

Comparison of Morphometry of Foramen Magnum and Posterior Cranial Fossa in Dry Human Skull

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ABSTRACT

Background: The foramen magnum and posterior cranial fossa are important landmarks of skull which play important role in pathophysiology of the posterior cerebral junction disorders. **Methods:** This is study of 40 dry normal skull bones taken in Department of anatomy, Government medical college & hospital, sector 32 Chandigarh. The objective is to make a data of various parameters of the foramen magnum and posterior cranial fossa in human skull of the region. The various parameters for foramen magnum measured were as follows: anteroposterior distance, Transverse diameter, perimeter, Area, Foramen magnum index, Shape of foramen magnum – oval, round, egg shaped, pentagonal, tetragonal, hexagonal and irregular. The measurement was taken with the help of vernier caliper which has minimum error of 0.01 mm. Similar measurements i.e. Height, transverse diameter, antero-posterior distance, volume were done for posterior cranial fossa. The data collected from dimensions of foramen magnum and posterior cranial fossa was entered in MS excel 2007 worksheet and statistically analyzed. **Results:** The various shapes of foramen magnum in 40 cases was observed as oval in 20%, round, egg & pentagonal in 5%, tetragonal in 17.5%, hexagonal in 40% and irregular in 7.5% cases. The mean AP (anteroposterior) distance was found to be 32.67mm & transverse diameter was to be 27.66mm. The perimeter calculated was found to be 93.08mm. FM index of foramen magnum was 83.13. However, area calculated for the opening of foramen magnum was 728.94mm². The posterior cranial fossa mean anteroposterior distance was 39.38mm. The transverse diameter was 103.06mm. The height of fossa was 40.65mm. The volume of posterior cranial fossa was calculated to be 100.97mm³. The anteroposterior distance of foramen magnum is less compared to posterior cranial fossa in oval shape 29.59mm and maximum is in irregular shape i.e. 44mm of posterior fossa. The transverse diameter of posterior cranial fossa is approximately four times transverse diameter of foramen magnum in almost all of the shapes. The perimeter of foramen magnum is maximum in egg shape 102.01mm and least in round shape 77.50mm. The width of foramen magnum is directed related to transverse distance of posterior fossa (0.366). Using signed 2 tailed test it was found to be significant (.020). The Pearson correlation depicts anteroposterior distance of foramen magnum is inversely related to anteroposterior distance of posterior cranial fossa. Using the signed two tailed test anteroposterior posterior fossa distance was found to be significant (0.013). **Conclusion:** The morphometric analysis of foramen magnum and posterior cranial fossa can be used for estimation of sex of fragmented incomplete or damaged dry human skulls. The present study may provide reference to clinicians, anatomists, anthropologists, forensic.

Keywords: Foramen magnum, posterior cranial fossa, shape.

INTRODUCTION

The foramen magnum and posterior cranial fossa are important landmarks of skull which play important role in pathophysiology of the posterior cerebral junction disorders. They are of particular interest for anthropology, anatomy, forensic medicine and other medical fields. Morphometry of

cranium also helps in establishing the origin of various neurological and skeletal pathology and also designing various surgical procedures and approaches. Foramen magnum is the largest foramen in the skull. It lies in an antero-median position and leads in to posterior cranial fossa. It is wider behind with greater anteroposterior diameter. Foramen magnum transmits lower end of medulla oblongata, meninges, vertebral arteries and spinal accessory nerve.^[1] The size and configuration of foramen magnum and posterior cranial fossa plays an important role in the pathophysiology of various disorders of posterior cranial fossa and craniovertebral junction. Stenosis of foramen magnum cause brainstem compression

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manifested by respiratory complications, lower cranial nerve dysfunction, upper and lower extremity paresis, hypotonia, hyper tonia, hyperflexia.^[2-4] The changes in posterior cranial fossa with cerebellar herniation in children having Costello Syndrome and posterior fossa crowding. It is rare genetic disorder associated with germ line mutations in the proto-oncogene HRAS.^[5-7] Foramen magnum and occipital bone are specific for particular population .From the qualitative and quantitative point of view ,features and morphometry of foramen magnum & occipital bone, when used are good indicators for the diagnosis of sex.^[8]

Configuration and size of foramen magnum play an important role in the pathophysiology of various disorders of craniovertebral junction. Thus a fundamental knowledge of normal anatomy and basic craniometric measurements for assessing craniovertebral relations is important to clinicians who diagnose disorders affecting region or to the surgeons who operates on this anatomy. A fundamental knowledge of normal anatomy and morphometry of foramen magnum and posterior cranial fossa is important to clinicians for diagnosis and treatment.

MATERIALS AND METHODS

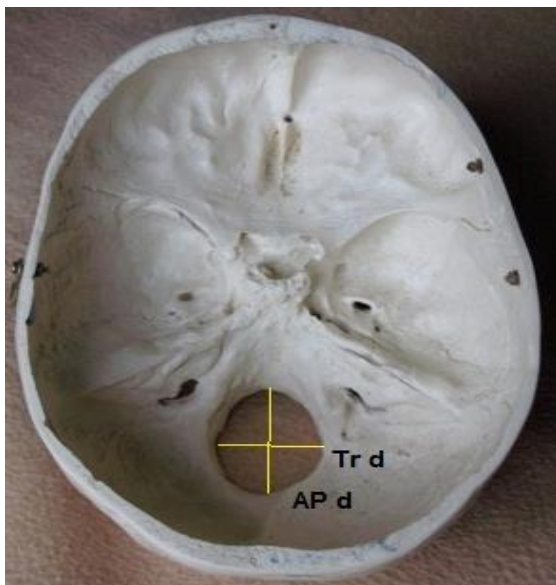


Figure 1: Parameter of Foramen magnum (APd- anteroposterior distance, Tr d-Transverse distance)

For the present study forty dry adult skull bones were taken in Department of anatomy, Government medical college & hospital, sector 32 Chandigarh. The skull with broken base and deformed shape was not included. The sex and origin of the skull could not be ascertained as some skulls were part of the skeleton bought from market. The objective is to make a data of various parameters of the foramen magnum and posterior cranial fossa in

human skull of the region. The various parameters for foramen magnum measured were as follows: Sagittal diameter (anteroposterior) from basion to opisthion; Transverse diameter (TD) (side to side) maximum diameter in transverse plane; Perimeter - length of the periphery of foramen magnum; Area of foramen magnum - $1/4 \times \pi \times Td \times APd$; Foramen magnum index - $(Td/AP d) \times 100$; Shape of foramen magnum – oval, round, egg shaped, pentagonal, tetragonal, hexagonal and irregular.

The measurement was taken with the help of vernier caliper which has minimum error of 0.01 mm. The perimeter was taken with the help of thread which was later measured with the calipers. All the measurements were taken twice and average was recorded. [Figure 1]

Next the parameters for posterior cranial fossa were measured as follows: Height: Anterior midpoint of dorsum sellae to basion; Anteroposterior distance: Posterior internal occipital protuberance to opisthion ;Transverse diameter: maximum distance along upper margins of groove for transverse sinus. Volume of posterior cranial fossa was measured by closing all the openings of posterior fossa and chana (gram) dal was put in it. Later dal was transferred to measuring cylinder to note the volume. [Figure 2] The process was repeated to cross check the accuracy of measurements.

The data collected from dimensions of foramen magnum and posterior cranial fossa was entered in MS excel 2007 worksheet and statistically analyzed.

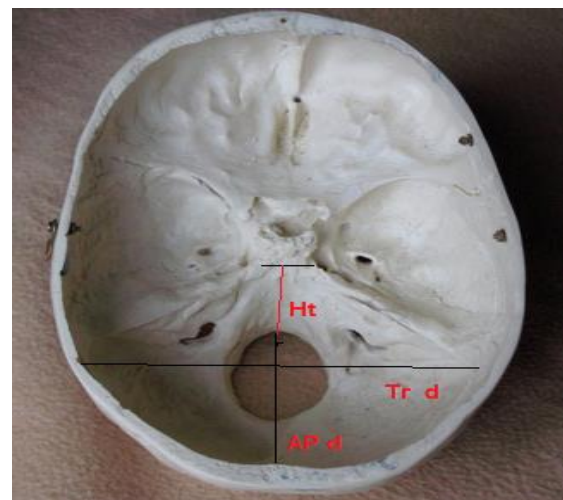


Figure 2: Parameters of Posterior cranial fossa (Ht- height, Trd- transverse distance, APd- anteroposterior distance)

RESULTS

The various shapes of foramen magnum in 40 cases was observed as oval in 20%,round ,egg & pentagonal in 5%, tetragonal in 17.5%, hexagonal in 40% and irregular in 7.5% cases. Various

parameters in regard to Foramen magnum was calculated as shown in [Table 1].

Table 1: Foramen magnum parameters

Parameters	Mean	Standard deviation	Standard error
AP	32.67	6.008	0.94
Transverse diameter	27.66	4.809	0.76
Perimeter	93.08	22.45	3.55
FM index	83.13	15.61	2.46
Area	728.94	147.15	23.26

The mean anteroposterior (AP) distance was found to be 32.67mm & transverse diameter was to be 27.66mm. The perimeter calculated was found to be 93.08mm with standard deviation of 22.45. FM index of foramen magnum was 83.13 with standard deviation of 15.61. However, area calculated for the opening of foramen magnum was 728.94mm².

Table 3: Parameters according to different shapes of foramen magnum

Shape	AP	Transverse	Perimeter	FM index	Area
Oval (8)	29.59	23.50	86.49	69.98	623.47
Round(2)	33.11	27.37	90.27	84.65	716.40
Egg(2)	35.22	27.26	102.01	77.39	755.37
Pentagonal(2)	31.30	27.79	90.51	88.98	683.50
Tetragonal(7)	34.00	29.13	100.41	85.62	777.64
Hexagonal(16)	33.56	28.92	91.80	86.62	764.05
Irregular(3)	32.01	29.01	98.09	92.01	730.37
Total(40)	32.67	27.66	93.08	83.13	728.94

Different parameters of foramen magnum according to different shape were studied. The AP distance was maximum in egg shaped to be 35.22mm which ranged from 29.59-35.22 mm. The transverse distance was maximum in tetragonal shape to be 29.13mm which ranged from 23.50-29.13mm. The perimeter was maximum in egg shape that is to be 102.01mm ranged from 86.49-102.01mm. The FM index was maximum in pentagonal shape i.e 88.98mm ranged from 69.98-92.01mm. The area was maximum in tetragonal shape 777.64mm² ranging from 623.47-777.64mm².

Table 4: Parameters of Posterior cranial fossa according to different shapes.

Shape	AP	Transverse	Height	PCFV
Oval (8)	38.82	99.49	40.05	99.37
Round(2)	32.79	100.47	35.02	77.50
Egg(2)	39.15	103.11	40.72	107.50
Pentagonal(2)	40.61	97.29	40.85	111.50
Tetragonal(7)	40.34	106.38	41.58	106.78
Hexagonal(16)	39.07	103.83	41.83	101.84
Irregular(3)	44.00	106.34	37.36	91.33
Total(40)	39.38	103.06	40.65	100.97

In 40 cases study done on posterior cranial fossa the AP distance was maximum in irregular shape 44mm and minimum in round shape with 32.79mm

Table 2: Posterior Cranial fossa parameters

Parameters	Mean	Standard deviation	Standard error
AP	39.38	4.71	0.74
Transverse	103.06	5.68	0.92
Height	40.65	5.83	0.89
Volume	100.97	15.14	2.39

The posterior cranial fossa mean anteroposterior distance was 39.38mm. The transverse diameter mean was 103.06mm with standard deviation 5.68. The height of fossa was 40.65mm. The volume of posterior cranial fossa was calculated to be 100.97mm³ with standard deviation of 15.14, Standard error of 2.39.

From above given table 1 & 2 comparing foramen magnum and posterior cranial fossa the AP & Transverse distance was more for posterior cranial fossa.

The AP distance ranged from 32.79-44mm. The transverse distance was maximum in tetragonal shape 106.38mm and minimum in pentagonal shape 97.29mm. The transverse diameter range from 97.29mm to 106.34mm. The height of posterior cranial fossa was maximum in hexagonal shape 41.83mm ranging from 35.02-41.83mm. The posterior cranial fossa volume was found maximum in pentagonal shape 111.50mm³. The volume of posterior cranial fossa ranges from 77.50-111.50mm³. The volume is maximum in pentagonal shape with 111.50 mm³ and minimum in round shape 77.50 mm³.

The Anteroposterior distance of foramen magnum is less compared to posterior cranial fossa in oval shape 29.59mm and maximum is in irregular shape i.e. 44mm of posterior fossa. The transverse diameter of posterior cranial fossa is approximately three times transverse diameter of foramen magnum in almost all of the shapes. The transverse diameter in foramen magnum i.e. Egg shape was found to be 27.26mm and in posterior cranial fossa was 103.11mm, almost three times greater than foramen magnum. The perimeter of foramen magnum is maximum in egg shape 102.01mm and least in round shape 77.50 mm.

Table 5: Comparison of FM & PCF parameters.

Shape	FM (AP)	PCF(AP)	FM(Trans.)	PCF(Trans.)	Perimeter FM	PCFV
Oval	29.59	38.82	23.50	99.49	86.49	99.37
Round	33.11	32.79	27.37	100.47	90.27	77.50
Egg	35.22	39.15	27.26	103.11	102.01	107.50
Pentagonal	31.30	40.61	27.79	97.29	90.51	111.50
Tetragonal	34.0	40.34	29.13	106.38	100.41	106.78
Hexagonal	33.56	39.07	28.92	103.83	91.80	101.84
Irregular	32.01	44.0	29.01	106.34	98.09	91.33

The correlation between width of foramen magnum and transverse posterior cranial fossa distance was calculated. The width of foramen magnum is directed related to transverse distance of posterior fossa (0.366). Using signed 2 tailed test it was found to be significant (.020). The pearson correlation depicts anteroposterior distance of foramen magnum is inversely related to anteroposterior distance of posterior cranial fossa. Using the signed two tailed test anteroposterior posterior fossa distance was found to be significant (0.013).

DISCUSSION

The knowledge of anatomy of foramen magnum & posterior cranial fossa and normal range is important in the proper planning of management. There are normal variations amongst various races, gender, geographical, religion and genetic factors. Various pathological conditions of PCF, axial tumors like medulloblastoma, cerebello pontine angle tumors, aneurysms of vessels of the posterior fossa, arterio-venous malformations, cranial nerve lesions, and the craniovertebral junction abnormalities like Arnold –Chiari malformations are quite common. A knowledge of PCF and FM including its normal dimensions and extent is essential clinically for accurate radiological diagnosis and in proper planning of various surgical interventions. The present study is concerned with measurements of FM and PCF on dry skull which would provide a baseline data for the surgeons.

The length of foramen magnum which is 32.67mm is greater than the transverse diameter 27.66mm. It reveals that anteroposterior diameter is more than transverse diameter. Berge and Bergmann¹⁰ found average sagittal diameter of 34mm and transverse diameter of 29mm. Muthukumar et al.^[11] found for sagittal diameter of 33.3mm and for transverse diameter of 27.9mm. Tubs et al.^[12] found anteroposterior diameter to be 31mm and transverse 27mm. The present study anteroposterior diameter and transverse was similar to that of Tubs study.

Sharma et al.^[13] found mean anteroposterior diameter and transverse diameter to be 47.70mm & 40.80mm. The mean area of foramen magnum in present study was found to be 728.94 mm² and

foramen magnum index was 83.13. As per result of Sharma et al mean area was of foramen magnum was 970.5mm². Burdan et al,^[14] 2012 reported the area of foramen magnum was 877.4mm² with foramen magnum index of 89.34. Teixeira found area to be 963.73mm² whereas Gunay and Altinkok found area of foramen magnum to be 909.91mm².^[15,16]

The foramen magnum and adjacent structures are preserved by the muscle attachment to the area. It suggests that male skull with larger skeletal muscles have a wider foramen magnum surface area than females. There exists a wide variability among genders in different studies due to different methods of investigation on dry skulls or CT scans.^[17]

The height of posterior cranial fossa in present study was found to be 40.65mm.

In the study conducted by Prabhuraman K the mean volume of posterior cranial fossa on MRI was 239 + 17cc whereas in the 44 control participants the average volume was 274+ 23cc.^[18] The volume of posterior cranial fossa was significantly smaller in patients with a Chiari malformation as compared with normal controls (p<0.001). The mean volume of posterior cranial fossa in dry skull bones was found to be 100.97mm³. Kanodia et al,^[19] reported that the mean posterior fossa height was 3.01cm in dry skull and 3.52cm in CT scans. Kanodia et al used both the formula abc/2 and a built in software to calculate PFV. They have reported that PFV was 122.49cm³ in the dry skull and 157.88cm³ in CT scans. In present study conducted on dry skull bones by filling method the volume of posterior fossa was to be 100.97cm³.

Morphometric and volumetric studies are useful tools in increasing of pathophysiological conditions. It could influence the natural history of patients with Chiari malformation as well as their prognosis after surgical treatment and could reduce risk of postoperative complications.

CONCLUSION

The morphometric analysis of foramen magnum and posterior cranial fossa can be used for estimation of sex of fragmented incomplete or damaged dry human skulls. The present study may

provide reference to clinicians, anatomists, anthropologists, forensic science.

REFERENCES

1. Standing, N.R. Borely, P. Collins, A.R Crossman, M.A.Gatzoulis and J.C. Cervicomedullary decompression for foramen magnum stenosis in Achondroplasia. *J neurosurg.*2006;104(3suppl):166-72.
- 2.
3. Dickman C, Spetzler RF, Sonntag VK. Surgery of the craniovertebral junction.,1st ed. New York, NY: Thieme Medical publishers:1998
4. Wang H , Rosenbaum AE, Reid CS, Zinreich SJ, Pyeritz RE. Pediatric patients with Achondroplasia: CT evaluation of the craniocervical junction. *Radiology.*1987;164:515-9.
5. Lorenz S, Lissewski C, Simsek-Kiper PO. Functional analysis of duplication in the switch II region of HRAS: New aspects of the molecular pathogenesis underlying Costello syndrome. *Hum Mol Genet* 2013;22: 1643-1653.
6. Gripp KW, Lin AE Stabley DL. HRAS mutation analysis in Costello Syndrome: Genotype and Phenotype correlation. *Am J Med Genet A* 2006; 140:1-7.
7. Aoki Y, Niihori T , Kawame H et al. Germline mutations in HRAS proto-oncogene cause Costello syndrome. *Nat Genet* 2005;37: 1038-1040.
8. Galdames ICS, Russo PP, Matamala DAZ, Smith RL. Sexual dimorphism in the foramen magnum dimensions. *International Journal of Morphology.* Vol 27(1): 21-23,2009.
9. Govsa F, Ozer MA, Celik S , Ozmutaf NM. Three Dimensional Anatomic Landmarks of the Foramen Magnum for the Craniovertebral junction. *The journal of craniofacial surgery.* Vol.22 (3).1073-1076,2011.
10. Berge JK, Bergmann RA 2001.variation in size and in symmetry of the foramina of human skull. *Clin Anat* 14:406-413.
11. Muthukumar N, Swaminathan R, Venkatesh G, Bhanumathy SP.2005.A morphometric analysis of the foramen magnum region as it relates to transcondylar approach. *Acta neurochir* 147:889-895.
12. Sindel M, Ozkan O, Ucar Y .Foramen Magnum anatomic variation. *Akd U Tip Fak Dergisi.*1989;6:97-102.
13. Sharma S, Sharma AK, Modi BS, Arshad M. Morphometric evaluation of the foramen magnum and variation in its shape and size :a study on human dried skull. *Int J Anat Res.*,2015;3(3):1399-03.
14. F.Burda, J.SzumiO, J.Walocha, L.Klepacz, B.Madej, W.Dworzanski, R.Klepacz, A.Dworzanska, E.Czekajska-Chehab, A.Drop. Morphology of the Foramen magnum in young eastern European adults. *Folia Morphol.*2012;71(4):205-216.
15. Teixeira WR. Sex identification utilizing the size of Foramen magnum. *Am J Forensic Med pathol.*1983;3:203-206.
16. Gunay Y, Altinkok M. The value of the size of foramen magnum in sex determination. *J Clin forensic Med* 2000;7(3):147-149.
17. Manoel C, Prado FB, Caria PHF et al. Morphometric analysis of the foramen magnum in human skulls of Brazilian individuals :its relation to gender. *Braz J Morphol Sci.*2009;26:104-108.
18. Prabhuraman K, Balasubramanian R, Magesh P. Morphometric analysis of the posterior cranial fossa in healthy adult population and patients with Chiari malformation. *Indian Journal of applied research.*2018;8(8):
19. Kandia G, Parihar V, Yadav YR, Bhatele PR, Sharma D. Morphometric analysis of posterior fossa and foramen magnum. *J Neurosci Rural Pract.*2012;3:261-6.

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