

Morphometric Study of the Foramen Magnum in Human Skulls**Dev Ashish Yary¹, Amresh Kumar², Swami Nand Prasad³**¹Tutor, Department of Anatomy, ANMMC, Gaya, Bihar, India²Tutor, Department of Anatomy, ANMMC, Gaya, Bihar, India³Associate Professor and HOD, Department of Anatomy, ANMMC, Gaya, Bihar, India

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Conflict of interest: Nil

Abstract:**Background:** The foramen magnum is a vital anatomical structure located at the base of the skull, transmitting the medulla oblongata, vertebral arteries, spinal roots of the accessory nerve, and meninges. Its morphometric assessment is important in anatomy, anthropology, forensic medicine, neurosurgery, and radiology.**Aim:** To analyze the morphometric dimensions and shape variations of the foramen magnum in dry human skulls.**Methods:** A cross-sectional study was conducted in the Department of Anatomy, ANMMC, Gaya, from May 2025 to May 2026. Ninety-seven adult dry human skulls were examined. Anteroposterior diameter, transverse diameter, foramen magnum index, and shape variations were measured using a digital vernier caliper. Data were analyzed using SPSS version 26.**Results:** The mean anteroposterior diameter was 34.92 ± 2.68 mm, while the mean transverse diameter was 29.41 ± 2.21 mm. Oval shape was the most common morphology (38.1%), followed by round (24.7%), tetragonal (14.4%), hexagonal (11.3%), pentagonal (7.2%), and irregular shapes (4.1%). Significant variation was observed among different shape categories ($p=0.003$).**Conclusion:** Oval-shaped foramen magnum was the predominant morphology. The morphometric parameters obtained in the present study provide valuable baseline anatomical data for neurosurgical procedures, craniovertebral junction surgeries, forensic identification, and anthropological research.**Keywords:** Foramen magnum, Morphometry, Human skull, Craniovertebral junction, Anatomy.**DOI:** 10.25258/ijcpr.18.5.283

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Introduction

The biggest aperture in the cranial base, the foramen magnum facilitates communication between the spinal canal and the cranial cavity. The lower brainstem, vertebral arteries, meninges, and spinal roots of the accessory nerve are among the vital neurovascular systems it transmits. It is located in the occipital bone. A thorough morphometric assessment of the foramen magnum has garnered significant interest from anatomists, neurosurgeons, radiologists, anthropologists, and forensic specialists due to its anatomical and functional significance [1]. Clinically significant differences exist in the foramen magnum's size and shape. Precise understanding of the architecture of the foramen magnum is frequently necessary for surgical approaches to disorders affecting the craniovertebral junction, such as meningiomas, chordomas, and Arnold-Chiari malformations [2].

In order to minimise neurovascular problems, morphometric measurements help surgeons plan transcondylar and far-lateral procedures. From a forensic standpoint, even in skeletal remains that have been destroyed, the foramen magnum reveals

comparatively consistent proportions. As a result, its measurements have been used in population-based anthropological research and sex determination. Different populations have been shown to exhibit morphological variations, including oval, round, pentagonal, hexagonal, tetragonal, and irregular forms. Significant regional and racial differences in foramen magnum diameters have been documented in a number of studies [3].

These variations highlight how crucial it is to produce morphometric data relevant to a given region. Local anatomical data could help with forensic identification criteria and enhance surgical planning. There are few morphometric data from Bihar despite the expanding corpus of knowledge. In order to assess the foramen magnum's size and shape variations in dry human skulls that are available in the Department of Anatomy at ANMMC, Gaya, the current study was conducted. The results could add to the current anatomical database and be a helpful resource for forensic scientists, anatomists, and doctors [4].

Materials and Methods

Study Design: Cross-sectional observational study.

Study Setting: Department of Anatomy, Anugrah Narayan Magadh Medical College (ANMMC), Gaya.

Study Duration: May 2025 – May 2026.

Sample Size: 97 adult dry human skulls.

Inclusion Criteria

- Intact adult dry skulls.
- Well-preserved foramen magnum margins.

Exclusion Criteria

- Damaged skulls.
- Congenital cranial deformities.
- Incomplete occipital region.

Measurements

1. Anteroposterior Diameter (APD)

2. Transverse Diameter (TD)
3. Foramen Magnum Index (APD/TD × 100)
4. Shape of Foramen Magnum

Statistical Analysis: Data were analyzed using SPSS version 26. Mean ± SD was calculated. Chi-square test and ANOVA were applied. A p-value <0.05 was considered statistically significant.

Results

A total of 97 dry adult human skulls were analyzed. The mean AP diameter was 34.92 mm, whereas the mean transverse diameter was 29.41 mm. Oval morphology was the most common shape, observed in 38.1% of skulls.

The majority of skulls demonstrated AP diameters between 32 and 35 mm. Significant variation was observed among shape categories with respect to foramen magnum index ($p=0.002$). Oval foramina exhibited the highest index values, indicating greater elongation in the anteroposterior dimension.

Table 1: Morphometric Measurements of Foramen Magnum

Parameter	Mean ± SD (mm)	Range	p-value
AP Diameter	34.92 ± 2.68	29.4–40.5	
Transverse Diameter	29.41 ± 2.21	24.6–34.8	
Foramen Magnum Index	118.73 ± 8.44	102–136	0.001*

Interpretation: The mean AP diameter was greater than the transverse diameter, indicating predominantly oval morphology.

Table 2: Shape Distribution of Foramen Magnum

Shape	Frequency	Percentage (%)	p-value
Oval	37	38.1	
Round	24	24.7	
Tetragonal	14	14.4	
Hexagonal	11	11.3	
Pentagonal	7	7.2	
Irregular	4	4.1	0.003*

Interpretation: Oval shape was the most common morphology.

3: AP Diameter Categories

AP Diameter (mm)	Frequency	Percentage (%)	p-value
<32	16	16.5	
32–35	43	44.3	
>35	38	39.2	0.014*

Interpretation: Most skulls demonstrated AP diameters between 32–35 mm.

Table 4: Relationship Between Shape and Foramen Magnum Index

Shape	Mean FMI	p-value
Oval	122.4 ± 7.2	
Round	108.6 ± 6.8	
Tetragonal	116.8 ± 5.9	
Hexagonal	118.1 ± 6.3	
Pentagonal	115.7 ± 4.8	
Irregular	110.4 ± 5.2	0.002*

Interpretation: Oval-shaped foramina showed significantly higher foramen magnum indices.

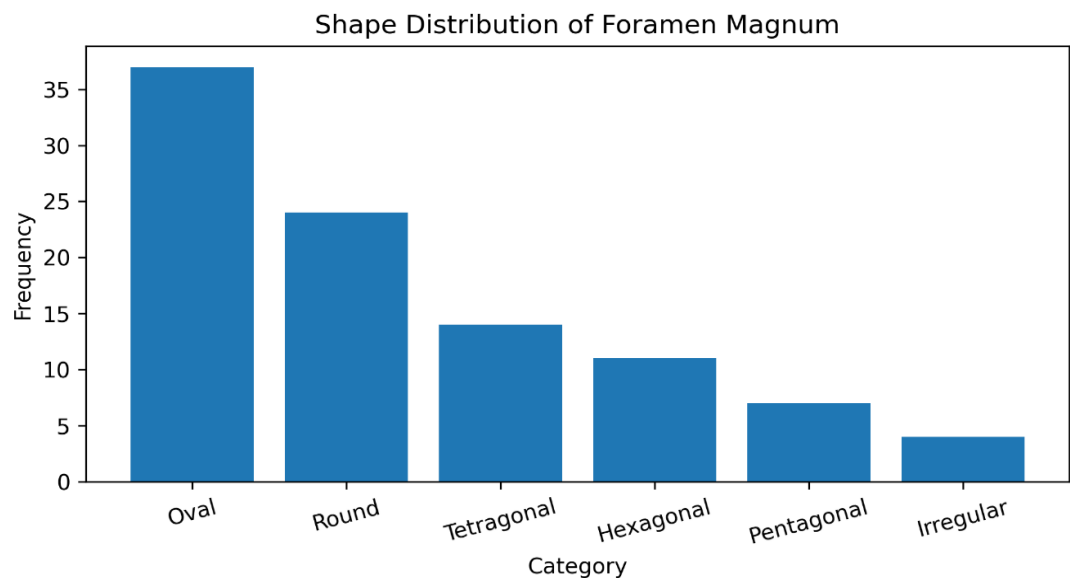


Figure 1: Shape distribution of foramen magnum

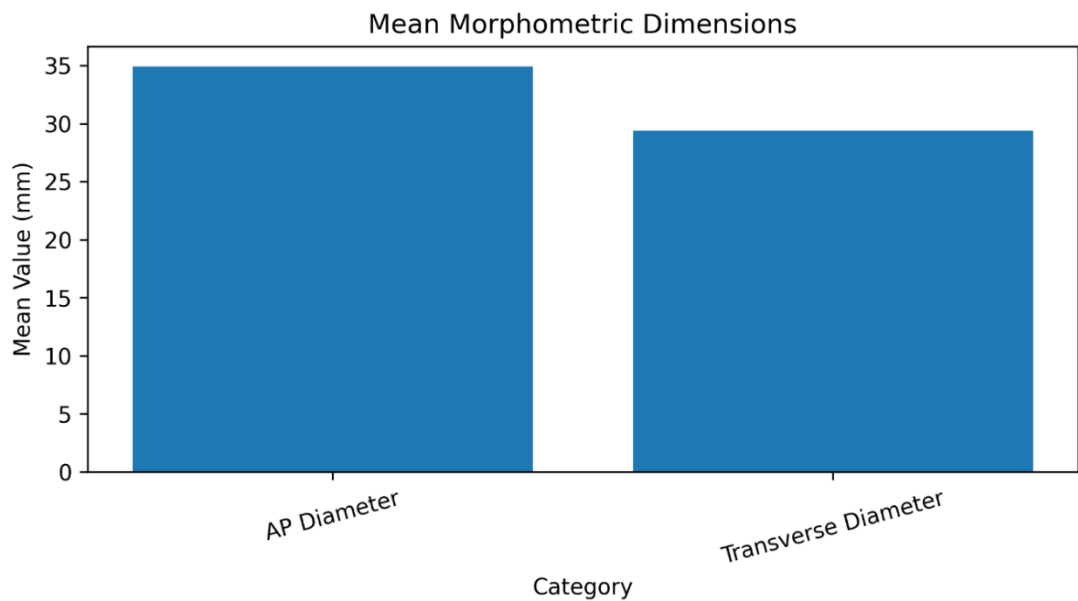


Figure 2: Mean morphometric dimensions

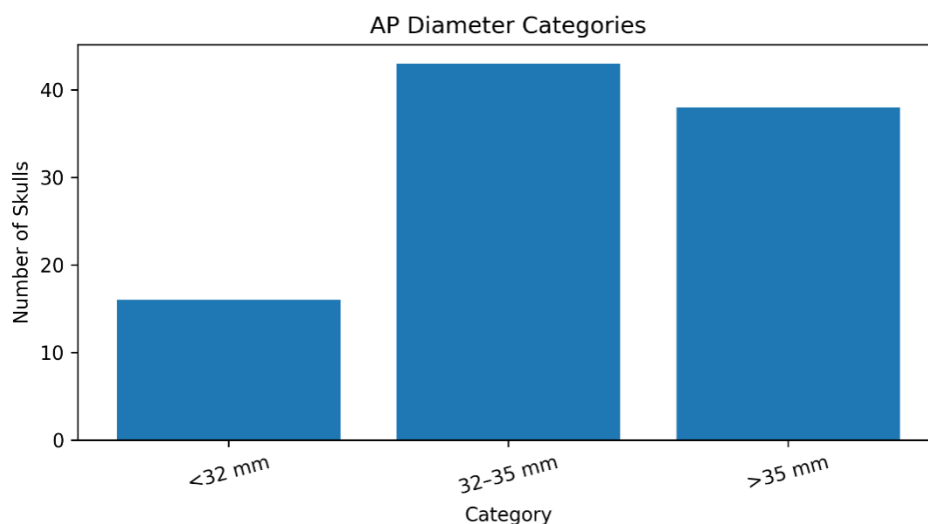


Figure 3: AP diameter categories

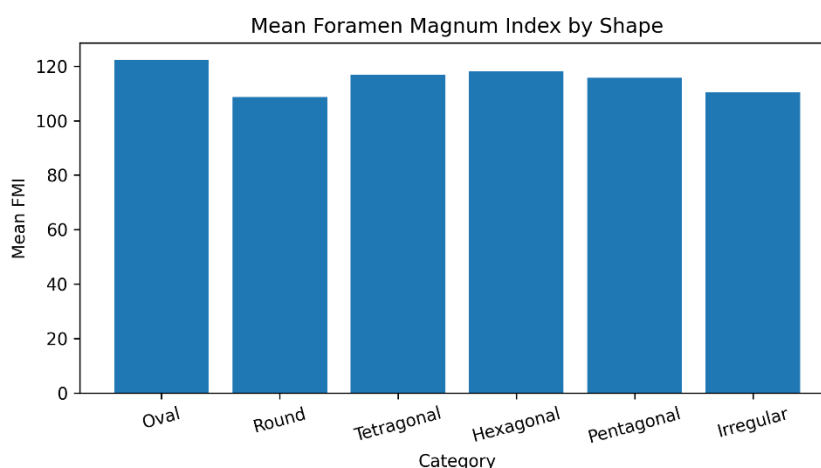


Figure 4: Mean foramen magnum index by shape

Discussion

The morphometric traits and shape variations of the foramen magnum in 97 adult dry human skulls were assessed in this cross-sectional investigation. Because of its significance in radiological evaluation, neuroanatomy, forensic anthropology, and craniovertebral surgery, the foramen magnum is an essential anatomical landmark [5]. The study found that the mean transverse diameter was 29.41 mm, and the mean AP diameter was 34.92 mm. These results are in line with a number of earlier investigations carried out in other demographics. The elongated shape frequently observed in human skulls is reflected in the larger AP dimension relative to transverse diameter [6].

The most prevalent foramen magnum morphology was found to be oval in shape. Numerous anatomical studies conducted throughout the world have shown similar findings. Developmental and evolutionary processes influencing occipital bone growth and cranial base formation may be responsible for the

preponderance of oval morphology. The majority of foramina were longer in the anteroposterior dimension than in width, as shown by the mean foramen magnum index of 118.73. The morphological diversity shown in human skulls is further supported by notable variations in index values across different form groups [7].

The foramen magnum's morphometric assessment has significant neurosurgical ramifications. To prevent damage to vital neurovascular systems during procedures involving the craniovertebral junction, detailed understanding of the size of the foramen magnum is frequently necessary. For transcondylar and far-lateral approaches, larger AP diameters might make surgical access easier [8]. Measurements of the foramen magnum have been widely employed in demographic studies and sex determination from a forensic standpoint. Even in cases where other skeletal components are compromised, preservation is possible due to the foramen magnum's comparatively protected

placement. As a result, morphometric standards based on local populations could increase the precision of forensic identification [9].

The current study provides important information about the morphometric features of the foramen magnum in the population of Bihar. It is important to recognise some limitations, though. Subgroup analysis was limited since the skulls' age and sex were not available. Additionally, the study did not include radiological examination and was limited to dry skull specimens [10]. Notwithstanding these drawbacks, the results offer helpful baseline anatomical data. To further improve knowledge of foramen magnum anatomy, future research with bigger sample sizes, CT-based morphometric analysis, and sex-specific examination is advised [11].

Conclusion

The current study shows that there is significant morphological and morphometric variation in the foramen magnum. The most common morphology was oval, which was followed by round and tetragonal shapes. The foramen magnum index was comparatively high because the mean AP diameter was larger than the transverse diameter. These discoveries give radiologists, anthropologists, neurosurgeons, and forensic specialists crucial anatomical knowledge. Forensic identification, morphometric research, and craniovertebral junction surgery all depend on precise measurements of the foramen magnum.

Future anatomical and clinical research may use the data produced by this study as a regional reference standard. Comprehending typical morphological variations can help differentiate pathological alterations and enable safer cranial base surgical procedures. To confirm these findings and create thorough morphometric standards for the Indian population, more multicentric research involving larger populations and radiological methods is necessary.

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