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A MORPHOMETRIC STUDY OF FORAMEN MAGNUM IN DRY ADULT HUMAN SKULL

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ABSTRACT

Aim: To study the morphology and morphometry of foramen magnum in dry adult human skull.

Materials and method: Ninety eight skulls were investigated for foramen magnum. The shape of foramen magnum was noted and classified into oval, round, tetragonal and asymmetrical. The length (antero-posterior) and width (transverse) of foramen magnum was measured using pair of dividers and ruler.

Results: 44 foramina magna were observed to be oval, 20 were tetragonal, 18 were round and 13 were found to be asymmetrical. The average length was 34.8 ± 2.45 (29-42) mm and average width was 30 ± 2.29 (26-36) mm. 3 skull showed occipitalization of atlas vertebra.

Conclusion: These data may be of use as a morphometric database for description of "normal" variants of foramen magnum morphology.

Key Words: Foramen magnum, Craniovertebral junction

INTRODUCTION

Foramen magnum is a Latin word meaning the largest aperture in skull. The foramen magnum is an important landmark for surgeries as it lies at the transition zone between spine and skull. The foramen magnum is a fundamental component in the complex interaction of bony, ligamentous and muscular structures composing the craniovertebral junction. Shape and size of the foramen are critical parameters for the manifestation of clinical signs and symptoms in craniocervical pathologies. Diseases associated with anomalies of the foramen magnum include occipital vertebra, basilar invagination, condylar hypoplasia, and atlas assimilation.

The transcondylar approach is being increasingly used to access lesions ventral to the brainstem and cervicomedullary junction. Understanding the bony anatomy of this region is important for this approach.

Focusing on forensic dentistry and medicine, the morphometric analysis of the skull can be used as part of an investigative process prior to more sophisticated and expensive analyses such as the DNA examination.[1]

Among developmental and acquired craniocervical junction disorders, achondroplasia is the commonly reported. Achondroplasia, the most common form of dwarfism, resulting in abnormal enchondral bone formation at the cranial base, leads to a narrow cervical spinal canal and a stenotic foramen magnum. Clinical manifestations of chronic brainstem compression by stenosis of the foramen magnum and related structures are respiratory complications, lower cranial nerve dysfunctions, upper and lower extremity paresis, hypo- or hypertonia, hyperreflexia or clonus, and general motor development delay.[2]

The configuration of the foramen magnum in patients with Chiari I and Chiari II malformations has been found to be different than in the normal population. Furthermore, development of symptoms has been found in patients with shorter anteroposterior diameters of the foramen magnum. Other diseases associated with stenosis of the craniovertebral junction include craniometaphyseal dysplasia, Jeune's asphyxiating thoracic dystrophy, and spherophakia-brachymorphism (Marchesani's syndrome). Stenosis of the foramen magnum has also been reported for Beare-Stevenson syndrome, a craniofacial syndrome characterized by hypertrophy of the bony margins. A wide foramen magnum has also been appreciated in patients with diastrophic dysplasia. The decision-making process for the diagnosis and treatment of such disorders with bony abnormalities resulting in changes

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of the anatomy of the foramen magnum demands a good understanding of the normal anatomy of this structure.[2]

MATERIALS AND METHODS

Ninety eight dry adult human skulls of indetermined gender were collected from the bone library of medical teaching institutes of Mumbai. The adult status of the skull was determined by the synostosis between the basi-occiput and basi-sphenoid at the cranial base. Data were collected using a pair of dividers, ruler and digital camera. The pair of dividers was spanned across the distances to be measured. Distances were transferred to a ruler to record the readings. Data so collected were statistically analysed for descriptive statistics and using Microsoft excel software. Following parameters were considered-

- The shape of foramen magnum was noted and classified as oval, round, tetragonal and asymmetrical (figure 1)
- The length of foramen magnum was measured from the anterior border (basion) through the centre of the foramen magnum until the posterior border (opistio) in the sagittal plane (figure 2)
- The width of foramen magnum was measured perpendicular to length in the coronal plane at a point where it was maximum (figure 2)

RESULTS

Out of the ninety eight skulls investigated, 95 foramina magna were considered for measurements and 3 foramina showed variations where measurements could not be taken.

In the 95 foramina magna, 44 foramina magna were observed to be oval, 20 were tetragonal, 18 were round and 13 were found to be asymmetrical (graph 1).

The average length of foramen magnum was 34.8 ± 2.45 mm within a range of 29 - 42 mm.

The mean width of foramen magnum was 30 ± 2.29 mm within the range of 26 - 36 mm.

3 skull showed occipitalization of atlas vertebra as shown in figure 3.

DISCUSSION

Configuration and size of the foramen magnum play an important role in the pathophysiology of various disorders of the craniovertebral junction. Thus, a fundamental knowledge of normal anatomy and basic craniometric measurements for assessing craniovertebral relations is important to the clinician who diagnose this region and the surgeon who operates on this anatomy.

In the present study, oval shape of foramen magnum was commonly seen (46%). This was followed by tetragonal (21%), round (19%) and asymmetrical (14%). The findings of previous studies are presented in table 1. Muthukumar N et al.[3] showed in their study in 2005 that, whenever the foramen magnum index was more than 1.2, the foramen was found to be ovoid. They calculated the index by dividing antero-posterior diameter by the transverse diameter. Forty six percent of the skulls studied exhibited an ovoid foramen magnum in their study.

In the present study, the average length of foramen magnum was 34.8 ± 2.45 mm within a range of 29 - 42 mm. The average length in the present study is comparable with Sukumar S[6], Muthukumar N[3], AvcI E[8], Manoel C[1], Kanodia G[10] and Radhakrishna SK[11]. The average lengths reported by these researchers are presented in table 2.

The mean width of foramen magnum was 30 ± 2.29 mm within the range of 26 - 36 mm in this study which is comparable with values reported by Furtado SV[4], Gruber P[5], Osunwoke EA[7], AvcI E[8], Manoel C[1] and RadhakrishnaSK[11]. Study average length of the foramen was greater than the width in the present study which is consistent with the oval shape of the foramen found commonly in the study sample.

Vineeta Saini et al.[12] found 2 skulls with assimilation of atlas vertebra in the anthropometric study of 126 skulls. Khamanarong K et al.[14] reported 2 skulls with occipitalization of atlas vertebra in the 633 thai adult skulls. In the present study, 3 (3%) skulls showed occipitalization of the first vertebra. The percentage of this variation is higher in the study sample as the bones were collected from bone libraries of medical college. Knowledge of occipitalization of the atlas is of substantial importance to orthopaedicians, neurosurgeons, physiotherapists and radiologists dealing with abnormalities of the cervical spine.

Occipitalization is a congenital synostosis of the atlas to the occiput. During the fourth week, sclerotome migrate around the spinal cord and the notochord to merge with cells from the opposing somite on the other side of the neural tube. As development continues, the sclerotome portion of each somite also undergoes a process called resegmentation. Resegmentation occurs when the caudal half of each sclerotome grows into and fuses with the cephalic half of each adjacent sclerotome. Thus each vertebra is formed from combination of the caudal half of one somite and the cranial half of its neighbour.[13]In a small number of cases, the disruption of this merging process may result in atlanto-occipital assimilation. This condition may be partial or complete. Occipitalization of atlas is associated with abnormalities as a result of narrowing of the foramen magnum, compressing the spinal cord or the brain stem. However, this anatomical variation may often go unnoticed but, incidentally, reveals its presence as a radiological, operative or autopsy finding.[12]

CONCLUSION

The average length and width of foramen magnum were 34.8 ± 2.45 mm and 30 ± 2.29 mm respectively. 3 skull showed occipitalization of atlas vertebra. This anatomic study elucidated the morphological and morphometric characteristics of foramen magnum and may serve as a future standard reference.

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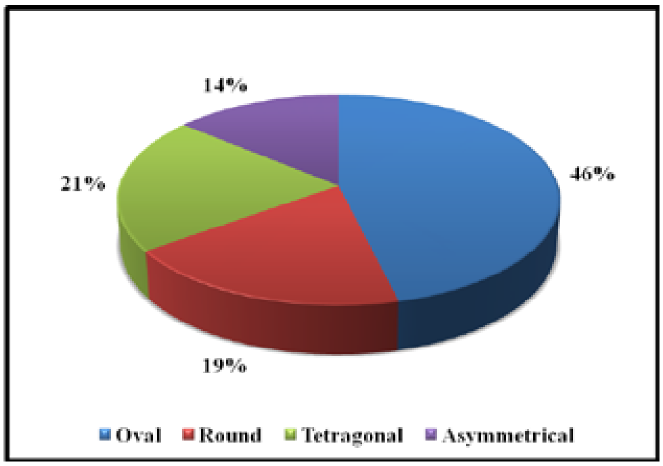

Graph 1: showing shape of foramen magnum in present study.

Table 1: Showing comparison of percentage of different shapes of foramen magnum .

Studies	Furtado SV[4] (India 2010)	Murshed KA[9] (Turkey 2003)	Radhakrishna SK[11] (India 2012)	Present study (2013)
Sample size (no. of skulls)	21	110	100	95
Method of study	Radiology CT MRI	CT-scan	Dry bone	Dry bone
Oval (%)	9.6	8.1	39	46
Round (%)	4.7	21.8	28	19
Tetragonal (%)	19.04	12.7	19	21
Asymmetrical (%)	19.04	19.99	-	14
Others (%)	Egg shaped-9.5 Pentagonal-9.6 Hexagonal-19.04	Egg shaped-6.3 Pentagonal-13.6 Hexagonal-17.2	Pentagonal-14	-

Table 2: Showing comparison of length and width of foramen magnum.

Studies	Sample size No. of skulls	Method of study	Length mean ± SD (Range) mm	Width mean ± SD (Range) mm
Furtado SV[4] (India 2010)	21	Radiology CT scan MRI scan	37.1	29.5
Tubbs[2]	72	Computer assisted image analysis system	31 (25 - 37)	27 (24 - 35)
Gruber P[5] (Switzerland 2009)	110	Bone study	36.6 ± 2.8 (30.1 – 42.6)	31.1 ± 2.7 (25 – 38.9)
Sukumar S[6] (India 2012)	54 Male-32 Female-22	3-D reconstruction Using CT scan	Male- 35.18 ± 2.84 Female- 31.77 ± 2.05	Male:29.53 ± 2.76 Female:26.31 ± 1.15
Osunwoke EA[7] (Nigeria 2012)	120	Dry bone	36.11 ± 2.6	29.56 ± 2.6
Muthukumar N[3] (India 2005)	50	Dry bone	33.3	27.9
Avcl E[8] (Turkey 2011)	30	Dry bone Dissection Radiology	34.5	29
Murshed KA[9] (Turkey 2003)	110	CT-scan	Male- 37.2 ± 3.43 (31 - 45) Female- 31.6 ± 2.99 (27 - 40)	Male:34.6 ± 3.16 (28 - 42) Female:29.3 ± 2.19 (24 - 33)

Table 2: (Continued)

Studies	Sample size No. of skulls	Method of study	Length mean ± SD (Range) mm	Width mean ± SD (Range) mm
Manoel C[1] (Brazil 2009)	215	Dry bone	Male- 35..7 ± 0.29 Female- 35.1 ± 0.33	Male:30.3 ± 0.2 Female:29.4 ± 0.23
Kanodia G[10] (India 2011)	100	Dry bone CT scan	3.41 ± 0.29 (cm)	2.75 ± 0.25 (cm)
Radhakrishna SK[11] (India 2012)	100	Dry bone	Male: 34.04 ± 2.36 Female: 31.72 ± 2.14	Male: 28.63 ± 1.89 Female:26.59 ±1.64
Present study (2013)	95	Dry bone	34.8 ± 2.45 (29 – 42)	30 ± 2.29 (26 – 36)

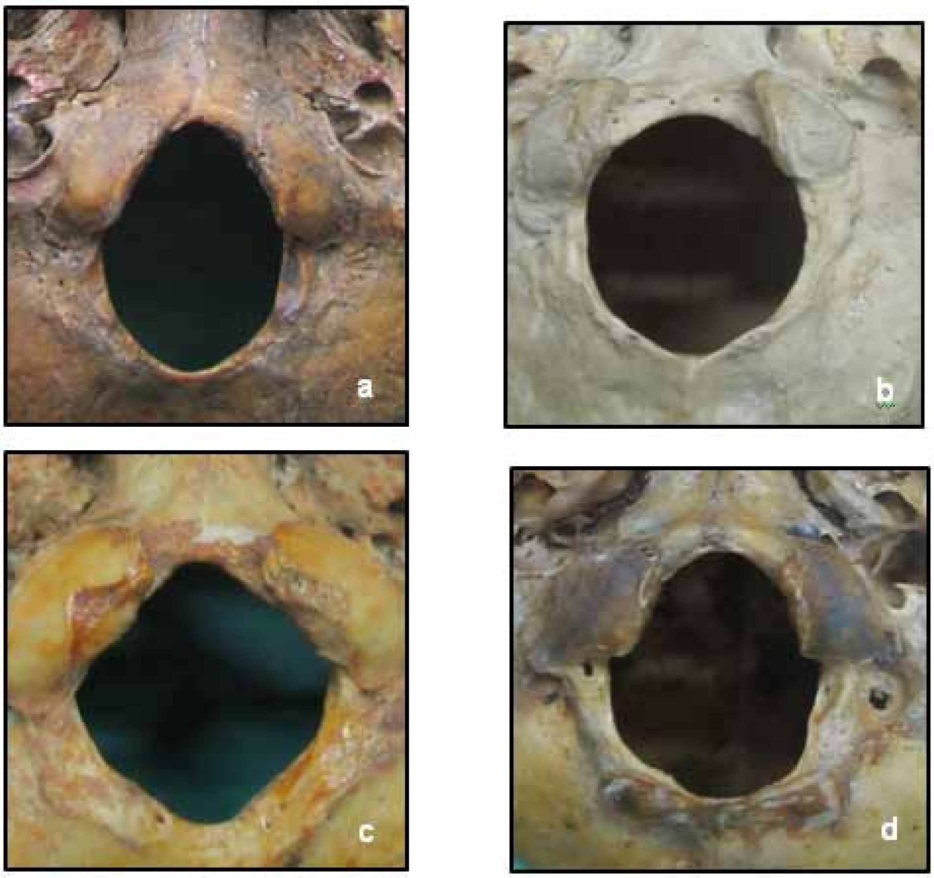

Figure 1: Showing different shaped of foramen magnum. a- oval, b- round, c- tetragonal, d- asymmetrical

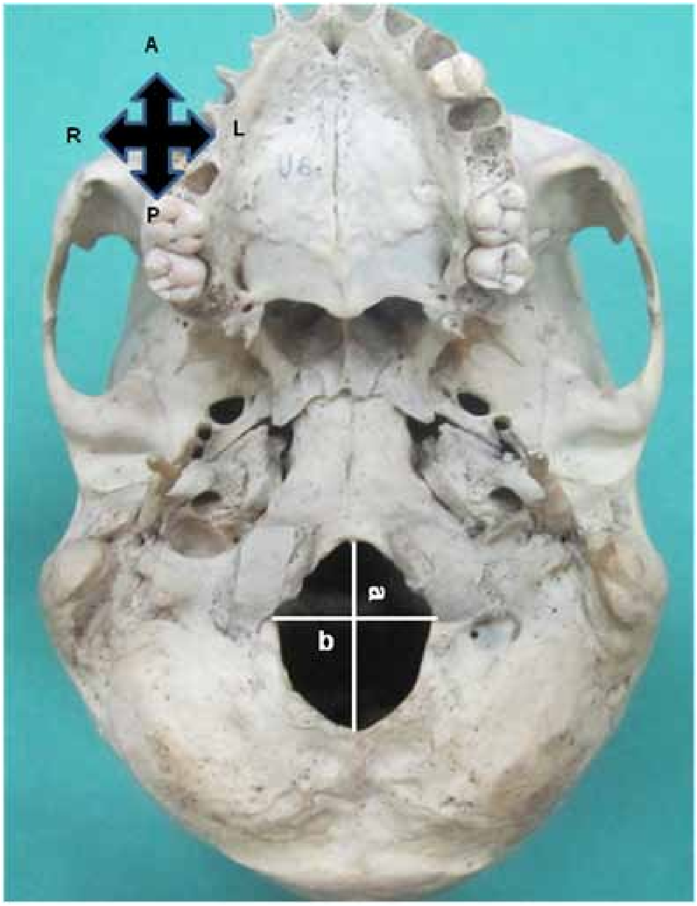

Figure 2: Showing base of skull and measurement of length and width of foramen magnum. a- length and b- width

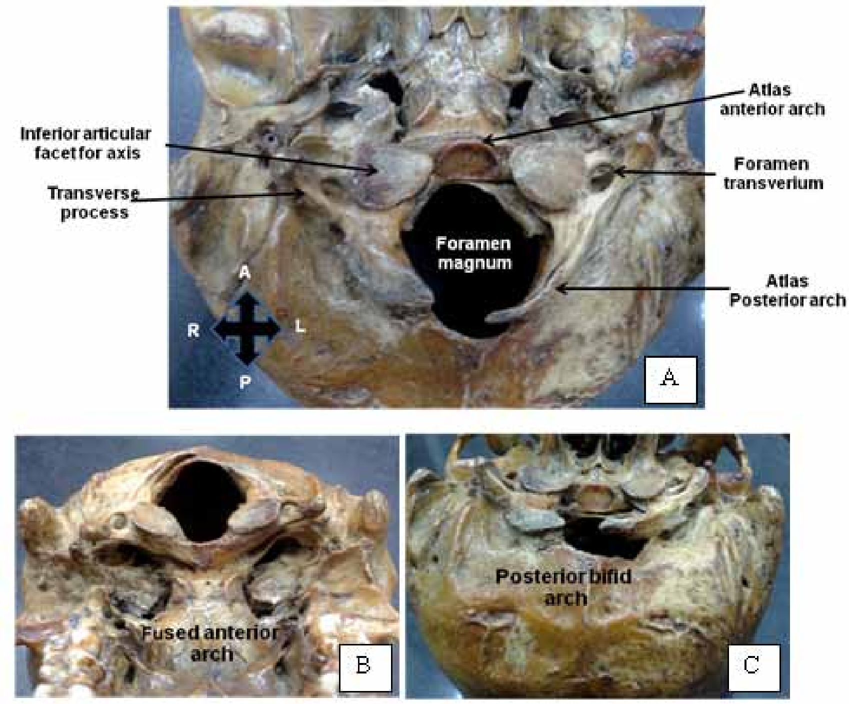

Figure 3: Showing occipitalization of altas vertebra (skull no: 6). A: inferior view, B: anterior view, C: posterior view