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ORIGINAL PAPER

Gender prediction: anthropometric study of mastoid process and foramen magnum

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ABSTRACT

Introduction*: Sex determination of human skeletal remains is considered as an initial step in identification. Sex determination of fragmented skeletal remains has immensely helped in identification of an individual. Foramen Magnum is an integral component of studies on skull in particular interest for anthropology, anatomy, forensic medicine, and other medical fields.* ***Objectives****: The aim of this study was to evaluate the use of mastoid process and foramen magnum measurements as a tool for sex determination in unidentified skeleton.* ***Methods****: Seventy seven completely undamaged skulls of known sex in book record were used for the study. Adult crania (age ranges between 20 -70 years) of known sex were obtained from various sources. Adult skulls of mature individuals, without destruction of mastoid process in the region of the craniometrical points, were chosen for the study. Skulls that showed evidence of injury/ fracture or deformity were excluded from this study. A measurement of the mastoid and foramen magnum was done as per Moore-Jansen et al. 1994, using vernier/ sliding calipers (0.01mm) and craniophore. Analysis was done using IBM – Statistical Package for Social sciences (SPSS) version 21. The means between the male and female samples were compared for significance using the Student's t – test.* ***Results****: Out of the 77 skulls studied, 45 were male and 32 were females. In male, mastoid length mean is 2.82, whereas in female it is 2.51. In male the mastoid width mean is 1.57 and in female is 1.38. Statistics revealed high significance in mastoid length and mastoid width (p value: 0.01 and 0.012 respectively). Mastoid index did not show much significance.* ***Conclusion****: Our study revealed statistically significant parameters ($p<0.05$) in mastoid length and mastoid breath. Reports on the use of mastoid process and foramen magnum as a tool for sex determination in unidentified human skeleton has been reported in different populations.*

Keywords*: Sex determination Mastoid length, Sexual dimorphism, South Indian population*

INTRODUCTION

Sex determination of human skeletal remains is considered as an initial step in identification. In cases of fragmented or mutilated body, it is difficult to identify the body. Sex determinations of such skeletal remains have immensely helped in identification of an individual. This skilful process is carried out by forensic and anatomy experts.

Anthropometry which aids the understanding[1] of anatomical structures constitutes the technique of expressing quantitatively, the form of human body and skeleton. Almost all bones of the human skeleton show some degree of sexual dimorphism.[2-4] Sex of the person can be determined using pelvis if cranium is not available for study. In cases where entire skull is not found, mastoid plays an important role in sex determination as it is the most dimorphic bone of skull.[5] The mastoid region, a fragmentary piece of the skull, is ideal for sex determination as it is resistant to damage due to its anatomical position at the base of skull and its toughness.

Hence we performed this study to evaluate the use of mastoid process and foramen magnum measurements as a tool for sex determination in unidentified skeleton.

METHODS

Adult crania (age ranges between 20 and 70 years) of known sex were obtained from the archives of the Department of Forensic Medicine and Toxicology and Department of Anatomy from

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Tagore Medical College & Hospital and Sri Ramachandra Medical College & Research Institute, Chennai, Tamil Nadu and also from Anthropology Department Sri Venkateshwara University, Tirupathi, Andhra Pradesh. Adult skulls of mature individuals, without destruction of mastoid process in the region of the craniometrical points, were chosen for the study. Skulls that showed evidence of injury/fracture or deformity were excluded from this study. Measurements for all crania were taken by the same person twice but at different sittings after formal training. Their average was then used in data analysis. Each cranium was placed on a flat surface and the measurements were taken from a particular landmark. Measurements of the mastoid and foramen magnum was done as per the method of Moore-Jansen, et al. 1994.[6]

The following measurements were taken:

Cranial length: Maximum cranial length was measured by using spreading calliper from glabella to opisthocranion.

Cranial breadth: At right angle to mid-sagittal plane, maximum breadth was taken above the level of mastoid crests with spreading calliper.

Cranial index: $\frac{\text{Maximum Cranial breadth}}{\text{Maximum Cranial length}} \times 100$

Basion (ba): The midline point on the anterior margin of the foramen magnum. (**Fig**. **1**)

Opisthion (o): The midline point at the posterior margin of the foramen magnum. (**Fig**. **1**)

Foramen Magnum Length (ba-o): Direct distance from basion (ba) to opisthion (o).

Tips of caliper should rest precisely on opposing edges of the border of foramen magnum.

Foramen Magnum Breadth: Distance between the lateral margins of foramen magnum at the points of greatest lateral curvature. **(Fig**. **1)**

Foramen magnum Index: $\frac{\text{Foramen Magnum Breadth}}{\text{Foramen Magnum Length}} \times 100$

Mastoid Length: vertical projection of the mastoid process below and perpendicular to the eye-ear (Frankfort) plane (**Fig**. **2**).

Mastoid Width: From the incisura mastoidea to a corresponding level on the external surface of the process, transversely with reference to the process itself and perpendicular to the incisura mastoidae.[7]

Mastoid index: $\frac{\text{Mastoid width}}{\text{Mastoid length}} \times 100$

DATA MANAGEMENT AND ANALYSIS

Analysis was done using IBM – Statistical Package for Social sciences (SPSS) version 21. The means between the male and female samples were compared for significance using Student t – test. Level of significance was fixed at $p < 0.05$.

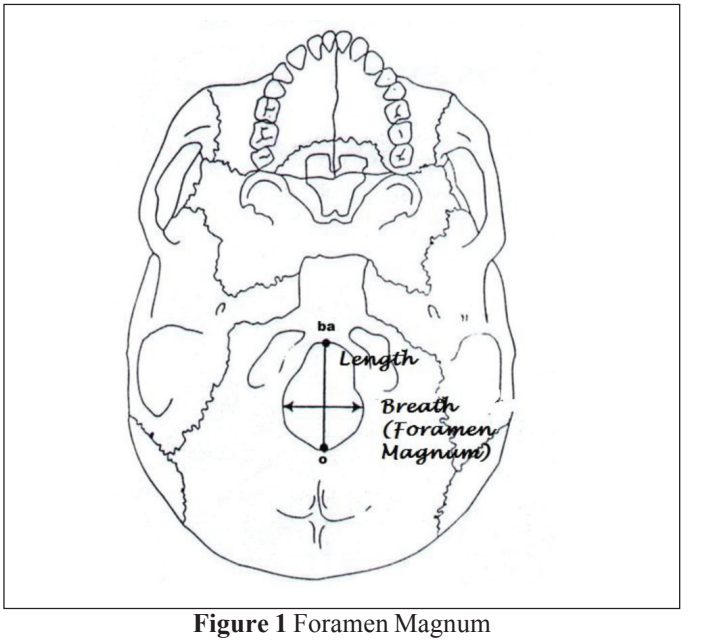

Figure 1 Foramen Magnum

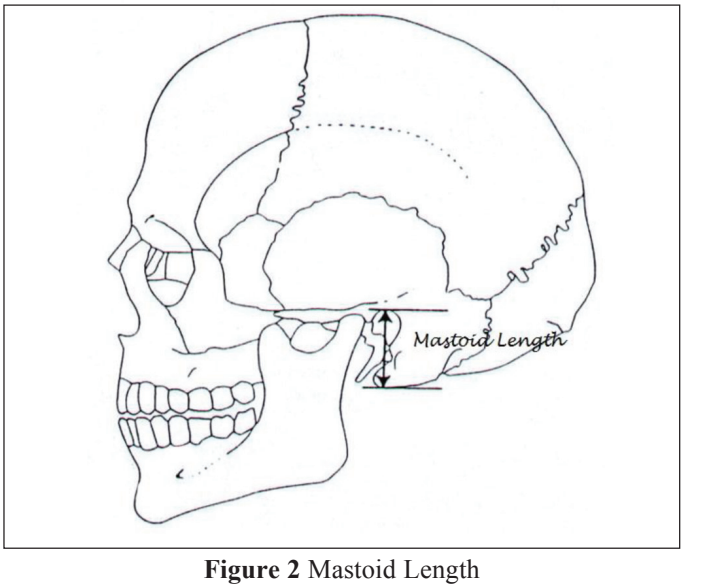

Figure 2 Mastoid Length

RESULTS

Out of the 77 skulls studied, 45 were male and 32 were females. Among the total population the mean Cephalic Index (C.I) was 71.51±5.3. The C.I was higher among the male subjects as compared to the females. Among the male subjects, the C.I ranged between 60.57 and 84.8(mean 71.75 ± 5.31). The female C.I ranged between 59.3 and 88.7(mean 71.51± 8.02) as shown in **Table 1**.

Table1 Various parameters of cranium

Sex	Mean	N	Standard deviation (SD)	Standard error of mean (SEM)	Maximum	Minimum	T value	P value
Male	71.75	45	5.319	.792	84.80	60.57	0.373	0.009
Female	71.18	32	8.029	1.419	88.70	59.30		
Total	71.51	77	6.539	.745	88.70	59.30		

Table 2 Various parameters of Mastoid process

Parameters	Gender	no	Minimum	Maximum	Mean	S.D	S.E	T value	P value
Mastoid length	Male	45	2.1	3.7	2.82	0.38	0.05	3.47	0.01*
	Female	32	1.7	3.3	2.51	0.37	0.06		
Mastoid width	Male	45	0.9	2.4	1.57	0.35	0.05	2.57	0.012*
	Female	32	.92	1.8	1.38	0.25	0.04		
Mastoid index	Male	45	26.1	92.3	57.16	16.24	2.42	.23	0.8
	Female	32	35.6	94.1	56.32	14.02	2.47		

*p<0.05 - statistically significant

There is significant difference in mastoid length and width among male and female (p<0.05). There is no significant correlation between mastoid index and cephalic index. The length of mastoid process in males and females was found to be 2.82 ± 0.38 and 2.51± 0.37 respectively. Mastoid index was found to be 57.16 ± 16.24 and 56.32 ± 14.02 in males and females respectively as shown in **Table 2**.

Table 3 Various parameters of Foramen Magnum

Parameters	Gender	no	Minimum	Maximum	Mean	S.D	S.E	T value	P value
FM length	Male	45	2.70	4.20	3.48	.28	.04	2.08	0.62
	Female	32	3.00	3.90	3.36	0.28	0.04		
FM breadth	Male	45	2.4	4.1	2.864	.29	0.04	0.86	0.59
	Female	32	2.46	3.6	2.78	0.26	0.04		
FMI	Male	45	66.67	122.22	82.5	9.33	1.39	0.77	0.02*
	Female	32	71	120	83.12	9.87	1.7		

*p<0.05 statistically significant

Table 4 Comparisons of findings of present study with others

Authors and years	Antero posterior diameter (cm)	Transverse diameter (cm)
Coin and Malkasian, 1971[8]	3.4	2.9
Sayee, et al., 1987[9]	3.4	2.8
Berge and Bergmann, 2001[10]	3.3	2.8
Kizilkant, et al., 2006[11]	3.4	2.9
Deshmukh and Devershi, 2006[12]	3.4	2.9
Damiani, et al., 2012[13]	3.4	2.8
Raghavendra, et al., 2012[14]	3.5	2.8
Radhakrishna, et al., 2012[15]	3.4	2.8
Singh and Talwar, 2013[16]	3.3	2.7
Muralidhar, et al., 2014[17]	3.3	2.8
Our study, 2016	3.4	2.9

The length and breadth of foramen magnum was more in male than in females as shown in **Table 3**. But the Foramen magnum index (FMI) was observed to be surprisingly more in females (83.12±9.87) than in males (82.5±9.33) and was statistically significant (p<0.05). The mean FMI of the study population was 83.28±10.4 as shown in **Table 3**.

DISCUSSION

Skull is an important tool for identification purpose. With the help of Moore-Jansen et al[6] parameters, measurements of mastoid process of skull of known sex were taken.

The length of mastoid process in males and females was found to be 2.82±0.38 and 2.51± 0.37 respectively. Mastoid index was found to be 57.16 ± 16.24 and 56.32 ± 14.02 in males and females respectively **Table 2**.

The length and breadth of foramen magnum was more in male than in females as shown in **Table 3**. But the FMI was observed to be surprisingly more in females (83.12±9.87) than in males (82.5±9.33) and was statistically significant (p<0.05). The mean FMI of the study population was 83.28±10.4 as shown in **Table 3**. Comparisons of foramen magnum (male) dimensions in various studies with our study are shown in **Table 4**.

CONCLUSION

In this study, we evaluated the use of mastoid process and foramen magnum measurements as a tool for sex determination in unidentified skeleton. Our findings revealed statistically significant parameters (p<0.05) in mastoid length and mastoid breath. Foramen magnum length and breadth did not show statistical significance in regard to sexual dimorphism. Observations of various authors suggest that the results obtained by our study are similar to their studies, and these parameters can be used in fragmentary remains also. We conclude that these parameters can be used in sex determination and can be used as a baseline data for anthropometric study.

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