Morphometric sex determination from mastoid triangle in South Indian population

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Abstract

Introduction

The living has responsibility for the dead, particularly, in civilized societies which recognize the need for identity both in living and dead. Identity of a person means individuality of that person[1]. Identification is one of the main objectives of any medico-legal autopsy. Unknown bodies in full or in part and sometimes skeletal remnants are brought for examination. Identification is vital in such situations, and determination of sex, age, and stature can reduce the given population in smaller group.

Forensic identification has evolved into an art of science which involves various specialties[2]. Forensic anthropology is one such sub-specialty within Forensic Science, which deals with human skeletonised remains and their environment[3]. In the field of Forensic anthropology determining gender from skeletal remains, especially from isolated bones, has been an age old problem. In this context skull plays an important role, being the second best region of skeleton to determine the gender, next to pelvis[3,4]. In the skull the mastoid region is favourable for sex determination, as it is the most protected region, due to its anatomical position at the base of the skull. Therefore this study has been undertaken to determine sex based on the triangular area calculated from the corresponding temporal bone obtained between the three easily identifiable carniometric landmarks i.e. the porion, mastoidale and asterion joining to form the mastoid triangle from both sides of the skull.

Methods

The present study was an autopsy based study of the mastoid triangle for sex determination of the skull. This study was conducted at the mortuary of the Government District Wenlock Hospital, Mangalore, South Canara, Karnataka, India. The study sample consisted of total 100 skull samples, 50 male and 50 female skulls autopsied at the centre mentioned above between June 2010 to July 2011. Cases with head injuries and fractures involving the mastoid triangle, temporal bone

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and base of the skull; partially fused ectocranial sutures surrounding the asterion; below 15 years of age (because the sutures at the asterion starts its fusion at this age) and above 60 years of age (asterion gets completely fused at this age); and partially or completely charred body were excluded from the study.

A coronal incision on skin was given from the tip of one mastoid process to the another running over the vertex. The scalp was retracted; the temporalis muscle and tendons of sternocleidomastoid muscle, trapezius muscle and splenius capitis muscle are separated with the help of scalpel and chiseled from the skull. Then the area corresponding to the mastoid triangle is scrapped off with sharp edge of chisel to clean the adherent pericranial tissue, then the area is cleaned with a clean piece of cloth and the three points are identified and marked.

The three points (Fig. 1) that are to be identified in this study are

1. Porion (Po) – the uppermost lateral point of the external auditory meatus[5].
2. Mastoidale (Ms) – the lowest point of the mastoid process[5].
3. Asterion (Ast) – the meeting point of the lambdoid, occipitomastoid, and parietomastoid sutures[5].

The points are located and marked by a single investigator on both sides of the skull and sliding vernier calliper was used to measure the distance between these three points in centimetres. The area of the triangle was calculated using Heron's formula[6].

The data were analyzed using Statistical Package for Social Sciences (SPSS) computer software assessing the correlation between the male and female the coefficient was calculated and its significance was tested by students "t" test. "P" value of less than 0.05 was considered as significant.

Result

The study comprised a total of 100 cadavers brought for medico legal autopsy at the centre mentioned above, of which 50 were male and 50 were female. The age distribution for males varies from 18 to 60 years with mean age 34.0 years, and for female the age varies from 18 to 56 years with mean age 31.58 years, as described in the table 1.

Table 1: Age of the sample study

Sex	Minimum age	Maximum age	Mean	Standard deviation
Male	18	60	34.0000	10.54824
Female	18	56	31.5800	11.11919

The side wise analysis of mastoid triangles of right and left with each other for both the sex showed no significant difference in size. Whereas it was found that the different measurements showed very high significant difference for both the sexes, which are illustrated in the table 2 for right side and table 3 for left side, given below.

Table 2: Sex determination from right mastoid triangle

Site	Side	N	Mean	Standard deviation	T
Asterion to porion (cm)	Male	50	4.5040	0.35339	4.18700
	Female	50	4.2400	0.27180	p<0.001
Asterion to mastoidale (cm)	Male	50	5.0880	0.33481	5.38700
	Female	50	4.6960	0.39069	p<0.001
Mastoidaleto porion (cm)	Male	50	3.1140	0.34107	4.32300
	Female	50	2.8140	0.35284	p<0.001
Area (cm^2)	Male	50	6.8888	0.92969	5.82600
	Female	50	5.8380	0.87314	p<0.001

Table 3: Sex determination from left mastoid triangle

Site	Side	N	Mean	Standard deviation	T
Asterion to porion (cm)	Male	50	4.5060	0.32097	4.26000
	Female	50	4.2600	0.25234	p<0.001
Asterion to mastoidale (cm)	Male	50	5.0980	0.31330	6.26400
	Female	50	4.6900	0.33761	p<0.001
Mastoidaleto porion (cm)	Male	50	3.1460	0.32212	5.10700
	Female	50	2.8200	0.31623	p<0.001
Area (cm^2)	Male	50	6.9792	0.89628	6.55300
	Female	50	5.8762	0.78312	p<0.001

Since the two mastoid triangles of a skull showed no significantly different in size, the right and left sides were pooled together (N=100) for both sexes. Then sex wise analysis which showed a significant difference as illustrated in the table 4.

Table 4: Sex determination from the mastoid triangle when (n = 100)

Measurements	Sex	N	Min	Max	Mean	Standard deviation	t
Asterion to Porion (cm)	Male	100	3.70	6.00	4.5050	0.33586	5.995
	Female	100	3.60	4.90	4.2500	0.26112	p<0.001
Asterion to Mastoidale (cm)	Male	100	4.50	6.00	5.0930	0.32263	8.23
	Female	100	3.50	5.40	4.6930	0.36328	p<0.001
Mastoidale to Porion (cm)	Male	100	2.40	3.90	3.1300	0.33044	6.668
	Female	100	1.40	3.70	2.8170	0.33335	p<0.001
Area (cm^2)	Male	100	5.40	9.67	6.9340	0.90965	8.767
	Female	100	2.98	8.04	5.8571	0.82538	p<0.001

In males, the length of Asterion to Porion varies from 3.70cm to 6.00cm with a mean 4.50, the length of Asterion to Mastoidale varies from 4.50cm to 6.00cm with a of mean 5.09, and the length of Mastoidale to Porion varies from 2.40cm to 3.90cm with a mean of 3.13.

In female, length of Asterion to Porion varies from 3.60cm to 4.90cm with a mean of 4.25, the length of Asterion to Mastoidale varies from 4.50cm to 6.00cm with a mean of 4.69, and the length of Mastoidale to Porion varies from 1.40cm to 3.70cm with a mean of 2.82.

Using the data, regression model equation was derived for sex determination for individual component of the mastoid triangle.

Regression model equation for estimation of sex from the length between Asterion to Porion:

D = 4.137 – 0.602 X Length between Asterion to Porion (cm)

In which:

R	R^2	Standard error	T
0.392	0.154	0.462	9.378 p<0.001

The cut-off point to say the sex of the individual = value less than 1.5 belongs to that of a male and value more than 1.5 belongs to that of a female.

The predicted analysis for sex in the sample collected:

		Male sample	**Female sample**	**Total**
Predicted as male	Count	70	35	105
	Percentage	70.0%	35.0%	52.5%
Predicted as female	Count	30	65	95
	Percentage	30.0%	65.0%	47.5%

Regression model equation for estimation of sex from the length between Asterion to Mastoidale:

D = 4.620 – 0.638 X Length between Asterion to Mastoidale (cm)

In which:

R	**R^2**	**Standard error**	**T**
0.505	0.255	0.433	12.152 p<0.001

The cut off point to say the sex of the individual = value less 1.5 belongs to that of a male and value more than 1.5 belongs to that of a female.

The predicted analysis for sex in the sample collected:

		Male sample	**Female sample**	**Total**
Predicted as male	Count	73	34	107
	Percentage	73.0%	34.0%	53.5%
Predicted as female	Count	27	66	93
	Percentage	27.0%	66.0%	46.5%

Regression model equation for estimation of sex from the length between Mastoidale to Porion:

D = 3.242 – 0.586 X Length between Mastoidale to Porion (cm)

In which:

R	**R^2**	**Standard error**	**T**
0.428	0.183	0.454	12.317 p<0.001

The cut off point to say the sex of the individual = value less than 1.5 belongs to that of a male and value more than 1.5 belongs to that of a female.

The predicted analysis for sex in the sample collected:

		Male sample	Female sample	Total
Predicted as male	Count	67	34	101
	Percentage	67.0%	34.0%	50.5%
Predicted as female	Count	33	66	99
	Percentage	33.0%	66.0%	49.5%

Regression model equation for estimation of sex from the length between Areas:

D = 3.161 – 0.260 X Area (cm^2)

In which:

R	R^2	Standard error	T
0.529	0.280	0.426	16.478 p<0.001

The cut-off point to say the sex of the individual = value less than 1.5 belongs to that of a male and value more than 1.5 belongs to that of a female.

The predicted analysis for sex in the sample collected:

		Male sample	Female sample	Total
Predicted as male	Count	66	23	89
	Percentage	66.0%	23.0%	44.5%
Predicted as female	Count	34	77	111
	Percentage	34.0%	77.0%	55.5%

In mastoid triangle the length between asterion to mastoidale gives the best predicted value for sex determination (r = 0.505) next to area of the mastoid triangle (r = 0.529). Therefore a combination of multiple measurements of the mastoid triangle is also formulated.

Regression model equation using multiple components of the mastoid triangle and the area of the mastoid triangle was derived.

D = 5.252 – 0.115 X Length between Asterion to Porion (cm) – 0.443 X Length between Asterion to Mastoidale (cm) – 0.381 X Length between Mastoidale to Porion (cm) + 0.008 X Area (cm^2)

In which:

R	R^2	Standard error
0.563	0.317	0.418

The cut off point to say the sex of the individual = value less than 1.5 belongs to that of a male and value more than 1.5 belongs to that of a female.

The predicted analysis for sex in the sample collected:

		Male	**Female**	**Total**
Male	Count	71	27	94
	Percentage	71.0%	27.0%	49.0%
Female	Count	29	73	106
	Percentage	29.0%	73.0%	51.0%

When all the components of mastoid triangle are combined and a formula is derived the predictability increased (r = 0.563). Therefore it is advisable to combine all the parameters instead of taking individual parameters. However the percentage of overlapping in between male and female is 52.5%.

Discussion

Identification is the basis of individuality of a person. Skeleton is the part of the body that resists all environmental insults for maximum time, and can help to determine the sex, estimate the age, race and stature of the person. Determination of sex is one important parameter. It has already been shown that people in different regions, different races and ethnic groups vary considerably in proportion of their respective skeletal frame. For identification one requires standard criteria which are specifically based to the group to which the person belongs. Due to lack of study in reference to sex determination from the mastoid triangle in this part of the World underlines the importance of the present study. In the skull the mastoid region is favourable for sex determination, as it is the most protected region and resistant to damage, due to anatomical position at the base of the skull[5].

The different measurement of the mastoid triangle i.e. Asterion to Porion, Asterion to Mastoidale, Mastoidale to Porion, and the area of the mastoid triangle, is taken from both sides of the skull. When the sidewise analysis was done for both the sex for each measurement, it was found that there is no significant difference (p = more than 0.622). But when sex-wise analysis was done the accuracy of determining sex from our study is found to be higher for all the parameters of the mastoid triangle, indicated by the highly significant p value (p < 0.001), which is in accordance with the study conducted by Paiva[5], Segre[5] in 2003, but his study was conducted on the Xerox copy of the mastoid triangle in dry skull.

In another study conducted by Galdames ICS[7], Matamala DAZ[7] and Smith RL[7], a similar result was seen in the Brazilian population, where in the mastoid triangle measurements were taken directly on the dry skull and was found to be sexually dimorphic. This study is superior to the study conducted by Paiva[4] and Segre[4] as this study in conducted on the dry skull.

The study conducted by Kemkes A[6] and Gobel[6] , in two different populations, one being German and another Portuguese population, concluded that the mastoid triangle is a population specific and that the Portuguese sample is more sexually dimorphic than the German population.

A study conducted in North India by Singh RP[8], Verma SK[8], and Tyagi AK[8s], come to a similar conclusion that Mastoid triangle was sexually dimorphic in North Indians. The study restricted itself to individual measurement and the area calculated in various age groups for male and female.

In the present study, we established that the Mastoid triangle is sexually dimorphic, the sides do not pose any difference in the determination in sex. The regression equations which were formulated can further help the Forensic experts to determine the sex with much ease. In relation to regression equation, area of the mastoid triangle showed high accuracy (52.9%), but when all the measurements were taken into account and regression equation is formulated, the accuracy was very significantly raised (56.3%). The percentage of overlapping (52.5%) in our study is also less as compared to the previous study (60%).

Conclusion

In conclusion, the results of the study indicate that the area of the mastoid triangle could be used to determine the gender in case of fragmentary remains of the skull. However the other measurements can be taken in account but are not a good indicator for sex determination when used individually. However, there is scope for further study with a larger sample size to emphasize the above findings and to arrive at accurate demarcating points.

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