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Original Research Article

A Study of Structural Variations of Jugular Foramen of the Dried Adult Human Skulls

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Abstract

Background: The internal jugular vein, in particular, travels via the jugular foramen (JF), a bigger, curving, irregular foramen located near the base of the skull. JF variations are more prevalent among people of the same or different ethnicities, gender, and crania. To perform microsurgeries in and around these foramina, a thorough understanding of anatomy is also required. The current study aimed to determine the morphological features of jugular foramen from dried skull bones.

Methods: This study was conducted in the Department of Anatomy at the Prathima Institute of Medical Sciences, Naganoor, Karimnagar. Dried Adult human skulls n=50 with 100 jugular foramina were studied. Using digital vernier calipers, we took metric measurements of the jugular foramen's anteroposterior and mediolateral diameter, width, and depth, then tabulated, analyzed, and compared the results.

Results: The anterioposterior diameter of JF on the left side mean values were 7.93 ± 1.47. On the right side, the mean value was 9.31 ± 2.11 mm. The mediolateral diameter of JF left side was 14.28 ± 2.29 mm and similarly, on the right side the mediolateral diameter of JF was 15.10 ± 3.57 mm. Bony partitions of skulls found bilateral septations (complete/partial) found in 14% of skulls, bilateral complete septations were found in 12% of skulls and bilateral partial septations were found in 10% of skulls. The width of the jugular fossa was measured it ranged from 5.5 to 13.2 mm on the right side and 0.0 to 10.5 mm on the left side. The Dome of the Jugular fossa was prominent in 86% of skulls out of which 72% were having a bilateral prominent dome.

Conclusion: Understanding the morphology, compartmentation, and arrangement of the structures within the jugular foramen (JF) enables one to infer the locations of numerous structures from photographs of the area surrounding the jugular foramen. The JF's surgical anatomy is intricate, as are its components. Therefore, when surgically treating this complicated area, having a thorough understanding of its variations and the connections between the neurovascular structures is essential to maximizing the surgical result and minimizing postoperative problems. The results of this may be utilized in interpreting JF imaging and understanding how neurovascular structures are involved or spared in JF lesions.

Keywords: Jugular Foramen, Morphology, Anteroposterior diameter, Mediolateral Diameter, Dome of Jugular Foramen

Introduction

After the foramen magnum, the jugular foramen (JF) is the largest aperture in the base of the skull. [1] The lateral portion of the occipital bone and the petrous portion of the temporal bone in the skull are connected by two apertures, one of which is called the jugular foramen. [2] Between the jugular process of the occipital bone and the jugular fossa of the petrous section of the temporal bone, the jugular foramen—a broad, irregular hiatus lies at the posterior end of the petro-occipital suture. This foramen is the passageway for several significant structures, including the internal jugular vein, glossopharyngeal, vagus, and auxiliary cranial nerves in the middle and the inferior petrosal sinus (anterior) (posterior). The auricular branch of the vagus nerve is transmitted by a mastoid canaliculus that passes through the lateral wall of the jugular fossa. On the ridge between the jugular fossa and the carotid canal's opening is the canaliculus for the branch of the glossopharyngeal nerve known as the tympanic nerve. The entrance of the cochlear canaliculus may be found at the apex of a small notch that is associated with the inferior glossopharyngeal ganglion and may be found medially, on the upper limit of the jugular foramen (it is easier to identify internally). [3] The anatomy of the jugular foramen varies widely. This variety may result from the uneven forms of the temporal and occipital bones that make up the jugular foramen (JF), as well as the embryological fact that the neurovascular systems that cross the foramen develop first and the bony structures come into existence later. [4] JF is traditionally separated into two portions by a fibrous or bony bridge, which acts as passages for the internal jugular vein, cranial nerves X and XI, and inferior petrosal sinus (pars nervina or Nervosa). There is still no widely accepted theory on the anatomy of the jugular foramen, as more recent anatomic research has refuted it. [5]

Asymmetry exists between the left and right jugular foramina. Typically, the left is smaller than the right, which is thought to be related to the right cerebral venous drainage's predominance. [1] This asymmetry is caused by two main elements: Both the transverse dural sinuses and the bone growth around the primitive foramen lacerum posterius exhibit variation. The latter element is typically more important and is mostly to blame for the significant variations in the size of the jugular foramina in a particular skull. The jugular foramina are hence likely to be symmetrical when the transverse sinuses are of similar size; conversely, when one transverse sinus is significantly larger than the other, the JF on the side of the large sinus is larger. [6] It is challenging to comprehend and access the jugular foramen surgically. It is challenging to conceptualize due to its complex irregular shape, curved course, formation by two bones, and the numerous nerves and venous channels that pass through it. It varies in size and shape in different crani, from side to side in the same cranium, and from its intracranial to extracranial end in the same foramen. The internal carotid artery anteriorly, the hypoglossal nerve medially, and the vertebral artery inferiorly, all of which impede access to the foramen and necessitate cautious management, contribute to the challenges in exposing this foramen. [7] Rare lesions in the jugular foramen, it is possible that jugular foramen-region lesions cannot be distinguished from one another. [8] A thorough radiographic investigation is necessary for a reliable diagnosis in these situations. Therefore, it would be helpful to have a thorough understanding of how the jugular foramen varies in size and form while interpreting radiographs of this region. [9] With this background, the

current study was conducted to determine the morphometric details of JF

Material and Methods

The current study was done in the Department of Anatomy, Prathima Institute of Medical Sciences, Naganoor, Karimnagar. The study was conducted on n=50 adult dried human skulls having n=100 JF. The deformed, damaged skulls, skulls of children were excluded from the study. The measurement of parameters was done with digital vernier calipers having a precision of 0.1mm. The measurements were done with regard to the Anterioposterior diameter of JF. The mediolateral diameter of JF is the distance between the medial most and lateral most points of JF. Septations: whether present or absent, indicated by the numbers. Jugular fossa width: Jugular fossa width at its maximum. The jugular fossa's dome's presence or absence was detected. Jugular fossa depth: If a dome is present, the distance between its peak and the inferior jugular fossa border is measured.

Statistical analysis: The data was collected and uploaded on an MS Excel spreadsheet and analyzed by SPSS version 22 (Chicago, IL, USA). Quantitative variables were expressed on mean and standard deviations and qualitative variables were expressed in proportions and percentages. Mann–Whitney U test has been used to find the difference between two proportions.

Results

Out of n=50 skulls of which n=100 jugular foramina were studied. The anterioposterior diameter of JF on the left side of the range was 5.3 – 10.66 mm and the mean values were 7.93 ± 1.47. On the right side, the range was 6.43 – 11.5 mm and the mean value was 9.31 ± 2.11 mm details depicted in table 1. AP diameter JF less than 5 mm was found in 2% JF diameter ranging from 5 – 10 mm in 82% of cases between and > 10 mm were found in 16% of skulls.

Table 1: Measurements of Jugular foramen and Jugular Fossa in the dried adult skulls

Measurements of Jugular Foramen in millimeters	*Right side*		*Left side*		*P value*
	Range	*Mean ± SD*	*Range*	*Mean ± SD*	
A – P Diameter	6.43 – 11.5	9.31 ± 2.11	5.3 – 10.66	7.93 ± 1.47	0.0012*
M – L Diameter	9.34 – 19.95	15.10 ± 3.57	8.16 -17.55	14.28 ± 2.29	0.125
Width- Jugular fossa	5.51 - 13.2	9.25 ± 1.77	0.00 – 10.5	7.77 ± 1.99	0.047*
Depth- Jugular fossa	1.99 -15.67	10.71 ± 3.61	0.00 – 13.5	7.19 ± 2.68	0.015*

* Significant

The mediolateral diameter of JF was studied on the left side the mean mediolateral diameter recorded was 14.28 ± 2.29 mm and similarly, on the right side, the mediolateral diameter of JF was 15.10 ± 3.57 mm the p values were not significant given in table 1. A mediolateral diameter of < 10 mm was found in 12% of cases and between 11 – 15 mm was found in 70% of cases and > 16 mm was found in 18% of cases.

Bony partitions of jugular foramen were studied out of the n=50 skulls bilateral septations (complete/partial) were found in 14% of skulls, bilateral complete septations were found in 12% of skulls and bilateral partial septations were found in 10% of skulls. Out of the n=100, JF septations were observed in 78% out of which complete septations were found in 40% of cases and partial septations were found in 38% of cases (table 1).

The width of the jugular fossa was measured it ranged from 5.5 to 13.2 mm on the right side and 0.0 to 10.5 mm on the left side. The mean value on the right side

was 9.25 ± 1.77 mm and the mean value on the left side was 7.77 ± 1.99 mm. The JF 0 – 5 mm was found in 8% of skulls and between 5 – 10 mm in 74% of skulls and > 10 mm was found in 16% of skulls.

The Dome of the Jugular fossa was prominent in 86% of skulls out of which 72% were having a bilateral prominent dome. The right-side prominence was found in 10% of skulls and the left-side prominence was found in 4% of skulls the details are depicted in figure 1.

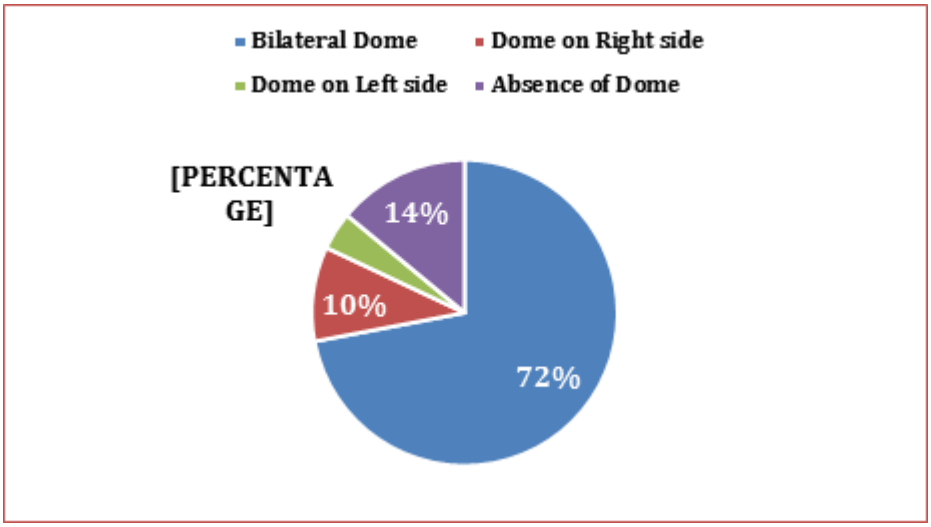

Figure 1: Dome of Jugular foramen in skulls of the study

The depth of jugular fossa the range on the right side was 1.99 -15.67 mm and the mean was 10.71 ± 3.61 mm and on the left the depth of the jugular fossa was 0.00 – 13.5 mm and the mean was 7.19 ± 2.68 mm. 12% cases showed the depth of jugular fossa < 5 mm and 82% cases showed the depth between 5 to 15 mm and 6% were found to have depth > than 15 mm details depicted in table 1.

Discussion

The sigmoid sinus, jugular bulb, inferior petrosal sinus, meningeal branches of the ascending pharyngeal and occipital arteries, the ninth through eleventh cranial nerves with their ganglia, the tympanic branch of the glossopharyngeal nerve, the auricular branch of the vagus, and the cochlear aqueduct are among the structures that cross the JF. The carotid artery anteriorly, the internal carotid artery, and other important nearby tissues make it difficult to expose this canal because of its deep placement. The size of the internal jugular vein and the existence or absence of a pronounced superior bulb is related to the size and form of the jugular foramen. Typically, the right foramen is larger than the left. The intracranial venous sinuses vary greatly from person to person. which explains the variance in jugular foramen size and form. At the 23mm stage of development, the human embryo already exhibits disparities in the size of the two internal jugular veins, which are likely due to variations in the pattern of development of the right and left brachiocephalic veins. [10] The measurements of the Anteroposterior diameter of JF were correlated with other similar studies in the past (table 2). Our results match with the observations of Pereira et al., [11] Anjali S et al., [12] and Shashanka M et al., [13] Smaller mean anterioposterior diameter was observed by Hussain S et al., [10] Roma Pet al., [14] and Shruthi BN et al., [15]

Table 2: Comparison of measurements of Anterioposterior (AP) diameter and Mediolateral Diameter with previous studies

Authors	*Year*	*A – P Diameter*		*M – L Diameter*	
		Right	*Left*	*Right*	*Left*
Ekinci et al., [16]	1997	08.40 mm	7.60 mm	16.00 mm	15.50 mm
Idowu et al., [17]	2004	10.22 mm	9.57 mm	13.90 mm	14.11 mm
Hussain S et al., [10]	2010	07.83 mm	6.83 mm	23.62 mm	22.86 mm
Pereira, et al., [11]	2010	09.21 mm	8.65 mm	15.82 mm	15.86 mm
Anjali S et al., [12]	2012	09.32 mm	7.34 mm	15.67 mm	14.85 mm
Roma P et al., [14]	2014	07.90 mm	6.20 mm	12.17 mm	11.00 mm
Shruthi B.N et al., [15]	2015	07.51 mm	7.16 mm	24.48 mm	21.24 mm
Shashanka M J et al., [13]	2018	09.20 mm	7.45 mm	14.42 mm	13.20 mm
Present Study	2022	09.31 mm	7.93 mm	15.10 mm	14.28 mm

There are wide variations in the incidence of septations observed by different studies. In the current study, there were complete septations in 40% of skulls and partial septations were found in 38% of skull bones. Hatiboglu et al., [18] observed complete septations in 9.9% of cases and partial septations in 22.2% of cases. Sturrock R.R et al., [19] found complete septations in 6.4% of cases and partial septations in 12.2% of cases. The results of the current study are in concordance made by Shifan K et al., P Roma et al., [21] and Shashanka M et al., [13] depicted in table 3.

Table 3: Comparison of septations with previous studies

Authors	Complete		Partial	
	Right	Left	Right	Left
Hatiboglu et al., [18]	05.60%	04.30%	02.60%	19.60%
Sturrock R.R et al., [19]	03.20%	03.20%	01.30%	10.90%
Patel et al., [21]	23.10%	17.60%	19.50%	59.30%
Hussain S et al., [10]	20.80%	16.80%	45.60%	58.40%
Shifan K et al., [20]	13.00%	04.00%	24.00%	07.00%
P Roma et al., [14]	16.00%	14.00%	29.00%	25.00%
Shashanka M J et al., [13]	15.00%	22.50%	25.00%	12.50%
Present study	16.00%	24.00%	28.00%	10.00%

Three major fenestrations were found in the early human fetal skull with regard to the morphogenesis of foraminal anomalies at the base of the skull: the foramen lacerum anterior-hiatus between the greater and lesser wing of the sphenoid; the foramen lacerum medius-opening between basisphenoid and periodic capsule; and the foramen lacerum posterior-hiatus between basiocciput and auditory bulla. The ingrowth of bony spicules divides these substantial fenestrations, resulting in the development of many foramina. The posterior foramen lacerum still exists in JF. As a sign of the continuous evolutionary process, variations in the septations of JF are attributed to variations in bone development surrounding primordial foramen lacerum posterior. [12] In the current study dome of the Jugular fossa was prominent in 86% of skulls out of which 72% were having a bilateral prominent dome. The right-side prominence was found in 10% of skulls and the left-side prominence was found in

4% of skulls. Sturrock R.R. et al., [19] analyzed 156 skulls and found that in 47 (30.1%) of the right-side skulls and 10 (6.4%) of the left-side skulls, the superior bulb of the internal jugular vein had formed a dome. In 84 (53.9%) skulls, the dome was bilaterally present; in 15 (9.6%), it was absent. [12] Patel M.M et al., [21] In their study of 125 skulls in a study of 91 skulls reported the presence of dome in 35 (38.5%) skulls on the right side only and in 13 skulls (14.3%) on the left side only. The dome was found bilaterally in 19 (21%) and was absent bilaterally in 18 (14.4%) skulls. In their study, Anjali S et al., [12] revealed that the average jugular fossa width and depth were 8.99 mm and 11.11 mm on the right and 7.54 mm and 11.04 mm on the left, respectively. The width of the jugular fossa in the current study was nearly identical to the study in comparison, but the depth of the jugular fossa in the current study indicated a significant difference by having high right-sided measures. The variance in jugular fossa size may be caused by the elevated jugular bulb, which when in touch with the tympanic membrane interferes with the ossicular chain and ultimately blocks the round window niche, resulting in conductive hearing loss.

Conclusion

Understanding the morphology, compartmentation, and arrangement of the structures within the jugular foramen (JF) enables one to infer the locations of numerous structures from photographs of the area surrounding the jugular foramen. The JF's surgical anatomy is intricate, as are its components. Therefore, when surgically treating this complicated area, having a thorough understanding of its variations and the connections between the neurovascular structures is essential to maximizing the surgical result and minimizing postoperative problems. The results of this may be utilized in interpreting JF imaging and understanding how neurovascular structures are involved or spared in JF lesions.

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