Original Article

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Metric Study of Mastoid Triangle for Sexual Dimorphism

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Abstract

Background & Aims: The mastoid region, a fragmentary piece of skull is ideal for sex determination as it is more robust and tough making it resistant to physical damage. The mastoid bone is most protected, due to its anatomical position at the baso-lateral region of the skull. In present study, mathematical dimensions of various parts of mastoid were used by craniometric techniques to identify the sex in fragmentary remains. *Material & Method:* The study was performed on 132 human skulls of known sex (80 Males & 52 Females) collected from Bone Bank of Department of Anatomy at Govt. Medical College, Aurangabad and various medical colleges of Marathwada region. The measurements were taken on mastoid region of skull by defining the three craniometrical points- Asterion, Porion and Mastoidale. Distance between these three craniometrical points were located and measured in mm to calculate the area in mm^2 by Heron's formula on both right and left side of skull. Unpaired't' test were used for data analysis. Total mastoid area was calculated by adding the right and left triangular areas. The total area being used as it would avoid asymmetry between the areas, so it can be used for sex determination. *Results:* The means of all mastoid measurements and total mastoid triangular area in males are significantly larger than those of the females ($p<0.001$). Result showed significant craniometric differences between male and female mastoid triangle on both right and left side of skull. *Conclusion:* The mastoid measurements and total mastoid triangular area provides an accurate method for sex determination in Marathwada population. Knowledge of above dimensions of mastoid process will be helpful to physical and forensic anthropologist for sexing of human skull from fragmentary skeletal remains.

Keywords: Craniometric Points; Mastoid Triangle; Sex Determination; Area.

Introduction

Mastoid process is a conical downward projection from the external surface of mastoid part of temporal bone. Mastoid process is absent at birth and appears during second year by the pull of sternocleidomastoid muscle when child moves his head [1]. It is more robust in males than in females and which is most likely due to the larger muscles that insert on the mastoid process in males. The visual assessment is commonly applied for sex estimation from mastoid region due to its relative ease of use, but it is critical as it reflects subjectivity in observation [2].

Sex determination of human skeletal remains is considered as a vital step in identification and is crucial for further analysis. In the skull, the temporal bone is highly resistant to physical damage, thus it is commonly found as a remainder in the skeletons that are very old age and of this the petrous portion has been described as important for sex determination [3].

The skull is the most dimorphic and easily sexed portion of skeleton after pelvis, providing up to 92% reliability. Both metrical and morphological characteristics may be helpful in fragmented skull bone to determine the sex [4].

Paiva and Segre (2003) [5] introduced an easy technique to determine the sex of skulls by indirect mastoid process measurements. They obtained the xerographic copy of each side of the skull. After that,

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three craniometric points like asterion, porion, and mastoidale were used for triangular area calculation by Heron's formula and made a summation of right and left triangle area to the total area value. The result showed significant differences between sexes in right and left triangle area and total area. This technique had a small observational error and high degree of predictability.

The validity of above sexual dimorphism in the mastoid triangle has been evaluated by Kemkes and Gobel [6] in German forensic and Portuguese cemetery sample by direct mastoid measurements on the skull with a sliding vernier caliper. However results of the study did not reveal the excellent results as like the previous study by Paiva [5].

Subsequently, Nagaoka T et al [7] measured height, width and length of the mastoid process in Japanese human skeletons to postulate the advantage of mastoid measurements as good sex determinators. The results revealed that the percentage accuracy of sex classification is more than 80% with one variable and increased to 82 to 92% with two variables. This indicated greater accuracy than previous studies.

According to method developed by De Paiva and Segre [5], different studies were done by different workers by using three reference points - porion, asterion and mastoidale, to calculate the area of mastoid triangle in Brazilian skulls [8], in Thais [9], in South Indian population [10], in Gujarat population [11].

Comparison of mastoid triangular area between CT scan and manual method in South Indian population were studied to evaluate the significance of measurements. But the results showed no significant difference between CT scan and manual method of area measurement of mastoid process [12].

The objective of the present study was to assess the sexual dimorphism in the dimensions and triangle area of the mastoid process in Marathwada region of Maharashtra, measured directly on the skull using three craniometric points of mastoid process.

Materials and Methods

The study sample was taken from the Bone Bank of Department of Anatomy, Government Medical College, Aurangabad and various medical colleges of Marathwada region. Total 132 dried adult human skulls (80 Males and 52 Females) were used to get craniometrical data of the mastoid process. Deformed and damaged skulls were excluded from the study. The present study was carried out using method applied by previous researchers [5], which was based on craniometric dimensions of mastoid part of the skull. The dimensions of the both sides of mastoid triangles were measured directly [6] on the skull by sliding vernier caliper, using the three craniometrical landmarks. [Figure 1].

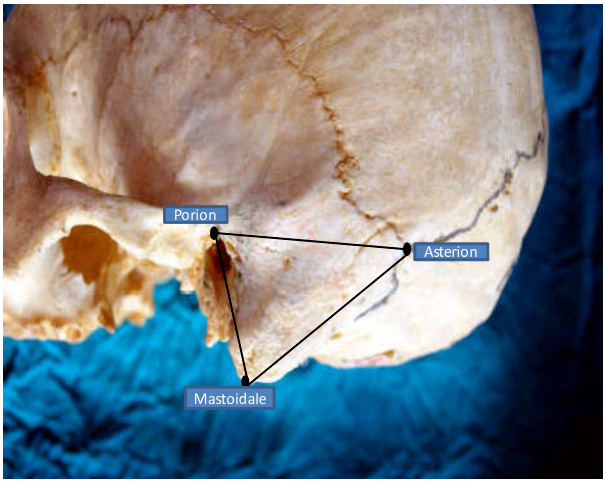

Fig. 1: Lateral view of the skull showing three craniometric landmarks: Porion (Po), Asterion (AST), Mastoidale (Ms) forming mastoid triangle

Porion (Po): Superior point of external acoustic meatus.

Mastoidale (Ms): is the tip of mastoid process.

Asterion (AST): is the meeting point of lambdoid, occipitomastoid and parietomastoid sutures.

The points were located and marked on both sides of the skull. Then the distance between the three landmarks were measured by a single investigator in order to eliminate interobserver error. The area of mastoid triangle was calculated in mm^2 by means of the Heron's formula. When one knew the lengths of sides, the area of triangle can be calculated by this formula.

$$= \sqrt{s(s \quad a)(s \quad b)(s \quad c)}$$

a, b, and c are the length of the sides.

$$s = (a + b + c) \div 2$$

After that, the descriptive statistics of all mastoid dimensions and mastoid triangle area were analyzed by using statistical package for social sciences (SPSS) computer software, assessing the correlation between the male and female. The mean, standard deviation and p value were calculated and

its significance was tested by students unpaired 't' test. "P"- Values of less than 0.05 were considered to be statistically significant difference between sexes.

According to the method described by De Paiva and Segre [5], the total area was calculated by adding the area obtained on both right and left side of skull.

Observation and Results

The study comprised of 132 adult dried Human skulls, of which 80 were males and 52 were females. Student's unpaired 't' test were applied for analysis of all the sampled skulls. The lineal dimensions of all the variables of mastoid region (AST-Ms; AST-Po; Po-Ms) and area of mastoid triangle on right and left side of skull were higher in males than in females. The descriptive statistics with mean, standard deviation of all mastoid parameters for both the sexes, which were illustrated in table 1 for right side and Table 2 for left side, given below. The 'p' value and 't'value was also presented in respective tables.

Table 1 showed that, all the mastoid variables were higher in males than in females on right side of skull. The difference was found to be statistically significant.

The side wise (right and left) analysis of female skull by applying student's unpaired't' test showed significant difference for all the above mastoid variables with p value of ≤ 0.05. Whereas in males, the sidewise (right and left) analysis skull showed that only asterion to porion length (AST- Po) was significant with p value of <0.05, rest of the variables were insignificant.

When unpaired 't' test was applied for sexwise (male and female) analysis of all the sampled skulls for right side as shown in table 1 and for left side as shown in Table 2, proved that, all the mastoid measurements were found to be significantly larger in males than in females on both sides of skull with p value ≤ 0.0001 levels. It was also found that, in both sexes, the values on right side of mastoid region were higher than on the left side.

Table 1: Descriptive statistics for sex determination from **right** mastoid triangle (in mm & mm^2) with p value & t value for differences in means between both sexes

Sr. No.	Mastoid variable	Sex	N	Mean	Standard deviation	t value p value
1	Asterion- Mastoidale (mm)	Male	80	48.92	0.338	5.565
		Female	52	45.38	0.356	0.0001*
2	Asterion- Porion (mm)	Male	80	45.82	0.250	5.558
		Female	52	43.30	0.235	0.0001*
3	Porion- Mastoidale (mm)	Male	80	30.32	0.252	7.050
		Female	52	27.12	0.272	0.0001*
4	Right triangular area (mm^2)	Male	80	586.05	6.117	7.190
		Female	52	508.47	5.39	0.0001*

*highly significant

Table 2: Descriptive statistics for sex determination from **left** mastoid triangle (in mm & mm^2) with p value & t value for differences in means between both sexes

Sr. No.	Mastoid variable	Sex	N	Mean	Standard deviation	t value p value
1	Asterion- Mastoidale (mm)	Male	80	47.75	0.843	3.906
		Female	52	39.80	1.486	0.0001*
2	Asterion- Porion (mm)	Male	80	44.10	0.762	3.427
		Female	52	37.61	1.38	0.0001*
3	Porion- Mastoidale (mm)	Male	80	29.40	0.518	5.120
		Female	52	23.23	0.8954	0.0001*
4	Right triangular area (mm^2)	Male	80	565.30	11.47	5.209
		Female	52	436.37	16.74	0.0001*

*highly significant

Table 3: Statistics for total mastoid triangular area in males and in females

Sr. No.	Parameter	Sex	Right area	Left area	Total area(mm2)	t value p value
1	Total mastoid triangle area	Male	586.05	565.30	1151.3	6.967
		Female	508.47	436.37	944.85	0.0001

Table 3 showed that, the mean total area of mastoid triangle in male skulls was 1151.3 mm^2 which was statistically highly significant when compared with mean total area of female skull (944.85 mm^2).

The maximum values for the total area calculated in the males and females were 1490.6 mm^2 and 1232.4 mm^2 respectively whereas the minimum values for the same were 950.9 mm^2 and 863.4 mm^2 in males and females respectively.

It was found that the unpaired student's t test was extremely significant when male right side was compared with female right side as well as male left side compared with female left side which indicates that the measurements of mastoid variables can be used for sex determination in unknown skull.

Discussion

The present study aimed to develop population-specific, sex determining anthropometric standards for the mastoid triangle which are important for anthropometrical and forensic purposes.

Previous authors agree that qualitative aspects of mastoid process such as their size, robustness due to large muscle attachment and inclination of mastoid process, are very good indicators of sexual dimorphism. They concluded that the mastoid process is more robust in males with its large size. However, various discussions have put forward from the quantitative point of view.

With respect to quantitative aspects, the present study analyzes the dimensions of the denominated mastoid triangle, defined according to that described by De Paiva and Segre [5] in their original article, but measured directly on the skull as like Kemkes and Gobel [6].

We found that, mean values of all the three sides of mastoid triangle (Asterion- mastoidale; Asterion-porion; Porion- mastoidale), and total area of mastoid triangle were larger in males on both right and left side of skull. The difference was found to be statistically highly significant as revealed by 'p' value of <0.0001.

In the study done by, De Paiva and Segre [5], the average area in males was 1505 mm2 and in females was 1211 mm2 which was more as compared to present study having mastoid area in males as 1151 mm2 and in females 944.8 mm2. These differences may be the effect of their method which was using xeroghraphic copy for indirect measurements.

In the Portuguese population, Kemkes & Gobel [6] (2006), found all the lineal dimensions of mastoid region and area of mastoid triangle to be statistically significant in determination of sex similar to the result of present study. Whereas in German population, only the two sides [except asterion-mastoidale distance] and total area were significant. They stated that, the measurements show disparity in the population – specific of sexual dimorphism between German and Portuguese samples but the technique was not practical when the skull remains have to be independently assessed. They concluded that using mastoid triangle area as a sex determination was highly questionable.

Suazo and co-workers [8], in their study found that distance between porion to mastoidale, right mastoid triangular area and total area showed statistically significant difference between both sex groups with p value <0.01. Further they concluded that, the parameters of mastoid triangle were debatable for sex diagnosis in practice.

In Thai population, C. Manoonpol [9] also found that the mean values of all the three sides of mastoid triangle are significantly larger in males, which is similar to the present study. The total area in males was 1778 mm^2 and in females it was 1486 mm^2 which is larger than present study. This may be due to population specificity.

The studies done in South Indian population [10], in Gujarat population [11], concluded that the total mastoid triangular area in males were significantly larger than those of females ($p \leq 0.01$). In the present study, we established that the mastoid triangle is sexually dimorphic.

Conclusion

The results of the present study indicate that all the three sides of mastoid triangle and area of mastoid triangle are sexually dimorphic in the sampled Marathwada region of Maharashtra.

Although population specific differences are evident, this should be considered cautiously as the methodologies employed to study of mastoid triangle differ in the various reports published. The sexual dimorphism in the present study was based on direct measurement of dimensions of mastoid region by vernier caliper, so this technique is easy to execute, offers quick results to meet the needs and realities of the forensic investigation.

Hence, the sexual dimorphism can be assessed by using above variables for either a complete or

fragmented skull. The findings presented can be applied in the procedures of physical anthropology, forensic anthropology and Bioarchaeology.

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