - 0.481 M= + 0.481	75%

Table 5: Classification result of mastoid variables

Right side predicted group membership

		Gender	0	1	Total
Original/ validated	Count	0	31	19	50
		1	20	30	50
	%	0	62.0	38.0	100.0
		1	40.0	60.0	100.0
Cross-validated	Count	0	31	19	50
		1	20	30	50
	%	0	62.0	38.0	100.0
		1	40.0	60.0	100.0

Left side predicted group membership

		Gender	0	1	Total
Original/ validated	Count	0	28	22	50
		1	22	28	50
	%	0	56.0	44.0	100.0
		1	44.0	56.0	100.0
Cross-validated	Count	0	28	22	50
		1	22	28	50
	%	0	56.0	44.0	100.0
		1	44.0	56.0	100.0

75.0% of original grouped cases a correctly classified. Cross validation classification procedure proves that the model was fairly reliable

Table no.6. Showing comparison between present study and previous studies for mastoid parameters. (AST-MS, AST-PO, PO-MS)

Table no. 6

Parameter/Authors	Population studied	N0. Of skulls(n)	AST-MS(mm)	AST-PO(mm)	PO-MS(mm)
Vineeta saini et.al(2012)	North India	M=104 F=34	M= 47.83 F= 43.0	M=47.89 F=44.69	M=31.77 F=27.98
Nidgula H (2013)	South India	M=40 F=40	M=50.11 F=46.51	M=44.48 F=42.87	M=29.52 F=24.26
Present study	Maharashtra	M=50 F=50	M=51.08 F=44.57	M=38.94 F=37.10	M=28.15 F=26.94

M=male; F=female; mm=millimeter

DISCUSSION; (table no.6) The present study showed a statistically significant difference for AST-MS (asterion to mastoidale distance), this coincide to other studies[12] [13] .But as per the 1 observation of kemes and Gobel [16] it is contrary, who found the AST-MS distance insignificant and stated the cause, may be the asterion position which varies with progression of age in a population- specific manner. In addition to metric and non-metric analysis, the highly objective discriminant function analysis was applied. The discriminant function equation for sex determination has been computed by few researchers like Sumati et al [8] for north Indian population, and for south Indian population [9] [13]. They revealed that sex with in a given race can be best described by unique discriminant function equation. In present study, the discriminant function equation derived will be unique to determine sex. In the present study AST-MS, AST-PO and PO –MS as best discriminant[12] and among south Indians PO-MS as a best discriminant.

CONCLUSION; the mastoid process is sexually dimorphic bone. The accuracy of sex determination by using mastoid variables was 75%. . The centroid value for male (Right) is 0.58 and female (right) - 0.58.

The centroid value for male (left) is 0.627 and for female (left) -0.627

The predictive mode for determining sex is

Z= -6.42+0.027MS+0.10AST-MS

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