

# Foramen Magnum: A Morphometric Study in Dried Human Skulls

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## ABSTRACT

**Introduction:** The foramen magnum is the largest foramen or opening present in the base of skull. The dimensions of foramen magnum are clinically important because many vital structures are passing through it.

**Objective:** The aim of the study was to determine the different shapes of foramen magnum and its antero-posterior diameter and transverse diameter.

**Methods:** This study was conducted on 32 dry human skulls of unknown age and sex. All the important parameters were studied using vernier caliper.

**Results:** The mean transverse diameter (TD) was found to be  $27.75 \pm 2.47$ mm (Mean  $\pm$  SD) and mean antero-posterior diameter (APD) was found to be  $34.62 \pm 3.58$ mm (Mean  $\pm$  SD). The various shapes of foramen magnum were observed. The most common shape was oval 46.9%, followed by round 18.8%, tetragonal 15.6%, hexagonal 12.5% and irregular 6.3%.

**Conclusions:** In our study, the most common shape of foramen magnum was oval; this can help the surgeons to perform post cranial surgery and surgery near foramen magnum as oval shape indicating the narrow operative field. The study may also be helpful for anatomist for study purpose and forensic experts to determine identity from different populations when compared to other studies.

**Keywords:** Anatomical variation; foramen magnum; shape; skull.

## INTRODUCTION

The foramen magnum is the largest foramen in the skull.<sup>1</sup> Foramen magnum is a wide opening in the posterior cranial fossa connecting the cranial cavity with the vertebral canal. It allows the passage of vital structures of brain through it.<sup>2</sup> The position of foramen magnum in the skull is antero-medial and it lies in the posterior cranial fossa. Its shape is oval, it is wider behind and the largest diameter is antero-posterior. It contains lower end of medulla oblongata, meninges, cerebro-spinal fluid, vertebral

arteries and veins, and spinal accessory nerve.<sup>3</sup>

The dimensions of the foramen magnum are clinically important because of the above-mentioned vital structures passing through it may endure compression such as in cases of foramen magnum herniation, foramen magnum meningiomas and foramen magnum achondroplasia.<sup>4</sup>

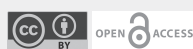
Configuration and size of the foramen magnum play an important role in the pathophysiology of various disorders of the cranio-vertebral junction. Thus, a fundamental knowledge of normal anatomy is important to the clinician who diagnoses disorder affecting this region or the surgeon who operates on this anatomy.<sup>1</sup>

Aim of the present study was to note the position of the foramen magnum in adult human dry skull, available at the department of Anatomy, Nepalgunj

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Medical College, Chisapani, District Banke, Nepal. The study illuminates the clinical importance of this region and also collects data which may be used in further studies.

## METHODS

A study of foramen magnum was conducted on total 32 dry adult human skulls of unknown age and sex from the collection of the Department of Anatomy, Nepalgunj Medical College, District Banke, Nepal. Only above mentioned numbers of skulls with good condition were available in the department. Deformed and damaged bones related with foramen magnum were excluded from the study. The ethical clearance was taken dated on 16<sup>th</sup> May 2021 from NGMCTH-IRC. The study was conducted for the period of 6 months from June 2021 to December 2021.

The instrument used in the present study.

1. Vernier caliper: To measure transverse diameter and antero-posterior diameter of the foramen magnum, a vernier caliper of 0.1mm accuracy made by Aerospace is used.

Each skull was numbered serially with numbering sticker to help in identification. The antero-posterior diameter and transverse diameter of foramen magnum for each skull was measured twice with a sliding vernier caliper of 0.01mm accuracy and an average was recorded. Antero-posterior diameter (APD) was measured from basion to opsthion. To transverse diameter (TD), the point of maximum concavity from left margin to point of maximum concavity from right margin was taken.

Following parameters were studied:

1. APD: Antero-posterior diameter (in mm).
2. TD: Transverse diameter (in mm).
3. Shape: Oval, Round, Hexagonal, Tetragonal and Irregular.

All the above parameter were carefully tabulated and analyzed. The dimensions of various parameters of foramen magnum were measured and recorded. SPSS version 20.0 was used for statistical analysis and to find the Minimum, Maximum, Mean and Standard Deviation of all the parameters.

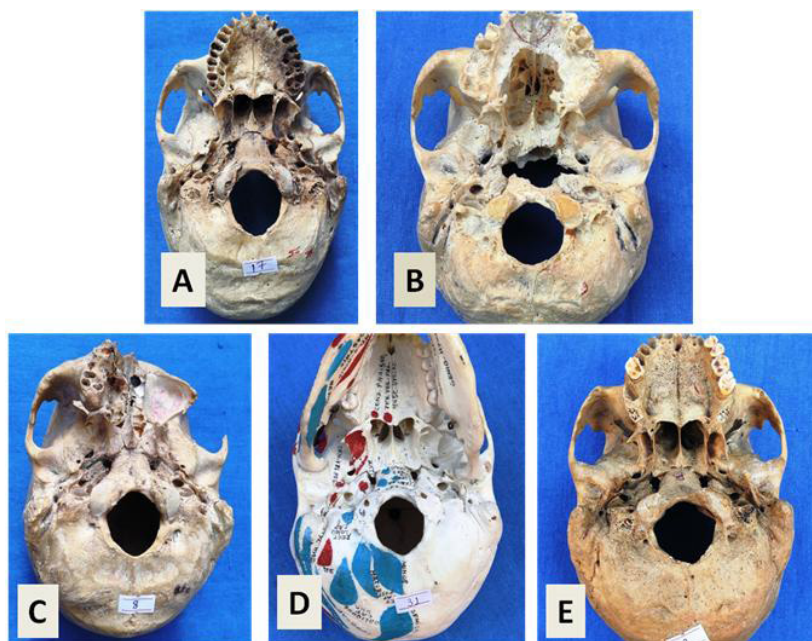


Figure 1: Various shapes of foramen magnum  
(a) Oval, (b) Round, (c) Tetragonal, (d) Hexagonal and (e) Irregular

## RESULTS

The measurement of various parameters of foramen magnum of skull is shown in Table 1 and 2. In the present study various shapes of foramen magnum were observed. The most common shape was oval in 15 (46.9%) skulls, followed by round 6 (18.8%), tetragonal 5 (15.6%), hexagonal 4 (12.5%), and irregular 2 (6.3%) skulls as shown in Table 1.

The mean transverse diameter (TD) was found to be  $27.75 \pm 2.47$  mm (Mean  $\pm$ SD) and mean antero-posterior diameter (APD) was found to be  $34.62 \pm 3.58$  mm (Mean  $\pm$  SD).

All the parameter of foramen magnum is depicted in Table 1, 2 & 3.

**Table 1: Showing the various types of shapes of foramen magnum.**

Shapes	Numbers	Percentage (%)
Oval	15	46.9
Round	6	18.8
Tetragonal	5	15.6
Hexagonal	4	12.5
Irregular	2	6.3

**Table 2: Showing the antero-posterior and transverse diameter of foramen magnum (n=32)**

Measurement	Min (in mm)	Max (in mm)	Mean (in mm)	Std. Deviation
APD	28.00	40.00	34.62	3.58
TD	23.00	32.00	27.75	2.47

**Table 3: Showing different measurements of TD and APD according to shape**

Shape		Minimum (in mm)	Maximum (in mm)	Mean (in mm)	Std. Deviation	N
Oval	TD	23.00	30.00	26.00	2.00	15
	APD	29.00	40.00	34.13	3.14	15
Round	TD	27.00	31.00	29.17	1.72	6
	APD	28.00	37.00	30.83	3.31	6
Tetragonal	TD	27.00	31.00	29.00	1.58	5
	APD	36.00	40.00	37.80	1.64	5
Hexagonal	TD	26.00	31.00	29.00	2.16	4
	APD	33.00	39.00	36.50	2.51	4
Irregular	TD	30.00	32.00	31.00	1.41	2
	APD	38.00	38.00	38.00	0	2

## DISCUSSION

The anatomical knowledge of foramen magnum is helpful to understand the clinical sign and symptoms in various cranio-cervical diseases. Because foramen magnum allows a passage to various important structures such as lower end of medulla oblongata, vertebral arteries, meninges, spinal accessory nerve, apical ligament of dens and membrana rectoria. It is formed by interaction of bony ligaments and muscular structures forming the complex cranio-vertebral junction. Knowledge about the bony parameters of foramen magnum is also needed for trans-condylar approach.<sup>5</sup>

The comparison of morphometry of foramen magnum with previous authors is shown in tabulated form in Table 4 and 5.

The present study shows that antero-posterior diameter of foramen magnum is found to be

34.62mm, whereas Sharma et al<sup>6</sup>, Nagwani M et al<sup>7</sup> and Radhakrishna SK et al<sup>8</sup> found it to be 34.44mm, 34.68mm and 34.04mm respectively. However, Chethan P et al<sup>9</sup>, Bharati SP et al<sup>10</sup>, Singh A et al<sup>11</sup>, Kaur R et al<sup>12</sup>, Singh R and Kumar R<sup>13</sup> and Shepur MP et al<sup>4</sup> reported lesser value. Whereas Murshed KA et al<sup>14</sup>, Radhika PM et al<sup>15</sup>, Sharma DK and Mehra S<sup>16</sup> and Kumar A et al<sup>17</sup> reported greater value.

The present study shows that transverse diameter of foramen magnum is 34.60mm whereas Nagwani M et al<sup>7</sup> and Kaur R et al<sup>12</sup> found it to be 27.24 and 27.66mm respectively. However Chethan P et al<sup>9</sup>, Bharati SP et al<sup>10</sup> reported lesser value. Whereas Kumar A et al<sup>17</sup>, Murshed KA et al<sup>14</sup>, Radhakrishna SK et al<sup>8</sup>, Radhika PM et al<sup>15</sup>, Sharma DK and Mehra S<sup>16</sup>, Sharma A et al<sup>6</sup>, Singh A et al<sup>11</sup>, Singh R and Kumar R<sup>13</sup>, Kumar A et al<sup>2</sup> and Shepur MP et al<sup>4</sup> reported greater value.

**Table 4: Comparison of antero-posterior diameter and transverse diameter among different studies.**

Authors	Mean(mm)	
	Antero-posterior diameter	Transverse diameter
Kumar A et al <sup>2</sup>	34.08	28.17
Shepur MP et al <sup>4</sup>	33.4	28.5
Singh A et al <sup>11</sup>	33.79	28.25
Bharati SP et al <sup>10</sup>	32.24	26.73
Sharma DK and Mehra S <sup>16</sup>	35.11	29.35
Sharma A et al <sup>6</sup>	34.44	30.46
Nagwani M et al <sup>7</sup>	34.68	27.24
Singh R and Kumar R <sup>13</sup>	33.8	28.2
Murshed KA et al <sup>14</sup>	35.9	30.45
Radhakrishna SK et al <sup>8</sup>	34.04	28.63
Chethan P et al <sup>9</sup>	31.0	25.2
Radhika PM et al <sup>15</sup>	35.3	29.4
Kaur R et al <sup>12</sup>	32.67	27.66
Kumar A et al <sup>17</sup>	36.78	30.05
Present study	34.62	27.75

**Table 5: Comparison of shape of foramen magnum among different studies**

Authors	Shape of foramen magnum in percentage (%)				
	Oval	Round	Tetragonal	Hexagonal	Irregular
Vinutha SP et al <sup>1</sup>	36.5	8.5	7.0	15.0	19.5
Kumar A et al <sup>2</sup>	58.0	12.0	-	10.0	-
Singh A et al <sup>11</sup>	33.3	13.3	16.6	16.6	-
Bharati SP et al <sup>10</sup>	23.3	46.6	-	-	-
Sharma DK and Mehra S <sup>16</sup>	22.67	14.67	14.67	16.0	10.67
Sharma A et al <sup>6</sup>	15.7	3.9	17.6	45.1	5.9
Nagwani M et al <sup>7</sup>	66.66	16.6	-	-	4.01
Singh R and Kumar R <sup>13</sup>	85.7	8.5	-	-	5.8
Murshed KA et al <sup>14</sup>	8.1	21.8	12.7	17.2	19.9
Radhakrishna SK et al <sup>8</sup>	39.0	28.0	19.0	-	-
Chethan P et al <sup>9</sup>	15.1	22.6	18.9	5.6	15.1
Radhika PM et al <sup>15</sup>	40.0	20.0	6.0	6.0	16.0
Present study	46.9	18.8	15.6	12.5	6.3

Our study found oval as most common shape of foramen magnum. Singh R and Kumar R<sup>13</sup>, Nagwani M et al<sup>7</sup>, Kumar A et al<sup>2</sup>, Radhakrishna SK et al<sup>8</sup>, Singh A et al<sup>11</sup>, Sharma DK and Mehra S<sup>16</sup>, Vinutha SP et al<sup>1</sup>, Radhakrishna SK et al<sup>8</sup> also observed oval as most common type. In other study Bharati SP et al<sup>10</sup>, Murshed KA et al<sup>14</sup>, Chethan P et al<sup>9</sup> reported round as common type. Whereas Sharma A et al<sup>6</sup> reported hexagonal as the most common type. Featuring the variations in shape of foramen magnum in different studies may be the presentation of differences in various populations when compared to each other. The different origin, race and ethnicity of different populations may be the factor of differences in shape of foramen magnum. Thus a detailed study is required to establish the reason of differences in shape of foramen magnum.

### Limitation

The major limitation of the study was that the gender and ethnic origin of the skulls were not known. Thus

a study with known gender and ethnicity of skulls is required to establish more conclusive opinion to help the clinicians and others like anatomists and forensic experts.

### CONCLUSIONS

In our study, the most common shape of foramen magnum was oval. This can help the surgeons to perform post cranial surgery and surgery near foramen magnum as oval shape indicating the narrow operative field. The study may also be helpful for anatomist for study purpose and forensic experts to determine identity from different populations when compared to other studies.

**Conflict of Interest:** None

**NJHS**

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