

MORPHOMETRIC ANALYSIS OF FORAMEN MAGNUM REGION IN ADULT INDIAN POPULATION:

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ABSTRACT

Introduction:

The dimensions of FM have clinical importance because the vital structures that pass through it may suffer compression as in cases of FM achondroplasia and FM brain herniation. 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. This study puts in an effort to understand the morphometry of the foramen magnum.

Material and Method: The present study was carried out on 40 dry human skulls of unknown age and sex from Kanachur Institute of Medical Sciences, mangalore and continued in Rajasthan in the department of JNUIMSRC, Jaipur, Rajasthan.

All the measurements were taken with the help of digital verniercalipers.

Results:

The foramen magnum was studied for its morphometry and dimension. Foramen magnum with different shapes and size were found.

The mean antero-posterior diameter was 34.36 ± 3.13 mm, the transverse diameter was 28.48 ± 3.97 mm, area was 773.53 ± 154.359 mm², and the FM index was 1.2345 ± 0.180 . The FM shapes were determined as oval (22.5%), egg-shaped (12.5%), round (17.5%), tetragonal (12.5%), pentagonal (12.5%), hexagonal (10.00%), and irregular (12.5%).

Conclusion: This study will be useful for surgical approach for the Neurosurgeon and Orthopaedic surgeon.

Key Words: Foramen Magnum, Achondroplasia, Arnold Chiari syndrome

INTRODUCTION

The foramen magnum region of the cranial base consists of the foramen magnum and the laterally placed occipital condyles for articulation with the superior facets of the first cervical vertebra.(1)The foramen magnum has gained interest across various disciplines like anthropology, comparative anatomy, evolutionary biology, and clinical sciences.(2) This foramen 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.(3)It plays a very significant role as a transition zone between spine and skull being in close proximity to brain and spinal cord.(4) Occipital condyle (OC) is an important part of craniovertebral or craniocervical junction located anterolaterally on either side of the FM.(dried adult skull). This region of the skull is covered by a large volume of soft tissue. Hence, the foramen magnum region is in a relatively well-protected anatomical position.(1)

Variations of the shape of FM have got diagnostic, clinical and radiological importance.(5) 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.(6)

The dimensions of FM have clinical importance because the vital structures that pass through it may suffer compression as in cases of FM achondroplasia and FM brain herniation. 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 foramen magnum region is a unique and complex anatomical region. The occipital condyles (OC) are the main bony structures which obscure the anterolaterally situated lesions of the FM.(7)

MATERIAL AND METHODS

The present study was carried out on 40 dry human skulls of unknown age and sex from Kanachur Institute of Medical Sciences, mangalore and continued in Rajasthan in the department of JNUIMSRC, Jaipur, Rajasthan. The study was conducted from Dec 2014 to April 2020.

All the measurements were taken with the help of digital verniercalipers.

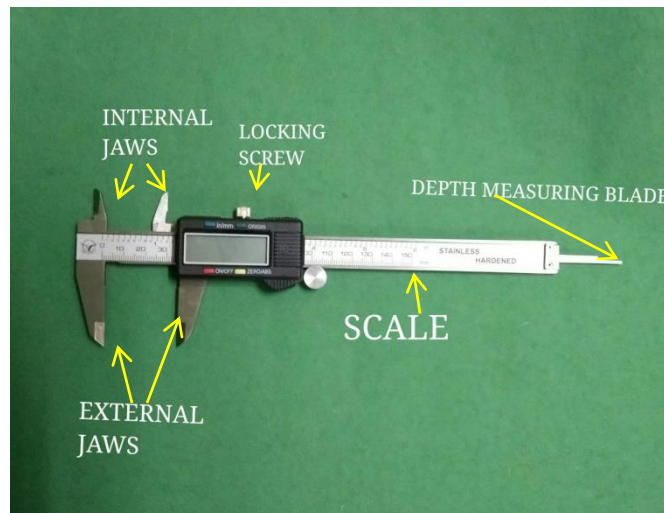


Figure-1: Digital Vernier Calipers

Following metric parameters were noted:

1. **Shapes of Foramen Magnum** - The different shapes of the foramen magnum were macroscopically noted and classified them as Oval, Egg, Round, Tetragonal, Pentagonal, Hexagonal and Irregular.
2. **Antero-Posterior Diameter (APD)** - It is the distance between Basion (midpoint of the anterior margin of the FM) and Opisthion (midpoint of the posterior margin of the FM) **Figure-4.**



Figure-4: Antero-Posterior Diameter



Figure-5: Transverse Diameter



3. **Transverse Diameters (TD)** - It is the distance between the lateral margins of the FM at the point of greatest lateral curvature **Figure-5.**

4. Foramen Magnum Index (FMI) – It is calculated by dividing the antero-posterior diameter by the transverse diameter (APD/TD).

5. Area of FM by Radinsky's formula – $A = \frac{1}{4} \times \pi \times W \times L$

$$\pi = \text{Pi, (22/7 or 3.14)}$$

W = Width (Transverse Diameter)

L = Length (Antero-Posterior Diameter)

RESULTS

The morphological and morphometric observations of the foramen magnum in 40 dried human skulls belonging to Rajasthan population are as follows:

Table-1: The no. and percentages of various shapes of the foramen magnum

Shapes of FM	No. of Specimens (n=40)	Percentage (%)
Oval	9	22.5
Egg Shape	5	12.5
Round	7	17.5
Tetragonal	5	12.5
Pentagonal	5	12.5
Hexagonal	4	10
Irregular	5	12.5

The most common shape was oval and the least common shape was hexagonal.

Table-2: Antero-posterior diameter and Transverse diameter

Parameter	APD (mm)	TD (mm)
Minimum	27.0	16.09
Maximum	38.87	38.11
Mean	34.36	28.48

Standard Deviation	3.13	3.97
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The mean antero-posterior diameter was 34.36mm. The maximum antero-posterior diameter was 38.87mm and minimum antero-posterior diameter was 27.0 mm observed in present study.

The mean transverse diameter was observed to be 28.48mm. The maximum transverse diameter was 38.11mm and minimum transverse diameter was 16.09mm.

Table-3: Foramen Magnum Index

Parameters	FMI
Minimum	0.970
Maximum	1.921
Range	1.04 - 1.41
Mean	1.2345
Standard Deviation	0.18

In the present study mean value of foramen magnum index was found to be 1.23 with minimum value of 0.970 **and** maximum being **1.921** with standard deviation of **0.187** for **40** specimens.

Table-4: Frequency and Percentage of Foramen Magnum Index

Foramen Magnum Index (FMI)	Frequency	Percentage (%)
<1.20	18	45
≥1.20	22	55
Total	40	100

When the FMI is >1.2, the foramen is found to be ovoid (Radhika PM et al 2014)

Table-5: Area of Foramen Magnum

Parameter	Area (mm²)
Minimum	390.41
maximum	1105.71
Mean	773.536
Standard Deviation	154.359

The mean value of area of FM was calculated **773.54 mm²**. The maximum area was 1105.71 mm² and minimum area was **390.41 mm²** calculated.

DISSCUSION

In the present study oval shaped foramen magnum was the commonest shape which is comparable to researchers of ethnic groups Kumar A et al (2015), Piras LAS et al (2016) and PelinIlhan et al (2018). **Table-6**

In the present study oval shaped foramen magnum was the Commonest shape which is comparable to Indian researchers Zaidi SH et al (1998), Radhakrishna et al (2012), Radhika et al (2014), Gopalkrishna et al (2015), Vinutha et al (2016), Devadas et al (2017), Rajkumar et al (2017), Remya k et al (2017), Singh KC et al (2017), Arora S et al (2017), Sampada PK et al (2017) and Mishra AK et al (2018)..

In the present study the Oval shape was observed in 22.5% of dry skull specimens in contrast to highest **64%** reported by Zaidi SH et al (1988) and lowest was reported by Veeramani R et al (2018) i.e. **6%**.

Mean antero-posterior diameter observed in the present study was **34.36 mm** which is comparable to Ethnic researchers of Mursed et al (2013), Suazo GIC et al (2009), Monoel et

al (2009), Lyrtizis et al (2016). They observed the mean value of antero-posterior diameter is 35.6 mm, 35.9 mm, 35.6 mm (in female), 35.7 mm (in male) & 35.1 mm (in female) and 35.05 mm respectively.

Mean transverse diameter was reported **28.48 mm** in the present study which is similar to findings of Ethnic researchers Suazo GIC et al (2009), Monoel et al (2009), Kumar A et al (2015), Lyrtizis et al (2016), Pires LAS et al (2017) that is 29.5 mm, 29.5 mm(in female), 29.4 mm, 29 mm, 29.49 mm (In female), 30.19 mm, 28.62 mm, 29.73 mm respectively.

Mean antero-posterior diameter observed in the present study was **34.36 mm** which is comparable to Indian researchers Kanchan T et al (2013), Radhika PM et al (2014), Sahoo S et al(2015), Rohinidevi M et al (2016), Arora S et al (2017), Sampada PK et al (2017), Veeramani et al (2018), Feridoz J et al(2018). They observed the mean value of antero-posterior diameter is 34.51 mm, 35.30 mm, 35.30 mm, 34.80 mm, 35.42 mm, 34.84 mm, 35.23 mm (in female), 35 mm respectively.

Mean transverse diameter was reported **28.48 mm** in the present study which is similar to findings of Indian researchers Radharkrishna et al (2012), Jain SK et al (2013), Shepur MP et al (2014), Radhika PM et al (2014), Vedanayagam et al (2015), Saini K et al (2015), Sahoo S et al (2015), Riyaz et al (2015), Rohinidevi M et al (2016), Sampada PK et al (2017), Mishra AK et al(2018), Feridoz J et al (2018) that is 28.63 mm, 29.5 mm (in female), 28.50 mm (in male), 29.49 mm , 28.5 mm, 29.39 mm, 28.22 mm, 29.4 mm respectively.

FMI of 1.2 has been reported in Karnataka population (Chethan P et al and Radhika et al) and Orissa population (Sahoo S et al). **Table-10**

In the present study in Rajasthan population FMI was also 1.2.

In the present study (Jaipur region, Rajasthan) Area was calculated as **773.53**

mm² which is similar to study of Jaitley M et al (2016) in female (**812.22 mm²**) in Indore region of Madhya Pradesh. **Table-9**

Another study by Rajkumar et al (2017) Udaipur region of Rajasthan have reported area of foramen magnum much lower (**754.32 mm²**).

The following tables are the comparisons of our study:

Table : 6 Shapes of Foramen Magnum

N= no. of skulls studied

Other ethnic groups – Red

Indian population - Black

Present study - Green

Authors	Year	Population	N	Sex	Shapes of Foramen Magnum						
					Oval	Egg Shape	Round	Tetragonal	Pentagonal	Hexagonal	Irregular
Zaidi SH et al	1998	Kanpur	200	-	64%	-	0.5%	-	7.5%	24.5%	3.5%
Murshed KA et)	2003	Turkish	110	-	8.1%	6.3%	21.8%	12.7%	13.6%	17.2%	A:10.9% B:9.09%
Chethan P et al	2012	Mangalore	53	-	15%	18.9%	22.6%	18.9%	3.8%	5.6%	15.1%
Radhakrishna et al	2012	Mangalore	100	-	39%	-	28%	19%	14%	-	-
Radhika et al	2014	Bangalore	150	-	40%	10%	20%	6%	2%	6%	16%
Rathva et al	2015	Gujarat	210	-	28.75%	11.90%	16.66%	10.47%	2.38%	4.76%	11.71%
Kumar A et al	2015	USA	36	-	50%	-	20%	6%	-	8%	16%
Riyaz et al	2015	Maharashtra	61	-	31.14%	-	29.50%	18.03%	1.63%	8.19%	11.47%
Gopalakrishna et al	2015	Kerala	55	-	41%	-	25%	14%	-	-	20%
Sharma S et al	2015	Tundla	50	-	16%	16%	22%	12%	8%	8%	18%
Vinutha et al	2016	Karnataka	200	Male	32%	11%	10%	12%	5%	11%	10%
				Female	35%	5%	13%	12%	5%	12%	8%
Pires LAS et al	2016	Brazil	77	-	53.24%	2.36%	24.67%	16.88%	1.29%	1.29%	-
Rohinidevi et al	2016	Tamilnadu	35	-	18%	4%	26%	11%	6%	6%	22%
Fathima et al	2016	Chennai	53	-	26%	36%	13%	-	4%	21%	-
Arora S et al	2017	Bareilly	40	-	60%	-	40%	-	-	-	-
Sampada PK et al	2017	Karnataka	100	-	58%	11%	9%	8%	1%	3%	10%
Mishra AK et al	2018	Lucknow	71	-	37.8%	-	30.9%	7.04%	7.04%	11.2%	9.85%
Veeramani R et al	2018	Puducherr	100	-	6%	12%	15%	11%	3%	21%	32%

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Present study	2019	Rajasthan		-						

TABLE-7: Antero-posterior and Transverse diameter of Foramen Magnum of Ethnic Groups.

Authors	Year	Population	N	Sex	APD±S.D. (mm)	TD±S.D. (mm)
Mursed et al	2003	Turkish	110	-	35.9±3.29	30.4±2.59
Suazo GIC et al	2009	Brazil	211	Male	36.5±2.6	30.6±2.5
				Female	35.6±2.5	29.5±1.9
Monoel et al	2009	Brazil	215	Male	35.7±0.29	30.3±0.20
Lyrizis et al	2016	Greek	141	-	35.05±2.57	30.19±2.69
Pires LAS et al	2017	Brazil	77	-	34.23±2.54	28.62±2.83
Chovalopoulou ME et al	2017	Greece	154	Male	36.69±2.47	32.48±2.70
				Female	34.87±2.41	30.62±2.18
Farid SA et al	2018	Egyptian	75		47.1±03.4	43.6±2.5
Present study	2019	Rajasthan		-		

N= no. of skulls studied

Table-8: Antero-posterior and Transverse diameter of Foramen Magnum of Indian population.

Authors	Year	Population	N	Sex	APD±S.D. (mm)	TD±S.D. (mm)
Chethan P et al	2012	Mangalore	53	-	31±2.4	25.2±2.4
Jain SK et al	2013	Moradabad (North Indian)	68	Male	36.9±0.2	31.5±0.27
				Female	32.9±0.3	29.5±0.28
Kanchan T et al	2013	Mangalore	118	Male	34.51±2.77	33.60±2.63
				Female	27.36±2.09	26.74±2.36
Patel R et al	2014	Surat	100	-	42.2	28.29
Shepur MP et al	2014	Karnataka	150	Male	33.40±2.60	28.50±2.20
				Female	33.10±2.70	27.30±2.00
Radhika PM et al	2014	Bangalore	150	-	35.30±2.7	29.49±2.6
Ganapathy et al	2014	Pondicherry	100		33.9	28.7
Vedanayagam et al	2015	Chennai	420	Male	18.4±0.7	28.2±0.6
				Female	17.6±1.0	21.8±0.7

Riyaz et al	2015	Maharashtra	61		33.4±2.5	28.5±2.2
Khanday et al	2016	Chennai	60		36.8	30.9
Jasuja VR et al	2016	Mumbai	100		34.13±2.73	27.82±3.32
Fathima et al	2016	Chennai	53		38.22	35.15
Rohinidevi M et al	2016	Tamilnadu	35		34.80	28.5
Naqshi et al	2017	Shrinagar	25		31.6±0.21	26.5±0.21
Singh et al	2017	Varanasi	50		33.76±2.18	28.09±1.92
Rajkumar et al	2017	Rajasthan	298		33.98±2.75	28.16±2.15
Remya et al	2017	Mangalore	50		33.64±0.228	27.04±0.214
Arora S et al	2017	Bareilly	40		35.42±3.22	27.90±2.58
Raikar et al	2018	Bengaluru	150		34.19±3.57	31.77±3.59
Feridoz J et al	2018	Chennai	50		35±2.8	29.4±2.9
Present study	2019	Rajasthan		-		

N= no. of skulls studied

Table-9: Area of Foramen Magnum

Authors	Year	Population	N	Sex	Area
Murshed et al	2003	Turkish	110	Male	931.7±144.29
				Female	795.0±99.32
Shepur MP et al	2014	Karnataka	150	Male	862.0±119
				Female	758.0±109
Sharma S et al	2015	Tundla	50	-	970.57
Kumar A et al	2015	USA	36	Male	876.88±88.83
				Female	776.87±68.51
Khanday et al	2016	Chennai	60	-	576
Singh KC et al	2017	Varanasi	50	-	834.45±75.79
Rajkumar et al	2017	Rajasthan	298	-	754.32±105.16
Remya et al	2017	Mangalore	50	-	714.99±0.844

Present study	2019	Rajasthan		-	
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Table – 10: Foramen Magnum Index (FMI)

Authors	Year	Population	N	Sex	FMI
Chethan P et al	2012	Mangalore	53	-	1.2±0.1
Radhika et al	2014	Bangalore	150	-	1.20±0.1075
Sahoo S et al	2015	Orissa	150	-	1.2028±0.1075
Dubey A et al	2017	Sagar& Jabalpur	80	Male	1.18±0.11
				Female	1.16±0.07
Present study	2019	Rajasthan		-	

Conclusion:

The morphological and morphometric analysis of foramen magnum and its variations is important not only to anatomist but also to the neurosurgeons, anesthetist, orthopedicians and radiologists. These variations have become significant because of newer imaging techniques such as computed tomography and magnetic resonance imaging in the field of diagnostic medicine.

This study will also be a help to Forensic medicine experts since ethnic variations as seen and compared with research of other ethnic region population researchers may help in identification of different races

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