

# Morphometric evaluation of foramen magnum

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## Abstract

**Background and Aim:** Foramen magnum is an important landmark in the posterior part of the skull base, vital structures pass through it. Those structures may suffer compression in cases of foramen magnum achondroplasia and foramen magnum brain herniation. The knowledge of foramen magnum diameters are needed to determine some malformations such as Arnold chiari syndrome, which shows expansion of transverse diameter. The purpose of this study was to evaluate the measurements of foramen magnum and to calculate area and index of foramen magnum. **Materials and Methods:** The present study was carried out on 134 dry skull bones, the diameters of foramen magnum were measured using digital vernier calipers and its Area and Index were calculated. **Results:** The mean anteroposterior diameter of foramen magnum was 34.56mm in males and 32.7mm in females. The mean transverse diameter of foramen magnum was 28.95mm in males and 27.57mm in females. The mean foramen magnum index was 84.07 and mean area of foramen magnum was 762.01mm<sup>2</sup>. **Conclusion:** Results of the present study may be useful for neurosurgeons in analyzing morphological anatomy of craniovertebral junction for transcondylar approach in brainstem lesions. Since mean anteroposterior diameter, transverse diameter and area of foramen magnum were more in males compared to females hence it may be use full in sex determination of human skull in forensic analysis and anthropology studies.

**Key Words:** Foramen magnum, morphometric evaluation, skull base, sex determination.

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## INTRODUCTION

The complexity of the base of the skull makes this study useful for surgeons and radiologists. The foramen magnum is a large opening in the base of skull which provides a wide communication between the posterior cranial fossa and vertebral canal. The lower end of the medulla oblongata, vertebral artery and spinal accessory nerve pass through it<sup>1</sup>. The dimensions of the foramen magnum are clinically as well as surgically important because these vital structures passing through it may be compressed in cases of foramen magnum herniation, meningiomas and achondroplasia<sup>2</sup>. The knowledge of foramen magnum diameters is needed to determine some

malformations such as Arnold chiari syndrome which shows expansion of transverse diameter<sup>3</sup>. In neurosurgical practice the transcondylar approach is commonly used to access the lesions which are ventral to the brain stem and cervicomedullar junction. It was reported that understanding bony anatomy of condylar region is important for this approach<sup>4</sup>. Gender determination in unidentified skeletons is not an easy task especially in war fare, explosions and other mass disasters, identification may be complicated because of skeletal fragmentation<sup>5</sup>. The dimensions of the foramen magnum are greater in male cranium compared with female cranium hence foramen magnum dimensions can be used to determine sex in medicolegal conditions and disasters where other bones were fragmented<sup>6</sup>. It has been noted that the cranial base remains intact in cases where the rest of the cranium has been compromised thus the researchers have made use of this fact by analyzing sexually significant dimorphic trait for this anatomical region<sup>5,7</sup>.

## MATERIALS AND METHOD

In the present study 134 dry human skulls (91 Male, 43 Female) in the department of Anatomy Shridevi institute of medical sciences and research hospital Tumkur were examined. The bones which were eroded and deformed

were excluded from the study, all other adult skull bones which were in good condition were included. Sex of each skull was determined by classic anatomic features, and the following parameters were recorded.

- a) The anteroposterior diameter was measured in millimeters (mm) from the end of anterior border (Basion) to the end of posterior border (Opisthion) (Figure-1).
- b) The transverse diameter was measured in millimeters(mm) from point of maximum concavity on the right margin to the maximum concavity on the left margin. (Figure-1),
- c) Area of the foramen magnum was calculated using Randinsky formula<sup>8</sup>. Foramen magnum area =  $\frac{1}{4} \times 3.14 \times \text{FML} \times \text{FMW}$  FML- Foramen magnum length(Anteroposterior diameter)

FMW-Foramen magnum width.(Transverse diameter)

- d) Foramen magnum index (FMI) was calculated by formula  $\text{FMI} = \frac{\text{FMW} \times 100}{\text{FML}}$ . The results were expressed as mean, range,  $\pm$  standard deviation (SD).

## RESULTS

In the present study 134 dry human skull bones were examined, among 134 91 were male and 43 were female skull bones. The mean value of FMW was 28.5mm, FML was 34.0mm, FMI was 84.07 and area of foramen magnum was 762.01mm<sup>2</sup>. The measurements comparing between male and female skulls were tabulated in table 1. The foramen magnum transverse diameter, longitudinal diameter and foramen magnum area in male skulls were more compared with the foramen magnum measurements in female skull bones as represented in Figure 2.

**Table 1:** Showing the range, mean, and standard deviation (SD) for Dimensions of foramen magnum in male and female skull

Parameters	Male			Female		
	Range	Mean	SD	Range	Mean	SD
FML(mm)	29.5-39.6	34.56	±2.04	29.0-36.5	32.71	±1.98
FMW(mm)	24.5-33.6	28.95	±2.10	23.0-31.5	27.57	±2.03
AREA(mm <sup>2</sup> )	581.26-1036.57	786.96	±88.25	543.67-879.63	709.21	±84.43
FMI	69.61-100.6	83.89	±5.984	67.44-101.96	78.17	±6.57

**Table 2:** Comparison of the anteroposterior and transverse diameters of the foramen magnum, in different studies

Author / Ethnicity	Gender	FML in mm	FMW in mm
Sayee R. <i>et al</i>	Male	34.2	28.5
Karnataka (1987) <sup>9</sup>	Female	33.5	28.0
Muralidhar P Shepur	Male	33.4	28.5
Karnataka (2014) <sup>10</sup>	Female	33.1	27.3
Routal RR <i>et al</i>	Male	35.5	30.6
Gujarati(1984) <sup>11</sup>	Female	32.0	27.1
Sauzo Gil <i>et al</i>	Male	36.5	30.6
Brazilian (2009) <sup>12</sup>	Female	35.6	29.5
Cataliana Herrera <i>et al</i>	Male	36.5	31.1
Spain white skulls(1987) <sup>13</sup>	Female	34.3	29.6
Gapert <i>et al</i>	Male	35.9	30.51
British (2008) <sup>14</sup>	Female	34.7	29.36
Arpan Dubay <i>et al</i>	Male	33.4	28.5
Madhyapradesh(2017) <sup>15</sup>	Female	33.1	27.3
P.Devadas <i>et al</i>	Male	36.7	29.7
Telangana(2017) <sup>16</sup>	Female	32.1	26.1
Present Study	Male	34.56	28.9
	Female	32.7	27.5

**Table 3:** Comparison of Area and Index of foramen magnum in various studies

Author /Year	Foramen magnum area(mm <sup>2</sup> )mean	Foramen magnum index(mean)
Gunay <i>et al</i> (2000) <sup>6</sup>	909.91	-
Burdan <i>et al</i> (2012) <sup>17</sup>	877.4	89.34
Jain <i>et al</i> (2014) <sup>18</sup>	-	86.69
Shikha Sharma <i>et al</i> (2015) <sup>19</sup>	970.57	87.68
Present study	762.01	84.07

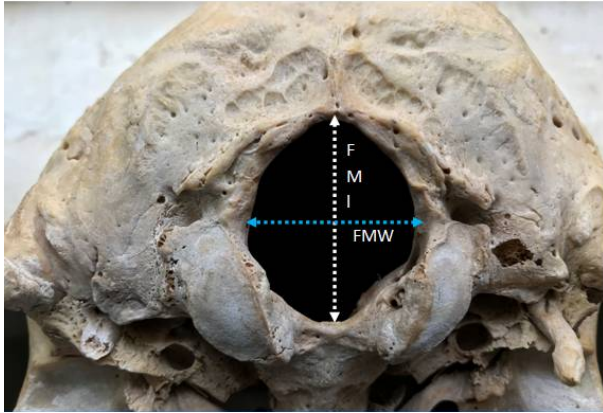


Figure 1

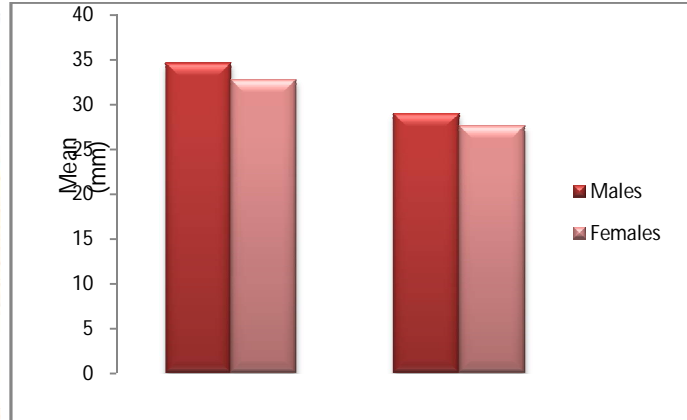


Figure 2

**Figure 1:** Measurements of Foramen magnum length (FML) and Foramen magnum width (FMW)

**Figure 2:** Graph showing transverse diameter and longitudinal diameters of foramen magnum in male and female skull

## DISCUSSION

The results of the present study were compared with the other studies on different ethnicity in Table -2 and Table -3. In the present study all the parameters of foramen magnum FML, FMW, FMI and area of foramen magnum had sexual dimorphism but in study conducted by muralidhar p shepur *et al*<sup>10</sup>, Arpan Dubay *et al*<sup>14</sup> does not show much difference in FML. The surface area of the foramen magnum in the present study were 786.96mm<sup>2</sup> and 709.21mm<sup>2</sup> in male cranium and female cranium respectively which was lower than the Spanish population, Telangana population and Turkish population study. In Telangana population 1089.99mm<sup>2</sup> in males, and 837.81mm<sup>2</sup> in females<sup>16</sup>. In Turkish population 909.9mm<sup>2</sup> in males and 819.01mm<sup>2</sup> in females<sup>2</sup> and in Spanish population 888.4mm<sup>2</sup> in males and 801.0 mm<sup>2</sup> in females<sup>13</sup>. Whereas the area of foramen magnum in Iraq population was lower than the present study it was 765.2mm<sup>2</sup> in males and 670mm<sup>2</sup> in females<sup>20</sup>. Thus the morphometry of foramen magnum shows sexual dimorphism and ethnic variance.

## CONCLUSION

In the present study all the parameters of foramen magnum recorded showed sexual dimorphism, which may help in sex determination of the human skull with other parameters of the skulls in forensic analysis and anthropological studies. Results of the study may also be useful in neurosurgeons and radiologists in surgeries and in determining radiological malformation of this region.

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