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A Study on Foramen Magnum Morphology and Morphometry.

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Abstract

Background: The anatomical variance of the foramen magnum may have some impact on certain surgical procedures such as vertebral artery and posterior inferior cerebellar artery aneurysm repairs, foramen magnum meningioma resections, and foramen magnum decompression among others. In an ovoid type foramen magnum, it is difficult for a surgeon to adequately expose the anterior portion of the foramen. As the total volume in the skull is fixed and consists of blood, cerebrospinal fluid, and brain tissue, the increased pressure may lead to compensation via cerebellar tonsil herniation through the foramen magnum. The present study was conducted to find morphological shapes and morphometric features of foramen magnum.

Materials and Methods: The present study conducted with 74 adult dry skulls We have used only intact skulls, which were without any pathological abnormality, which appears with clean look and dry. We have observed the shapes of foramen magnum and incidence of shapes. We have recorded morphometric measurements like anterior-posterior diameter and transverse diameter of foramen magnum with help digital Vernier sliding calliper.

Results: Oval shape foramen magnum was observed in 32 number of skulls and the incidence was 43.24%, tetragonal shape foramen magnum was observed in 8 number of skulls and the incidence was 10.81%, hexagonal shape foramen magnum was observed in 6 number of skulls and the incidence was 8.11%, round shape foramen magnum was observed in 16 number of skulls and the incidence was 21.62%, pentagonal shape foramen magnum was observed in 7 number of skulls and the incidence was 9.45% and pear shape foramen magnum was observed in 5 number of skulls and the incidence was 6.75%.

Conclusion: The present study data may be helpful to neurosurgeons, forensic practice and anthropologists to assess variations in shapes of foramen magnum and its size.

Keywords: Foramen Magnum, Atlanto-Occipital joint, Neurosurgery, Meningeal layers.

Introduction

The foramen magnum, occipital condyles and the first two cervical vertebrae are commonly referred to as craniovertebral junction. The foramen magnum is a large orifice located in the base of the skull, which provides a passageway for the medulla oblongata, spinal cord and neurovascular structures that leave the skull. The foramen magnum is surrounded by different parts of the occipital bone, i.e., two condylar, squamous and occipital parts[1]. The foramen magnum is the largest opening and is outlet through which medulla oblongata and spinal cord along with meninges, vertebral arteries, anterior and posterior spinal arteries, tectorial membrane, alar ligaments, and spinal branch of the accessory nerve. Occipital condyle is an important part of craniovertebral or craniocervical junction located anterolaterally on either side of the foramen magnum[2].

The transcondylar approach is being increasingly used to access lesions ventral to the brainstem and cervicomedullary junction. Understanding the bony anatomy of this region is important for this approach. The foramen magnum, as an anatomical structure, holds clinical and functional significance due to its strategic location in the craniovertebral transition. A detailed understanding of its dimensions and shapes is crucial for better comprehension of related pathologies and for enhancing neurosurgical techniques within a specific population[3].The morphometric data of foramen magnum can be used for diagnosis of various congenital disease such as Arnold Chiari malformation in which expansion of transverse diameter more than anteroposterior diameter. The diameter of the foramen magnum is also needed prior to the surgery of the posterior cranial fossa lesions as greater contra lateral exposure required where antero-posterior diameter is more. The morphological parameters of the foramen magnum are more in males than in females, which can be utilize for differentiation of sex in various medicolegal conditions. Various studies show of foramen magnum shows that the antero-posterior & transverse diameter is 3.5cm & 3 cm. Compression of brainstem due to various pathological conditions causes life threatening respiratory complications [4].

All the bones of the skull develop from paraxial mesoderm and neural crest cells. During gastrulation in the third week, mesenchymal cells migrate through the primitive streak to form the mesoderm. At the end of the third week, the paraxial mesoderm is segmented into somites that differentiate to become sclerotomes During the fourth week, the occipital sclerotomes concentrate around the notochord under the influence of signals from the rhombencephalon.These sclerotomes derive membrane and cartilage, the developmental origin of the occipital bone. Four primary cartilaginous centers, the anterior basioccipital, the lateral exoccipitals and the posterior supraoccipital, in addition to a fifth membranous element, referred to as the interparietal combine around the foramen magnum to form the occipital bone. The mendosal suture runs horizontally between the developing inferior supraoccipital and superior interparietal bones[5].There are a number of pathological states directly associated with the foramen magnum. Elevated intracranial pressureoften results from sources of edema such as stroke, trauma, mass effect, and infection and represents a serious prognosis. As the total volume in the skull is fixed and consists of blood, cerebrospinal fluid, and brain tissue, the increased pressure may lead to compensation via cerebellar tonsil herniation through the foramen magnum. The clinical picture of any herniation includes hypertension, bradycardia, and respiratory depression, but cerebellar herniation specifically causes compression of the respiratory centres of the medulla and may be fatal. The anatomy of the foramen magnum may influence the displacement of the herniated tissues [5,6,7,8]. The Present study was conducted to find the morphological and morphometric variations of foramen magnum in adult dry skulls.

Materials and Methods

The present study conducted with 74 adult dry skulls, the gender was not determined, this study was done in department of anatomy of Govt medical college, Nagarkurnool, Osmania Medical College, Hyderabad and Siddartha Govt Medical College, Vijayawada A.P. The damaged skulls were not included in study.We have used only intact skulls, which were without any pathological abnormality, which appears with clean look and dry. We have observed the shapes of foramen magnum and incidence of shapes. We have recorded morphometric measurements like anterior-posterior diameter and transverse diameter of foramen magnum with help digital Vernier sliding calliper which is accurate to 0.01 mm. Values of each measurement were expressed in the form of Mean$\pm$SD.

Results

The present study was conducted in 74 skulls with unknown gender skulls, as morphological features, oval shape foramen magnum was observed in 32 number of skulls and the incidence was 43.24%, tetragonal shape foramen magnum was observed in 8 number of skulls and the incidence was 10.81%, hexagonal shape foramen magnum was observed in 6 number of skulls and the incidence was 8.11%, round shape foramen magnum was observed in 16 number of skulls and the incidence was 21.62%, pentagonal shape foramen magnum was observed in 7number of skulls and the incidence was 9.45% and pear shape foramen magnum was observed in 5 number of skulls and the incidence was 6.75%.The Anterior – Posterior diameter (mm) Foramen Magnum was 37.14$\pm$6.72mm, minimum anterior- posterior diameter was observed 32.37mm and maximum was 43.62mm. The transverse diameter (mm) foramen magnum 32.15$\pm$1.12mm, minimum diameter was 27.32mm and maximum was 92.62mm.

Figure 1. The skull with oval shaped foramen magnum

Discussion

The anatomical variance of the foramen magnum may have some impact on certain surgical procedures such as vertebral artery and posterior inferior cerebellar artery aneurysm repairs, foramen magnum meningioma resections, and foramen magnum decompression among others. In an ovoid type foramen magnum, it is difficult for a surgeon to adequately expose the anterior portion of the foramen. Additionally, the occipital condyle and jugular tubercle are the main bony prominence obstructing the anterolateral portion of the foramen magnum. Extension of the occipital condyles into the foramen magnum may indicate the need for more extensive bony removal in certain procedures[5,9,10,11].The knowledge of foramen magnum morphometry is also needed to determine some developmental and acquired craniocervical junction disorders. Achondroplasia is a genetic disorder that results in dwarfism and abnormal endochondral bone formation at the cranial base, leads to a narrow cervical spinal

canal and a stenotic foramen magnum. Clinical appearances of constant brainstem compression by stenosis of the foramen magnum and related structures are respiratory complications, lower cranial nerve dysfunctions, upper and lower extremity paresis, hypotonia or hypertonia and general motor development delay [12,13].

According to study of Seth Hendricks[1] the mean length and width of the foramen magnum was found to be 35.19 mm and 27.77 mm. The mean index of the foramen magnum was 1.3, which indicated that the foramen magnum was predominantly oval-shaped within the selected sample. The occipital condyles have a mean length and width of 21.73 mm and 12.87 mm, respectively. Furthermore, the most prevalent shape of the occipital condyles was oval. The mean length and width of the hypoglossal canals were 5.14 mm and 3.87 mm, respectively. While the most prevalent shape of the hypoglossal canal was oval and round on the right and left sides, respectively. The study by Chethan P, et al [14] conducted with 53 dry human cadaver skulls found the foramen magnum as a round shape in 22.6% of cases, egg shape in 18.9%, tetragonal in 18.9%, oval in 15.1%, irregular in 15.1%, hexagonal in 5.6% and pentagonal in 3.8% of the cases. In 20.7% of skulls, the occipital condyle was observed to protrude into the foramen. The mean antero-posterior and transverse diameter of the foramen magnum was determined as 31 ± 2.4 mm and 25.2 ± 2.4 mm respectively. The average foramen magnum index was 1.2 ± 0.1.

The study of Degno S [2] with 54 skulls found the mean values of anteroposterior and transverse diameters of the foramen magnum were 35.19 and 30.17 mm, respectively, and the mean area of the foramen magnum was 853.36 mm. The shapes of foramen magnum were determined as round in 22.2%, oval in 18.5%, egg like in 20.4%, triangular in 3.7%, pentagonal in 11.1%, hexagonal in 7.4%, irregular in 13%, and rectangular in 3.7% of the cases. N study of Cirpan S et al[15] the mean antero-posterior diameter and transverse diameter of anteroposterior diameter by transverse diameters were found as 34.38 ± 2.38 and 28.95 ± 2.19, respectively. According to estimated foramen magnum index of the 150 adult dry skulls, 87 (58%) of skulls were described as being round in shape and 63 (42%) of skulls were described as being oval in shape.The study of Yataco-Wilcas CA et al [16] the average measurements of the skull base revealed a foramen magnum with a mean length of 33.80 mm and a width of 28.70 mm, along with right condyles measuring 25 mm in length and 14.10 mm in width, and left condyles measuring 23.80 mm in length and 13.90 mm in width.In study of Archana Singh et al [17] found the most common shape of foramen magnum was oval in 40 (33.3%) skulls; followed by tetragonal in 20 (16.6%) skulls and hexagonal in 20 (16.6%) skulls. Round shapedforamen magnumwas present in 16 (13.3%) skulls, pentagonal foramen magnum in 16 (13.3%) and pear-shapedforamen magnumwas present in 8 (6.6%) skulls.The mean of Anteroposterior diameter was 33.79±2.60 mm; transverse diameter was 28.25±1.83 mm and foramen magnum index were 83.91±6.43.

Conclusion

The present study has determined the various shapes of foramen magnum and its morphometry. The results of our study may be of useful to the neurosurgeon in analyzing the morphological anatomy of craniovertebral junction. The findings are also helpful to the anthropologists, morphologists and clinical anatomists.

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