

MORPHOLOGICAL AND MORPHOMETRIC STUDY OF JUGULAR FORAMEN IN SOUTH INDIAN POPULATION

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ABSTRACT

Background: The jugular foramen, the bony opening on the base of skull, is an opening through which pass the ninth, tenth, and eleventh cranial nerves, two dural sinuses, and the meningeal branches of the occipital and ascending pharyngeal arteries. The increasing use of modern diagnostic procedures and new surgical approaches has created a need for much more detailed anatomical studies and explanations. This article reveals some additional features. **Material and Methods:** 324 jugular foramina of skulls of persons of unknown age and gender were examined. The morphological characteristics of all the investigated jugular foramina were described, measured, and compared, taking into consideration their side. **Results:** Jugular foramina were studied for a review of its morphology, morphometry and its comparison with previous studies. Different shapes and sizes of jugular foramen were seen. Laterality was also noticed, compartmentation was also observed which was found to be statistically significant. **Conclusions:** A detailed examination of the jugular foramen anatomy was performed. The main types of jugular foramina and the frequencies of bipartite or tripartite division were established. Several dimensions of the parts of the jugular foramen were measured. Some new data could provide important information about the anatomy of the jugular foramen for reliable surgical interventions in this area.

KEYWORDS: Jugular Foramen; Inferior Petrosal Sinus; Compartmentation; Club shaped; Bipartite; Tripartite.

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Access this Article online

Quick Response code



Web site: International Journal of Anatomy and Research
ISSN 2321-4287
www.ijmhr.org/ijar.htm

Received: 24 Sep 2013

Peer Review: 25 Sep 2013 Published (O):25 Nov 2013

Accepted: 15 Oct 2013 Published (P):30 Dec 2013

INTRODUCTION

Jugular foramen of human skull is one of the most fascinating foramina. It is a complex bony canal, many important structures including nerves and vessels are transmitted out of base of skull.

Since 1500 A.D many researchers including Versalius [1] were intrigued by the variations in shape and for the jugular foramen. Versalius (1543) in his illustrations of base of skull has mentioned compartmentations of jugular foramen. Several studies including osteological,

radiological and microdissections were performed to solve the mystery of compartmentation and variations in the anatomy of jugular foramen, which led to conflicting observations.

Most of the intracranial and extracranial lesions of posterior cranial fossa may effect 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.

In radical dissection of neck, Internal jugular vein is ligated which is prone to infarctions and most of the researchers attribute it to the ligation of the dominant internal jugular vein.

Since the neurosurgeons have become bolder in approaching this region, so arises a need of familiarity with this region.

The present study was embarked on to examine the anatomy of jugular foramen including its dimensions, compartments and to discover the degree of predominance if any.

MATERIALS AND METHODS

The study was conducted in the Department of Anatomy, Sri Ramachandra University and nearby medical colleges in Chennai. 648 Jugular Foramina from 324 skulls of South Indian origin were studied. All skulls were adult type and without any signs of erosion.

Following parameters were studied:

INCLUSION CRITERIA:

Healthy Skulls

EXCLUSION CRITERIA:

The Skulls that have been eroded and deformed
Osteometric parameters:

- Side .
- Dome
- Latero-medial diameter(Length)
- Anteroposterior diameter (width)
- Height of foramina
- Spicules
- Septations
- Separate foramen for inferior petrosal sinus.
- Area

Above parameters were measured using Vernier caliper and scale.

SIDE: Right or left

DOMES: The bony roof is related to the presence of Superior jugular bulb.

LENGTH: Maximum Latero-medial diameter of the foramen

WIDTH: The Anteroposterior diameter of the foramen.

HEIGHT: The 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.

OBSERVATIONS

The Morphometric analysis of the present study revealed the following observations. The data were statistically analysed and tabulated.

Dome: In 20% skulls the dome was present Bilaterally. present on right side in 40% and 29% left sides. The dome was absent in 11%.

DOMES	PRESENT STUDY
BILATERAL	20
RT SIDE	40
LT SIDE	29
ABSENT	11

Length(latero-medial) measurement: On Right side the mean length was 1.46 cm and for left side 1.39 cm. (fig 2)

	PRESENT STUDY
R>L	70
R<L	24
R=L	6

Width-anteroposterior measurement: The mean width on right side was 1.006 and left side 0.8.9 (fig 2).

Height: The mean height on right side is 1.01 and 0.9 on left side.

Area: The mean area on right side is 1.18 and 0.9 on left side.



Fig 1: Showing Spicule in Jugular foramen.

AREA

Presence of septations: Of the total 648 Analysed foramina it was noticed that in 13 foramina complete septation were seen on Right side, incomplete septations in 24. On left side 9 foramina showed complete and 15 incomplete septation. 284 did not show bony septum on right side and 294 on left side.

SEPTATION		PRESENT STUDY
COMPLETE	RT	13
	LT	4
PARTIAL	RT	24
	LT	7

SEPTATIONS

Separate Opening for IPS: Out of 324 skulls 28(8.6%) showed separate openings for IPS and 32 (9.8%) on left side.

RT. SIDE	8.6
LT. SIDE	9.8

Bony bridges or spicules: Present on right side in 53 skulls and 22 skulls in left side.

RT. SIDE	53
LT. SIDE	22

SPICULES:

Tripartate jugular foramen: 2 skulls had a tripartate jugular foramen. Tripetal type of JF was seen which is a rare finding.

Contracted jugular foramina: 2 skulls showed contracted jugular foramina.



Fig 2: Showing Bipartite Jugular foramen.

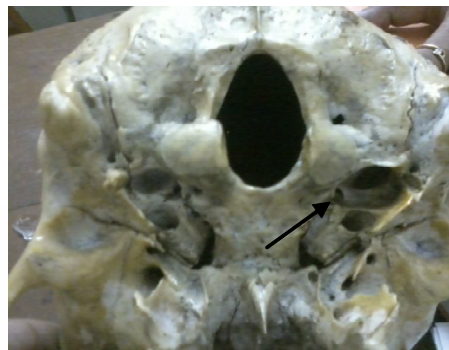


Fig 3: Showing separate foramen for IPS (Arrow).



Fig 4: Showing club shaped Jugular foramen (Arrow).

DISCUSSION

The jugular foramen is difficult to understand and to access surgically; the difficulties in exposing this foramen is created by its deep location and the surrounding structures such as carotid artery anteriorly, the facial nerve laterally, hypoglossal nerve medially and vertebral artery inferiorly.

The size and shape of the jugular foramen is related to the size of the internal jugular vein and the presence or absence of a prominent superior bulb the right foramen is usually larger than the left. The difference in size of the two internal jugular veins is already visible in the human embryo at the 23mm stage and probably results from differences in the pattern of development of the right and left brachiocephalic veins.

Standard text books suggests that the superior sagittal sinus drains into the right transverse sinus but there is a very wide variation in the anatomy of the intra cranial venous sinuses which accounts for variation in size and shape of jugular foramina.

SIZE AND DOME (JUGULAR FOSSA)

In Sturrock's [2] investigation of 156 skulls the right foramen was larger in 68.6%, the left larger in 23.1% and equal on both side in 8.3%.

The jugular fossa was present in 30.1% cases on the right side, 6.4% cases on the left side, 53.9% cases bilaterally and absent bilaterally in 9.6% of cases.

Hatiboglu and Anil [3] studied 300 Anatolian skulls from the 17th and 18th centuries and observed that in 61.6% the foramen was larger on the right side and in 26% it was larger on the left side and in the remainder of equal size. Presence of jugular fossa was observed bilaterally in 49%, on the right only in 36%, on the left only in 4.7% and absent bilaterally in 10.3% of skulls.

Patel and Singel [4] 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. The jugular fossa was observed in 38.5% cases on the right side, 14.3% cases on the left side, 21% cases bilaterally and absent in 25.3% of skulls.

In the present study of 324 skull jugular foramina were larger on the right side in 70%, larger on left side in 24% and equal in size in 06%.

The jugular fossa was present bilaterally in 20% cases, on the right only in 40% cases, on the left only in 29% cases and absent on both sides in 11%.

As to domed bony roof presence the results are almost similar to the observation of Patel and Singhel [4].

SEPTATIONS OR COMPARTMENTS:

Sturrock's [2] observed that complete septation of jugular foramen was present on Rt side in 3.2% and Lt side in 3.2%. Partial or incomplete septation on Rt side in 1.3% and on Lt side in 10.9%.

Patel and Singhel's [4] study observed that complete septation of jugular foramen was present on Rt side in 23% and Lt side in 17.6%. Partial or incomplete septation on Rt side in 49.5% and on Lt side in 59.3%.

Hatiboglu and Anil [3] observed that complete septation of jugular foramen was present on Rt side in 5.6% and Lt side in 4.3%. Partial or incomplete septation on Rt side in 2.6% and on Lt side in 19.6%.

Hussain Saheb [5] observed that complete septation of jugular foramen was present on

Rt side in 20.3% and Lt side in 16.8%. Partial or incomplete septation on Rt side in 45.6% and on Lt side in 58.4%.

Present study observed that complete septation of jugular foramen was present on Rt side in 13% and Lt side in 4%. Partial or incomplete septation on Rt side in 24% and on Lt side in 7%.

When compared with previous studies the present study showed variations in septation in jugular foramina.

SEPARATE FORAMEN FOR INFERIOR PETROSAL SINUS:

A separate foramen for inferior petrosal sinus was seen in 8.6% skulls on right side and 9.8% on the left side. The foramen are clearly demarcated from the rest of jugular foramen.

Rhoton et al [6,7]. and DiChiro et al [8]. observed a separate bony canal anterior to the *pars nervosa* in 6% of skulls, while Patridge [9] noted a frequency of 25%.

As far as separate foramen for Inferior petrosal sinus is concerned the findings are greater than Rhotons and lesser than the observations of Patridge.

SPICULES OR BONY BRIDGES:

Small bony spurs projecting into the jugular foramen were seen in 53% on right side and 22% on the left side. Tekdemir et al. [10] observed no partition in his series while Ekinci et al [11]. Found bony bridges in 20%. Rhoton and Buza [12,6] noted 26% bony bridges; this was bilaterally represented in 8%. A bony bridge in 3 (7.5%) of the JF with bilateralism in 1 skull was found in this series. Rhoton et al [6,7] and DiChiro et al [8]. observed a separate bony canal anterior to the *pars nervosa* in 6% of skulls, while Patridge noted a frequency of 25%. Presence of spicules and bony bridges is more than the previous studies.

TRIPARTATE JUGULAR FORAMINA:

0.6% i.e 2 skulls were noted to have a tripartate division. Ekinci et al [11]. found tripartite jugular foramen in 0.7%.

AREA OR VOLUME:

Present study observed the area (volume) of jugular foramen and observed that area of

Rt jugular foramen is greater than Lt jugular foramen in 70%. Rt jugular foramen is lesser than Lt jugular foramen in 24%. Rt jugular foramen is equal to Lt jugular foramen in 06%. Idowo [13] study observed the area (volume) of jugular foramen and observed that area of Rt jugular foramen is greater than Lt jugular foramen in 55%. Rt jugular foramen is lesser than Lt jugular foramen in 25%. Rt jugular foramen is equal to Lt jugular foramen in 1%.

Patel and Singhel [4] observed the area (volume) of jugular foramen and observed that area of Rt jugular foramen is greater than Lt jugular foramen in 60.4%. Rt jugular foramen is lesser than Lt jugular foramen in 15.4%. Rt jugular foramen is equal to Lt jugular foramen in 24.2%.

Hatiboglu and Anil [3] observed the area (volume) of jugular foramen and observed that area of Rt jugular foramen is greater than Lt jugular foramen in 61.6%. Rt jugular foramen is lesser than Lt jugular foramen in 78%. Rt jugular foramen is equal to Lt jugular foramen in 37%.

Hussain sahib [5] observed the area (volume) of jugular foramen and observed that area of Rt jugular foramen is greater than Lt jugular foramen in 64.8%. Rt jugular foramen is lesser than Lt jugular foramen in 24.8%. Rt jugular foramen is equal to Lt jugular foramen in 10.4%.

Navsa and Kramer [14] found a larger volume for the jugular foramen on the right side of female skulls both for the white and the black race. Schelling [15] reported a significantly larger volume of the jugular foramen on the right side of female skulls. Predominance of JF appeared in 83% of cases in Wysocki's [16] series and the predominance of the left and the right side were equally possible. In 61.4% of cases the right JF was larger in Ekinci's series, while Rhoton et al noted that 68% of JF were larger on the right, 12% equal and 20% smaller. Findings do not make it evident a difference between the right side and the left side regarding width and length measurements; although the analysis of the latero-medial measurement for genus regardless of laterality the largest measurement in male skulls.

The Figures reported by Idowu [13] who found the mean length of 13.9 mm on the right side, and 14.11 mm on the left side, and the mean width of 10.2 mm on the right side, and 9.57 mm on the left side in Nigerian skulls. When width was analysed regarding genus data showed themselves apart from Idowu's, because a significant difference was found in this. Right jugular foramen with uncompleted septum; left jugular foramen with septum lack, carotid canal. measurement for the skulls, which presented a wider right side. Hatiboglu and Anil [3] in Turkish subjects' skulls, and Sturrock (1988), in a sampling of Roman-British skulls, have also found a larger area on the right side, although with a genus-independent analysis. According to Wysocki, Reymond and Skarzyński [17, 18], results variation can be explained by racial and individual factors. As to the individual factors, these authors mention the significant correlation between the size of the JF and also the hypoglossal channel with skull volume, thus pointing to the significance of cranial capacity for brain venous drainage. As to completed or uncompleted septum, the obtained results are near Sturrock's [2], who found completed septa on the right side in 3.2% of the foramina, and the same in foramina of the left side, besides uncompleted septa in 1.3 and 10.9% on the right side and the left side, respectively.

As to domed bony roof presence in the jugular foramen the results are similar to the ones by Sturrock, who reported 30% on the right side, and 6% on the left side, and results are also similar to the ones by Hatiboglu and Anil, with 36.6 and 4.6% on the right side and the left side, respectively.

CONCLUSION

In conclusion variations in the size, shapes and compartments of jugular foramen might be a part of the ongoing evolutionary process. During the past few decades, biological consideration of discrete cranial traits such as their ontogeny, asymmetry, sex differences and intertrait association 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 depi-

-cted 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. Existence of genetic factors in the expression of the bridging trait is known, the bridging trait can thus be studied in anthropological studies in different study populations.

These findings will also be of help to understand the involvement /sparing of neurovascular structures in the Jugular foramen lesions and the interpretation of images of the Jugular foramen.

Conflicts of Interests: None

KEY TO ABBREVIATION

- Mm-Millimeter
- Rt-Right
- Lt-Left
- SD-Standard Deviation
- JF-Jugular foramen
- %-Percent

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How to cite this article: Shifan Khanday, Ramesh Kumar Subramanian, Melani Rajendran, Ashfaq Ul Hassan, Sajad Hamid Khan. MORPHOLOGICAL AND MORPHOMETRIC STUDY OF JUGULAR FORAMEN IN SOUTH INDIAN POPULATION. *Int J Anat Res*, 2013;03:122-27.