

Morphometric Study of Foramen Magnum to Determine the Sex of Skull in Karnataka Population

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Abstract

Content: Foramen magnum is a big foramen found at the base of skull in posterior cranial fossa, it transmits vital structures like spinal cord, vertebral artery. This foramen belongs to occipital bone. The basal region of occipital bone is covered by a large volume of soft tissue and is, therefore, in a relatively well protected anatomical position and as such, classification of sex using occipital bone may prove useful in cases of significantly disrupted remains of skeleton. **Aim:** To study the dimensions of foramen magnum and determine the sex of skulls. **Materials and Methods:** A sample of 100 dry adult human skulls (50 known male and 50 known female) available from the department of Anatomy in RIMS, Raichur and GIMS, Gulbaraga were taken TD, LD of foramen magnum of this skulls were measured with help of vernier's calipers, area of foramen was calculated with the help of formula. **Results:** The longitudinal diameter, transverse diameter and area of Foramen magnum were significantly higher in male skulls than in female skull. **Conclusion:** The observation and results of present study demonstrate significant sexual dimorphism in the dimensions of foramen Magnum of the Karnataka population. Hence, dimensions of foramen magnum help forensic investigator and an anthropologist to determine the sex of disrupted remains of skeleton.

Keywords: Occipital Bone; Foramen Magnum; Longitudinal Diameter; Transverse Diameter and Sexual Dimorphism.

Introduction

Foramen magnum is present in occipital bone. It is oval in shape wider behind, with its greatest diameter being anteroposterior. It contains the lower end of the medulla oblongata. It contains the lower end of the medulla oblongata, the vertebral arteries and spinal accessory nerve [1,2].

Foramen magnum communicates with the posterior cranial fossa of the skull i.e the vertebral

canal. It measures about 3.5cm anteroposteriorly and 3 cm transversely. The middle point of anterior margin of foramen magnum is known as the basion [3,4].

Identification of human skeletal remains is of major importance in medico-legal situations such as criminal cases, mass disasters and human rights abuse investigations. One of the principal biological indicators of identity is the sex of the individual. This is relatively easy to achieve when the skeletal remains are complete [5]. When the skeleton exists completely, sex can be estimated with 100% accuracy. This estimation rate is 98 % in existence of pelvis and cranium, 95% with only pelvis or pelvis and long bones, 80-90% with only long bones [6]. However, fragmented or dispersed remains result in an incomplete assessment, which may result in some aspects of identity being inconclusive, including sex evaluation. The most sexually dimorphic areas of the human skeleton are the os coxae and the skull. In skull, the basal region of occipital bone is covered by a large volume of soft tissue and is, therefore, in a

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Received | 27.04.2018, Accepted | 14.05.2018

relatively well protected anatomical position, and as such, classification of sex using occipital bone may prove useful in cases of significantly disrupted remains [5].

Teixeira has reported the usefulness of occipital condyles and the foramen magnum in determining the sex, particularly with incomplete skeleton or fractured cranial bones [7]. Zaidi and Dayal in their study classified a sample of Indian skulls according to the shape and dimensions of the foramen magnum, reporting differences between the skulls of male and female [8]. Routal et al. claimed high accuracy up to 100% in predicting sex from the foramen magnum region [9]. Uysal et al. reported sexual dimorphism by analyzing the dimensions of the foramen magnum in 3D computed tomography with 81% accuracy in determining the sex [10]. The study of Gapert et al demonstrated significant sexual dimorphism in the cranial base of eighteenth and nineteenth century British samples [5].

Despite its importance, few osteometric studies of foramen magnum size have been published so far in India and abroad. Accordingly, this present study is designed to assess the presence of sexual dimorphism in foramen magnum size and thus determine whether foramen magnum can be effectively used, by a forensic investigator and an anthropologist, as a criterion for sex determination.

Most of the text books do not give any information about measurements of foramen magnum and its sexual dimorphism. So, this study has been taken up which will be beneficial to forensic experts.

Material and Methods

Source of Data

A sample of 100 dry adult human skulls (50 known male and 50 known female) available from the Department of Anatomy in RIMS, Raichur and GIMS, Gulbarga were studied. The skulls were selected for the study based on the following inclusion and exclusion criteria.

Inclusion Criteria

Skulls which are dry, intact of known sex and estimated age of more than 18 yrs.

Exclusion Criteria

Skulls which are wet, fractured, eroded or dimorphic features of entire skull or foramen magnum and estimated age less than 18 yrs.

Methodology

The Longitudinal diameter and Transverse diameter of foramen magnum will be measured using

Vernier's Calipers to within 0.01mm. All the measurements will be made in millimeters (mm).

Longitudinal diameter (LD) is the distance between basion and opisthion. Transverse diameter (TD) is the maximum distance between the lateral curvatures of foramen magnum.

The foramen magnum will be considered to be an oval/ellipse in shape, and the Area is calculated using the formula:

$$A = \pi R_1 R_2 \quad \text{where, } R_1 = LD/2$$

$$R_2 = TD/2$$

$$\pi = 22/7 \text{ (mathematical constant)}$$

$$\text{So, } A = \pi (LD/2) (TD/2) \text{ mm}^2$$

Results will be tabulated and statistically analyzed using student 't' test, and discriminant analysis, where

- Student 't' test will be used to compare the measurements between the male and the female skulls.
- Discriminant analysis will be used to determine the sex by using foramen magnum dimensions.

Observation and Results

In the present study, TD, LD of foramen magnum, of 50 known male skulls and 50 known female skull, were measured and the area of respective foramen was calculated and the observation and results are shown in the Table 1.

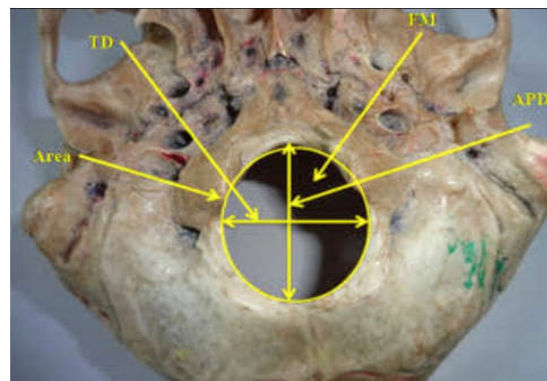


Fig. 1: Diagram showing diameters of Foramen Magnum and abbreviations used in article:

FM = Foramen Magnum.

APD = Antero-Posterior Diameter.

TD = Transverse Diameter.



Fig. 2: Diagram showing Foramen Magnum of Female Skull



Fig. 3: Diagram showing Foramen Magnum of Male Skull

Table 1: Foramen Magnum measurements in Present Study

Gender	L.D in mm Mean (SD)	T.D in mm Mean (SD)	Area mm ² Mean (SD)
Male n =50	34.69 (2.59)	29.49 (2.35)	805.66(100.61)
Female n=50	32.49 (2.35)	26.86(1.59)	687.45(75.05)
Difference in value	2.20mm	2.63mm	118.21mm.sq.

Table 2: Foramen magnum measurements in previous studies

Dimensions	L.D. Mean in mm		T.D. Mean in mm		Area Measure in mm ²	
	Male	Female	M	F	M	F
Routal et al. (in 1984)	35.5	32.0	29.6	27.1	819.00	771.00
Sayee et al. (in1987)	34.2	33.5	28.5	28.0	Area not calculated	
Deshmukh et al. (in 2006)	34.0	34.0	29.0	28.0	Area not calculated	
Gapert et al. (in 2009)	35.91	34.71	30.51	29.36	783.82	730.28
Raghavendrabadu et al.	36.59	32.57	28.91	28.19	811.67	722.66

Discussion

In the present study the mean LD of foramen magnum in male skulls was 34.69 (with SD 2.59) and that in female skull it was 32.49 (with SD 2.35). Mean TD of Foramen Magnum in male skulls it was 29.49 (with SD 2.35) and that in female skulls it was 26.86 (with SD 1.59). Mean area of foramen magnum in male skulls was 805.66 (with SD 100.61) and that in female skulls it was 687.45 (with SD 75.05). P value obtained was <0.001. The mean values and P value obtained show that there is much significance in sexual dimorphism in dimensions of Foramen Magnum.

According to study done by Routal et al in 1984 , mean L.D of male skulls was 35.5 mm and that of female was 32.0 mm. Mean transverse (T.D) of F.M. of male skulls was 29.6 mm and that of female was 27.1 mm. Mean area calculated by them, for male skulls F.M. is 819.00mm.sq and that of female it was 771.00. They concluded that there is sexual dimorphism in the dimensions of foramen magnum, as they got big differences in mean values of male and female skulls [9].

In one of the study done by Sayer et al in 1987 showed mean value of L.D. of Foramen Magnum in males it was 34.2 mm, in females it was 33.5. Mean T.D. of Foramen Magnum of male it was 28.5 and in females it was 28.0. They did not calculate area of foramen magnum. This study did not show much significance in sexual dimorphism in dimension of foramen magnum [11].

Yasemin gunay and aftinkok in 2000 have measured foramen magnum diameters LD & TD, the area of foramen magnum using the mean diameter as the radius for calculation, the mean of foramen magnum area was significantly different in male and female skulls 909.91± 126.02 mm² in males; 819.0±117.24 mm² in females. The results confirmed that the mean of foramen magnum area in females is lower than in males. Correlation coefficient between the areas of FM and sex was 0.27. Hence area of FM is not a way useful indicators sex identification and can be used only under some circumstances as a supportive finding [12].

Uysal et al in 2005 studied foramen magnum diameter using three dimensional computed tomography (3DCT) and concluded that there was

statistically significant sex differences in diameters of FM. They have mentioned accuracy of sexual dimorphism around 81.1 percent [10].

Deshmukh et al studied foremen magnum in 2006 and they could not find much differences mean values LD & TD of male & female skulls, they did not calculate area of foremen magnum. They concluded that by their study there is no accuracy sexual dimorphism in the dimensions of Foramen Magnum [13].

But the study done by Gapert et al in 2009 showed that mean L.D of male FM was 35.91 and that of females was 34.71. The mean TD of male FM was 30.51 and that of female was 29.36. The mean area of FM in males was 783.82 and that of females it was 730.28. They concluded that there was significant sexual dimorphism in the cranial base of 18th and 19th century British samples [5].

The recent study done by RadhaKrishna et al with 55 male skulls and 45 female skulls in South Indian population. The mean LD/APD of FM in males was 34.04 2.36 and in females it was 31.722.14. The mean TD of FM in males was 28.63 1.89 and in females it was 26.59 1.64, and P value was less than 0.05 They have concluded that diameter of FM are more significant in sexual dimorphism [14].

The study conducted by Y.P. Raghavendra Babu and et al in a coastal region of Southern India utilized binary Logistic Regression (BLR) for estimation of sex from the foreman magnum measurements and derived regression models for sex estimation with regard to each dimension of foamen magnum considered individually for its strength in sex determination of the Crania, ROC (Receiver Operating Characteristic Curves drawn for the predicted probabilities obtained from BLR analysis from different variables) analysis in their reveals antero- posterior diameter to be most reliable variable for sex estimation followed by the area of the foremen magnum. TD of FM shows least predictability in sex estimation when compared to the length and area of FM [15].

Key Message

In present study the difference value of male and female mean LD of Foramen Magnum is 2.20 mm, and that of mean T.D is 2.63mm. The difference value of area of Foramen Magnum is 118.21 mm². All this values are significant and hence L.D, T.D and area of skull can be used to estimate sex of skull. The difference in dimensions of male and female foramen magnum is genetically determined and these dimension will be helpful for forensic expert to estimate sex of skull.

Conclusion

The measurements of foramen magnum and their significance in sexual dimorphism has not been mentioned in most of the text books of anatomy. Most of the the previous studies show that there is statistical significance in dimensions of Foramen Magnum to determine sex of skull. Forensic experts should know the actual dimensions of Foramen Magnum and it's correlation with the sex. Hence the present study was undertaken. With the help of observation and results we can say that sexual dimorphism is present in the foreman magnum.

Acknowledgement

We wish to acknowledge the Dept. of Anatomy, RIMS, Raichur and GIMS, Gulbarga and Mr. Ramesh statistician RIMS, Raichur for their co-operation in this study.

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