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"Morphometric Measurements of Mastoid Process for Gender Differentiation in Dried Skull"

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Abstract:
INTRODUCTION: *Generally gender can be identified by using the mastoid process based on inspecting its size i.e. larger or small. The size of male mastoid is larger than that of female but the problem is that, there are no standard criteria for identification purpose. A simply calling the mastoid smaller or larger is subjective and may vary depending on inspection. Therefore error may occur when inspection is done by unexperienced person. For these reasons this study is designed tried to find a criteria for identifying sex by measuring the size of the mastoid.*
AIMS AND OBJECTIVE: *To determine the sex from the cadaveric skull in North Indian population. The variables measured are-Mastoid length, breadth, A-P diameter& size.*
MATERIALS AND METHODS: *The present study was conducted in the Department of Anatomy, LLRM Medical College Meerut & Saraswathi Institute of Medical Sciences, Hapur on 100 dried skulls of cadaveric origin*
RESULT: *Present study showing variation in the size of the mastoid process among males and females.On comparing the mastoid parameters in between males and females, mean of mastoid length in males is 28.624 ± 8.99302 and in females is 23.922 ± .3603,mastoid breadth in male was 12.336 ± .1218 and in females12.389 ± 1.564,mastoid A-P diameter in males was 17.360 ± .1458 and in females it was 15.393 ± 1.8157 &mean of the mastoid size in males was 61.469 ± 1.091 and in females was 10.466 ± 1.480.*
CONCLUSION: *Variation in the size of the mastoid process among males and females was demonstrated, for each measurement, the male mean is slightly larger than the female mean and the reference range of each parameter is tabulated.*
Key Words: *Mastoid process, Mastoid process length, Mastoid process breadth, Mastoid process A-P diameter& Mastoid process size.*

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I. Introduction

Determination of sex is critical for identification of an individual. Advanced decomposition and mutilation incineration of the body necessitates the examination of skeletal remains for sex determination. In modern societies identification of human remains is necessary for both legal and social reasons (Buchner et al 1985).

Skull is considered next only to the pelvis in determining the sex (Bass et al-1971). Since it is composed of hard tissue usually preserved after death. Conventionally gender differentiation with skull is done using visual morphological assessment based on morphological traits posed by various bones of craniofacial structure. Accuracy of sex determination from skull ranges between 77-92% (Biggerstaff et al-1977).

The mastoid bone is a part of temporal bone of skull that had good part in sex identification.). Temporal bone has four part- Squamous part, Tympanic part, Petromastoid part and Styloid process. Mastoid process is a conical prominence projecting from the undersurface of mastoid portion of temporal bone, located just behind the external acoustic meatus and lateral to the styloid process. Its size vary, it is larger in males than in females.

Generally sex can be identified by using the mastoid process based on inspecting its size i.e. larger or small. The size of male mastoid is larger than that of female but the problem is that, there are no standard criteria for identification purpose. A simply calling the mastoid smaller or larger is subjective and may vary depending on inspection. Therefore error may occur when inspection is done by unexperienced person. For these reasons this study is designed tried to find a criteria for identifying sex by measuring the size of the

mastoid. Sex determination from the mastoid process is done metrically and nonmetrically by various authors. Studies on determination of sex by mastoid process in India are few, so the present study was conducted to determine the sex from the morphometery of mastoid process in cadaveric skull of western U.P.

II. Aims And Objective

The present study aims to assess the mastoid measurement as it has maximum sex discriminatory power among all skull variables to determine the sex from the cadaveric skull in Indian population. The variables measured are-

1.Mastoid length
2.Mastoid breadth
3.Mastoid A-P diameter
4.Mastoid size

III. Materials And Methods

The present study was conducted in the Department of Anatomy, LLRM Medical college Meerut & Saraswathi institute of Medical Sciences, Hapur on 100 dried skulls of cadaveric origin. The skulls were studied to determine the accuracy of mastoid process in sex determination. The skull of known sex in which spheno-occipital junction was synostosed and mastoid process of temporal bone was intact were included for study.The skull with physical damage were discarded.

The mastoid measurement were taken on both sides i.e right and left with the help of sliding vernier caliper and then the average of both were considered for statistical analysis.The parameters measured were-Length, Breadth, Antero-posterior diameter & Size of mastoid process.With the skull lying on its right side and facing the observer, the fixed arm of the vernier calipers was kept tangent to the upper border of the auditory meatus (Frankfurt plane) and the mastoid length was measured from this line to the tip of the mastoid process.Medio-lateral diameter was measured as the distance measured between the highest surfaces of mastoid process within the digastric fossa to the most lateral point of the process on the same level.

Antero-posterior diameter was measured as a distance between lowest point where tympanic plate abuts against anterior surface of mastoid process and the posterior border of the process on the same level.Size of mastoid process was obtained by multiplying the above said three variables and then dividing the product by 100.

Fig-1 Measurement of length of mastoid process

Fig-2 Measurement of width of mastoid process

Fig-3 Measurement of AP diameter of mastid process

IV. Observation

Present study showing variation in the size of the mastoid process among males and females as demonstrated by descriptive statistics. For each measurement, the mean of male variables is slightly larger than the female.

Independent t-test reveals that there is a significant difference between males and females, with p value much less than 0.05. On applying the t-test on the four variables (length, breadth, AP diameter and size) of mastoid process we found that all the variables were statistically significant.

TABLE-1 Comparison of mastoid length among males and females

GENDER	N	MEAN	SD	SEM	P	MIN	MAX
MALES	50	28.624	.6354	0.0910	.000	27.68	30.36
FEMALES	50	23.922	1.5475	0.3603	.000	18.62	27.60

On comparing the mastoid length in between males and female we observed that, mean of mastoid length in males is 28.624 ± 8.993E-02 and females is 23.922 ± .3603. The measurement when compared was statistically significant with p- value <.000. Table-1 also shows the minimum and maximum range of mastoid length among males and females

TABLE-2 Comparison of mastoid breadth among males and females.

GENDER	N	MEAN	SD	SEM	P	MIN	MAX
MALE	50	12.336	.8616	.1218	.000	11.08	15.00
FEMALE	50	12.389	1.564	.2213	.000	10.06	14.43

On comparing the mastoid breadth of males and females we observed that mean of the mastoid breadth in male was 12.336 ± .1218 and in females12.389 ± 1.564. These measurement when compared were statistically significant with p value = .000

TABLE-3 Comparison of mastoid A-P diameter among male and females

GENDER	N	MEAN	SD	SEM	P	MIN	MAX
MALE	50	17.360	1.031	.1458	.00I	16.60	20.54
FEMALE	50	15.393	1.815	.2568	.001	11.50	18.60

On comparing the mastoid A-P diameter between males and females we observed that mean of mastoid A-P diameter in males was 17.360 ± .1458 and in females it was 15.393 ± 1.8157. These measurement when compared were statistically significant with p value=.001

TABLE-4 Comparison of mastoid size among males and females

GENDER	N	MEAN	SD	SEM	P	MIN	MAX
MALES	50	61.469	7.716	1.0913	.012	53.91	85.57
FEMALES	50	10.466	10.466	1.480	.012	30.74	71.99

Size of mastoid process = Mastoid length × breadth × A-P diameter / 100

On comparing the mastoid size between males and females we observed that mean of the mastoid size in males was 61.469 ± 1.091 and in females was 10.466 ± 1.480. These measurement when compared were statistically significant with p value =.012

V. Discussion

The analysis of mastoid process is important in the determination of sex for forensic purposes. The present study has provided base line data for sex determination of skulls in western U.P. population. The sexual diamorphism of the mastoid process have been studied both by metric and nonmetric techniques.

Klaatsch et al (1908) observe that female skulls generally preserve infantile type of small mastoid process while the male present great variability.

Hoshi et al (1962) classified the mastoid process into 3 main types , viz M ,N and F type (M-male, N-neutral, F-female type) based on the direction of the mastoid process in relation to a vertical plane as assessed visually. He also suggested that when skulls were placed on flat surface, the male skulls rest on the mastoid process while female skulls on occipital condyles or other portion of skull.

Lanarch and Machintosh (1970) calculated the size of the mastoid process and divided it into five grades (very small, small, medium, large or very large). They concluded from their consecutive studies that females have predominantly very small to small sized mastoids in comparison to males who have predominantly medium to large sized mastoids.

Williams et al (2006) identified mastoid size as one of the high quality trait (>=80% accuracy and =<10% intra observer error) for sex determination in comparison to Roger's who proved it to be a tertiary consideration.

In present study length, breadth, A-P diameter, and size of mastoid process are measured on 100 dried skulls of western U.P. population with the help of vernier caliper in our department. We found that all the parameters measured for the mastoid process of males are larger than that of females and all the parameters are statistically significant.

Few researcher studied the sexual dimorphism in mastoid process by metric approach.

Keen's, Giles and Elliot (1950) observed that mean mastoid length was more in skulls of male individuals as compared to skulls of male individuals as compared to skulls of female individuals irrespective of race or region.

Kristen et al (2009) examine the two qualitative observation supramastoid crest size, and mastoid process size. He found that supramastoid crest is more consistent than scoring the size of mastoid process. Three paired quantitative classification were also calculated for the three mastoid measurements by him (mastoid radius, mastoid breadth and height) among males and females. Among these variables mastoid radius is the most consistent, measurement for determining the sex. In our study all the four variables shows higher values among males and lower values among females, and all the four variables were highly significant.

Sarawut (2011) studied the mastoid width and height on left and right side in Thais populations. He taken four parameters (left mastoid width-w, right mastoid width-W, left mastoid height-h, right mastoid height-H).In his study the mean of the right mastoid width (W) was 11.63 and in females it was 10.05 with p value <.001 which was clinically significant and the mean of length of right mastoid process was 25.17in males and 20.57 in females while in our study the mean of the width or A-P diameter of mastoid process in males is 17.36 and 15.39 in females, with p value .001 which is clinically significant and the mean of mastoid length is 28.62 in males and 23.92 in females, with p value <.00 which is clinically significant.

Sumati et al (2012) studied on 100 North Indians skulls, by taking four mastoid variables (mastoid length, breadth, A-P diameter and size).

Group Statistics for Mastoid Measurement by Sumati Et Al

	MALE		FEMALE		P VALUE
	MEAN	SD	MEAN	SD	
MASTOID LTH	28.30	4.04	23.18	4.24	<0.0001
MASTOID BDTH	11.46	2.70	8.68	2.59	0.0001
MASTOID A-P DIA	17.52	4.69	13.69	3.67	0.0008
MASTOID SIZE	60.18	31.33	30.99	22.67	0.0001

In the above study they find that mean of mastoid length was 28.30 while breadth was 11.46, A-P diameter was 17.52 and size was 60.18 among males and in females length was 23.18, breadth was 8.68, mastoid A-P diameter 13.6 and mastoid size was 30.99 while in our study we found that mean of the mastoid length is 28.62, breadth 12.33 and size is 61.46. These values are more than the values which are observed by Sumati et al. Only A-P diameter is smaller (17.36) than the A-P diameter (17.52) observed by Sumati et al.

Sanjai et al measures various parameters in the cranium and mandible of Thais for determining the sex by modified Krogman's cranioscopy and found that, males had a wider base and a higher mastoid process in

comparison to female. According to his study Mastoid breadth in males was-23.83 and in female was-19.30, Mastoid height in males was-17.59 and in femaleswas-13.59 while in our study the mastoid breadth in males was -12.33 and in female-12.38

Paiva et al (2003) determine the sex by measuring a triangular area over the mastoid process by the xerographic projection of 3 craniometric points related to the mastoid process : Porion: uppermost lateral part of the external auditory meatus, Asterion: the meeting point of the lambdoid, occipitomastoid and parietomastoid sutures. Mastoidale: the lowest point of the mastoid process. Then they draw a triangle linking these three points, this triangle was transferred to tracing paper and its area calculated on both right area(D) and left area(E) and the value of the total of these two measurement, the total area (T). The mean of the right area of the male skull was 752.10mm^2 and the total area of left area was 753.22mmand total area was 1505.32mm^2 while in females the values were 608.70mm^2 on right, 602.54mm^2 on left and 1211.24mm^2 was the total area. From this observation they concluded that the area that were equal or greater than 1447.40mm^2 belong to male crania, value less than or equal to 1260.36mm^2 belonged to female crania .

Suazo et al (2008) analysed 81 Brazilian skulls and determine the sex by using triangular area by taking 3 points, porion, asterion, mastoidale. The mastoid triangle area was calculated by means of Heron formula. On contrasting the equality hypothesis among the males and females, the area of right mastoid triangle and the total area was higher and more significant in male ($p<0.01$).

Patil et al (2005) studied lateral cephaometric radiograph of central Indian individuals and selected 10 cephalometric variables that helped in sex determination. These cephalometric variables included mastoid height and width. A discriminant function equation based on 10 cephalometric variables has also been derived.

Nagaoka et al (2008) diagnose the sex by using the mastoid process on the basis of discriminant function analysis, variable taken by them given below. In his study the accuracy of the sex classification was 80% by using single variable, 82-92% by two variable (MH_1 and MW).This accuracy is equal or better than that reported by some previous studies of sex determination using the cranium.

$MH_{I=}$Tip to mastoid between porion and posterior end of Incisura mastoidale.
MH_2=mastoid to the Frankfort plane
MH_3= Along the process itself
MW=at its base from incisura mastoidale to the corresponding level on the external surface
ML_1=from porion to posterior end of incisura mastoidale
ML_2=Porion to the asterion
(MH=mastoid height, MW=mastoid width, ML=mastoid length)

In the present study 4 variables of mastoid process were measured & in each measurement, the male mean is slightly larger than the female mean.

VI. Conclusion

Skull is also considered as the bone of choice for determining the sex, conventionally gender differentiation with skull is done using visual morphological assessment based on morphological traits posed by various bones of craniofacial structure. Accuracy of sex determination from skull ranges between 77-92%. Morphometric method using linear and angular dimensions have also contributed in the evaluation of skull in sexing in the modern practice. Present study will provide reference range for various parameters of mastoid process for gender differentiation.

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