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Morphometric Analysis of Foramen Magnum in Dry Human Skulls of North Karnataka Region

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ABSTRACT
Foramen Magnum is the largest foramen in the posterior cranial fossa. It is the transistion zone between spine and skull . It plays an important landmark because of its close relationship to key structures such as brain, spinal cord and vertebral arteries. The shape and size of (APD and TD) of foramen magnum is important parameter as many vital and vulnerable structures pass through it and could be compressed in FM achondrplasia, FM brain herniation and atlanto- occipital fusion. Thus the present study was conducted to know the variations in shape and size of FM in North Karnataka region. Forty five dry adult human skulls of unknown age and sex were examined in the Department of Anatomy, Mahadevappa Rampure Medical College, Kalaburagi. Shape, APD and TD of foramen magnum recorded. The measurements were carried out using vernier calipers. Data collected was statistically analysed. Majority of the foramen magnum were oval in shape 28 (62.22%), followed by round 11 (24.44%), tetragonal 3 (6.67%) and pentagonal 3(6.67%). Min APD was 31mm max38mm, Min TD-25mm, max32mm, min FM index 1.03 and max 1.23. Mean+/-SD of APD was 33.53mm+/-2.36mm, Median APD-33mm. Mean+/-SD of TD was 29.13mm+/-1.96mm, Median TD- 29mm. Mean+/-SD of FM index was 1.15+/-0.079 and Median index was 1.14. The present study will help posterior and lateral approaches to the craniovertebral junction by neurosurgeons and orthopaedician of this region. Prior morphometric knowledge helps to prevent inadvertent complications such as haemorrhage, atlantooccipital instability and injury to major structures passing through foramen magnum.

INTRODUCTION

The largest foramen in the posterior cranial fossa is Foramen Magnum, through which the brain and spinal cord are continuous with each other[1]. Foramen Magnum is a Latin word meaning largest aperture in the skull. Foramen Magnum is situated in an anteromedian position, and is oval, being wider behind with its greatest diameter being anteroposterior[2]. The foramen magnum lies one third in front and two third behind the line formed by joining tips of mastoid process[3]. The foramen magnum is about 1.5 inches in diameter from before backwards and 1 inch from side to side, contains the lower part of the brain stem the spinal roots of the accessory nerves and the vertebral arteries[4].

Anatomical and morphometric knowledge of the foramen is important for understanding the pathophysiology of various disorders of the craniovertebral junction as well as for planning surgical procedures. Besides anatomists, the morphometric study of foramen magnum is essential for neurosurgeons, orthopedicians, radiologists and anaesthetist also. Hence, the present study was done to determine and analyse the morphological types and diameters of the foramen magnum in adult dry skull of North Karnataka so that the data can help in improving the efficacy and minimize the failure rates in surgical procedures in posterior cranial fossa particularly involving the approaches through foramen magnum.

MATERIALS AND METHODS

The study was conducted on 45 dry adult human skulls of unknown age and sex, obtained from the Department of Anatomy, Mahadevappa Rampure Medical College, Kalaburagi, Karnataka, India. The study included all the dry and complete skulls and excluded broken and deformed foramen magnum. The shape of the foramen noted and classified as oval, round, tetragonal and pentagonal. Morphometric measurements like anteroposterior diameter and transverse diameter were measured using vernier calipers. Anteroposterior diameter was measured from basion (median point on anterior margin of foramen magnum) to opisthion (median point on posterior margin of foramen magnum) in the sagittal plane. Transverse diameter was measured perpendicular to AP diameter at maximum point in coronal plane Fig 1.

RESULTS

The present study showed variations in shapes (Fig. 2), most common being oval 28 (62.22%), followed by round 11 (24.44%), tetragonal 3(6.67%) and pentagonal 3(6.67%). Hexagonal and irregular foramen magnum were not found in the study group. Table 1: Showing No and percentages of various shapes. Min APD was 31mm max 38mm, Min TD-25mm, max 32mm, min FM index 1.03 and max 1.23. Mean+/-SD of AP was 33.53mm+/-2.36mm, Median AP-33mm. Mean+/-SD of TD was 29.13mm+/-1.96mm Median TD-29mm. Mean+/-SD of FM index was 1.15+/- 0.079 and Median was 1.14. Table 2: Showing Range Mean+/-SD, Median of APD,TD and FM Index.

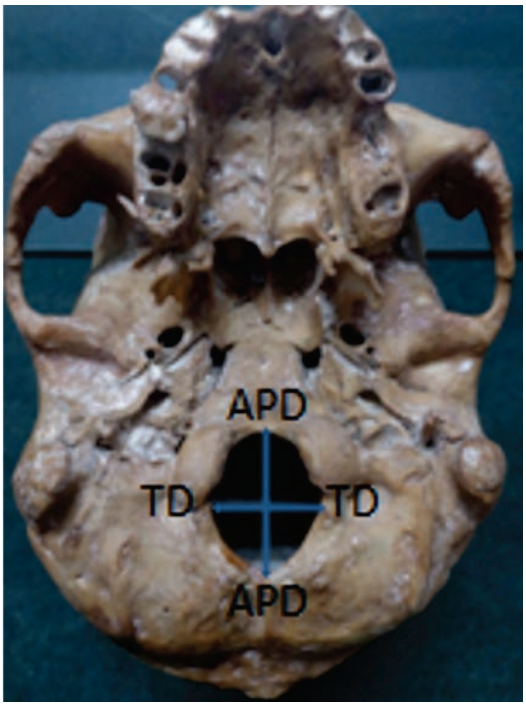

Fig. 1: showing APD and TD

Fig. 2: Showing various shapes of Foramen Magnum (R-Round, O-Oval, T-Tetragonal, P-Pentagonal)

Table 1: And percentage of shapes

Shape	No. Percentage
Round	11 (24.44)
Oval	28 (62.22)
Tetragonal	3 (6.67)
Pentagonal	3 (6.67)
Total	45

DISCUSSIONS

The most prominent feature in the floor of the posterior cranial fossa is foramen magnum, through which many vital and vulnerable structures pass. The present study was done to know the average dimensions and different kinds of FM in this region so that knowledge helps the clinicians.

Table 2: Showing Mean+/-SD, Median of APD, TD and FM Index

Variables	Range (mm)	Mean	Standard deviation	Median
APD (mm)	31-38	33.53	2.36	33
TD (mm)	25- 32	29.13	1.96	29
FM Index	1.03-1.23	1.15	0.079	1.14

Table 3: Comparison of shapes of FM of present study with different authors

Shape	Present Study N = 100	Radhika *et al*.[5] N = 150	Sharma *et al*.[6] N = 50	Chetan *et al*.[7] N = 53	Lucas *et al*.[8] N = 77	Singh *et al*.[9] N = 120	Sharma *et al*.[10] N = 62	Kumar *et al*.[11] N = 347
Oval	28 (62.22%)	60 (40%)	8 (15.7%)	15. 1%	41 (53.23%)	40 (33.3%)	22 (35.48%)	156 (44.9%)
Round	11 (24.44%)	30 (20%)	2 (3.9%)	22.6%	19 (24.67%)	16 (13.3%)	11 (17.74%)	107 (30.84%)
Tetragonal	3 (6.67%)	9 (6%)	9 (17.6%)	18.9%	13 (16.88%)	20 (16.6%)	7 (11.29%)	6 (1.73%)
Pentagonal	3 (6.67%)	3 (2%)	2 (3.9%)	3.8%	1 (1.29%)	16 (13.3%)	1 (1.61%)	18 (5.19%)
hexagonal	---	9 (6%)	23 (45%)	5.6%	1 (1.29%)	20 (16.6%)	6 (9.68%)	32 (9.22%)
Egg	---	15 (10%)	3 (5.9%)	18.9%	2 (2.36%)	---	12 (19.35%)	5 (1.44%)
[Irregular	---	24 (16%)	3 (5.9%)	15. 1%	---	---	3 (4.84%)	23 (6.63%)
Pear shaped	---	---	---	---	---	8 (6.6%)	---	---

Table 4: Range, Mean, SD and Median of APD, TD and FM index of present and other studies

Shape	Present Study N = 100	Radhika *et al*.[5] N = 150	Sharma *et al*.[6] N = 50	Chetan *et al*.[7] N = 53	Lucas *et al*.[8] N = 77	Singh *et al*.[9] N = 120	Sharma *et al*.[10] N = 62	Harode *et al*.[12] N = 347	Rajani *et al*.[13] N = 35
Range- APD (mm)	31-38	27-43	--	--	26.90-39.29	--	--	--	30- 40
Mean-APD (mm)	33.53	35.30	34.44	31	34.23	33.79	34.17	34.41	33.8
SD- APD (mm)	2.36	2.70	--	2.4	2.54	2.60	--	--	2.5
Median APD (mm)	33	35	--	--	34.29	--	--	--	35
Range-TD (mm)	25- 32	24-35	--	--	22.67-36.01	--	--	--	22-33
Mean-TD (mm)	29.13	29.49	30.46	25.2	28.62	33.79	28.86	29.24	28.2
SD-TD (mm)	1.96	2.57	--	2.4	2.83	1.83	--	--	2.6
Median TD (mm)	29	30	--	--	28.15	--	--	--	28
Range-FM index	1.03-1.23	--	--	--	--	--	--	--	1-1.45
Mean-FM index	1.15	1.20	--	1.2	--	--	--	1.17	1.21
SD-FM index	0.079	--	--	0.1	--	--	--	--	0.11
FM index	1.14	--	--	--	--	--	--	--	1.21

Radhika. *et al*.[5] in their study on 150 foramen's found 60 (40%) oval, 15 (10%) egg, 30 (20%) round, 9 (6%) tetragonal, 3 (2%) pentagonal, 9 (6%) hexagonal and 24 (16%) were irregular in shape. She further mentions Mean APD-35.30mm, TD-29.49mm, Standard deviation APD-2.70, TD-2.57, Median APD-35mm, TD-30mm, range of APD as 27mm-43mm, TD as 24mm-35mm FM index as 1.20. Sharma *et al*.[6] in their study on 50 dry skulls found 8 (15.7%) oval, 2 (3.9%) round, 3 (5.9%) egg, 2 (3.9%) pentagonal, tetragonal 9 (17.6%), 23 (45%) hexagonal and 3 (5.9%) irregular foramen's. Mean APD-34.44mm, TD 30.46. Chetan *et al*.[7] in their study on 53 dry skulls opined, 22.6% round, 18.9% egg, 18.9% tetragonal, 15. 1% oval, 15. 1% irregular, 5.6% hexagonal and 3.8% pentagonal shapes. Mean APD was 31+/-2.4mm, TD-25.2+/-2.4mm and the average FM index calculated was 1.2+/-0.1. Lucas A. S. Pires et al in their study on 77 dry skulls of Brazilian population opined that most common shape was oval 41 (53.23%), followed by round 19 (24.67%), tetragonal 13 (16.88%), egg shaped 2 (2.36%), Pentagonal 1 (1.29%) and hexagonal 1 (1.29%). Mean APD was 34.23mm, TD- 28.62mm, SD of APD-2.54, TD-2.83, median of APD 34.29mm, TD- 28.15, APD values ranged from 26.90- 39.29mm and TD ranged from 22.67- 36.01mm. Singh *et al*.[8] in their study on 120 dry human skulls also opined that most common shape was oval 40 (33.3%), followed by tetragonal 20 (16.6%), hexagonal 20 (16.6%), round 16 (13.3%), pentagonal 16 (13.3%) and pear shape in 8 (6.6%). Mean +/-SD of APD was 33.79+/-2.60mm and TD was 33.79+/-1.83mm[9].

Sharma *et al*.[10] in their study on 62 dry human skulls mentions most common shape to be oval 22 (35.48%), then round 11 (17.74%), egg shape 12 (19.35%), tetragonal 7 (11.29%), pentagonal 1 (1.61%), hexagonal 6 (9.68%) and irregular 3 (4.84%). Mean APD was 34.17mm and TD was 28.86mm. Kumar *et al*.[11] in their study of different shapes of foramen magnum on 347 dry human skulls mentioned shapes in the following order oval 156 (44.9%), round 107 (30.84%), hexagonal 32 (9.22%), irregular 23 (6.63%), pentagonal 18 (5.19%), tetragonal 6 (1.73%) and egg shaped 5 (1.44%). Harode *et al*.[11] in their study on 60 dry human skulls opined mean APD to be 34.41mm, TD as 29.24mm and index as 1.17[12]. singh *et al*.[13] in their study on 35 dry human skulls opined mean APD as 33.8mm, TD-28.2mm, index-1.21, Standard deviation of APD-2.5mm, TD-2.6mm, index-0.11, median of APD 35mm, TD-28mm, index-1.21, range of APD 30-40mm, TD 22-33mm and index 1-1.45mm.

From comparison of present study with different authors (Table 3 and 4), we know that shape and morphometric measurements differ from region to region. The most common shape being oval followed by other shapes with varied percentages in different regions. The present study was done to know the shapes and range, mean+/-SD, median of APD, TD and FM index in North Karnataka region.

CONCLUSIONS

Although the sample size of present study is small, morphological analysis may help orthopedician, neurosurgeons for basilar approach from lateral or posterior side of foramen magnum for surgical procedures, The shape and size of (AP and TD) of foramen magnum is important parameter as many vital and vulnerable structures pass through it and could be compressed in FM achondrplasia, FM brain herniation and atlanto- occipital fusion.

Abbrevation:

FM: Foramen Magnum
APD: Antero-posterior diameter
TD: Transverse diameter
SD: Standard Deviation

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