

**Original article:**

## **Morphometric and morphological analysis for sex determination of dry human skull**

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### **Abstract:**

**Introduction:** Determination of sex from skull by morphological and morphometric analysis has been of interest among researchers. 35 dry human skull of unknown sex were taken for morphometric and morphological analysis. 5 parameters were taken for measurement from Foramen Magnum and from mastoid region with the help of Vernier caliper and analyzed. 13 morphological parameters were also noted. Foramen magnum and the mastoid process were well preserved and less likely to undergo changes. Through Foramen Magnum passed vital structures and any change in its morphometric measurement is of interest from clinical point of view. Morphological parameter was found higher in males than females hence this could be used for sex determination and biological profile constitution.

**Material and method:** A morphometric and morphological analytical study was carried out in North Bengal Medical College between November 2017 to May 2018. 35 dry human adult skull of unknown sex which did not have any deformity were studied. Digital Vernier caliper was used for taking measurements of Foramen magnum and of mastoid process in Frankfurt's plane. Antero posterior diameter was measured from basion to opisthion. The transverse diameter was measured from the point of maximum concavity on right and left margin. The length of the mastoid process was measured in Frankfurt's plane from its tip to the upper rim of zygomatic arch of both right and left mastoid process. Along with this 13 morphological parameters were used for sex determination. Each measurement was taken by two observers and the average was taken.

**Results:** The mean AP diameter of Foramen magnum was 24.63 mm transverse diameter was 20.48 mm and surface area was 436.89 mm<sup>2</sup> & mean Foramen magnum index was 83.45.

**Conclusion:** Foramen magnum and mastoid process are well preserved regular structure and can be used for sex determination of unknown skull. Knowledge of these dimensions are helpful for neurosurgeons and radiologists in diagnostic procedures with further emphasis laid down by the 13 morphological parameters.

**Key words:** Foramen magnum, Base of skull, mastoid process.

### **Introduction**

Pelvis has been taken as the most valuable guideline for sex determination and next to it is the Skull which is used as a guideline for gender determination. Metric assessments are more accurate than visual assessments for sex determination of unknown skull. Foramen Magnum is a Latin word which means 'a great hole' [1,2,3,4]. Foramen Magnum is a regular structure and is well preserved due to its anatomical position as it is situated at the base of the skull. The Foramen Magnum establishes communication between posterior cranial fossa and vertebral canal [5]. The mastoid process of Temporal bone is also well preserved and compact bone and both these structures are less likely to undergo changes and destruction [6]. Our present study aims to determine the gender of unknown skull using mastoid process and Foramen Magnum by metric measurements and also by

morphological traits. The dimensions of Foramen Magnum and Mastoid process is of great interest for anthropology, forensic medicine, neurosurgery and anatomy. Vital structures pass through the Foramen Magnum and any alteration in the dimensions may be of clinical interest.

#### **Aims and objectives**

The aim of our present study is morphological evaluation and morphometric study of dimensions of foramen magnum and mastoid process and to use these dimensions for sex determination of unknown skull.

#### **Material and Method**

35 dry human skull of unknown sex were studied from December 2017 to June 2018. The sample was collected from Anatomy Department and museum of North Bengal Medical College. Skull with any deformity were excluded from the study. Metric measurements with the aid of Digital Vernier Caliper were taken. Antero Posterior and transverse diameter were taken intra cranially. Antero posterior diameter was measured from Basion to Opisthion. The transverse diameter was measured from the point of maximum concavity on right and left margin. For accurate measurement prongs of vernier caliper was placed internally in the Foramen Magnum, screw was fixed and the reading of AP and transverse diameter were taken. 2 readings were taken separately by 2 observers and the average reading was finally noted in a tabulated Sheet. Measurements were taken to the nearest mm. The mastoid length was taken from tip of the mastoid process to the highest point on the line of Zygomatic arch in Frankfurt's plane. Surface area of foramen magnum was calculated using formula derived by Radinsky. Foramen magnum index was also calculated.<sup>[1,7]</sup> Statistical analysis was done using Mann Whitney u test and a p value <0.005 was considered significant.

#### **The morphological traits that were taken are**

1. General size
2. Architecture
3. Supra orbital ridge
4. Mastoid process
5. Occipital area
6. Frontal eminence
7. Parietal eminence
8. Orbits
9. Forehead
10. Cheek bones
11. Palate
12. Occipital Condyle
13. Muscle lines and protrubearance

The difference between male and female skull morphologically was considered from the criteria which was previously standardized by Krogman, W.M. cited by S.K. Jain.<sup>[8]</sup>

**Observation and Results**

**Table 1: Morphometric measurements of dry human skull of unknown sex**

Sr. No.	AP diameter (in mm)	Tr diameter (in mm)	Mastoid Lenth (in mm)		Foramen Magnum Area (in mm <sup>2</sup> )	FMI	Shape
			Rt	Left			
1	35.95	28.87	28.4	32.7	820.6 mm <sup>2</sup>	80.2	Hexagonal
2	32.24	26.71	19.29	26	680.29 mm <sup>2</sup>	82.85	Hexagonal
3	32.20	26.97	23.3	26.1	686.06 mm <sup>2</sup>	83.76	Tetragonal
4	33.75	25.11	29.57	25.55	669.49 mm <sup>2</sup>	74.4	Tetragonal
5	34.69	28.03	33.89	32.23	768.16 mm <sup>2</sup>	80.8	Oval
6	32.23	28.85	34.43	34.98	734.57 mm <sup>2</sup>	89.5	Round
7	29.57	26.69	37.05	33.01	623.49 mm <sup>2</sup>	90.2	Oval
8	29.71	25.09	30.55	31.2	588.88 mm <sup>2</sup>	84.4	Oval
9	32.34	25.99	29.82	30.88	664.01 mm <sup>2</sup>	80.3	Oval
10	31.45	28.89	25.04	26.10	717.79 mm <sup>2</sup>	91.8	Round
11	34.1	30.1	26.7	26.6	810.86 mm <sup>2</sup>	88.2	Round
12	30.1	26.4	27.1	32.1	627.77 mm <sup>2</sup>	87.7	Oval
13	30.2	26.7	22.8	29.2	637.01 mm <sup>2</sup>	88.4	Oval
14	36.2	22.6	30.7	32.9	646.31 mm <sup>2</sup>	62.4	Round
15	32.4	29.1	32.5	37.8	744.84 mm <sup>2</sup>	89.8	Oval
16	30.3	27.4	29.5	28.3	655.87 mm <sup>2</sup>	90.4	Oval
17	33.5	26.4	29.2	27.0	698.68 mm <sup>2</sup>	78.8	Round
18	20.71	15.62	14.6	14.14	255.56 mm <sup>2</sup>	75.4	Tetragonal
19	18.01	14.68	11.75	10.04	208.86 mm <sup>2</sup>	81.5	Tetragonal
20	15.61	13.45	11.6	10.8	165.86 mm <sup>2</sup>	86.2	Tetragonal
21	15.42	13.01	10.47	14.5	158.48 mm <sup>2</sup>	84.4	Hexagonal
22	19.36	13.65	12.01	14.91	208.77 mm <sup>2</sup>	70.5	Oval
23	18.29	14.48	13.32	16.72	209.22 mm <sup>2</sup>	79.2	Hexagonal
24	15.70	15.95	14.59	12.29	197.83 mm <sup>2</sup>	101.5	Round
25	16.93	14.34	16.15	17.33	191.79 mm <sup>2</sup>	84.7	Pentagonal

26	18.66	14.74	13.85	15.46	217.29 mm <sup>2</sup>	78.9	Hexagonal
27	18.26	14.97	13.56	15.09	215.95 mm <sup>2</sup>	81.9	Hexagonal
28	17.67	13.09	12.51	13.24	182.73 mm <sup>2</sup>	74.1	Oval
29	16.89	14.46	16.26	14.18	192.94 mm <sup>2</sup>	85.6	Tetragonal
30	15.35	12.49	13.59	13.65	151.46 mm <sup>2</sup>	81.4	Hexagonal
31	14.69	13.94	14.58	13.49	161.78 mm <sup>2</sup>	94.9	Round
32	17.47	15.06	14.14	15.23	207.85 mm <sup>2</sup>	86.2	Round
33	16.99	14.35	18.22	19.22	192.60 mm <sup>2</sup>	84.5	Pentagonal
34	17.30	13.48	15.64	16.74	184.23 mm <sup>2</sup>	77.9	Oval
35	17.87	15.09	15.45	14.08	213.03 mm <sup>2</sup>	84.4	Oval

**Table-II Sexing of Skull using morphological traits**

Skull Number	Male	Female
1	Male	
2	Male	
3	Male	
4		Female
5		Female
6		Female
7		Female
8		Female
9		Female
10		Female
11		Female
12	Male	
13		Female
14		Female
15	Male	
16		Female
17		Female
18		Female
19	Male	
20	Male	
21		Female

22	Male	
23	Male	
24		Female
25	Male	
26		Female
27	Male	
28		Female
29	Male	
30	Male	
31		Female
32		Female
33	Male	
34		Female
35	Male	

**Table III: Comparisons of morphometric data between male and female dry human skull**

**Median Value**

Parameters	Male (IQR)	Female (IQR)	P Value
AP (in mm)	18.26 (16.93-32.2)	29.95 (17.5-33.2)	0.240
Tr (in mm)	14.68 (14.34-26.7)	25.10 (14.8-27.22)	0.254
Foramen Magnum area (sq mm)	209.22 (192.6-680.29)	630.25 (200.33-691.38)	0.364
Foramen Magnum index	8376 (81.4-85.60)	84.4 (78.13-90.03)	0.780

**Table IV: Showing comparison of mastoid length of male female skull**

	Male (IQR)	Female (IQR)	P value
Mastoid length right	16.15 (13.3-23.3)	25.87 (14.58-30.36)	0.074
Mastoid length left	16.72 (14.8-26.10)	26.35 (14.68-31.12)	0.240

**Table V: Showing the percentage of different shapes of foramen magnum**

Types of Foramen Magnum	Number	Percentage
Oval	12	34.28%
Round	8	22.85%
Hexagonal	7	20%
Tetragonal	6	17.14%
Pentagonal	2	5.71%

The distribution of the values of AP TR, Rt. ML, Lt. ML, FM area and FMI were non normal. Therefore the median values (with interquartile range) have been reported. The FMI values were normally distributed. But for uniformity the median value were reported for FMI also. Comparison between the values in male and female skull parameters were done by the Mann Whitney U test.

**Discussion:**

Base of skull is well preserved in the process of decomposition and second best choice for study of sex determination<sup>[9]</sup>. There is wide variation in the diameters depending upon racial groups and ethnic groups<sup>[10][11]</sup>. In our present study the median value of AP and Tr diameter in male is 18.26mm and 14.68mm, the median value of Foramen magnum area is 209.22sqmm and Foramen index is 83.76. In case of females the median value of AP and Tr diameter is 29.95mm and 25.10mm. The foramen magnum area is 630.25 sq. mm. and foramen index is 84.4. The median value of right mastoid length for male is 16.15mm and left mastoid length is 16.72mm while that of female right mastoid length is 25.87mm and of left mastoid is 26.35mm. Comparison between the values in male and female skull parameters were done by Mann Whitney U test. Our present study found no statistically significant difference in the AP and Tr. diameter and area of Foramen Magnum between male and female which is similar to report of Arpan Dubey et al<sup>[9]</sup>. Different shapes of the foramen magnum were reported like oval, round tetragonal and pentagonal in our present study which was similar to findings of Radha Krishna<sup>[10]</sup>. In our study 34.28% cases of F. Magnum were oval in shape and 22.85% were round in shape.

**Conclusion:**

The study is helpful for Neurosurgeons, Radiologists, Forensic Experts, Anatomists, Anthropologist, Orthopaedicians, Anesthetists. For skull based microsurgical approaches as in case of tumor resection from Foramen Magnum a knowledge of the dimensions of the parameters are important<sup>[12]</sup>. It is a dry bone study and a larger sample size is required and use of advance techniques like CT scan images can be done along with it.

**Photograph showing various shapes of Foramen Magnum**



**Oval**



**Hexagonal**



**Round**



**Tetragonal**



**AP diameter is measured using digital Vernier caliper**



**Tr diameter is measured using digital Vernier caliper**



**Mastoid Length diameter is measured using digital Vernier caliper**

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