



## RESEARCH ARTICLE

### MORPHOMETRIC VARIATIONS OF THE JUGULAR FORAMEN OF THE HUMAN SKULL IN SOUTH INDIAN POPULATION

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#### ARTICLE INFO

##### Article History:

Received 19<sup>th</sup> February, 2016  
Received in revised form  
26<sup>th</sup> March, 2016  
Accepted 04<sup>th</sup> April, 2016  
Published online 10<sup>th</sup> May, 2016

##### Key words:

Jugular foramen, Jugular fossa,  
Compartments, Septation.

#### ABSTRACT

The jugular foramen is a hiatus located at the base of the skull. The ninth, tenth and eleventh cranial nerves pass through this foramen. The increasing use of modern diagnostic procedures and new surgical approaches has created a need for detailed anatomical studies of the foramen. Hundred dry south Indian human skulls were collected from the Department of Anatomy Vydehi Institute of Medical Sciences and Research Center and a study was undertaken to measure the size of jugular foramen. The length, width and depth of jugular foramen on both sides were measured using digital Vernier callipers and the incidence of septation of jugular foramen was noted. Statistical analysis was done using SPSS Version 21. The Independent Sample t test was used after checking the normality of the data. In 57% of skulls length of jugular foramen on right was more than on the left. It was observed that 21 skulls had complete septa on the right and 18 had complete septa on the left, while 79 skulls had incomplete septa on the right and 82 skulls had incomplete septa on the left side. It was observed that Jugular foramen was larger on the right which was statistically significant.

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**Citation:** Vini Talwar, Shashirekha, M., Geetanjali Mohan, Athul Antony Simon, Aga Ammar Murthuza and Varsha Mokhasi, 2016. "Morphometric variations of the jugular foramen of the human skull in south Indian population", *International Journal of Current Research*, 8, (05), 30672-30676.

## INTRODUCTION

Jugular foramen of human skull is a complex bony canal which lies between the occipital bone and the petrous part of the temporal bone. It is large and irregular in shape. (Hussain Saheb *et al.*, 2010) It is situated at the posterior end of the Petro-occipital fissure (Anitha *et al.*, 2013). The edge of the occipital bone forms a notch and the petrous temporal is excavated to form a fossa which accommodates the superior bulb of the jugular vein (Romanes, 1972). The jugular foramen is commonly divided into three compartments-two venous and a neural or intrajugular compartment. Structures of clinical importance traverse the jugular foramen which is the sigmoid sinus in the jugular fossa, the inferior petrosal sinus, meningeal branches of the ascending pharyngeal and occipital arteries, the glossopharyngeal, vagus and accessory nerves with their ganglia (Hussain Saheb *et al.*, 2010). The jugular foramen varies considerably in shape and size on the two sides in the same cranium, and in different crania, also in racial groups and sex. Most of the intracranial and extracranial lesions of posterior cranial fossa may affect the structures in jugular foramen in addition to intrinsic abnormalities.

Pathologies like Meningiomas, paraganglionomas, schwannomas and other inflammatory lesions of inner ear are known to effect the structures in jugular foramen (Anitha *et al.*, 2013).

#### Aims and objectives

Anomalies of the jugular bulb such as glomus tumors are related with the jugular foramen, as they come in direct contact with structures that cross it (Chandni Gupta *et al.*, 2014). Thus the knowledge of relevant anatomical details and dimensions of jugular foramen in the regional population would be of great help to ENT surgeons, neurosurgeons, radiologist and forensic experts. Hence, this study was carried out to analyze the shape, size, and presence of septa and jugular fossa measurements of the jugular foramen in dry adult skulls.

## MATERIALS AND METHODS

The present study was undertaken using 100 adult dry human skulls procured from the Department of Anatomy, Vydehi Institute of Medical Sciences & Research Center. Malformed and damaged skulls and fetal skulls were excluded. Digital Vernier Caliper with a resolute accuracy of 0.01mm +/-

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0.02mm (<100mm), was utilized to measure the parameters. The parameters were:

- Antero-posterior diameter (X) of jugular foramen in mm was taken from the posterior border of the carotid canal anteriorly to the posterior wall of the foramen posteriorly.
- Medio-lateral diameter (Y) of jugular foramen in mm was taken from the root of the styloid process laterally to the medial end of the foramen medially.
- Depth of jugular fossa in mm was measured from the floor of the fossa to the summit on the wall of the fossa.
- Distance between the center of the mastoid process and the outer and margins of the foramen were taken in mm.
- Septa touching the two ends of the foramen were considered as complete while those septa which were not touching both anterior and posterior wall were taken as incomplete.

Statistical analysis was done using SPSS Version 21. The Independent Sample t test was used after checking the normality of the data.



Figure 1. Image is showing measurement of antero posterior diameter

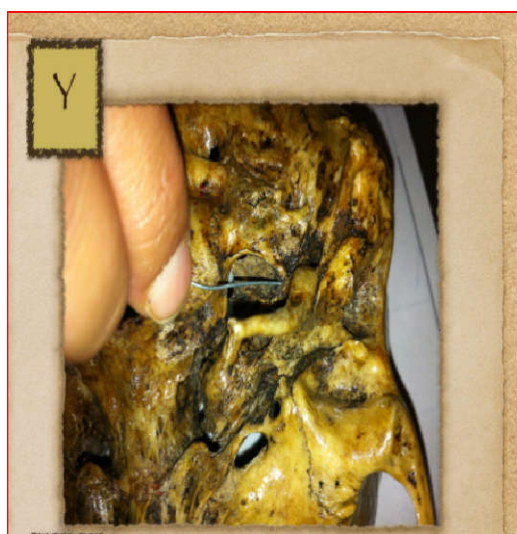


Figure 2. Image is showing Measurement of transverse Diameter



Figure 3. Showing complete septation

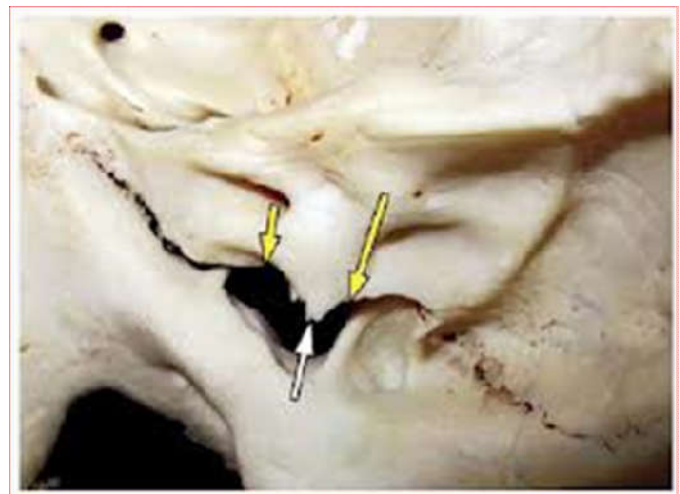


Figure 4. Showing incomplete septation

## RESULTS

The present study found that the size of the jugular foramen varied on the two sides. The mean lengths of jugular foramen on right and left side were 15.57 mm and 10.59 mm respectively which had a p value 0.012 which is statistically significant. Mean width of right & left jugular foramen were 15.90mm & 15.45mm respectively. The mean depths of jugular foramen on right and left side were 12.76mm and 11.34mm respectively. The outer margin of the foramen is at a distance of 16.81mm and 18.50mm from the mastoid process on the right and left side respectively both of which had a p value less than 0.001 which is statistically significant while the inner margins are at a distance of 33.03mm and 32.96 respectively. (Table 1). It was observed that the AP Diameter, ML Diameter, depth were larger on the right than left in 58%, 57% and 68% respectively. Distance of the outer margin from the mastoid process was greater on the right than left in 21% skulls and distance of inner margin from the mastoid process was larger on the right than left in 46% skulls.

**PRESENCE OF SEPTA:** It was observed that 21 skulls had complete septa on the right and 18 had complete septa on the left, while 79 skulls had incomplete septa on the right and 82 skulls had incomplete septa on the left side.

Table 1. Present study results

DIMENSIONS	SIDE		P values
	Right(mm)	Left (mm)	
Anteroposterior diameter	11.57+/-2.53SD	10.59+/-2.99SD	0.012*
Mediolateral diameter	15.90+/-3.11SD	15.45+/-3.34SD	0.325*
Depth	12.76+/-3.33SD	11.34+/-2.89SD	0.001*
Distance of outer margin from mastoid process	16.81+/-2.81SD	18.50+/-4.11SD	0.001*
Distance of inner margin from mastoid process	33.03+/-3.32SD	32.96+/-4.46SD	0.899*

\*independent sample t test

Table 2. Comparing relative size of foramen in present and other studies

STUDY	NUMBER OF SKULLS STUDIED	RELATIVE FORAMEN SIZE IN %		
		R>L	R=L	R<L
Sturrock et al (1988) <sup>[8]</sup>	156	69	8	23
Tahir et al (1992)	300	61.6	12.4	26
Ekinci et al(1997)	100	61.4	14.3	24.3
Patel et al (2007) <sup>[10]</sup>	91	64	24.2	11.8
Hussain et al (2010) <sup>[11]</sup>	125	64.8	10.4	24.8
Anita et al (2012) <sup>[2]</sup>	100	88	-	12
<b>Present study (2013)</b>	<b>100</b>	<b>Anteroposterior-58</b>	.	<b>Anteroposterior-42</b>

Table 3. Comparing AP Diameters of present and other author studies

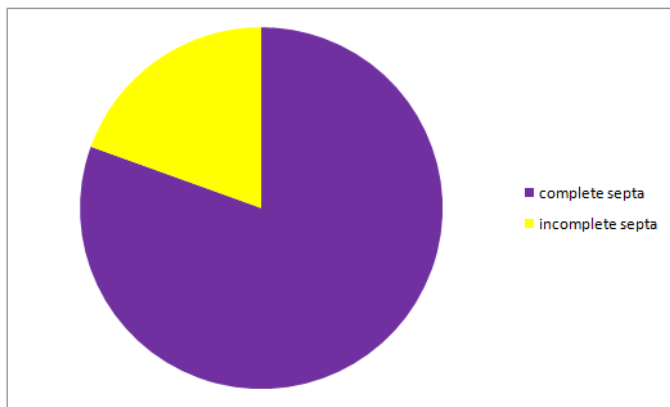
Study	No of skulls	Mean values(mm)	
		AP Diameter	
		Right	Left
Ekinci <i>et al</i>	100	8.4	7.6
Pierra <i>et al</i> (2010)	111	9.21	8.65
Osunwoke <i>et al</i> (2012)	120	15.76	13.39
Singla (2012)	50	9.32	7.34
Chandini gupta	50	11.22	9.52
Present study	100	11.57	10.59

Table 4. Comparing ML Diameters of present and other author studies

Study	No. of skulls	Mean values(mm)	
		ML Diameter	
		Right	Left
Ekinci <i>et al</i>	100	16	15.50
Pierra <i>et al</i> (2010)	111	15.82	15.86
Osunwoke <i>et al</i> (2012)	120	9.34	7.54
Singla (2012)	50	15.67	14.85
Chandini gupta	50	16.52	16.02
Present study	100	15.90	15.45

Table 5. Comparing Depths of present and other author studies

Study	No of skulls	Mean values (mm)	
		Depth	
Singla (2012)	50	11.11	11.04
Chandini gupta	50	11.58	11.13
Present study	100	12.76	11.34



**PIE CHART 1- showing presence of complete and incomplete septa. 161 complete and 21 incomplete septa in the 200 foramina observed**

**Table 6. Comparing septation in present and other author studies**

Study	Complete septations(%)		Partial septations(%)	
	Right	left	Right	Left
Sturrock	3.2	3.2	1.3	10.9
Hatiboglu	5.6	4.3	2.6	19.6
Patel and singel	23.1	17.6	49.5	59.3
Hussain	20.8	16.8	45.6	58.4
Present study	21	18	79	82

## DISCUSSION

Sturrock examined the jugular foramina in 156 skulls and found out that, in 69% of cases the right was larger than the left and in 23% the left was larger, in rest of skulls being equal size and complete septation of the right and left jugular foramen was found in 3.2% (Sturrock, 1998). Hatiboglu examined the jugular foramen in 300 Anatolian skulls from the 17th and 18 centuries. In 61.6% (185 skulls) the foramen was larger on the right and in 26% (78 skulls) on the left, with the remainder being of almost equal (Hatiboglu and Anil, 1992). Patel and Singel studied 91 Indian skulls (Saurashtra region) and observed in 60.4% cases larger right foramen, in 15.4% larger left foramen and in 24.2% equal on both sides (Patel and Singel, 2007). Osunwoke E.A et al. did morphometric analysis of the jugular foramen of 120 dry adult skulls in Southern Nigeria and found the mean length of the right and left jugular foramen was 15.76±0.22mm and 13.39±0.23mm respectively, while the mean width of the right and left jugular foramen was 9.34±0.18mm and 7.54±0.20mm respectively. Significant difference between the right and the left jugular foramen was observed.

The right jugular foramen was found to be larger than the left in Southern Nigeria (Osunwoke *et al.*, 2012). Hussain found in his study of 125 skulls that jugular foramina were larger on the right side in 64.8%, larger on left side in 24.8% and equal in size in 10.4%. (Hussain Saheb *et al.*, 2010) Singla *et al.* found the mean right and left depth of jugular fossa as 11.11 mm and 11.04 mm. While Chandini *et al.* got the values as 11.58 mm and 11.13 mm respectively. (Chandni Gupta *et al.*, 2014) Regarding the septation of compartments Sturrock R.R

observed complete septation on right side in 3.2%, left side in 3.2% and partial septation on the right side in 1.3%, on left side in 10.9%. Hatiboglu and Anil observed complete septation on the right side in 5.6%, on the left side in 4.3% and partial septation on the right side in 2.6%, on the left side in 19.6%. Patel and Singel observed complete septation on the right side in 23.1%, on the left side in 17.6% and partial septation on the right side in 49.5%, on the left side in 59.3% (Hussain Saheb *et al.*, 2010). In the present study of 200 jugular foramina in 100 South Indian dry skulls was analysed and mean length and breadth on the right side was found to be larger than left which was statistically significant. The size and shape of the jugular foramen are associated to the size of the internal jugular vein and the presence or absence of a dome for superior bulb the right foramen is frequently larger than the left. The superior sagittal sinus is the largest dural venous sinus (Drake *et al.*, 2008). The large size on the right attributes with the fact that right internal jugular vein is larger than the left in most of the individuals. The larger superior sagittal sinus continues in succession as right transverse sinus, right sigmoid sinus and right internal jugular vein, on the other hand the smaller inferior sagittal sinus continues in succession as straight sinus, left transverse sinus, left sigmoid sinus and into left internal jugular vein. Different studies have shown wide variation in the anatomy of the intracranial venous sinuses (Seegar, 1939). The dissimilarity in size of the two internal jugular veins is already noticeable in the human embryo at the 23 mm stage and perhaps is due to the differences in the pattern of development of the right and left brachiocephalic veins (Khanday *et al.*, 2013).

## Conclusion

The jugular foramen exhibits complex anatomical relationships and contains significant vessel and neural structures. The present study observed the right jugular foramen to be larger than left in South Indian region. Such discrete cranial traits have been addressed to assess a possible genetic background. Knowledge of morphology, compartments and arrangement of structures within the foramen helps in deducing position of various structures from the available data of jugular foramen depicted by this study. The knowledge may also be utilized by the clinicians to understand clinical presentations and progression of the lesions of the jugular foramen lesions and planning for the possible approaches for the operations. Findings obtained in the present study supports previously reported morphometric variations of jugular foramen besides adding data on the South Indian population. These findings will be of utmost usefulness to ENT surgeons, neurosurgeons, forensic experts and radiologists.

The compartmentalization of the jugular foramen is an oversimplification and has no surgical significance. The depth maybe related to high jugular bulb causing conductive hearing loss due to its contact with the tympanic membrane and complications during cochlear implants. Thus knowledge of the anatomic variations of the depth will help the neurosurgeon and ENT surgeon. The postauricular transtemporal approach, the most common approach selected for a lesion in the jugular foramen, accesses the region from laterally, through the

mastoid, hence knowledge of the relation of the foramen with mastoid process may be useful.

### Acknowledgement

Sincere thanks to all the teaching and non-teaching staff of the Department of Anatomy, VIMS &RC Bangalore, Department of Radiology, VIMS&RC Bangalore, Department of Neurosurgery, VIMS &RC Bangalore and Department of Community Medicine, VIMS &RC.

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