



## “MORPHOLOGICAL AND MORPHOMETRIC STUDY OF FORAMEN MAGNUM IN DRY HUMAN SKULLS OF KASHMIR”

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### ABSTRACT

**INTRODUCTION:** Morphological and morphometric analysis of foramen magnum of dry human skulls in Kashmir was done which is helpful in ruling out compression in diseases associated with foramen magnum like meningiomas and herniations. Morphometric evaluation can be used before heading towards costly examination.

**MATERIAL AND METHOD:** The present study was conducted on 15 skulls and 10 occipital bones. Anteroposterior and transverse diameters were measured using a digital vernier calliper. Their knowledge is important in malformations like Arnold Chiari syndrome, in which transverse diameter of foramen magnum is more than the anteroposterior diameter. The area and width of the foramen were calculated using formulae.

**RESULTS:** The average anteroposterior diameter and transverse diameter of foramen magnum were  $3.16 \pm 0.216$  cm and  $2.65 \pm 0.212$  cm respectively. The average area and index of the foramen magnum were calculated as  $6.60 \pm 0.9$  cm and  $83.64 \pm 5.71$  cm respectively.

**CONCLUSION:** The present study on the foramen magnum showed that the average anteroposterior diameter of foramen magnum was more than the transverse diameter. These findings are of use to neurosurgeons, forensic experts and anatomists. Morphological study is also a valuable tool to assess the malformations of foramen magnum.

**KEYWORDS :** Foramen magnum, condylus tertius, morphometry

### INTRODUCTION:

Spinal osteometry is a very important tool in the field of basic medical sciences and anthropology.<sup>[1]</sup> Foramen magnum plays a very significant role as a transition zone between spine and skull, being in close proximity to brain and spinal cord.<sup>[2]</sup> Foramen magnum is the largest opening in the skull base, via which medulla and spinal cord passes.<sup>[3]</sup> It is 3-D opening, placed in the central part of the occipital bone.<sup>[4]</sup> It is an oval structure, anteromedian in position. Its wider behind and its anteroposterior diameter is the greatest.<sup>[5]</sup> Its anterior border is formed by the basilar process of the occipital bone, the left and right ex-occipitals form the lateral border and posterior border is formed by supra orbital part of the occipital bone.<sup>[6]</sup> The anterior edge of foramen magnum lying between anterior condylar ends is slightly thickened.<sup>[7]</sup> A small heterogeneous group of medical papers focus on simple morphometrical study of foramen magnum.<sup>[2]</sup> Knowledge of the foramen magnum has significance in the field of anatomy, anthropology and neurosurgery.<sup>[8]</sup> Its morphometry is of use in medicine and forensic dentistry. Morphometric evaluation can be used before heading towards costly examination like DNA analysis.<sup>[9]</sup> In our understanding of human evolution, the positioning of foramen magnum in the body has an important role to play. Its location is linked to bipedalism. Its anatomical position help it to sustain physical stresses more easily as compared to other parts of the skull.<sup>[10]</sup> Craniometric measurements of craniovertebral region and basic knowledge about morphometry of foramen magnum is important for the pathophysiology of the region. Various structures which pass through the foramen magnum may get compressed in cases of herniation, meningiomas and achondroplasia in the area.<sup>[11]</sup> Diameters of foramen magnum help in the determination of various malformations like Arnold Chiari syndrome.<sup>[12]</sup> Transverse and saggital dimensions of foramen magnum were significantly higher in men as compared to women.<sup>[13]</sup> Its dimensions help in the determination of sex in the medico legal cases especially in accidents.<sup>[14]</sup> A review of literature on foramen magnum in Indian population reveal scanty information about it. Therefore, present study has been done to increase data about foramen magnum.

The present study is being conducted to measure the anteroposterior diameter and transverse diameter of the foramen magnum in human skulls in the region of Kashmir and any anomalies in this region of the skull. Moreover, the area and index of the foramen magnum are also calculated. This study is being conducted for the augmentation of existing literature.

### MATERIAL AND METHOD:

The present study was done on 15 skulls and 10 occipital bones. The data was taken from the Department of Anatomy, Government Medical College, Srinagar. Prior permission was sought from Head of Department for the study. The bones used for the study were free from any fracture or other deformities. Morphometric measurements of the foramen magnum were taken with vernier calliper graduated to the last 0.01 mm.

The following diameters were measured:

- Maximum length of the foramen magnum or longitudinal diameter of the foramen magnum (LD) (Fig 1): It is the distance between opisthion and basion along midsagittal plane
- Maximum width of foramen magnum or transverse diameter of the foramen magnum (TD) (Fig1): It is the maximum distance between the lateral margins measured approximately perpendicular to principal axis of the foramen.



Fig 1. Red line depicts transverse diameter of foramen magnum and white line depicts anteroposterior diameter of foramen magnum

### AIMS AND OBJECTIVES:

- c). Area of the foramen magnum (A): It was calculated from length and width of foramen magnum using formulae given by Radnsky formulae  $\frac{1}{4} lfm \times wfm \times 3.14$ , where lfm and wfm are length and width of foramen magnum respectively.<sup>[15]</sup>
- d). Index of foramen magnum (I): It was calculated by formula,  $transverse\ diameter \times 100 / antero\ posterior\ diameter$ .<sup>[16]</sup>

The foramen magnum was also examined for any anomalies in its shape, size and structure.

**RESULTS:**

The various parameters related to the foramen magnum were measured. The average anteroposterior diameter of foramen magnum was  $3.16 \pm$  cm, range being from 2.8 cm to 3.7 cm (Fig 2a) (Table 1a). The mean transverse diameter of foramen magnum was 2.64 cm, range being from 2.2cm to 3 cm(Fig.2b) (Table 1b). The mean area and index of foramen magnum were  $6.60 \pm 0.9$  cm and  $83.64 \pm 5.71$  cm respectively (Table 1c).



Fig 2(a)

Fig2(b)

Fig 2 a.) measurement of anteroposterior diameter of foramen magnum. b). Measurement of transverse diameter of foramen magnum

Table 1a: showing average anteroposterior diameter of the foramen magnum in cms

Sample size	Average anteroposterior diameter (cm)	SD(cm)	Range(cm)
25	3.16	0.216	2.8 - 3.7

Table 1b: showing average transverse diameter of the foramen magnum in cms

Sample size	Average transversediameter(cm)	SD(cm)	Range(cm)
25	2.65	0.212	2.2 - 3

Table 1c: showing mean area and mean index of the foramen magnum in cms

Sample size	Mean area (cm)	SD(cm)	Mean index (cm)	SD(cm)
25	6.60	0.9	83.64	5.71

A Skull was found to have a bony prominence at the anterior margin of the foramen magnum. (Fig.3)It was an oval prominence with a central depressed area.Margins were lined with thick cortical bone while the central depressed portion consisted of spongy bone. The maximum antero-posterior length was 10mm, maximum transverse length was 14mm and maximum height was 6mm. The inferior surface of the prominence was in the shape of an articular facet. On both the sides, the condylar canal and the jugular foramen did not exhibit any abnormal features. No other associated anomalies were observed.

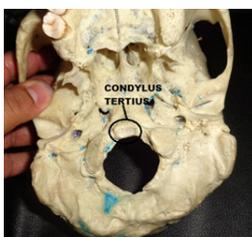


Fig.3. shows presence of condylus tertius

**DISCUSSION:**

In human cranium, determination of sex is based on robustiaty and on size differences.<sup>[17]</sup> These differences are being effected by socio economic, environmental and genetic elements.<sup>[18]</sup> The adult size of foramen magnum is gained early in childhood phase, henceforth it is unlikely to respond to significant secondary sexual changes.<sup>[6]</sup> Growth of foramen magnum is not much effected because nervous system becomes mature in early childhood. Chronic intracranial pressure can result in the formation of large foramen magnum.<sup>[19]</sup>

**Table 2:** Showing comparison of anteroposterior(AP) and transverse (T) diameters of foramen magnum.

Author	Popula tion	Sample size	AP dia- meter	T diam- eter	Area	Index
Chethan et al <sup>[20]</sup>	Indian	53	3.1 ± 0.24	2.5 ± 0.24	-	-
Sayee et al <sup>[21]</sup>	Indian	-	3.42	2.72	7.69	-
Osunwoke EA <sup>[22]</sup>	Nigeria	120	3.61 ± 0.26	2.95 ± 0.26	-	-
Sanjukta Sahoo <sup>[23]</sup>	Indian	150	3.53 ± 0.27	2.94 ± 0.25	-	-
Shikha Sharma <sup>[24]</sup>	Indian	50	3.87	3.34	9.70	-
Govsa et al <sup>[25]</sup>	Turkey	144	3.72 ± 0.35	3.08 ± 0.29	8.29	-
Muthukumar N <sup>[26]</sup>	Indian	50	3.33	2.79	-	-
Kizikanat et al <sup>[27]</sup>	Turkey	59	3.48 ± 0.22	2.96 ± 0.24	-	-
Berge and Bergmann <sup>[28]</sup>	USA	100	3.38	2.83	-	-
Jain et al <sup>[29]</sup>	Indian	100	3.35	2.61	6.86	-
Rajkumar et al <sup>[30]</sup>	Indian	298	3.41 ± 0.24	2.83 ± 0.2	7.54	83.14
Present study	Indian	25	3.16 ± 0.21	2.65 ± 0.21	6.60	83.64

In the present study, the average anteroposterior diameter of foramen magnum was 3.16 cm within range from 2.8cm to 3.7cm (Table 1a) and the average transverse diameter was 2.64cm within range from 2.2 cm to 3cm.(Table 1b) The comparison of above mentioned diameters of our study with the measurements done by other authors are shown in table 2 . The average antero posterior diameter was similar to the findings of Chethan et al<sup>[20]</sup>. The results of Sayee et al<sup>[21]</sup>, Osunwoke EA<sup>[22]</sup>, Sanjukta Sahoo<sup>[23]</sup>, Shikha Sharma<sup>[24]</sup> and Govsa et al<sup>[25]</sup>, Muthukumar N<sup>[26]</sup>, Kizikanat et al<sup>[27]</sup> and Berge and Bergmann<sup>[28]</sup> have higher values as compared to the present study.

The average transverse diameter in the present study is in coherence with the study of Jain et al<sup>[29]</sup> whereas the other mentioned results in various studies mentioned in table no 2,above are having higher values as compared to the present study except for Chethan et al<sup>[20]</sup> where values are lower than the present study.

In the present study it is observed that the average anteroposterior diameter is greater than the transverse diameter. Same observation is made in the various studies in the table no 2. The mean area of foramen magnum was  $6.60 \pm 0.9$  cm which was incoherent with the studies of Govsa et al<sup>[25]</sup>. (Table 1c) The mean index of foramen magnum was 83.64 cm which was coherent with the study of Rajkumar et al<sup>[30]</sup> (Table 1c).

Congenital anomalies of the occipital bone and the first cervical vertebra have been recognized for many years. They were first recognized by anatomists. Meckel was one of the first to describe a large osseous process of the occipital bone which was situated in the median plane on the anterior rim of the foramen magnum in a human skull<sup>[31]</sup>. As their clinical implications become increasingly apparent ,they were discussed more frequently in the medical literature.<sup>[32]</sup>

The hypochordal bow is an arcual strip of mesenchyme ventral to

the axial sclerotome. In humans, only the hypochordal bows of the proatlas and  $C_1$  resegmented sclerotome persist.<sup>[33]</sup> The hypochordal bow of the proatlas normally forms a small midline osseous tubercle attached to the ventral surface of the basioccipital below the rim of the foramen magnum. Rarely, it remains as a fully ossified structure distinct from the basioccipital bone. If the entire arc is preserved, it is called a pre-basioccipital arch, which looks like a U-shaped bony valance on the underside of the anterior rim of the foramen magnum. If only the paramedian arch persists, two parasagittal spikes project downwards from the clivus, called the basilar processes.<sup>[34][35][36]</sup> Neither of these bony excrescences encroach on the foramen magnum and are thus harmless. Occasionally, however, the median portion of the proatlas hypochordal bow becomes exuberantly hyperplastic and forms a prominent bone spur that juts obliquely backwards from the basioccipital tip that does cause neural compression. This median bony process is firmly attached to the basion and, elongating it, frequently forms true synovial joints with the anterior arch of  $C_1$  and the odontoid apex,<sup>[36]</sup> it is thus rather aptly termed a median or third occipital condyle (condylus tertius). Thus when the hypochordal bow of the 4<sup>th</sup> occipital sclerotome, the proatlas persists or when it has failed to integrate, an osseous remnant may be present at the distal end of the clivus called the condylus tertius or the third occipital condyle.<sup>[32]</sup> Although typically single, multiple supranumerary ossicles may be present.<sup>[33]</sup> They may form a joint or pseudojoint with the odontoid process or the anterior arch of atlas and may lead to limitation in the range of motion of the CVJ.<sup>[36]</sup> The condylus tertius can be of various shapes and sizes and located in various positions. A cartilaginous surface may form either with the dens of axis or the anterior arch of the atlas.<sup>[32]</sup>

## CONCLUSION:

The present study on the morphometric study of foramen magnum showed that the average anteroposterior diameter of foramen magnum was more than the transverse diameter. These findings can be of use to neurosurgeons, forensic experts and anatomists. In neurosurgery it will be easy to approach the cranial base safely with less damage, if surgeon knows about the various parameters.

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