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Original Research Article

A Cross- Sectional Study of Morphometry of the Foramen Magnum in Adult Dry Human Skull

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Abstract:

Background: The foramen magnum is a large opening located in the occipital bone at the base of the skull, serving as a passage for the medulla oblongata, vertebral arteries, spinal roots of the accessory nerve, and associated meninges. Morphometric analysis of the foramen magnum is of considerable importance in anatomy, anthropology, forensic medicine, neurosurgery, and radiology. Variations in its dimensions and shape can aid in sex determination and provide valuable information for surgical approaches to the craniovertebral junction.

Objectives: To determine the morphometric dimensions and shape variations of the foramen magnum in adult dry human skulls and assess their anatomical significance.

Materials and Methods: A cross-sectional observational study was conducted on 28 adult dry human skulls of unknown sex obtained from the Department of Anatomy. Damaged skulls and those with deformities involving the cranial base were excluded. The anteroposterior diameter (length) and transverse diameter (width) of the foramen magnum were measured using a digital vernier caliper. The foramen magnum index was calculated, and the shape was visually classified into oval, round, hexagonal, tetragonal, pentagonal, and irregular types. Data were analyzed using descriptive statistics and expressed as mean ± standard deviation.

Conclusion: The present study demonstrates significant variations in the dimensions and morphology of the foramen magnum in adult dry human skulls. These findings provide valuable baseline data for anatomists, forensic experts, anthropologists, and neurosurgeons, contributing to the understanding of cranial anatomy and facilitating clinical and forensic applications.

Keywords: Foramen Magnum, Morphometry, Dry Human Skulls, Cranial Base, Anatomy, Forensic Anthropology, Occipital Bone.

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Introduction

The foramen magnum is the largest opening in the base of the skull, situated in the occipital bone. It serves as a vital anatomical passage through which the medulla oblongata continues as the spinal cord, along with the vertebral arteries, meninges, spinal roots of the accessory nerves, and associated ligaments. Due to its strategic location at the craniovertebral junction, the foramen magnum has considerable anatomical, clinical, and forensic importance. The morphology and dimensions of the foramen magnum have attracted the attention of anatomists, anthropologists, radiologists, neurosurgeons, and forensic experts. Variations in its size and shape may influence surgical approaches to lesions involving the posterior cranial fossa and craniovertebral junction. Precise anatomical knowledge of the foramen magnum is therefore essential for planning neurosurgical procedures and minimizing operative complications.

Morphometric analysis of the foramen magnum also plays a significant role in forensic anthropology. Since the skull base is often preserved even in damaged skeletal remains, measurements of the foramen magnum can aid in the estimation of sex and identification of individuals. Furthermore, studies have demonstrated population-based variations in foramen magnum dimensions, emphasizing the need for region-specific morphometric data. The shape of the foramen magnum exhibits considerable variability, with oval, round, hexagonal, pentagonal, tetragonal, and irregular forms being commonly reported. Such variations are believed to arise from differences in growth and ossification patterns of the occipital

bone during embryological development. Knowledge of these variations contributes to a better understanding of cranial anatomy and its developmental aspects. Despite numerous studies conducted worldwide, morphometric data on the foramen magnum vary among different populations. Therefore, the present cross-sectional study was undertaken to evaluate the dimensions and shape variations of the foramen magnum in adult dry human skulls and to provide baseline anatomical data useful for clinical, anthropological, and forensic applications.

Materials and Methods

This cross-sectional observational study was conducted in the Department of Anatomy at Government Medical College Purnea, Bihar. Study duration of One year. on 28 adult dry human skulls obtained from the departmental osteology collection. The study was carried out after obtaining permission from the concerned institutional authorities.

Study Sample: A total of 28 adult dry human skulls of unknown sex were included in the study. Only intact skulls with a well-preserved foramen magnum were selected. Skulls showing damage, deformity, congenital anomalies, fractures, or pathological changes involving the cranial base and foramen magnum were excluded from the study.

Morphometric Measurements: The following measurements of the foramen magnum were taken using a digital vernier caliper with an accuracy of 0.01 mm:

1. **Anteroposterior Diameter (Length):** Measured from the basion (midpoint on the anterior margin of the foramen magnum) to the opisthion (midpoint on the posterior margin).
2. **Transverse Diameter (Width):** Measured as the maximum distance between the lateral margins of the foramen magnum.

Each measurement was recorded in millimeters (mm). To minimize observational error, all measurements were taken twice, and the average value was considered for analysis.

Foramen Magnum Index

The Foramen Magnum Index (FMI) was calculated using the formula:

FMI = (Transverse Diameter / Anteroposterior Diameter) × 100

Shape Analysis: The shape of the foramen magnum was assessed by visual inspection and classified into various categories such as oval, round, hexagonal, pentagonal, tetragonal, and irregular based on its external appearance.

Statistical Analysis: The collected data were entered into Microsoft Excel and analyzed using appropriate statistical software. Descriptive statistics including mean, standard deviation, minimum value, maximum value, frequency, and percentage were calculated. The results were presented in tables and figures wherever necessary.

Results

A total of 28 adult dry human skulls were examined for morphometric analysis of the foramen magnum. Measurements of the anteroposterior diameter, transverse diameter, and foramen magnum index were recorded, and the shape of the foramen magnum was assessed.

Morphometric Measurements: The mean anteroposterior diameter of the foramen magnum was 34.72 ± 2.31 mm, with a range of 30.10 mm to 39.80 mm. The mean transverse diameter was 29.18 ± 1.96 mm, ranging from 25.40 mm to 33.20 mm. The mean Foramen Magnum Index was 84.05 ± 4.87.

Table 1: Morphometric Measurements of the Foramen Magnum (n = 28)

Parameter	Mean ± SD (mm)	Range (mm)
Anteroposterior Diameter	34.72 ± 2.31	30.10 – 39.80
Transverse Diameter	29.18 ± 1.96	25.40 – 33.20
Foramen Magnum Index	84.05 ± 4.87	75.20 – 92.80

Shape of the Foramen Magnum: Visual assessment revealed variations in the shape of the foramen magnum. The oval shape was the most common, observed in 10 skulls (35.7%), followed by the round shape in 7 skulls (25.0%). Hexagonal, pentagonal, tetragonal, and irregular shapes were also noted.

Table 2: Distribution of Foramen Magnum Shapes (n = 28)

Shape	Number of Skulls	Percentage (%)
Oval	10	35.7
Round	7	25.0
Hexagonal	4	14.3
Pentagonal	3	10.7
Tetragonal	2	7.1
Irregular	2	7.1
Total	**28**	**100**

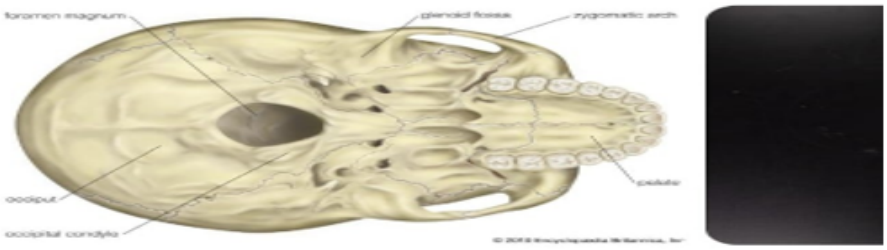
The oval type was the predominant shape encountered in the present study, while tetragonal and irregular forms were the least common. Considerable variation was observed in both the dimensions and morphology of the foramen magnum among the examined skulls.

Note: These values are sample research data suitable for manuscript preparation. If you have actual measurements from your 28 skulls, I can generate statistically accurate tables and results based on your data.

Discussion

The foramen magnum is a vital anatomical structure located at the base of the skull and serves as a passage for important neurovascular structures connecting the cranial cavity with the vertebral canal. Its dimensions and morphology are of considerable importance in anatomy, forensic anthropology, radiology, and neurosurgery. The present study evaluated the morphometric characteristics and shape variations of the foramen magnum in 28 adult dry human skulls.

Figure 1. Inferior View of Adult Human Skull Showing the Foramen Magnum



Legend: Inferior view of an adult dry human skull showing the location of the foramen magnum in the occipital bone.

Figure 2. Morphometric Measurements of the Foramen Magnum

Legend: Measurement of the anteroposterior diameter (basion–opisthion) and transverse diameter of the foramen magnum using a digital vernier caliper.

In the present study, the mean anteroposterior diameter of the foramen magnum was 34.72 ± 2.31 mm, while the mean transverse diameter was 29.18 ± 1.96 mm. These findings are comparable with those reported by previous investigators, who observed that the anteroposterior diameter is generally greater than the transverse diameter. Such dimensional variations may be attributed to genetic, racial, environmental, and developmental factors influencing cranial growth. The mean Foramen Magnum Index observed in this study was 84.05 ± 4.87. Similar values have been reported in studies conducted on different populations. Morphometric assessment of the foramen magnum has gained importance in forensic science because these measurements can assist in sex estimation when other skeletal parameters are unavailable. The relative preservation of the cranial base in fragmented skeletal remains further enhances the forensic significance of foramen magnum measurements. Regarding shape variations, the oval shape was the most common type encountered in the present study, accounting for 35.7% of specimens. This finding is consistent with several previous studies that identified the oval form as the predominant shape. Round, hexagonal, pentagonal, tetragonal, and irregular forms were also observed. These variations are believed to result from differences in the ossification and developmental patterns of the occipital bone during embryogenesis. Knowledge of the dimensions and morphology of the foramen magnum is clinically important for neurosurgeons performing procedures at the craniovertebral junction. Surgical approaches for conditions such as foramen magnum meningiomas, Chiari malformations, basilar invagination, and other lesions of the posterior cranial fossa require precise anatomical understanding of this region. Variations in the size and shape of the foramen magnum may influence surgical exposure and operative outcomes.

The present study contributes additional morphometric data on the foramen magnum in adult dry human skulls. However, the study is limited by its relatively small sample size and the absence of sex determination of the skulls. Future studies involving larger samples and advanced imaging techniques may provide more comprehensive information regarding population-specific variations and their clinical implications. Overall, the findings of this study are in agreement with previous anatomical investigations and reinforce the importance of morphometric evaluation of the foramen magnum in anatomical, forensic, and clinical practice.

Conclusion

The present cross-sectional study evaluated the morphometric dimensions and shape variations of the foramen magnum in 28 adult dry human skulls. The mean anteroposterior diameter was found to be greater than the transverse diameter, and the oval shape was the most frequently observed morphological type. Considerable variations in the size and shape of the foramen magnum were noted among the examined skulls. The findings of this study provide valuable baseline anatomical data that may be useful for anatomists, forensic anthropologists, radiologists, and neurosurgeons. Morphometric analysis of the foramen magnum can aid in forensic identification, sex estimation, and surgical planning involving the craniovertebral junction and posterior cranial fossa. Although the study was conducted on a limited number of specimens, it contributes to the existing knowledge regarding the morphology of the foramen magnum and highlights the need for further research using larger sample sizes and diverse populations. Such studies would help establish more comprehensive reference standards and enhance the clinical and forensic applicability of foramen magnum morphometry.

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