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Morphometry of Foramen Magnum: An Anatomical Study

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ABSTRACT

Introduction: The knowledge of foramen magnum dimensions is important for clinicians to highlight the malformations like Arnold Chiari malformation and Achondroplasia. Its morphometry is helpful for neurosurgeons and for forensic experts as well. Foramen magnum (FM) is a large oval opening in the occipital bone of skull that transmits part of brain stem, spinal cord and many related structures

Aims & Objectives: To determine the variations in transverse and antero posterior diameters of foramen magnum and foramen magnum index in dry skulls of adults in Pakistani population.

Place and duration of study: The study was conducted at FMH College of Medicine & Dentistry, Lahore in December 2021 on 99 dry human skulls.

Material & Methods: The foramen magnum of 99 dry skulls of human adults of unspecified gender and of unknown exact age, from the collection of Anatomy Department in FMH college of Medicine and Dentistry, Lahore, Pakistan, was examined to evaluate the dimensions of FM. Digital caliper was used to measure the antero-posterior diameter (APD) and transverse diameter (TD) of foramen magnum (FM) in dry skulls of human adults and then foramen magnum index FMI was calculated by dividing APD by TD.

Results: The mean values of transverse and antero posterior diameters of foramen magnum in dry human skulls were found as23.18 ± 7.68 and 29.22 ± 7.52 respectively. The mean value of foramen magnum index was 1.30 ± 0.22.

Conclusion: Our study determined variations in diameters of FM and FMI in the skulls of Pakistani population. Antero posterior diameter of foramen magnum is more than its transverse diameter and majority of skulls show oval shaped FM. The results of this study may help the neurosurgeons, anthropologists, morphologists, clinical anatomists and forensic experts.

Key words: Foramen magnum, Transverse diameter, Antero posterior diameter, Foramen magnum index.

INTRODUCTION

Foramen magnum (FM) is a wide, oval opening, antero medially located in the posterior part of norma basalis of skull. It has more antero posterior diameter than its transverse one. It forms a communication between the posterior cranial fossa and vertebral canal. Anterolateral marginsare related to two occipital condyles (OC). Apical ligament of dens and tectorial membrane pass through its anterior part. Posteriorly it transmits lower part of medulla oblongata and spinal cord with their covering meninges. Spinal arteries, spinal accessory nerves and vertebral arteries with sympathetic nerves plexus also traverse it.[1]

Foramen magnum is a junctional zone between skull and vertebral column and it has a very close relation to brain and spinal cord. The tumors of these vital organs, lesions of related vessels and rheumatoid disease of cranio-cervical area are very common. Surgery in this region is very complicated because of its relations with lower vermis, tonsils of cerebellum, 4th ventricle, lower part of medulla with cranial nerves, upper part of spinal cord with cervical nerves. Different surgical procedures are

greatly dependent on the morphometry of foramen magnum.[2]

Oval shaped occipital condyles cover foramen magnum on its both anterolateral aspects. Tumors located anterior to the spinal canal can be reached from ventral side or dorsal side. Nowadays in order to reach foramen magnum tumors, condyles are excised by transcondylar surgery. For that purpose, measurements of FM and OC are useful for adopting lateral surgical approaches for the removal of tumors of this region. More antero posterior diameter of foramen magnum provides good exposure for surgical procedures. [3, 4]

Anatomical disproportion in normal size and shape of foramen magnum, as in the conditions like achondroplasia and herniation of brain may affect the structures traversing it and may obstruct the blood flow and cerebrospinal fluid flow. In achondroplasia, narrow foramen magnum can lead to respiratory distress and death of a baby. In the same way Arnold Chiari malformation type 1 can be diagnosed due to disproportion between measurements of FM and hind brain. [2,3,4]

The knowledge about dimensions of all foramina in the base of skull is immensely important not only for neurosurgeons but for anesthetists and acupuncture practitioners as well.[5]

Nowadays computed tomography (CT) scan and magnetic resonance imaging (MRI) can give accurate information about the size and shape of all foramina located in the base of skull in a living individual. In diagnostic medicine through these techniques the pathological lesions of the structures traversing these foramina of the skull can be highlighted. Many diseases like neurofibromatosis and osteopetrosis can lead to enlargement or narrowing of these foramina of the skull. Radiologists and oncologists can get help for seeing a tumor encroaching on a foramen. [5]Helical CT scan not only provides reliable measurements of FM but also performs gender classification of the individuals on the basis of this morphometry.[6]

To the best of our knowledge, till now no study has been done in Pakistan on the morphometry of FM of adult human dry skulls, Therefore, our study may provide data of disparities in measurements of FM that may prove helpful for neurosurgeons, orthopedic surgeons and forensic experts and many other specialists in medical field.

MATERIAL AND METHODS

This study was conducted at FMH College of Medicine and Dentistry, Lahore, approved by Institutional Review Board. 99 adult dry human skulls of un-identified gender and unknown exact age from the collection of Anatomy Department in FMH college of Medicine and Dentistry at Lahore, Pakistan were examined to evaluate the dimensions of FM. All damaged skulls were not included in this study. A Digital caliper was used to measure the antero-posterior diameter APD and transverse diameter TD of FM (Fig-1) and then foramen magnum index FMI was calculated in human skulls using these two diameters. The parameters examined were as follows:

1. TD of foramen magnum: Distance between lateral margins of FM at the point of maximum lateral curvature.
2. APD of foramen magnum: Direct distance between basion (midpoint of anterior margin) and opisthion (midpoint of posterior margin).
3. Foramen magnum index: APD divided by TD of foramen magnum.

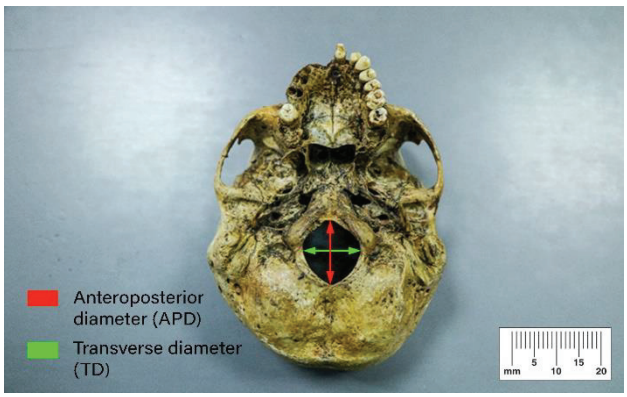

Fig-1: Norma basalis of a skull showing foramen magnum, red and green arrows indicate the antero posterior and transverse diameters of foramen magnum respectively.

Statistical analysis: The data was analyzed by SPSS, version 22. Mean values and standard deviations (SD) were calculated and tabulated.

RESULTS

The total number of 99 adult human dry skulls was examined for the dimensions of FMs. The

maximum, minimum and mean values with standard deviation of TD, APD and FMI were calculated, tabulated and represented in the form of Table-1 and Figure-2. The mean values of TD, APD and FMI were found as 23.18±7.68, 29.22±7.52 and 1.30±0.22 respectively.

Sr. No	Measurements of foramen magnum	Min.	Max.	Mean	Standard deviation SD
1.	Transverse diameter TD (mm)	9.30	32.66	23.18	7.68
2.	Anteroposterior Diameter APD (mm)	13.80	39.25	29.22	7.52
3.	Foramen magnum index FMI	0.990	2.320	1.30	0.22

Table-1: Results of the examined Foramen magnum measurements.

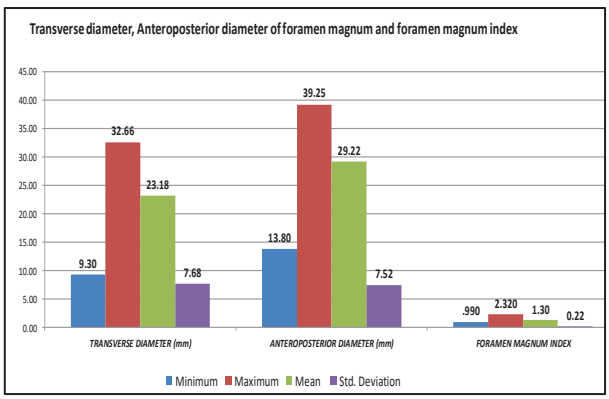

Fig-2: Bar graph showing the results of the examined foramen magnum measurements

DISCUSSION

In the present study the mean values of TD and APD of foramen magnum of adult human dry skulls were found as 23.18 mm and 29.22 mm respectively. Chethan et al.,[4] in his study on human dry skulls measured APD and TD of foramen magnum as 31±2.4mm and 25.2±2.4mm respectively. These findings are very close to ours. The data was found useful for surgeon to operate on craniovertebral junction in Indian population. Sandeep et al.,[5] observed mean APD and mean TD as 35.42mm and 27.90mm respectively in Indian population. He also noted that 60% of skulls were having oval shaped FM. He concluded that the variations in these metrical studies are due to racial and geographical differences. Cirpan et al.,[2] did measurements of FM of dry human skulls and found the mean values of APD and TD of FMs as 34.8±2.38 and 28.95±2.19. He noted that for surgical procedures in the area of FM greatly depends upon the location of a tumor and the measurements of FM, to avoid complications due to involvement of vital tissues. Joy.,[7]noted the mean APD 3.28cm and mean TD 2.86cm of foramen magnum of dry cranii in Nepalese population. The data was found helpful to the neurosurgeons to reach the lesions of medulla and vertebral artery from lateral sides. Bhaskar et al.,[8] did measurements of FMs in District of Southern India and found the mean. APD as 34.81mm and mean TD 28.72. He added that this information is important for radiologists and neurosurgeons in doing head and neck surgeries. In another study in India, the average antero posterior length of the foramen magnum was 33.3 mm and the width was 27.9 mm. This study was found helpful for the neurosurgeons to reach the tumors anterior to the brain stem using transcondylar approach.[9]

Knowledge of gender of an individual's very important in medico legal cases, in forensic medicine and in identification of an unknown. Metrical values of FM are specifically helpful in determining the gender. Jain et al.,[10] noted that the measurements of FM in men skulls are significantly higher than in female skulls. Lyrtzis et al.,[11] observed the same findings when he did a study on FM, OC and hypoglossal canals of skulls in Greeks. It was found that the mean values of the measurements of all these parameters were significantly high in male skulls than female skulls and age-related decrease in certain values was also noted. These morphometric results may prove useful for surgery in cranio-cervical area. According to Natsis et al.,[12], mean FM width and length were found 30.31 ± 2.79 and 35.53 ± 3.06 mm, respectively. He also worked on measurements of OCs of skull. Regarding all these measurements he noted gender differences as well. This metrical information about FM region helps in doing effective surgeries in this area with good exposure as well.

Shepur et al.,[13]noted that the mean Longitudinal and transverse diameters and area of foramen magnum of male skulls were greater than females. Between male and female values of FM highly significant difference was noted. This data of the FM is useful for clinicians as many vital structures are traversing it and it is important to determine radiological malformations like Arnold Chiari's syndrome and Achondroplasia. Metrical values of FM are helpful

for operating on foramen magnum for posterior cranial fossa lesions and also for sex determination of skulls.

Zdilla et al.,[14] observed that, within each well-defined population, the size of the FM is significantly larger in males than in females; however, there are no significant differences in the shapes of the foramina between sexes. When comparison is done among groups of different populations, significant differences in the size and shape of the FM are noted.

Kanodia et al.,[15] in his study found that all measurements of posterior fossa and FM are higher in males than in females. Dry skull values may be different from that of CT scan of living individuals because of reduction of bone tissue due to loss of minerals.

Regarding FMI, in the present study mean value was calculated as 1.30±0.22 and majority of skulls were found to be having oval shaped FM. Chethan et al., [4] Joy et al.,[7] and Zdilla et al., [14] calculated mean values of FMI as 1.2±0.1, 1.15 and 1.14 respectively. It was found that skulls with FMI greater than 1.2 need more bone resection during surgeries. The knowledge of metrical values of FM has medicolegal significance specially to know the unknown individuals.

Cipran et al., [2] found that the skulls having FMI equal to 1.2 or greater than this value, they were having oval foramen magnum and if the value is less than 1.2, the foramen magnum is round in shape. He found 58% skulls with FM round shaped and 42% skulls with FM oval shaped. During the surgical procedures for the tumors of vital organs located in FM, an oval shaped FM requires more bone removal than round shaped FM for a good exposure of its anterior part. Muthukumar et al., [9] observed the same results of FMI. The foramen magnum index in 46% of skulls was equal to or more than 1.2, these foramina were found to be oval that require more bony removal during surgeries in this area. [9]

CONCLUSION

Our study showed variations in transverse and antero-posterior diameters of FM and FMI in dry human skulls. Antero posterior diameter was found more than transverse diameter of FM in the dry skulls and majority of skulls were having oval shaped FM.

Findings of the present study of dry human skulls would help the medical professionals dealing with neurosurgery, orthopedics, forensic medicine, radiology, oncology, clinical anatomy and anthropology in their practice.

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