

Morphological Variations of the Foramen Magnum in Adult Human Dry Skull in Eastern UP (India) Population

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ABSTRACT

Introduction: Foramen magnum is an important landmark present at the skull base, due to its close association with brain stem and spinal cord. Its morphometric analysis is clinically important due to the vital structure passing through it.

Methods: We conducted this study on 50 dry human skulls in the department of anatomy Heritage Institute of Medical Sciences. The foramen magnum was analysed for its shape, anteroposterior and transverse diameter, area and foramen index. We also measured bicondylar breadth, minimum and maximum distance between the occipital condyles at medial margins. All the measurements were done using Vernier Calliper.

Results: The common shape observed was oval (34%). The anteroposterior and transverse diameter were respectively 33.76 ± 2.18 mm and 28.09 ± 1.92 mm while area and index of foramen were respectively 834.45 ± 75.79 mm² and 84.65 ± 6.32 . The bicondylar breadth was 45.83 ± 2.15 mm and least distance between two occipital condyles was 14.97 ± 2.03 mm while maximum distance was 25.19 ± 3.12 mm. The external hypoglossal canals were 32.29 ± 4.26 distance apart.

Conclusion: Our data may serve as an aid to neurosurgeons in assessing the morphology of cranio-vertebral junction and in transcondylar resection which are important approaches in brain stem lesion.

Key words: Foramen Magnum, Occipital Condyles, Foramen Magnum Index, External Hypoglossal Canal.

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INTRODUCTION

Morphometrical features of bones are of wide use in the determination of age, gender, ethnicity and stature, all of which can be applied in the forensic investigations or anthropological study of unidentified individuals.¹ Skull being the important part of the human skeleton serves as the chief landmark for such studies. At the base of the skull, there is the presence of a large three dimensional opening² anteromedially, known as foramen magnum which is formed mainly by occipital bone and acts as a communicator of vertebral column with posterior cranial fossa.³ Foramen magnum allows the passage of vital structures like medulla oblongata (lower end), vertebral arteries, meninges, spinal accessory nerves, apical ligament of dens as well as the tectorial membrane.^{4,5}

The foramen is mainly oval in shape with wider anteroposterior diameter.⁶ It has anterior border (formed by basilar process of occipital bone), posterior border (formed by supraoccipital part) and lateral borders (formed by right or left ex-occipitalis).⁷

Convex condylar facets are also present on either side of the foramen, that articulate with first cervical vertebrae forming synovial-atlanto-occipital joint.⁷

Dimensions of foramen magnum have proven to be important in forensics, anthropology and other medical fields,⁸ since base of cranium is shown to remain intact in those cases where other regions are compromised.⁹ As the vital structures traverse the foramen magnum, its morphometrical study acts as an important guide to diagnose and treat various complications like meningiomas, foramen magnum stenosis, cerebral herniation and achondroplasia.^{3,10}

Therefore, besides anatomists, the morphometric study of foramen magnum is important for neurosurgeons, radiologist, anesthetist and orthopedicians also. Therefore we aimed to conduct this study so that the results of our study may help the researchers or clinicians to clinically correlate morphological features of foramen magnum with different fields of medicine.

MATERIALS AND METHODS

50 dry human skulls of unknown gender and age were collected from the Department of Anatomy, Heritage Institute of Medical Sciences.

The skulls were analysed for the following parameters:

1. Shape of foramen magnum (round, oval, tetragonal, pentagonal, hexagonal and irregular)
2. Anteroposterior diameter (APD) or length of foramen magnum (from end of anterior border, also called basion to the end of posterior border, also called opisthion).
3. Transverse Diameter (TD) or length of foramen magnum (distance between maximum concavity on both right and left margins).
4. Area of foramen magnum: It was calculated using Radinsky formula³

$$\text{Area} = 1/4 \times \pi \times \text{FML} \times \text{FMW}$$

Where FML= Foramen magnum length or APD
 FMW= Foramen magnum breadth or TD
 $\pi = 3.14$

5. Foramen magnum index (FMI): It was calculated using the relation

$$\text{FMI} = \frac{\text{Foramen magnum width}}{\text{Foramen magnum length}} \times 100$$

6. Bicondylar breadth (BCB): It is the distance between the left and right condylar facets at the lateral margins.
7. Minimum distance between left and right occipital condylar facets at medial border (Min. D)
8. Maximum distance between left and right occipital condylar facets at medial border (Max. D)
9. Distance between external hypoglossal canals (EHC)

The dimensions of foramen magnum was measured by vernier caliper and the data collected were analysed statistically.



Figure 1: Round shaped



Figure 2: Oval shaped



Figure 3: Tetragonal shaped

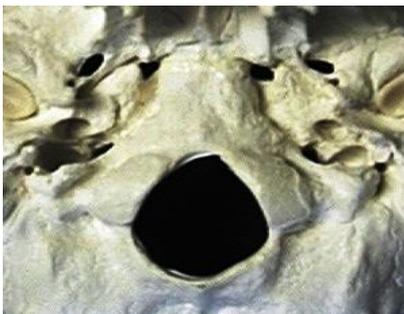


Figure 4: Pentagonal shaped



Figure 5: Hexagonal shaped



Figure 6: Irregular shaped

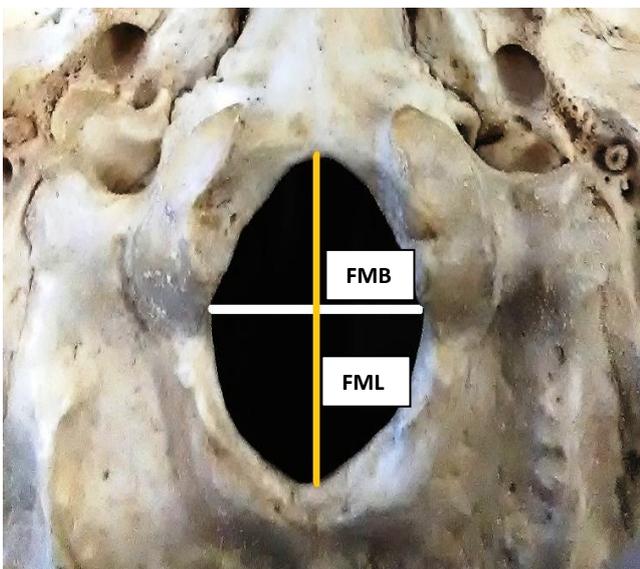


Fig 7: Foramen magnum indicating FMB and FML

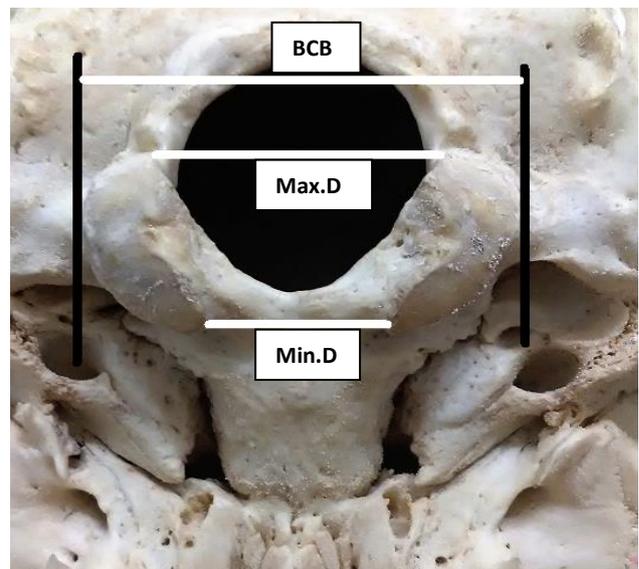


Fig 8: Skull showing BCB, Max D, Min D

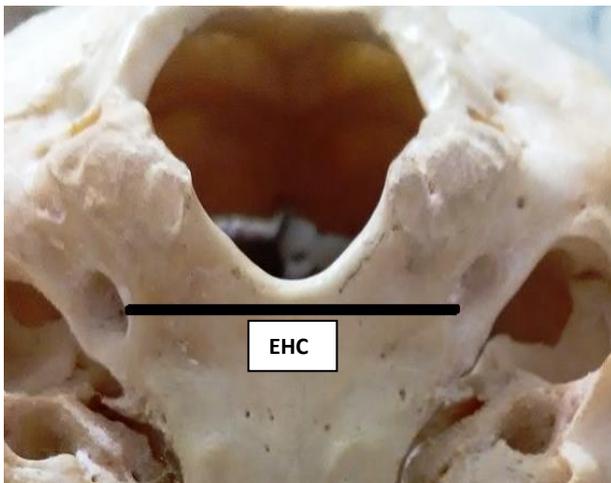


Fig 9: Skull showing EHC

RESULTS

The shape of foramen magnum were found to be round, oval, tetragonal, pentagonal, hexagonal and irregular in 20%, 34%, 16%, 4%, 18% and 8% skulls respectively. The mean APD was 33.76 ± 2.18 while TD was 28.09 ± 1.92 . Similarly the mean area and foramen magnum were respectively 834.85 ± 75.79 and 84.65 ± 6.32 . The maximum and minimum distance between two occipital condyles at the medial border was 25.19 ± 3.12 and 14.97 ± 2.03 respectively, while the bicondylar breadth (BCB) was 45.83 ± 2.15 . The hypoglossal canals at the base of the skull were 32.29 ± 4.26 distance apart.

Table 1: Shape of the foramen magnum

Shape	Number (%)
Round	10(20%)
Oval	17 (34%)
Tetragonal	8 (16%)
Pentagonal	2(4%)
Hexagonal	9 (18%)
Irregular	4 (8%)

Table 2: Morphometric dimensions of foramen magnum

Parameter	Mean \pm sd (mm)
Anteroposterior diameter (APD) or length	33.76 ± 2.18
Transverse diameter (TD) or width	28.09 ± 1.92
Area of foramen magnum	834.45 ± 75.79
Foramen magnum index	84.65 ± 6.32

Table 3: Occipital condylar and EHC measurements

Parameter	Mean \pm sd (mm)
BCB	45.83 ± 2.15
Min. D	14.97 ± 2.03
Max. D	25.19 ± 3.12
EHC	32.29 ± 4.26

DISCUSSION

Foramen magnum is the regular part of skeleton with lesser chance of undergoing morphological changes. Hence it is widely used in forensic medicine and anthropometry. In our study, the common shape of foramen magnum was observed to be oval (34%). The shape and morphology of foramen magnum guides in the neurological interpretation. The irregularity in the shape of the foramen may be due to developmental anomalies related to bones and soft tissues at the base of cranium.¹¹ Zaidi et al¹² reported oval, hexagonal, pentagonal, irregular and round shaped foramen magnum in 64%, 24.5%, 7.5%, 3.5% and 0.5% of cases respectively whereas in the study of Murshad et al⁶, oval shaped foramen magnum was present in 8.1% of cases. The foramen according to them was round, pentagonal, hexagonal and irregular in 6.3%, 10.9%, 13.6% and 13.6% respectively.

The mean APD and TD in our study were 33.76 ± 2.18 and 28.09 ± 1.92 respectively. Sharma et al found the same to be 47.70 mm and 40.80 mm respectively.³ Our finding was similar to that of Tubs et al¹³ who showed APD to be 31 mm and transverse Diameter to be 27 mm. The results were also in accordance with that of Catalina et al.³

In the present study we also calculated the area and index of foramen magnum. The area of foramen magnum was found to be 834.85 ± 75.79 mm² while FMI was observed to those of Burdan et al¹⁴ and Jouin et al.¹⁵ As per result of Sharma et al, mean area of foramen magnum is 970.5mm² with the index of 87.68.³ Uthman et al quoted that area of foramen magnum is one of the most reliable parameter used to study sexual dimorphism.⁴

The foramen magnum considered as a landmark for safe occipital condylar resection.¹⁶ In the present study we also measured the bicondylar breath (BCB) and maximum (Max D) as well as minimum (Min D) between the two occipital condyles at the medial border. BCB was found to be 45.83 ± 2.15 while 25.19 ± 3.2 and 14.97 ± 2.03 correspond respectively to Max D and Min D. In the study of sign et al BCB, Max D and Min D were demonstrated to be 46.73 ± 2.79 , 14.88 ± 2.26 and 26.15 ± 3.31 respectively for male while they were respectively 44.29 ± 2.34 , 14.33 ± 2.56 and 24.71 ± 4.57 respectively for females.¹⁷ The EHC distance measured in our study 32.29 ± 4.26 which was similar to that of Singh et al.¹⁷

CONCLUSION

Our study represents the morphological and morphometric dates of foramen magnum, which may be helpful in medicolegal cases for identification of unknown individual as well as they may act as guide to the anatomists, neurosurgeons and in other medical fields. Also with development of modern technology (CT and MRI), the anatomical study of foramen magnum has become more interesting in the field of medicine. However, since the present study included small number human skulls, it is necessary that further researches including large sample size should be undertaken to further check in the depth the reliability of morphometry of foramen magnum in clinical correlation.

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