Original Article

Morphometric study of foramen magnum in human skulls

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Abstract

Aim: The objectives were to study the morphology of the foramen magnum in dry skulls and to evaluate its antero-posterior diameter, transverse diameter and morphological variants of the shapes of foramen magnum. **Materials and Methods:** The foramen magna of 61 dry human cadaver skulls that were obtained from Department Anatomy IIMSR Warudi, Badnapur Different shapes of the foramen magnum were macroscopically noted and classified. The antero-posterior and transverse diameters were measured. **Results:** The foramen magnum shapes were determined as a round shape in 29.50% of cases, tetragonal in 18.03%, oval in 31.14%, irregular in 11.47%, hexagonal in 8.19% and pentagonal in 1.63% of the cases. The mean antero-posterior and transverse diameter of the foramen magnum was determined as 39± 2.2 mm and 37.5 ± 2.5 mm respectively. **Conclusion:** The present study has determined the various shapes of foramen magnum and its morphometry. The data obtained may be of useful to the neurosurgeon in analyzing the morphological anatomy of craniovertebral junction. The findings are also enlightening for the Anthropologists, morphologists and clinical anatomists.

Keywords: Foramen magnum, Morphology, Morphometry, Shape, Skull.

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INTRODUCTION

In anatomy, the foramen magnum (Latin: “great hole”) is a large opening in the occipital bone of the cranium. It is one of the oval or circular apertures in the base of the skull (the foramina), through which the medulla oblongata (an extension of the spinal cord) enters and exits the skull vault. Apart from the transmission of the medulla oblongata and its membranes the foramen magnum transmits the vertebral arteries, the anterior and posterior spinal arteries, the membrana tectoria and alar ligaments. It also transmits the spinal component of the accessory nerve in to the cranial fossa[1]. The dimensions of the FM have clinical importance because the vital structures that pass through it may suffer compression such as in cases of FM achondroplasia [2] and FM brain herniation[3,4]. In neurosurgical practice, the transcondylar approach is commonly used to access the lesions which are ventral to the brainstem and cervicomedullary junction. It was reported that understanding the bony anatomy of the condylar region is important for this approach[5]. The knowledge of foramen magnum diameters is needed to determine some malformations such as Arnold Chiari syndrome, which shows expansion of transverse diameter[6]. In a computerized tomographic study of Catalina and Herrera, dimensions of the foramen magnum of 63 achondroplastic individuals were compared to standards established for nonachondroplastic individuals. The size of the foramen magnum in patients with achondroplasia was small at all ages, particularly in those with serious neurological problems[7]. Furthermore, Wanebo *et al.*[8] stated that longer FM antero-posterior dimensions permitted greater contralateral surgical exposure for condylar resection. The foramen magnum (FM) is an important land- mark of the base of skull and is of particular interest to many folds of medicine. Variations of the shape of FM have got diagnostic clinical and radiological importance [9]. The diameters and area of the foramen magnum are greater in males than in females,

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hence its dimensions can be used to determine sex in the medicolegal conditions, especially in the following circumstances, such as explosions, aircraft accidents and war fare injuries[6,10]. FM evaluations are very important in not only to establish the most proper operational techniques, but also to obtain useful data for unknown sex estimation and determination and identity in forensic medicine. Despite its particular clinical importance, there are only a very few anatomical reports are available in the literature. The goal of this research work was to document and analyze the foramen magnum shapes and to determine the average dimensions of the FM in dry cadaver skulls.

MATERIAL AND METHODS

61 dry human skulls were taken for observation from department of anatomy IIMSR Warudi, Badnapur. All skulls were adult type. The exact age and sexes of the skulls were not. They were used for tutorial teaching for medical students. With the help of simple venire caliper antero-posterior and transverse diameter of foramen magnum were measured. The length of the foramen magnum was measured from the anterior border (basion) through the centre of the foramen magnum until the end of the posterior border (opistio), The transverse diameter was measured from the point of maximum concavity on right and left margins (fig.1). The different shapes of FM were macroscopically noted and classified as oval, round, tetragonal, pentagonal, hexagonal and irregular shapes.

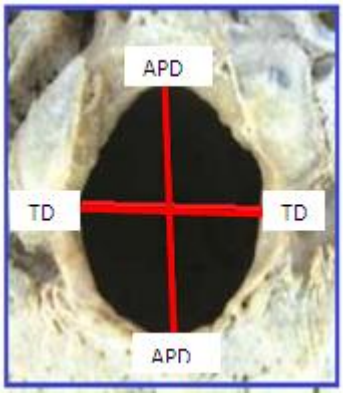

Figure: 1 Measurement of diameters of foramen magnum in skull

OBSERVATION AND RESULTS

The dimensions of Foramen Magnum are shown in Table1. Surface area of Foramen Magnum was calculated by using formula stated bellow. [11]

AREA= $\Pi \times\{(hXw)/4\}$

h=antero-posterior diameter

w=transverse diameter

π=22/7

Table 1: Dimensions of foramen Magnum

Values	APD(mm)h	TD(mm)w	Surface area(mm2)
Maximum	39.8	37.5	1172.67
Minimum	26.7	24.7	518.17
Mean ± SD	33.4±2.5	28.5±2.2	747.92

Table 2: Showing the Frequency of Different Shapes of Foramen Magnum (n=61)

Shape	Number	Frequency
round	18	29.50%
Tetragonal	11	18.03%
oval	19	31.14%
irregular	07	11.47%
hexagonal	05	8.19%
pentagonal	01	1.63%

In present study the average antero-posterior diameter of the foramen magnum was 33.4mm (range 26.7-39.8mm) and the transverse diameter was 28.5mm (range 24.7-37.5).The mean surface area of foramen magnum was 747.92mm².The various shapes of FM which were observed in the present study are shown in Figure 1. The FM was observed to have round shape in 29.5%, tetragonal in18.03%, oval in 31.14%, irregular in 11.47%, hexagonal in 8.9% and pentagonal in 1.63% of the cases. The frequencies of different shapes of FM are represented in Table 2.

DISCUSSION

The dimensions of the foramen magnum are clinically important because vital structures passing through it. In present study the average antero-posterior diameter of the foramen magnum was 33.4 (range 26.7-39.8mm) and the transverse diameter was 28.50mm (range 24.7-37.5). The mean surface area of foramen magnum was 747.92mm². Muthukumar and Swaminathan observed that the average antero-posterior length of the foramen magnum was 33.3 mm (range 27–39 mm) and the transverse diameter was 27.9mm (range 23–32 mm)[5]. There is statistically significant difference between present study and observation done by Muthukumar and Swaminathan ($p<0.01$). Berge and Bergmann reported an average antero posterior diameter of 34 mm and an average transverse diameter of 29 mm[13]. In a study done on skulls of Karnataka the mean longitudinal diameter of foramen magnum in male was 33.4mm and female was 33.1mm and by CT Imaging method in male was 38.5mm and female was 35.2mm. The mean transverse diameter of foramen magnum in male was 28.5mm and female was 27.3mm and by CT Imaging method in male was 29.1mm and female was 27.6mm[14].

Philipp Gruber, in his study on skulls from western Europe found the antero posterior diameter ranges 30 mm to 43 mm with mean of 36.6mm. The transverse diameter

ranges from 25 mm to 39mm with the mean of 31.1mm[15]. Tubbs RS found that the mean anter oposterior diameter was 31mm, and the mean horizontal diameter was 27 mm and the mean surface area of the foramen magnum was 558 mm²,[11]. In Catalina-Herrera's anatomic study of the FM, the diameters were 35.2 mm for the antero posterior and 30.3mm for the transverse diameter[7]. In the Morphometric analysis of the foramen magnum in human skulls of brazilian individual in relation to gender Manoel, C. found that mean antero-posterior diameter of foramen magnum was 35.7 mm in male and 35.1mm in female. The transverse diameter was 30.3mm in male, 29.4mm in female[16]. Wanebo and Chicoine[17], in their study on cadaveric CT images measurements, found that the mean area of the FM is 820.0 ± 100.0 mm2, the mean length (SD) 36.0 ± 2.0 mm and the mean width (TD) 32.0 ± 2.0 mm. Fatma Hayat Erdil studied fifty-four cranial CT scans obtained from the archives of Department of Radiology and observed that mean antero-posterior diameter of the foramen magnum was 35.58mm and transverse diameter was 29.84mm.The mean antero-posterior diameter in male and female was 30.75mm and 29.98mm respectively. The mean transverse diameter in male and female was 36.95mm and 34.41mm respectively. There was a significant difference between the anteroposterior diameter of male and femalecases[18]. Günay Y, Altinkök M.; the mean of foramen magnum area was 909.91mm² males, 819.01mm² in females which was significant (p value<0.001)[9]. Since the FM includes specific neuroanatomic structures[19-20] and lesions occupied in that area which need especially microsurgical intervention[19], choosing and establishing the most appropriate surgical techniques require a meticulous planning mainly based on the FM sizes to refrain from any neurological impairment[20,21,22]. In addition, it is quite difficult to detect many pathological situations not only by neurological examination but also needs support with the radiological findings[20,25] It was reported that some of the osteological features in the skull like FM have undergone evolutionary changes[25,26].During the early fetal growth, the development of skull base begins as a cartilaginous mass with multiple centers of ossification and the FM alone is one such center[26]. It was described that the FM is morphologically variable. The irregular shape of FM is accentuated by the developmental anomalies of the bone and soft tissues at the cranio-vertebral junction[27]. Zaidi and Dayal[28] reported the hexagonal shape in 24.5%, pentagonal in 7.5%, irregular in 3.5% and round in 0.5% of the skulls. In contrast, Sindel *et al*.[29] reported that the FM was hexagonal in 5.3%, pentagonal in 4.2%, irregular in 6.3%, round in 15.8% and tetragonal in 49.4% of the subjects. In the present study, the FM was observed to have round shape in 18 cases (29.5.6%), tetragonal in 11 (18.3%), oval in 19 (31.14%), irregular in 7 (11.47%), hexagonal in 5 (8.9%) and pentagonal in 1 (1.63%) of the cases. The difference in shapes of the FM from various reports indicates racial variability among the morphology. The present study agrees with Murshed *et al*. [30] as in both these studies the round shape was the most common type.

CONCLUSION

The present study elucidates the morphometric data and the variations in the morphology of the FM with emphasis on their clinical implications. These morphological characteristics have medicolegal importance and helps in the identification of unknown individuals. The knowledge of diameters of the foramen magnum are needed to determine radiological malformations (Arnold Chiari's syndrome) and prior to cutting off of foramen magnum or posterior cranial fossa lesions, or sex determination of skulls. So the knowledge of dimensions of foramen magnum are important for neurosurgeons, radiologist as well as anthropologists Though the present study has a limitation as the exact age and sexes of skull were not determined, this study may provide an important reference and the measurements may be used as a data for the description of normal morphological variants of FM. Since the anatomy of the FM is of interest to many fields of medicine due to increased application of CT and MRI scans, this investigation was undertaken. We believe that the data obtained from the present study will be of useful to the neurosurgeons and is also certainly enlightening to the anthropologists, morphologists and clinical anatomists.

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