

Study of Morphometric Variations in Jugular Foramen and Jugular Fossa of Dried Adult Human Skulls

Lovely Jain SR¹, Rajendra Singh Kushwah²

ABSTRACT

Introduction: Jugular foramen is most complex irregular bony canal. Many important nerves and vessels are passing through it. Anatomical variation in the course of the nerves and vessels adds more complexity to jugular foramen. Study was done to access morphometric anatomical variations in jugular Foramen and fossa

Material and methods: Anteroposterior and mediolateral diameter, depth, width, presence of dom, septations and degree of predominance of Jugular Foramen and fossa in 250 skulls measured by manual vernier caliper

Result: Mediolateral diameter of jugular foramen and width of jugular fossa is significantly higher on the right side (p value <.05). Unilateral slit like jugular foramen found in one skull with Anteroposterior (AP) diameter of 2.37 mm. Bilateral complete septation of jugular foramen into two and three compartments is observed in 10% and 4% of the skull respectively. The doomed bony roof is noted in 54.8% of the skull on both sides.

Conclusion: The observed variations of jugular foramen are possibly due to constitutional, racial or genetic factors. Knowledge of the observed variation of this foramen is very important for neurosurgeons, radiologists and anthropologists.

Keywords: Jugular Foramen, Carotid Canal, Occipital Condyle, Mastoid Process, Septation, Skull, Periosteal Capsule, Ala Temporalis, Parachordal Plate of Chondrocranium, Petro-Occipital Suture

INTRODUCTION

Jugular foramen is most complex irregular bony canal. Many important nerves and vessels are passing through it. The foramen presents variations regarding shape, size and laterality for the same skull besides differences related to sex and race. Versalius¹ studied variations in shape and compartmentations. Many osteological, radiological and micro dissections studies tried to solved the mystery of partitions and variations of the foramen. Jugular foramen develops by the fusion and ossification of petrous capsule and ala temporalis with parachordal plate of chondrocranium.²⁻³ Foramen is a large opening at the posterior end of the petro-occipital suture between petrous temporal anterolaterally and occipital bone postero medially. Its inferior smooth part is formed by lateral part of occipital bone and superior sharp irregular border formed by petrous part of temporal bone having a notch (intra jugular process) which divides foramen into two compartments.

Anteromedial small compartment (petrosal part /pars nervosa) contains inferior petrosal sinus with a branch of the ascending pharyngeal artery and glossopharyngeal

nerve. Posterolateral large compartment (sigmoid part /pars vascularis) receives drainage of sigmoid sinus as internal jugular vein with meningeal branch of occipital artery, vagus and spinal accessory⁴⁻⁵ (Fig-1).

Anatomical variation in the course of the nerves and vessels adds more complexity to jugular foramen.

The term foramen is not strictly accurate because it resembles a canal with endocranial and exocranial openings. This canal is triangular in shape with its apex pointing anteromedially.

It courses anteriorly, laterally and inferiorly through the skull base. Anteriorly it is separated from the inferior carotid opening by a bony ridge carotico jugular spine. It is lateral to hypoglossal canal separated by an osseous bar.

The relationship and significance of the jugular foramen to the deep fascial planes of the neck are extremely important. Most of the intracranial and extracranial lesions of posterior cranial fossa and intrinsic pathologies (glomus tumor, meningiomas, paragangliomas, schwannomas) and inflammatory lesions of inner ear may affect the structures in jugular foramen. Improvements in microsurgical techniques such as the lateral sub occipital access have allowed for the removal of these lesions.

In radical dissection of neck internal jugular vein which is prone to infarctions is ligated. Since the neurosurgeons have become bolder in approaching this region so arises a need of familiarity with this region.

The present study is focused to examine the anatomy of jugular foramen its dimensions, compartments and to discover the degree of predominance if any.

MATERIAL AND METHODS

The study was conducted in the department of Anatomy N.S.C.B Medical College Jabalpur (M.P.) India. 500 Jugular foramina from 250 dried adult skulls from Mahakoushal Area (Central India) were studied. The skulls were obtained from the osteological collections of the dry skulls in the Department of Anatomy. Manual vernier caliper were modified by welding for the measurement of jugular

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Parameters	Right Jugular foramen		Left Jugular forame		
	Range	Mean ± SD	Range	Mean ± SD	t-test
AP dia-jugular foramen (mm)	3.19-13.4	9.32 ± 2.04	2.37-13.44	7.34±2.04	0.00*
ML dia-jugular foramen (mm)	10.86-22.7	15.67±2.28	7.29-22.95	14.85±2.89	0.06
Width-jugular fossa(mm)	5.62-14.62	8.99±1.92	3.05-13.5	7.54±2.07	0.00*
Depth of jugular fossa (mm)	7.41-17.85	14.11±2.96	4.77-24.23	11.04±3.75	0.97

Table-1: Dimensions of jugular foramen and jugular fossa

Name of study	Right (mm)		Left(mm)	
	AP	ML	AP	ML
Pereira et al ¹³	9.21	15.82	8.65	15.86
Idowe ¹⁴	10.02	13.9	9.57	14.14
Ekinci ¹⁵	8.4	16.0	7.6	15.5
Hussain Saheb.S. ¹⁶	7.83	23.62	6.83	22.86
Chandni Gupta ¹⁷	11.22	16.52	9.52	16.02
Present study	9.32	15.67	7.34	14.85

Table-2:

Name of study	R>L	L>R	R=L
Sturrock's ¹¹	68.60%	23.10%	8.30%
Patel and Singel ¹⁸	60.40%	15.40%	24.20%
Hussain Saheb S. ¹⁶	64.80%	24.80%	10.40%
Ekinci and Unur ¹⁵	61.40%	24.30%	14.30%
Present study	70%	22.00%	8.00%

Table-3:

foramen. The Antero-Posterior Diameter and Transverse Diameter of the jugular foramen were analysed exocranially for both right and left sides.

Inclusion criteria:

Skulls without erosion

Exclusion criteria

Skulls that have been eroded and deformed.

Osteometric parameters

Side: Right or left

Length: Maximum Mediolateral diameter of the foramen

Width: Maximum Anteroposterior diameter of the foramen (fig-2)

DOMES: Bony roof is related to the presence of Superior jugular bulb

Height: Height of the dome was taken as the height of the foramen

Spicules: Bony projections

Septations: Bony bridges dividing the foramen into compartments.

Separate foramen for inferior petrosal sinus: A well defined opening with bony circumference present in the JF. Above parameters were measured using manual Vernier caliper with 0.02 mm least count (fig-3).

STATICAL ANALYSIS

The data of the present study was recorded / fed into the computers and after its proper validation, check for error;

coding and decoding was compiled and analyzed with the help of SPSS 20 software for windows. Appropriate univariate and bivariate analysis and the descriptive statistics were carried out and other statistical tests such as Student's t-test for continuous data and Fishers Exact Test or 2 test for categorical data were applied. All means are expressed as mean ± standard deviation and the proportion as in percentage (%). The critical value for the significance of the results was considered at 0.05 level.

RESULTS

1-Anteroposterior diameter of jugular Foramen (width)

Mean AP diameter on the right and left side was found to be 9.32mm. and 7.34 mm. respectively.6% were having narrow jugular foramen with AP diameter less than 5mm. on left side. 23% were having AP diameter more than 15mm. Right is large which is highly significant (P=0<0.05). A slit like jugular foramen was observed in one skull on left side with AP diamter of 2.3±mm and ML diamter was 13.48 mm.

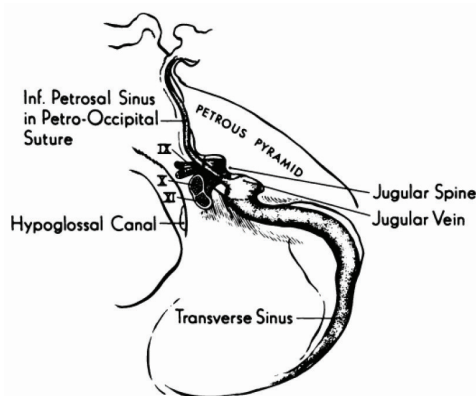


Figure-1: Skull Base From Above

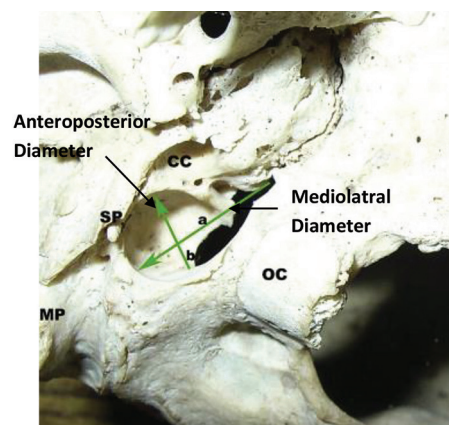


Figure-2: Parameters of jugular foramen (CC=carotid canal, OC=occipital condyle, MP=mastoid process)

	Comparison of dome of jugular fossa with other authors				Comparison of partition of jugular foramen with other authors				
	Bilateral presence of dome	Dome present on right side	Dome present on left side	Bilateral absence of dome	Single complete partition right side	Single complete partition left side	Bilateral complete partition into two comp.	Bilateral complete partition into three comp.	Bilateral interjugular process
Present study 2017	54.8%	30%	6.8%	8.4%	5.2%	8%	4%	6%	77%
Patel and Singel (2007) ¹⁸	21%	38.5%	14.3%	25.2%	23.1%	17.6%	-	-	59.3%
Hatiboglu and Anil (1992) ¹²	49%	36.1%	4.6%	10.3%	5.6%	4.6%	-	-	90.1%
Sturrock (1988) ¹¹	53.9%	30.1%	6.4%	9.6%	3.2%	3.2%	-	-	93.6%

Table-4: Comparison of dome of jugular fossa and partition of jugular foramen with previous studies.

2-Mediolateral diameter of Jugular foramen (length)

Average ML diameter was found to be 15.67 and 14.85mm on the right and left side, which statistically not significant ($P=0>0.05$). 72% were found to have ML diameter between 12 and 17mm, 6% between 7 to 12mm and 22% were noted to have more than 17mm.

3-Presence of Septation in jugular foramen

Jugular foramen is normally divided into three compartment by two marked construction partially. In our study we analysed 500 foramina and noticed 3.2% skulls with bilateral complete and 2% incomplete septation. On right side 5.2% foramina with complete septation and 9.6% with incomplete septation while On left side 3.6% foramina showed complete and 6% incomplete septation, rest shows no septation (fig-4).

4-Separate Opening for Inferior Petrosal Sinus

Out of 250 skull 21 (8.4%) showed separate opening for Inferior Petrosal Sinus on Right and 29 (11.6%) on Left side.

5-Bony bridges or Spicules

Present on 45 (18%) skull on right side and 17(6.8%) skull on left side.

6-Width of Jugular Fossa

Mean width of jugular fossa was found to be 8.99 and 7.54mm. respectively on right and left side. About 77% of fossa were having width in the range of 5 to 10mm, 17% between 10 to 15mm and only 6% were with less than 5mm. right side showing the larger

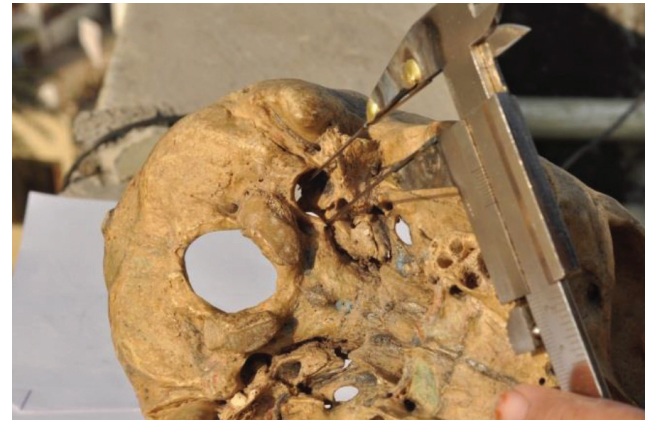


Figure-3: Measurement taking by Vernier caliper

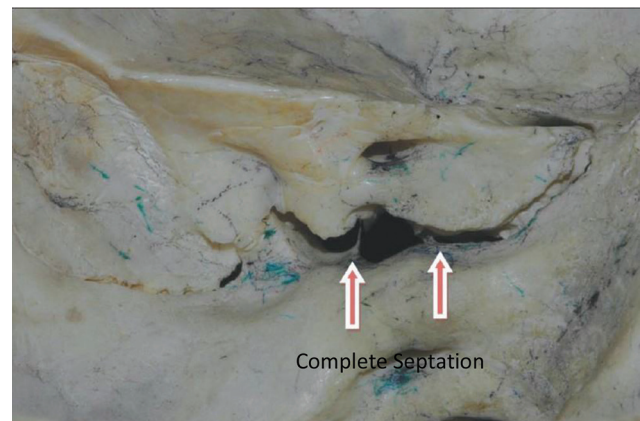


Figure-4: Presence of septation in jugular foramen

measurement, which is statistically significant ($P=0<0.05$)

7-Dome of Jugular Fossa

A dome indicating the presence of a prominent superior jugular bulb was present bilaterally in 54.8% skulls, right side only in 30% skull and on the left side one in 6.8% skulls were as dome absent bilaterally in 8.4% skulls.

8-Depth of Jugular fossa

Mean depth of jugular fossa if domed roof present on the right and left was measured to be 14.11 and 11.04mm. respectively. Most of the foramina were having depth between 8 and 17 mm. But one extreme of normal variation was very deep tunnel was found with a depth of 24.23 mm. on the left side.

Mediolateral diameter of the foramens are more than the anteroposterior diameter, with most of the foramina having AP and ML diameter between 7-12 and 12-17 mm. respectively (Table-1). Most of the foramina were with domed bony roof. Division of foramen into two by a complete bony septum is rare feature.

DISCUSSION

The jugular foramen is difficult to understand, access and exposing due to its deep position and adjacent structures.

The shape and size of Jugular foramen is obviously related to the size of the internal jugular vein and the presence or absence of prominent superior bulb. Standard anatomical text books describe the superior sagittal sinus to be draining into the right transverse sinus, thus right foramen is expected

to be larger than the left. Variation in the anatomy of intracranial venous sinuses is responsible for variation in Jugular Foramen.

The dissimilarity in size of the two internal jugular veins is already noticeable in the human embryo at 23 mm stage (8 weeks old) and perhaps since due to the difference in the pattern of development of right and left brachiocephalic vein.⁸

Comparison of Anteroposterior and Mediolateral diameter with other studies given in table no 2 and Comparison of relative size of jugular foramen with other studies given table no 3.

Rastogi and Budhiraja⁶ find a slit-like jugular foramen on the left side with AP and ML dimensions of 2.47 and 7.74 mm respectively, we also found a solitary skull with a slit like jugular foramen with AP and ML diameter of 2.37 and 13.45 mm respectively. So ML diameter of this slit-like jugular foramen in our study was almost double than as reported by Rastogi and Budhiraja⁶

The average width of jugular fossa in the present study was found to be 8.99 and 7.54 mm on the right and left side respectively thus occupying almost more than half of the total width of ML diameter of the foramen. Right being larger and statistically highly significant ($p = 0 < 0.05$). In literature no comparative data are available for width of jugular fossa as per our knowledge.

Anson⁷ noted the depth of jugular fossa to range from 0-14 mm with most of the specimens with less than 7 mm. But in our investigation most of the cases were having a depth between 5 and 15 mm (mean 11 mm). Extreme variation was noted in one case with a depth of 24.23 mm on the left side which was even more than double the average depth of fossa. Complete bilateral partition of the foramen into three compartments and the dehiscence of the jugular fossa were also noted in this case. This depth may be related to high jugular bulb which may cause conductive hearing loss, complications during cochlear implantation and risk during surgery for vestibular schwannomas. Their for neurosurgeon evaluate these variations prior to any surgical procedure.^{8,9,10} Sturrock¹¹ reported bilateral domed roof in 53.9% which was comparable to 55% of bilateral domed bony roof in our investigation. There was a marked difference in another studies conducted by Pereira et al⁹ reported the bilateral domed roof 68.5% and Patel and Singel (2007)¹⁸ who found in only 21% of the skulls.

Sturrock¹¹ and Hatiboglu and Anil¹² observed complete septation on right side in 5.6% of skulls and 3.2% of the foramina respectively. Pereira et al¹³ observed the bilateral complete bony septum in 0.9% of cases. In our study complete bilateral and unilateral (Right) septation was observed in 8(3.2%) and 13(5%) cases respectively. So the present findings regarding bilateral septation are more than recorded by Pereira et al¹³ and almost similar to as recorded earlier for unilateral septation (Table 4).

Shapiro and Robonson²⁻³ Clarify the morphogenesis of foraminal anomalies at the base of skull, stated that three major fenestrations are observed in early human fetal skull

the third one is foramen lacerum posterius-hiatus between basiocciput and the auditory bullae persists as jugular foramen, variations in the jugular foramen compartmentation are due to variability in bone formation. It appears that compartmentalization of jugular foramen might be a part of ongoing evolutionary process.

CONCLUSION

The observed variation of jugular foramen is possibly due to constitutional, racial or genetic factors. This study is expected to provide a clear understanding of the jugular foramen anatomy and supports reported morphometric variations. Anatomical variations especially slit like jugular foramen and jugular fossa with high depth may be the reason for unusual clinical diagnosis. Variations from normal may put the structures of jugular foramen and fossa at risk during microsurgical procedures in this region. So the knowledge of these variations may be important for neurosurgeons, radiologists as well as anthropologists

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