MAK HILL Publications Research Journal of Medical Sciences

Research Article
doi: 10.59218/makrjms.2023.1076.1079

Morphology and Morphometric Analysis of the Foramen Magnum in Dried Adult Skulls in East Indian Region

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ABSTRACT

The foramen magnum (FM), which is located near the base of the skull, is a therapeutically significant landmark because of its intimate connection to the spinal cord and brain stem. Because the structures passing through it may be compressed in cases of foramen magnum meningioma, foramen magnum achondroplasia and foramen magnum herniation, the foramen magnum dimensions are important for identifying some malformations, such as Arnold Chiari syndrome, which exhibits expansion of transverse diameter. The present study was carried out to characterize the morphology and morphometry of the foramen magnum of dry human skulls in the East Indian population. Thirty six dry skulls of adult humans were investigated. Vernier calipers were used to measure the foramen magnum's anterior and posterior and transverse diameters and the shapes were evaluated visually. Furthermore, formulas were used to calculate the foramen magnum's area and index. The data acquired could be used to assist neurosurgeons in evaluating the anatomy of the craniovertebral junction in lateral transcondylar surgical approaches to reach lesions in the cranial base's middle and posterior regions. The results will also be useful to anesthetists, orthopaedic surgeons, radiologists, forensic expert, anatomists and anthropologists.

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Key Words
Skull, foramen magnum, shape morphology, morphometry

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Received: 1 August 2023
Accepted: 29 August 2023
Published: 30 August 2023

Citation: Sutandro Choudhury, Tanmoy Paul, Prasanta Chakraborty, Debasish Ghosh and Provas Banerjee, 2023. Morphology and Morphometric Analysis of the Foramen Magnum in Dried Adult Skulls in East Indian Region. Res. J. Med. Sci., 17: 1070-1073, doi: 10.59218/makrjms.2023.1076.1079

INTRODUCTION

Wide communication is possible between the spinal canal and the posterior cranial fossa thanks to the foramen magnum. It is traversed by the spinal accessory nerve, the vertebral artery and the lowest portion of the medulla oblongata. It has an oval shape, is broad at the back and its largest diameter is at the Anterolateral Expert. The dens' apical ligament and the tectorial membrane pass through it to connect to the internal basi-occiput. It also contains the medulla oblongata's lower end, meninges, vertebral arteries and the spinal accessory nerve. The occipital condyles, which descend to articulate with the superior articular facets on the lateral masses of the atlas, anteriorly overhang the foramen magnum's edge only slightly. In the world of diagnostic medicine, emerging imaging tools like These variations have become significantly more meaningful as a result of computed tomography and magnetic resonance imaging.

Background: The neurosurgeon, orthopedic surgeon and radiologist will find this study intriguing and helpful due to the intricacy of the base of the skull. Because these critical structures may compress in situations The proportions of the foramen magnum are affected by foramen magnum herniation, foramen magnum meningiomas and foramen magnum achondroplasia. become crucial both clinically and medically. It is crucial to assess the foramen magnum's size because important anatomical structures travel through it. These tissues may become squeezed under a variety of circumstances, Foramen magnum stenosis, achondroplasia and brain herniation are a few examples. These could be cause upper and lower extremity paresis, lower cranial nerve palsies and potentially fatal respiratory problems. In Arnold Chiari syndrome there is an increase in transverse diameter, hence measuring FM diameter is necessary. Males have larger FM diameters than females, hence research on FM dimensions can be applied to the field of forensic medicine to identify sex in situations including airplane injuries and war-related injuries. In forensic medicine and anthropology, the FM dimensions can be used to identify the gender of human skulls. Additionally, foramen magnum index, cranial index and other characteristics are used in craniometry to compare racial differences. The transcondylar technique is frequently used in neurosurgery to address lesions close to the brain stem and cervico-medullary junction.

MATERIALS AND METHODS

There are 36 adult human dry skulls, 19 men and 17 women, were randomly selected for the study sample. In the anatomy departments of a few medical colleges in West Bengal, morphological research on the foramen magnum was done. The research did not include the skulls of children or those that were damaged or incomplete. By taking into account the traditional anatomical traits, the sex was established. Two distinct observers independently measured each parameter using a specified approach to avoid inter- and intra-observer error. On the Foramen magnum of dried human skulls, measurements were made using Vernier calipers, which are precise to 0.01 mm.

The following parameters were measured:

- **Foramen magnum length (FML):** Anteroposterior diameter: From basion, the median position on the foramen magnum's anterior edge, to opisthion, the median point on the foramen magnum's posterior edge, there is a maximum straight anteroposterior diameter
- **Foramen magnum width (FMW):** Transverse diameter: Maximum straight transverse diameter between the foramen magnum's two most laterally positioned locations on the margins

The Vernier calipers were used to measure the length and width of the foramen magnum over the graded metallic scale, which were then manually fixed with the supplied screw at the stated landmarks.

- **Area of foramen magnum (FMA):** The Radinsky formula was used to determine the size of the Foramen Magnum

Radinsky's formula (FMA): 1/4×FML×FMW

where, (mathematical constant) is 22/7, FML is Foramen magnum length and FMW is Foramen magnum width.

- **Foramen magnum index (FMI):** Calculated by: 100 divided by the foramen magnum's length
- **Shape of foramen magnum:** Macroscopically, the foramen magnum's many forms were identified and categorized as oval, circular, tetragonal, hexagonal and irregular

Statistical analysis: We gathered, tabulated and statistically evaluated the data. In order to analyze the data, SPSS 17.0 was used. For each parameter, descriptive statistics such as the range, mean and standard deviation were computed. The difference in mean between males and females was examined using an unpaired't' test with an alpha level of 0.05. The mean, standard deviation and range were used to express the results. To compare males and females, an unpaired't' test was utilized. For statistical significance, a p value of 0.05 or less was used.

RESULTS

The foramen magnum's longitudinal diameter varied from 25.6-38.9 mm in male skulls, with a mean of 36.2±2.7 mm (mean SD), whereas it varied from 28.0-39.3 mm in female skulls, with a mean of 34.2±2.9 mm. Male skulls' mean longitudinal diameter was not appreciably larger than female skulls' ($p = 0.68$). In male skulls, the foramen magnum's transverse diameter ranged from 25.4-36.8 mm with an average of 29.1±2.4 mm, whereas in female skulls, it ranged from 23.6-33.6 mm with an average of 27.5±2.1 mm. Male skulls had a foramen magnum with a mean transverse dimension that was considerably bigger than female skulls ($p<0.05$).

The foramen magnum has a mean surface area of 735.12 mm±2113.76 mm^2, with a range of 502.76 mm^2 to 924.43 mm2. It was discovered that the mean foramen magnum index was 81.08±8.02. In 29.69% of the instances, the foramen magnum was discovered to be oval. 27.39% to be round, in 17.58% to be tetragonal, in 11.96% to be egg-shaped, in 6.02% to be hexagonal, in 5.89% to be irregular and in 4.65% of the cases to be pentagonal. Among the several varieties analysed, the oval-shaped foramen magnum was shown to have the highest incidence (Fig. 1).

DISCUSSIONS

According to Muthukumar *et al*.[1], the foramen magnum has an average anteroposterior length of 33.3 mm and a transverse width of 27.9 mm. Foramen magnum average anteroposterior and transverse diameters were 34.84 mm and 29.39 mm, respectively, according to Sampada *et al*.[2]. In a research of Mishra *et al*.[3] conducted on 71 skulls from Uttar Pradesh, the mean anteroposterior and transverse foramen magnum diameters were 34.09±2.23 mm and 28.22±2.19 mm, respectively. However, Gruber *et al*.[4] discovered that the average anteroposterior diameter

Fig. 1: Oval-shaped foramen magnum

of foramen magnum was 36.6 mm within range of 30.1-42.6 mm and the average transverse diameter was 31.1 mm, with a range of 25-38.9 mm. in their study on skulls from Western Europe. Wanebo and Chicoine *et al*.[5] noted that the foramen magnum's length and breadth had mean dimensions of 36 and 31 mm, respectively. In a study of sixty human skulls, Solan[6] found that the foramen magnum's mean anteroposterior diameter was 36±2.9 mm and its mean transverse diameter was 32.2±2.9 mm.

The average size of the foramen magnum in 92 dry skulls studied by Praveen and Singh[7] was 792.61±91.01 mm^2. Sharma *et al*.[8] examined 50 dried skulls and found that the foramen magnum had an average area of 970.57 mm^2. In 2017, Rajkumar *et al*.[9] measured 298 dry skulls of unknown sex and found that the foramen magnum measured 754.32±105.6 mm^2. According to a research conducted on a population in south India, the average foramen magnum measured 803.8-83.42 mm^2. When Rohinidevi and Vimala[10] examined 35 skulls, they found that the foramen magnum's area was 820.53 mm^2. The ethnic group included and the size of the research sample may be to blame for the variances shown in the aforementioned studies.

Using 50 dried skulls of unknown sex, Singh *et al*.[11] did a research and discovered that the mean foramen magnum index was 84.5±66.32. According to a research by Rohinidevi and Vimala[10] on 35 dry skulls from India, the foramen magnum index was on average 82.54. Rajkumar *et al*.[9] did a research on 298 skulls and they found that the mean foramen magnum index was 83.1±46.33 mm.

CONCLUSION

The current study clarifies the morphometric information and the variances in the foramen magnum's morphology. When performing procedures to remove lesions from the posterior cerebral fossa or the foramen magnum, or to diagnose Arnold Chiari Syndrome, a surgeon's understanding of the foramen magnum's morphometry is crucial. This is important because the size and variability of these foramina affect the results of different surgical operations. These results are significant for anesthetists, orthopaedists, radiologists, forensic specialists, anatomists and anthropologists in addition to neurosurgeons.

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