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MORPHOLOGICAL AND MORHOMETRIC STUDY OF JUGULAR FORAMEN AND ITS CLINICAL SIGNIFICANCE

Anatomy

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ABSTRACT

INTRODUCTION: The Jugular Foramen is a large irregular hiatus in the base of skull, between the jugular notch of the anterior border of the jugular process of the occipital bone 1,2,3,4 and the jugular fossa of the petrous part of the temporal bone. It is located at the posterior end of the petro-occipital suture. The anterior smaller venous (petrosal) part of the Jugular Foramen transmits the inferior petrosal sinus; its intermediate (neural) part transmits glossopharyngeal nerve, vagus nerve and cranial accessory nerve; its posterior larger venous (sigmoid) part transmits the internal jugular vein. [2,5] **AIM AND OBJECTIVE:** To study the morphological & morphometric details & variations in Jugular foramen in dried human skulls. The data will be useful to radiologists, ENT surgeons and neurosurgeons for preoperative planning and management of Jugular Foramen surgeries. **MATERIALS AND METHODS:** The study was done on 24 dry adult human skulls (48 sides) available in the Department of Anatomy, Osmania Medical College, koti, Hyderabad. Damaged skulls were omitted from the study. Dimensions of both exocranial and endocranial aspect of jugular foramen were measured with the help of Vernier caliper. Presence and absence of domed bony roof of jugular fossa and compartmentalization of jugular foramen were also noticed. **RESULTS:** In the present study in the Exocranial aspect of skull it was found that the mean mediolateral diameter of the Jugular Foramen was 14.65 ± 2.38mm on the right side and 13.69 ± 2.28mm on the left side. The mean anteroposterior diameter of the Jugular Foramen was 11.20 ± 2.09mm on the right side and 10.05 ± 1.82mm on the left side. The mean area of the right Jugular Foramen was 163.55 ± 47.16mm2 and the same of the left Jugular Foramen was 145.96 ± 41.24mm 2 . The Jugular Foramen showed side dominance in most of the specimens. Right side was dominant in 80% and left side was dominant in 16%. The mean width of the Jugular Fossa was 7.29 ± 1.89mm on the right side and 7.03 ± 1.68mm on the left side. The mean depth of the Jugular Fossa was 11.01 ± 2.98mm on the right side and 9.98 ± 2.62mm on the left side. The Jugular Foramen and Jugular Fossa exhibited statistically significant asymmetry in size. The mean distance of stylomastoid foramen from lateral margin of jugular foramen was 4.38 ± 1.73mm on the right side and 4.96 ± 1.49mm on the left side. On Endocranial aspect of skull base the mean of the maximum length of jugular foramen was 13.10 ± 1.66 on right side and 10.97 ± 1.01 on left side. The mean of the width of anteromedial parts of jugular foramen was 4.5 ± 0.85 on right side and 4.52 ± 1.49 on left side. The mean of the width of posterolateral parts of jugular foramen was 7.41 ± 1.16 on right side and 5.52 ± 1.54 on left side. The mean of the distance of posterior margin of jugular foramen from intrajugular process of temporal bone was 6.27 ± 1.25 on right side and 5.58 ± 1.02 on left side. The mean of the distance of posterior margin of jugular foramen from intrajugular process of occipital bone was 6.67 ± 1.33 on right side and 6.20 ± 1.01 on left side. Domed Jugular Fossa was present bilaterally in 54%, unilaterally on the right side in 29%, unilaterally on the left side in 13% and was bilaterally absent in 4%. The Jugular Foramen was partitioned by one septum in 42% on the right side and 29% on the left side. The incidence of complete septum was 13% on the right side and 13% on the left side. The incidence of incomplete septum was 29% on the right side and 16% on the left side. **CONCLUSION:**The data obtained will be useful for neurosurgeons and otorhinolaryngologists for achieving a less morbid and more favourable outcome in surgeries of the Jugular Foramen region. The findings are also enlightening to anthropologists, radiologists and anatomists.

KEYWORDS

JUGULAR FORAMEN, JUGULAR FOSSA, JUGULAR BULB, SEPTUM, DOME.

INTRODUCTION

The Jugular Foramen is a large irregular hiatus in the base of skull, between the jugular notch of the anterior border of the jugular process of the occipital bone [1,2,3,4] and the jugular fossa of the petrous part of the temporal bone. It is located at the posterior end of the petro-occipital suture. Anteriorly it is related to the lower opening of the carotid canal which is separated from it by a raised ridge of bone. On the lateral side of the Jugular Foramen lies the medial aspect of the sheath of the styloid process. Medially it is separated from the anterior condylar canal by a thin osseous bar.The anterior smaller venous (petrosal) part of the Jugular Foramen transmits the inferior petrosal sinus; its intermediate (neural) part transmits glossopharyngeal nerve, vagus nerve and cranial accessory nerve; its posterior larger venous (sigmoid) part transmits the internal jugular vein. [2,5] The jugular foramen contains the transition of sigmoid sinus to internal jugular vein and the termination of inferior petrosal sinus [6], with 60% of the area of all venous foramina of the skull occupied by the jugular foramina.[7] Dome of the jugular bulb is generally covered by a bone, which is called the dome of the Jugular Fossa. Other structures that the Jugular Foramen transmits are the meningeal branches of the ascending pharyngeal artery in the anterior compartment and meningeal branch of occipital artery in the posterior compartment. [1] However, nowadays authors[8,9,10] more frequently consider this important cranial venous drainage area as a canal and not as a real foramen. They describe its endocranial opening and exocranial opening, both oriented in different planes. Its endocranial opening is triangular and exocranial opening has alembic shape leading into the Jugular Fossa in which the jugular bulb is located. [11]

AIM AND OBJECTIVE: To study the morphological & morphometric details & variations in Jugular foramen in dried human skulls. The data will be useful to radiologists, ENT surgeons and neurosurgeons for preoperative planning and management of Jugular Foramen surgeries.

MATERIALS AND METHODS: The study was done on 24 dry adult human skulls (48 sides) available in the Department of Anatomy, Osmania Medical College, koti, Hyderabad. Damaged skulls were omitted from the study. Dimensions of both endocranial and exocranial aspect of jugular foramen were measured and noted. The following measurements were taken with vernier callipers :

ON EXOCRANIALASPECT:

(i) Maximum mediolateral diameter of Jugular Foramen (MLD): The distance between the medial most and lateral most points of the Jugular Foramen. This corresponds to the length of the Jugular Foramen.

(ii) Maximum anteroposterior diameter of Jugular Foramen (APD): The distance between the anterior most and posterior most points of the Jugular Foramen. This corresponds to the breadth of the Jugular Foramen.

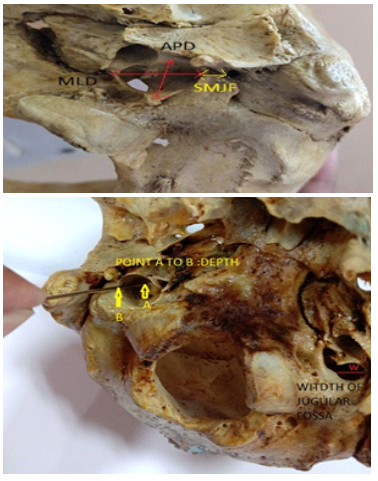
(iii) Area of Jugular Foramen(AJF): Derived as the length of Jugular foramen multiplied by the breadth of Jugular Foramen.

(iv) Side dominance of Jugular Foramen: Identified by comparison of the area of right and left Jugular Foramina of the same skull. Right sided dominance- Area of right JF more than area of the left JF .Left sided dominance- Area of left JF more than area of the right JF .No side dominance- Area of the right JF equal to area of left JF.

(v) Width of Jugular Fossa(FJW): The maximum diameter of jugular fossa measured as the distance between lateral most and medial most points in the Jugular Fossa.

(vi) Depth of Jugular Fossa(FJD): Measured as the distance between the deepest point in the Jugular Fossa/summit of dome, if domed roof is present (point A) and a vertically corresponding point on the inferior border of the jugular fossa (point B) using a needle.

(vii)Distance of stylomastoid foramen from lateral margin of jugular foramen(SMJF) .



ON ENDOCRANIAL ASPECT:

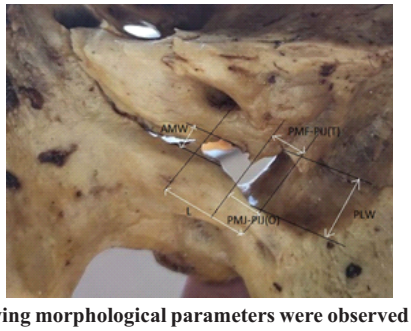
(i) Maximum length along the long axis (L): distance between the Medial most and Lateral most points of jugular foramen.

(ii) Maximum width of anteromedial part of jugular foramen (AMW): distance between the Anterior most and Posterior most points of anteromedial part of jugular foramen.

(iii) Maximum width of posterolateral (PLW) parts of jugular foramen: distance between the Anterior most and Posterior most points of posterolateral part of jugular foramen.

(iv) Distance between the posterior margin of the jugular foramen (PMF) and the peak of the intrajugular process (PIJ) of the temporal bone (PMF-PIJ [T])

(v) Distance between the posterior margin of the jugular foramen (PMF) and the peak of the intrajugular process of the occipital bone (PMF-PIJ [O])



The following morphological parameters were observed by naked eye examination.

(I) Presence of domed Jugular Fossa: Analysed by the presence of domed bony roof of Jugular Fossa.

(ii) Presence of septum in the Jugular Foramen: Analysed by the presence of bony bridge(septum) dividing the Jugular Foramen into compartments.

(A) The Jugular Foramen is classified as follows:

(a) Bipartite Jugular Foramen- presence of one septum

(b) Tripartite Jugular Foramen- presence of two septa.

(B) Type of septum in the Jugular Foramen: The nature of the bony bridges is described as whether complete or incomplete.

(a) A complete septum extends from the upper border of the jugular fossa of the petrous temporal bone to the jugular process of the occipital bone and completely divides the foramen.

(b) Incomplete septum is shorter and divides the foramen only partially.

RESULTS:

The morphometric and morphological parameters of exocranial and endocranial aspect were studied on the right and left sides in the Jugular Foramina of 24 adult dry human skulls and results recorded. All the parameters were analysed bilaterally.(Number of skulls n=24)

ON EXOCRANIAL ASPECT:

Parameters	SIDE	Min	Max	Range	Mean	S.D
MLD in mm	Rt	9.12	20	10.88	14.65	2.38
	Lt	8.15	19.23	11.08	13.69	2.28
APD in mm	Rt	7.38	15.43	8.05	11.20	2.09
	Lt	7.16	14.86	7.7	10.05	1.82
AJF in	Rt	67.30	308.6	241.3	163.55	47.16
	Lt	58.35	285.75	227.4	145.96	41.24
FJW in mm	Rt	5.01	13.10	8.09	7.29	1.89
	Lt	3.98	11.50	7.52	7.03	1.68
FJD in mm	Rt	5.02	21.53	16.51	11.01	2.98
	Lt	5.03	17.25	12.22	9.98	2.62
SMJF in mm	Rt	2.1	7.39	5.29	4.38	1.73
	Lt	2.5	7.45	4.95	4.96	1.49

SIDE DOMINANCE OF JUGULAR FORAMEN:

Size	Rt dominance	Lt dominance	No dominance
Number	19	4	1
Percentage	80%	16%	4%

ON ENDOCRANIAL ASPECT:

PARAMETERS	SIDE	Min	Max	Range	Mean	S.D
L	Rt	9.34	15.71	6.37	13.10	1.66
	Lt	8.11	14.76	6.65	10.97	1.01
AMW	Rt	2.04	5.64	3.6	4.5	0.85
	Lt	3.51	7.05	3.54	4.52	1.49

PLW	Rt	4.22	8.65	4.43	7.41	1.16
	Lt	2.85	8.35	5.5	5.52	1.54
PMF-PIJ(T)	Rt	4.58	9.96	5.38	6.27	1.25
	Lt	4.29	8.92	4.63	5.58	1.02
PMF-PIJ(O)	Rt	5.18	9.23	4.05	6.67	1.33
	Lt	5.03	8.28	3.25	6.20	1.10

The following morphological parameters were observed by naked eye examination:

Sl.No.	Authors	Rt APD(mm)	Lt
1.	Shifan Khandey et al15	10.06	8.9
2.	Vijisha P et al 17	12.13	9.27
3.	Avanish Kumar et al18	10.6	9.2
4.	Chandni Gupta et al 19	11.22	9.52
5.	N. Himabindu et al16	9.61	8.24
6.	Present study	11.20	10.05

(ii) INCIDENCE OF DOMED JUGULAR FOSSA AND SEPTATE JUGULAR FORAMEN WITH SIDE DISTRIBUTION:

	SIDE	NUMBER	PERCENTAGE
Domed Jugular Fossa	**Right**	**20**	**83%**
	Left	**16**	**67%**
Presence of one septum- Bipartite JF	**Right**	**10**	**42%**
	Left	**7**	**29%**

(ii) INCIDENCE OF DOMED JUGULAR FOSSAAND SEPTATE JF, BIPARTITE TYPE (n= 24 SKULLS):

		Bilaterally present	Unilaterally present		Bilaterally absent
			Right side	Left side	
Domed Jugular	**No**	**13**	**7**	**3**	**1**
	%	**54%**	**29%**	**13%**	**4%**
SEPTATE JF, BIPARTITE TYPE	**No**	**5**	**5**	**2**	**12**
	%	**21%**	**21%**	**8%**	**50%**

(iii)TYPE OF SEPTUM IN THE JUGULAR FORAMEN WITH SIDE DISTRIBUTION:

Type of septum in Bipartite JF	Right side (n=24 sides)	Left side (n=24 sides)	
Complete	Number	3	3
	Percentage	13%	13%
Incomplete	Number	7	4
	Percentage	29%	16%

DISCUSSION:

The findings of the present study were compared with findings of other similar studies.

(A) ON EXOCRANIAL ASPECT:

(i) MEDIOLATERAL DIAMETER (MLD) OF THE JUGULAR FORAMEN:

Sl No	Authors	Rt MLD(mm)	Lt MLD(mm)
1.	Namita A Sharma et al[12]	15.59	13.83
2.	Ketu Chauhan et al [13]	13.46	13.10
3.	Anitha MR et al [14]	15.21	13.39
4.	Shifan Khandey et al[15]	14.6	13.9
5.	N. Himabindu et al [16]	14.6	12.69
6.	**Present Study**	**14.65**	**13.69**

(ii) ANTEROPOSTERIOR DIAMETER (APD) OF THE JUGULAR FORAMEN :

Sl No.	Authors	Rt AJF-mm^2	Lt AJF-mm^2
1.	Vijisha P et al [17]	210.87	141.93
2.	Chandni Gupta et al[19]	187.34	153.2
3.	**Present study**	**163.55**	**145.96**

(iii) AREA OF JUGULAR FORAMEN:

Parameter	Anjali Singla et al23	Chandni Guptaet Al19	**Present study**
Rt FJW(mm)	8.99	6.83	**7.29**
Lt FJW(mm)	7.54	5.69	**7.03**
Rt FJD(mm)	11.11	11.58	**11.01**
Lt FJD(mm)	11.04	11.13	**9.98**

(iv) SIDE DOMINANCE OF JUGULAR FORAMEN :

Parameter	*Kotgirwar and Athavale*[24]	Das et al[25]	**Present study**
Rt	4.72	4.76	**4.38**
Lt	5.87	5.13	**4.96**

(v) WIDTH OF JUGULAR FOSSA (FJW) AND DEPTH OF JUGULAR FOSSA (FJD) :

Sl No.	Authors	R>L (%)	L>R (%)	R=L (%)
1.	Hussain Saheb et al[20]	64.8	24.8	10.4
2.	Rahul Rai et al[21]	74	19	7
3.	Roma Patel et al[22]	75	23	2
4.	**Present study**	**80**	**16**	**4**

(B) ON ENDOCRANIAL ASPECT:

Parameters	*Right/Left*	*Present study*	*by Das et al*[25]	*Vlajkovic et al*[26]
L	*Right*	13.10	13.25	14.21
	Left	10.97	12.26	13.24
AMW	*Right*	4.5	4.34	4.21
	Left	4.52	5.08	4.34
PLW	*Right*	7.41	7.07	7.78
	Left	5.52	5.51	6.42
PMF-PIJ [T]	*Right*	6.27	6.38	7.11
	Left	5.58	6.09	5.86
PMF-PIJ [O]	*Right*	6.67	6.62	8.34
	Left	6.20	6.18	7.60

(C) Morphological parameters observed by naked eye examination:

(i) PRESENCE OF DOMED JUGULAR FOSSA :

Sl No.	Authors	B/L present%	U/L present- Rt side%	U/L present- Lt side%	B/L absent %
1	Hussain Saheb et al [20]	49.6	27.2	8.8	14.4
2	Namita Sharma et al[12]	58	28	8	6
3	Vijisha P et al[17]	70	26.6	3.33	0
4	Avanish Kumar et al[18]	57.35	29.4	8.82	4.41
5	Present study	54	29	13	4

(ii) TYPE OF SEPTUM IN BIPARTITE JF:

Sl No.	Authors	Bipartite right JF	Bipartite left JF
1.	Shifan Khandey et al[15]	36.3	24.1
2.	Roma Patel et al[22]	45	39
3.	Present study	42	29

(iii) INCIDENCE OF SEPTATE JUGULAR FORAMEN-BIPARTITE TYPE :

Sl No.	Authors	Complete septum-R	Complete septum-L	Incomplete septum- R	Incomplete septum-L
1.	Ruchira Sethi et al[27]	10.7	10	7.1	4.3
2.	Shifan Khandey et al[15]	12.6	12.8	23.7	11.3
3.	Roma Patel et al[22]	16	14	29	25
4.	Present study	13	13	29	16

CONCLUSION:

MEDIOLATERAL DIAMETER (MLD) OF THE JUGULAR FORAMEN: Knowledge about these dimensions is essential for neurosurgeons operating on the JF region. In the present study, the mean MLD is greater on the right side. This goes well with the fact that right IJV is larger than the left in most of the individuals.

ANTEROPOSTERIOR DIAMETER (APD) OF THE JUGULAR FORAMEN : These dimensions are of relevance to neurosurgeons and vascular surgeons operating on JF tumours like the glomus tumor and the anteriorly related carotid canal. Mean Rt APD is greater than the mean Lt APD and this can be attributed to the size difference between right and left IJV where the right is larger than the left in most of the individuals. The difference in size of the two internal jugular veins, when present, is visible in the 23mm stage human embryo (8weeks post conception) and probably results from differences in the pattern of development of right and left brachiocephalic veins.[28]

AREA OF JUGULAR FORAMEN: The wide range of values raise concern as this can modify the topical relations of JF and the structures within it, thereby producing otologic implications. This warrants caution to the neurosurgeons and ear surgeons to prevent intra operative as well as postoperative complications. The mean area on the right side is more than that on the left side, suggesting that right JF plays greater role than the left in venous drainage of the cranial cavity and its contents.[29]This can be attributed to the IJV being larger on the right side in most of the individuals.

SIDE DOMINANCE OF JUGULAR FORAMEN : Right sided JF dominance of 80% observed in the present study goes well with right sided jugular venous dominance occurring in 70% to 80% of cases.[30] During surgeries like radical neck dissection, destruction of IJV, especially at the dominant side, may lead to cerebral haemorrhage, infarct and dural arteriovenous malformations.[7,31] The knowledge is also useful to interventionists performing cannulation of IJV.

WIDTH OF JUGULAR FOSSA (FJW) AND DEPTH OF JUGULAR FOSSA (FJD) : The size of Jugular Fossa is related to the presence or absence of a prominent superior bulb of IJV.[19,40] The jugular bulb has great anatomic variations in dimensions.[32] Occasionally there may be an excessive enlargement of the jugular bulb(JB) or ectasia of the jugular bulb, causing a larger Jugular fossa resulting in upward arching of the internal auditory canal and inner ear, which might cause tinnitus, dizziness, or mild hearing impairment.[56] It could also cause complications like profuse bleeding and air embolism during surgical interventions.[11,33]. An asymmetrically large JB and Jugular Fossa is a common finding which becomes an imaging problem, when the radiologist discovers it during evaluation of tinnitus, rarely it being the cause. Paragangliomas can be ruled out by the preservation of normal bony margins and intact intrajugular process (septum) in the asymmetrically but proportionately enlarged Jugular Foramen as the Jugular Fossa.[34]

DISTANCE OF STYLOMASTOID FORAMEN FROM LATERAL MARGIN OF JUGULAR FORAMEN(SMJF): Different surgical approaches have been developed to operate upon the tumors of jugular area. These include infratemporal, transcondylar, suboccipital, transsigmoid, and extreme lateral approaches. Among these approaches, infratemporal is the more popular but requires rerouting of the facial nerve.[35,36] As the facial nerve emerges from the stylomastoid foramen, the distance of facial nerve from jugular foramen from the distance of stylomastoid foramen to the lateral margin of jugular foramen (SMJF) can servex as a guide for neurosurgeons, during the procedure of rerouting of facial nerve.

On Endocranial aspect the following parameters were taken : L, AMW, PLW ,PMF-PIJ [T],PMF-PIJ [O]. All these parameters are essential as there may be compression of neurovascular structures passing through jugular foramen in case of tumours invading jugular foramen such as schwannoma, meningioma, glomus tumour, and chordoma can produce multiple cranial nerve palsies, i.e., jugular foramen syndrome (Vernet's syndrome).[25,37,38,39].The jugular foramen has constantly fascinated ENT, radiologists, and neurosurgeons because of modern advances in surgical procedures involving skull base and middle ear.In Computerised Tomography images most tumours of the Jugular Foramen manifest as areas of infiltrative bone destruction, although schwannoma and meningioma cause smooth enlargement of the foramen.[40]Anatomical variants like asymmetrically enlarged Jugular Foramen, high jugular bulb, high dehiscent jugular bulb, or a jugular bulb diverticulum may be misdiagnosed as pseudomasses in the JF.[10,11]In such cases the hypervascular paragangliomas can be ruled out by the presence of preservation of normal bony margins and intact compartmentation by intrajugular process in the asymmetrically but proportionately enlarged JF.[34]

PRESENCE OF DOMED JUGULAR FOSSA: More frequent drainage of superior sagittal sinus through right transverse, then right sigmoid sinus and right IJV might be associated with the greater incidence of prominent superior jugular bulb(JB) and dome of jugular fossa on the right side.[8] An exposed jugular bulb characterised by absence of dome is more prone to injury in middle ear surgeries, especially because the vessel wall is thin in this area.[32] The upper extremity of jugular bulb is at the level of Jugular Fossa dome.[33] A high JB, characterised by a deep dome requires modification of surgical technique by lowering the jugular bulb to explore the lower cranial nerves, during translabyrinthine and retrosigmoid approaches for cerebellopontine angle tumours in lateral skull base surgery as work area inferior to the internal acoustic canal is considerably reduced.[33,41] So the data will be useful to ENT surgeons and neurosurgeons.

INCIDENCE OF SEPTATE JUGULAR FORAMEN-BIPARTITE TYPE : Insight on the incidence of septa can avoid their misinterpretation as abnormal bony growth leading to narrowing of JF. The JF has two vascular compartments that may be affected by tumour, laterally the jugular bulb where the sigmoid sinus continues as IJV and medially a passage for inferior petrosal sinus. Tumours may also penetrate the JF along the fibro-osseous diaphragm, which divides these two vascular channels.[42] Preservation of compartmentation signals the radiologists against neoplastic pathology of Jugular Foramen. Abnormally broad septa can accentuate the clinical presentation of JF tumours. The compartmentation of JF might be a part of ongoing evolutionary process. [9,43] Hence this data is of relevance to radiologists, neurologists and neurosurgeons and anthropologists.

TYPE OF SEPTUM IN BIPARTITE JF: In life the incomplete septa were probably completed by cartilage.[44,45] The difference in the anatomical nature and incidence of bridging can be attributed to factors like variability in bone formation around the primitive foramen lacerum posterior. The course of cranial nerves within the foramen may have anatomical variations, depending upon the bridging pattern and its types.[27]

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