Abstract:
Background: Cranial morphometry is used for human studies like age estimation, stature, and ethnicity. Foramen magnum lies in floor of base of skull an antero-median position and leads to posterior cranial fossa. It is oval and wider behind with its greater diameter being the antero-posterior diameter. Through Foramen magnum lower end of medulla oblongata, meninges, vertebral arteries and spinal accessory nerve. The morphometric measurement of foramen magnum is important because most of the vital structures are passing through it and useful for knowing compression such as in cases of brain stem herniation and foramen magnum meningiomas.

Objective: To measure the anteroposterior diameter and transverse diameter of the foramen magnum in human dried skulls and studied about variations in shape of foramen magnum

Materials and Methods: A total of 38 dried human adult skull of unknown age and sex were collected from the Department of Anatomy, Jaipur National University Institute for Medical Sciences And Research Centre (JNUIMSRC) Jaipur were used for this study. The antero-posterior diameter, transverse diameter, shape were measured by using digital vernier caliper. The area and index of foramen magnum were also calculated.

Results: In the current study the mean Antero-posterior diameter was 30.59mm. The maximum Antero-posterior diameter was 39.23 mm and minimum Antero-posterior diameter was 22.31mm. The mean transverse diameter was 22.8mm. The maximum transverse diameter was 28.8 mm and minimum transverse diameter was 15.7 mm. The most common shape of foramen magnum were oval in 17 skull 44%, rounded in 9 skull 23%, irregular shaped in 5 skull 13%, hexagonal shaped in 4 skull 10, pentagonal in 2 skull 5.26%, , tetragonal in 1 skull 2.63%. The mean area of foramen magnum was 547.49982mm². The mean index for foramen magnum was 54.49.

Conclusion: The present study gives a morphometric reference to various types of foramen magna in Indian population and its clinical significance. These findings are useful to neurosurgeons, forensic experts and anatomists. In neurosurgery it will be easy to approach the cranial base safely with less damage, if surgeon knows about the various parameters of foramen magna.

Keywords: Foramen magnum, Antero-posterior diameter, Transverse diameter, Foramen magnum area, Foramen magnum index.

Introduction
Cranial morphometry is used for human studies like age estimation, stature, and ethnicity. These parameters are important for forensic investigations and anthropological examinations of unknown individuals.

Foramen magnum plays a very significant role as a transition zone between spine and skull being in close proximity to brain and spinal cord. Foramen magnum plays a very significant role as a transition zone between spine and skull being in close proximity to brain and spinal cord.
Foramen magnum lies in an anteromedian position and leads to posterior cranial fossa. It is oval and wider behind with its greater diameter being the antero-posterior diameter. Foramen magnum contains lower end of medulla oblongata, meninges, vertebral arteries and spinal accessory nerve. The apical ligament of dens and tectorial membrane pass through the foramen magnum. The morphometric measurement of foramen magnum is important because most of the vital structures are passing through it may lead to compression such as in cases of brain stem herniation and foramen magnum meningiomas. Knowledge about the dimensions of foramen magnum is clinically important for neurosurgeons in performing surgeries on foramen magnum. The transverse diameter of foramen magnum is more in Arnold Chiari Syndrome. Studies comparing the shape of human foramen magnum with other primates have been done earlier. The position of the foramen magnum in humans is unique compared to other mammals. In humans it has migrated well forward in the occipital bone from the back of the skull, to a position beneath the center mass of the skull and brain. The present study is being conducted to measure the anteroposterior diameter and transverse diameter of the foramen magnum in human dried skulls and studied about variations in shape of foramen magnum.

This morphometric analysis of foramen of magnum can be useful to the neurosurgeons and anaesthetics for understanding the anatomy and location of skull foramina is essential for performing effective nerve block during surgeries and avoiding injuries to the neurovascular bundles during neuro and orofacial surgeries. The study would also help the radiologist and oncologist to evaluate the tumor involvement of foramina on imaging.

**Objective**

To measure the anteroposterior diameter and transverse diameter of the foramen magnum in human dried skulls and studied about variations in shape of foramen magnum

**Materials and Methods**

The present study was conducted in Department of Anatomy at Jaipur National University Institute for Medical Sciences and research Center, Jaipur. A total of 38 dry skulls held by the Department of Anatomy were analyzed. The osteological collection consisted of disarticulated skeletons that had been selected 3 years previously for educational and research purposes. The, damaged skulls, children skull, fetal skull and skulls with pathological conditions were excluded from the study. The different shapes of foramen magnum were studied macroscopically. The antero-posterior and transverse diameters were studied by using manual vernier calliper. These are the parameters which we have taken in the study:-

1. **Maximum Anteroposterior diameter**: It is the maximum distance between two points, one at the anterior and one at the posterior margin of foramen magnum in the principal axis. It was measured with the help of vernier caliper and the measurements were recorded in millimeters.
2. **Maximum Transverse diameter**: It is the maximum distance between two points, on the lateral margins of the foramen magnum perpendicular to the anteroposterior diameter recorded. It was measured with the help of vernier caliper and the measurements were recorded in millimeters.
3. **Area of foramen magnum**: was measured by Radinsky formula: \(\frac{1}{4} \times 3.14 \times \text{foramen magnum length} \times \text{foramen magnum width}\).  
4. **Foramen magnum index**: was calculated by Foramen magnum width \(\times 100/\text{Foramen magnum length}\).
Result
Antero-posterior, transverse, diameters of foramen magnum were measured using a Vernier Caliper to an accuracy of 0.1mm. In our study the mean Antero-posterior diameter was 30.59mm. The maximum Antero-posterior diameter was 39.23 mm and minimum Antero-posterior diameter was 22.31mm. The mean transverse diameter was 22.8mm. The maximum transverse diameter was 28.8 mm and minimum transverse diameter was 15.7 mm. The most common shape of foramen magnum were oval in 17 skull 44%(Fig-2), rounded in 9 skull 23%(Fig-3), irregular shaped in 5 skull 13%(Fig-4), hexagonal shaped in 4 skull 10(Fig- 5), pentagonal in 2 skull 5.26% (Fig.6), tetragonal in 1 skull 2.63%(Fig-7). The mean area of foramen magnum was 547.49982mm$^2$, The mean index for foramen magnum was 54.49.

Figure 1: Measures undertaken in Foramen Magnum Adult Human Dry Skull

Fig. 2: Showing oval shape foramen magnum
Foramen magnum

Fig. 3: Showing Rounded shape
Foramen magnum
Fig. 4: Showing irregular shaped Foramen magnum

Fig. 5: Showing hexagonal shaped Foramen magnum

Fig. 6: Showing pentagonal shaped Foramen magnum

Fig. 7: Showing tetragonal shaped Foramen magnum.
Discussion
According to M. Rohinidevi et al in 35 dried human skulls of unknown sex studied the mean antero posterior and transverse diameter of foramen magnum were 34.80mm and 28.5mm respectively. The most common shape of foramen magnum was round shaped 26%. The foramen magnum index was 82.53. The mean area of foramen magnum was 820.53mm$^2$.

Jain et al stated that in 68 dried human skulls of known sex the mean antero-posterior and transverse diameters of foramen magnum in male were 36.9mm and 31.5mm respectively. The mean antero-posterior and transverse diameter of foramen magnum in female were 32.9mm and 29.5mm respectively. According to Muralidhar et al, in 150 dried human skulls of known sex the mean antero-posterior and transverse diameters of foramen magnum in male were 33.40mm and 26.70mm respectively. The mean antero posterior and transverse diameter of foramen magnum in female were 33.6mm and 28.00mm respectively. The area of foramen magnum was 748.60mm$^2$ in male and in female was 711.10mm$^2$.

In our present study the mean antero-posterior diameter was 30.59mm. The mean transverse diameter was 22.8mm. The most common shape of foramen magnum was oval in 17 skull 44%. The mean area of foramen magnum was 547.49mm$^2$. The mean index for foramen magnum was 54.49.

Conclusion
The present study gives a morphometric reference to various types of foramen magnum in Indian population and its clinical significance. The present study on the morphometric study of foramen magnum showed that the average anteroposterior diameter of foramen magnum was more than the transverse diameter. The mean antero-posterior and transverse diameters were 30.59mm and 22.8mm respectively. These findings can be of use to neurosurgeons, forensic experts and anatomists. In neurosurgery it will be easy to approach the cranial base safely with less damage, if surgeon knows about the various parameters.

This study was to generate data that would be useful to the neurosurgeons and anaesthetics for understanding the anatomy and location of skull foramina is essential for performing effective nerve block during surgeries and avoiding injuries to the neurovascular bundles during neuro and orofacial surgeries. The study would also help the radiologist and oncologist to evaluate the tumor involvement of foramina on imaging.

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