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Original article

Morphometry of foramen magnum and its clinical implications. An institutional study.

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Abstract:

Background: Foramen magnum is the largest foramen in the skull. It acts as a significant signpost for the several structures that pass through it. Forensic specialists, neurosurgeons, and radiologists alike must have a thorough understanding of the morphometry and morphology of the foramen magnum. The lesion's in ventral proximity to the brain stem and cervicomedullary junction favours the transcondylar approach, which highlights the significance of the foramen magnum's morphometric analysis and accurate measurement of its dimensions.

Aims: The present study aims to measure the various morphometric parameters of foramen magnum. **Material and methods:** 52 dried human skulls were taken in this study excluding the broken and deformed ones. The anteroposterior and transverse diameters of foramen magnum were measured with the help of a vernier caliper. The area of foramen magnum was calculated using the above parameters. **Results:** The mean anteroposterior diameter and the transverse diameter of foramen magnum was found out to be 32.60mm ± 1.98mm SD and 27.94mm ± 1.73mm SD, respectively. The mean area of foramen magnum was found out to be 716.41mm^2 ± 64.18mm^2 SD. Various shapes of foramen magnum were observed. Foramen magnum was observed to have a round shape in 30%, oval in 22 %, Tetragonal in 18%, egg-shaped in 16%, irregular in 10%, hexagonal in 4% and pentagonal in 4% of the cases.

Conclusion: The current study's data has helped determine the morphology and the morphometry of foramen magnum. This data can prove to be of great importance for neurosurgeons, radiologists, clinical anatomists, and the forensic experts

Keywords: Foramen magnum, morphometry, transcondylar approach**,**

Introduction

The Largest opening of the posterior cranial fossa in the occipital bone of the skull is the Foramen Magnum (FM). Its front limit is produced by the basiocciput, while its posterior boundary is formed by the supraocciput. It is laterally confined by the occipital condyles.[1] FM joins the posterior cerebral fossa to the spinal canal, which allows the meninges, other vital structures, including the distal portion of the Medulla Oblongata to enter and exit it.[2] Two significant landmarks are present in FM: an opisthion and a basion. The opisthion is the midpoint of the FM's posterior margin, and the basion is the midpoint of its anterior margin. The alar ligament is a fibrous cord whose ends are attached to the tubercle

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of occipital condyles and divide the foramen magnum into two separate compartments(anterior and posterior). The anterior compartment is smaller than the larger posterior compartment.[3]

The morphometric features of the FM are significant as many vital structures passing through it may get compressed due to various conditions like brain stem tumours, herniation of the hindbrain and occipital dysplasia. Achondroplasia is a condition in which the size of this foramen is relatively smaller [4-6]. Arnold-Chiari malformation presents with abnormalities and bony deformities, especially in the posterior cranial fossa, in which the transverse diameter of FM is significantly increased.[7] The difference in the shape of FM has clinical and diagnostic importance. Neurosurgeons approach the lesions anterior to the brainstem and cervicomedullary junction via the transcondylar approach. The precise knowledge of the dimensions of FM is considered to be very important for this approach.[8] The dimensions of FM are larger in males than in females. So, it is conducive to determining sex in medicolegal cases.[9]

Aims: The present study aims to measure the various morphometric parameters of foramen magnum.

Material and methods

This cross-sectional study was carried out in the Department of Anatomy, Government Medical College, Srinagar. The study material included 52 dry skulls of the Indian population. Broken and deformed skulls were excluded from the study. The diameters of the FM were measured with the help of manual Vernier caliper. The anteroposterior (sagittal) diameter was calculated as the distance between the basion and opisthion(fig.1B). The transverse diameter was measured between the points of maximum concavity on the right and left margins (fig.1C). The data were transferred to Microsoft Excel for analysis and presented as mean ± SD. The different shapes of FM were macroscopically noted. The shapes and dimensions were determined after discussing with a team of three departmental colleagues to avoid observational bias. The total area of FM was calculated by using the formula:

$A = \prod \times (a/2) \times (t/2)$

Where A= area of foramen magnum,

a= anteroposterior diameter

t= transverse diameter

$\prod$ = Mathematical constant.

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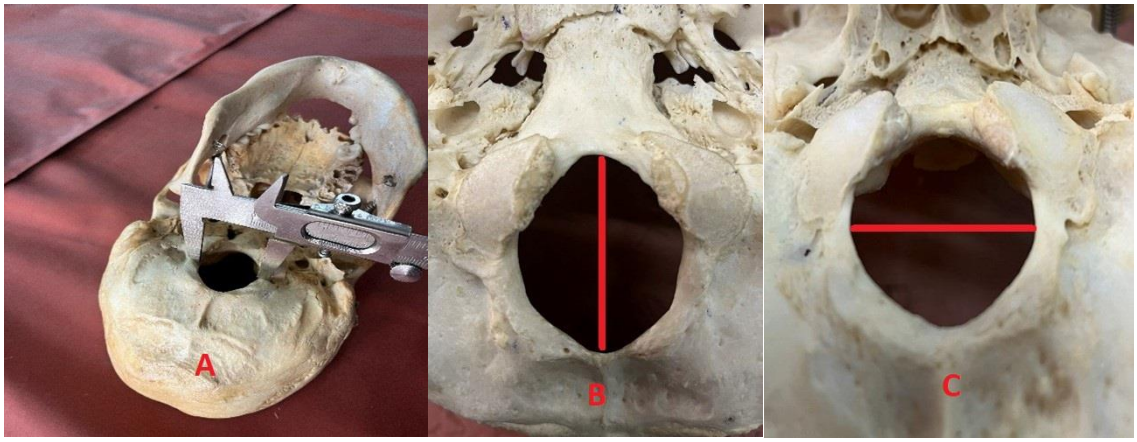

Figure 1: A: shows the use of the vernier caliper in the study for measuring the parameters, and photographs B and C show the distance measured for the anteroposterior and transverse diameter of the Foramen magnum, respectively.

Results

The foramen magnum's anteroposterior and transverse diameter was found to be 32.60mm ± 1.98mm SD and 27.94mm ± 1.73mm SD, respectively. The area of FM was calculated, and the mean area was 716.41mm^2 ± 64.18mm^2 SD. The results are shown in the table no 1.

Table no 1: showing the dimensions of foramen magnum.

Parameters measured	Mean	Standard Deviation
Area	716.41mm^2	64.18mm^2
Antero-posterior diameter	32.60mm	1.98mm
Transverse diameter	27.94mm	1.73mm

Various shapes of FM were observed in this study. There was a good amount of diversity seen in the shapes of FM, including round, oval, egg-shaped, hexagonal, tetragonal, and irregular. The various shapes and frequencies of FM are shown in Table 2 and Figure 2. Foramen magnum was observed to have a round shape in 30%, oval in 22 %, Tetragonal in 18%, egg-shaped in 16%, irregular in 10%, hexagonal in 4% and pentagonal in 4% of the cases.

Table no 2: showing the frequencies of various shapes of foramen magnum.

Shape of foramen magnum	Number	Percentage
Round	15	30%
Oval	11	22%
Tetragonal	9	18%
Egg shaped	8	16%

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Irregular	5	10%
Hexagonal	2	4%
Pentagonal	2	4%

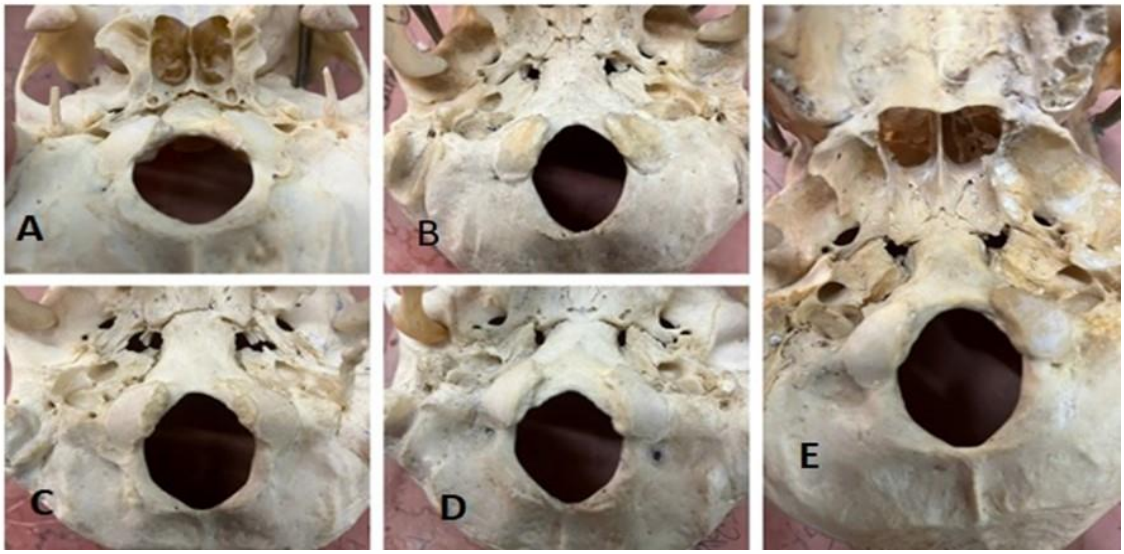

Fig 2: Showing the various shapes of Foramen magnum (A- round; B -Oval; C- hexagonal; D- pentagonal; E-egg shaped)

Discussion

Murshed et al. (2003)[8] conducted a study on the morphometric evaluation of foramen magnum and variation in shapes and concluded that round shape was most common (in 21 % of the cases), which is at par with our study. Khanday and Chakaravarthy (2006)[10] studied the morphometric of FM variation in shapes. They concluded that round (in 21 %) and oval shape was most common, which is at par with our study. In a study conducted by Zaidi and Dayal (1988)[11] oval shape of FM was found to be the most common in 64% of skulls. Chetan P et al. (2012) [12] conducted a similar study and found a round shape of FM in 22.6% of cases, egg shape in 18.9%, tetragonal in 18.9%, followed by oval, irregular, hexagonal, and pentagonal which is quite similar to our results.

Nayak and Gyanaranjan (2017)[13] conducted a morphometric study of FM and found average anteroposterior and transverse diameters to be 3.4 and 2.79 cm, respectively; they found that the mean area of FM was found to be 7.49 cm^2. A similar study was conducted by Patel et al. (2014) [14] in which the mean anteroposterior, transverse diameter, and the area of foramen magnum were found to be 3.37cm, 2.83cm, and 7.55cm, respectively. Khanday and Chakravarthy (2006) [10] found the mean anteroposterior and transverse diameters to be 3.68 and 3.09 cm, respectively. The mean area was 5.76 $cm^{2,}$ which is comparatively lower than what was found in our study. Tubbs et al. (2010) [15] observed the mean sagittal diameter to be 3.1 cm and the mean transverse diameter to be 2.7 cm. The mean area was reported to be 5.58 cm.

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Conclusion

The foramen magnum is the most important landmark in the posterior cranial fossa. Its position and the structures passing through it make it an important anatomical entity. The variations in the shape and dimensions of the FM have clinical and radiological importance. FM with a small aperture may compress the vital structures passing through it, while a larger opening can lead to herniation of the brain stem. The neurosurgeons approach the lesions ventral to brainstem and cervicomedullary junction via the transcondylar area. Knowing the dimensions of the FM is of utmost importance before approaching the lesions of the posterior cranial fossa. FM also shows gender differences, making its morphometric analysis very useful for forensic science. In Arnold-Chiari syndrome, the transverse diameter is significantly increased, so the morphometric analysis of FM helps us to determine this syndrome. In a nutshell, the morphometric study of FM can be of great use to neurosurgeons, radiologists, and forensic experts.

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