

Complete morphometric analysis of jugular foramen and its clinical implications

ABSTRACT

Introduction: Tumors affecting structures in the vicinity of jugular foramen such as glomus jugulare require microsurgical approach to access this region. These tumors tend to alter the normal architecture of the jugular foramen by invading it. Therefore, it is not feasible to have correct anatomic visualization of the foramen in the presence of such pathologies. Hence, a comprehensive knowledge of the jugular foramen is needed by all the neurosurgeons while doing surgery in this region.

Aim: Due to the inadequate knowledge of the accurate morphology of the jugular foramen in different sexes, the aim of this osteological study was to provide a complete morphometry including gender differences and describe some morphological characteristics of the jugular foramen in an adult Indian population.

Materials and Methods: The study was done on 114 adult human dry skulls (63 males and 51 females) collected from the osteology museum in the department. Various dimensions of both endo- and exocranial aspect of jugular foramen were measured. Presence and absence of domed bony roof of jugular fossa and compartmentalization of jugular foramen were also noticed. Statistical analysis was done using Chi-square test and Student's *t*-test in SPSS version 23.

Results: All the parameters of right jugular foramen were greater than the left side, except the distance of stylomastoid foramen from lateral margin of jugular foramen (SMJF) which was greater on the left side. Gender differences between various measurements of jugular foramen, presence of dome of jugular fossa, and compartmentalization patterns were reported.

Conclusion: This study gives knowledge about the various parameters, anatomical variations of jugular foramen in both sexes of an adult Indian population, and its clinical impact on the surgeries of this region.

Key words: Glomus jugulare; internal jugular vein; jugular foramen; morphometry.

Introduction

The jugular foramen is a bony canal in the posterior cranial fossa, located between the temporal and occipital bones at the posterior end of the petro-occipital fissure, above and lateral to the foramen magnum. The upper border of the foramen contains an intrajugular process, which divides the foramen into a large posterolateral compartment, the sigmoid part, which contains the sigmoid sinus accompanied by a meningeal branch of the occipital artery; and a small anteromedial compartment, the petrosal part, which contains the inferior petrosal sinus accompanied by a meningeal branch of the ascending pharyngeal artery. The glossopharyngeal, vagus, and accessory nerves course between the petrosal part and sigmoid part, lying medial to the intrajugular process.^[1]

The jugular foramen has constantly fascinated ENT, radiologists, and neurosurgeons because of modern advances in surgical procedures involving skull base and middle ear. Tumors in this area such as schwannoma, meningioma, glomus jugulare, and chordoma can produce multiple cranial

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nerve palsies, i.e., jugular foramen syndrome (Vernet's syndrome).^[2-6] Most of the approaches for resection for these tumors such as retrosigmoid, transjugular craniotomy require partial petrosectomy traversing the jugular fossa.^[7] Thus, the knowledge of anatomical details and dimensions of jugular foramen would be a great help to these surgeons while approaching this area.

Various morphometric data of jugular foramen on Indian population are available, but they were done from the exocranial aspect of skull base only,^[3,8-13] which is not a complete morphometry of jugular foramen. No data were also available regarding the sexual differences of jugular foramen. Thus, due to the inadequate knowledge about complete morphometry of the jugular foramen in both sexes, this study was conducted to perform an in-depth morphometric analysis and report variations of jugular foramen.

Materials and Methods

The study was conducted on a sample of 114 adult human dry skulls (63 males and 51 females) collected from the osteology museum in the department. Sexing of skulls was documented through the museum catalog. Skulls exhibiting obscuring pathologies such as bone deterioration were excluded from the study. The dimensions of the jugular foramen measured with the help of a digital Vernier calliper (accuracy up to 0.01 mm) in millimeters were as follows:

On exocranial aspect [Figure 1]

- i. Maximum width along the long axis (MW)
- ii. Maximum length perpendicular to the long axis (AP)
- iii. Maximum depth of jugular fossa - if domed, measured from the summit of dome to lower border of jugular fossa (DEPTH JF)
- iv. Maximum width of jugular fossa - if domed (WJF)
- v. Distance of stylomastoid foramen from lateral margin of jugular foramen (SMJF).

On endocranial aspect [Figure 1]

- i. Maximum length along the long axis (L)
- ii. Maximum width of anteromedial (AMW) and posterolateral (PLW) parts of jugular foramen
- iii. 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])
- iv. Distance between the posterior margin of the jugular foramen (PMF) and the peak of the intrajugular process of the occipital bone (PMF-PIJ [O])
- v. Width of the sigmoid sinus groove (SSG) at the level of the posterior margin of the jugular foramen.

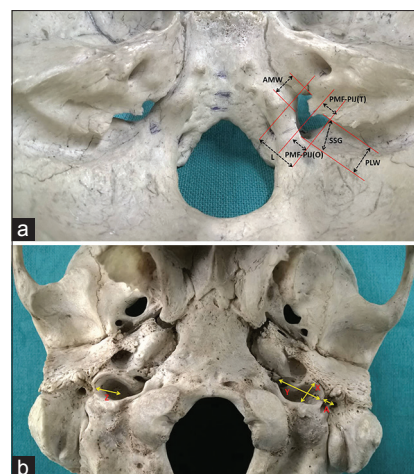


Figure 1: (a) Endocranial aspect of skull base; maximum length (L), maximum width of anteromedial (AMW) and posterolateral (PLW*) parts of JF, distance of posterior margin of JF from intrajugular process of temporal bone (PMF-PIJ [T]), distance of posterior margin of JF from intrajugular process of occipital bone (PMF-PIJ [O]), width of sigmoid sinus groove (SSG). (b) Exocranial aspect of skull base. X: Maximum length (AP*), Y: Maximum width (MW), Z: Maximum depth of jugular fossa (DEPTH JF), B: Maximum width of jugular fossa (WJF*), A: Distance of stylomastoid foramen from lateral margin of jugular foramen. (*significant parameters)

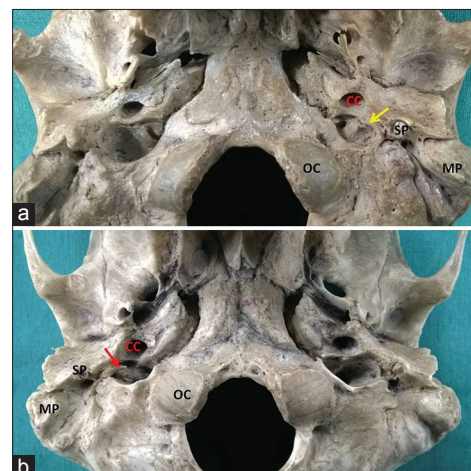


Figure 2: Inferior view of skull base showing: (a) absent dome of left jugular fossa*; (b) absent dome of right jugular fossa. CC: Carotid canal, MP: Mastoid process, SP: Styloid process, OC: Occipital condyle. (*significant parameter)

The presence or absence of bony septum of jugular foramen was also observed.

All the measurements were taken bilaterally, and photography was done using Kodak M1063 digital camera.

The mean, standard deviation, and range of each measurement were calculated. Incidence of bridging pattern of jugular foramen was also calculated as percentage. Statistical analysis was performed using Chi-square test for nominal categorical data and Student's *t*-test for normally distributed continuous variables in IBM SPSS Statistics for Windows version 23.0,

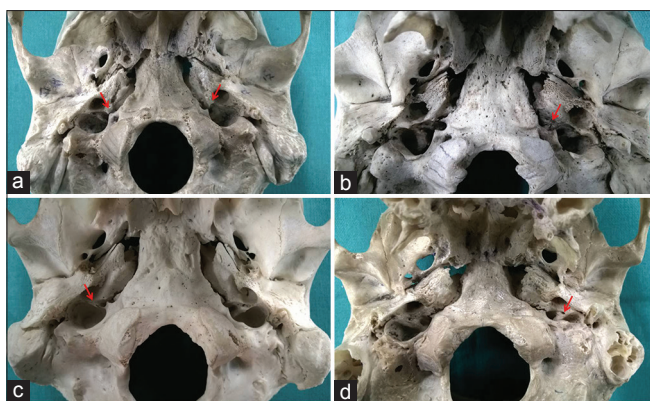


Figure 3: Inferior view of skull base showing: (a) Incomplete septation of bilateral jugular foramen, (b) complete septation of left jugular foramen, (c) incomplete septation of right jugular foramen, (d) incomplete septation of left jugular foramen

USA to assess the relationship between the examined variables. A level of significance of $P < 0.05$ was used. All the observations and results were tabulated and compared with previous studies.

Results

The results of the quantitative parameters of jugular foramen are shown in Tables 1-3. All the parameters of the endocranial aspect of right jugular foramen were greater than the left side but were not significant except the maximum width of the posterolateral (PLW) part of jugular foramen which was significant ($P < 0.05$). Furthermore, the parameters of exocranial aspect of right jugular foramen were greater than the left side except the distance of stylomastoid foramen from lateral margin of jugular foramen (SMJF) which was greater on the left side. These exocranial parameters were not significant except the maximum length perpendicular to the long axis (AP) and maximum width of jugular fossa - if domed (WJF) which were significant.

Gender differences between various measurements of jugular foramen were reported [Table 2]. All measurements were greater in males as compared to females except maximum length along the long axis (L), distance between the posterior margin of the jugular foramen and the peak of the intrajugular process of the temporal bone (PMF-PIJ [T]), and distance between the posterior margin of the jugular foramen and the peak of the intrajugular process of the occipital bone (PMF-PIJ [O]) on both sides, in which females had greater values. The gender differences between L, PMF-PIJ (T) on left side, and AP on the exocranial aspect of right jugular foramen was statistically significant.

A significant difference was noted between the presence of dome in the right jugular fossa (96.83% in males and

96.08% in females; total 96.49%) as compared to the left jugular fossa (84.13% in males and 90.2% in females; total 86.84%) [Figure 2]. Bilateral dome of jugular fossa was present in 62.3% (60.32% in males and 64.71% in females) of cases. Bilateral absence of dome of jugular fossa was not noticed [Table 3].

In our study, we observed complete left bipartite compartmentalization in 8 cases (5 in males and 3 in females; total 7%), incomplete right and left bipartite compartmentalization in 4 (3 in males and 1 in females; total 3.5%) and 13 (7 in males and 6 in females; total 11.4%) cases, respectively. We also noticed 3 cases (2 in males and 1 in females; total 2.6%) of bilateral incomplete bipartite compartmentalization [Table 4 and Figure 3].

Discussion

The diverse anatomy of the jugular foramen, the relationships of the neurovascular structures which pass through it, the variations in its size and shape, as well as surgical approaches to this key part of the skull base, attracts the minds of many neurosurgeons and radiologists.

Standard anatomical textbook^[1] states that the superior sagittal sinus drains into the right transverse sinus, thus the right jugular foramen is expected to be larger than the left. The size and shape of the jugular foramen are also related to the size of the internal jugular vein and the presence of superior jugular bulb. The differences in the size of the right and left internal jugular veins are evident in the human embryo at the 23 mm stage (8 weeks postconception) and most likely results from the difference in the outline of the development of the right and left brachiocephalic veins.^[17] Many authors have also reported larger diameters of the right jugular foramen as compared to the left on both endo- and exocranial aspects in various ethnic groups [Table 5].

Our findings also supported and were very nearer to these previous works. Thus, the chances of compression of neurovascular structures passing through jugular foramen may be more common on the left side and also approach to the tumors in this area may be more difficult as all the diameters of left-sided jugular foramen are lesser.

Kotgirwar and Athavale^[3] reported a significant difference between the mean right (9.38 mm) and left (7.16 mm) MW diameter on the exocranial aspect in the south Indian population, but the present study did not find any significant difference in the MW diameter. They also reported mean AP diameter to be 15.21 mm and 13.74 mm on the right and left side, respectively (exocranial aspect), in south Indian

Table 1: Various morphometric measurements of jugular foramen of total 114 dry adult human skulls

Cranial surface	Parameters	Right/left (n=114)	Range minimum-maximum (mm)	Mean±SD (mm)	Significance (P)
Endo-cranial	AMW	Right	2.01-5.6	4.34±1.13	0.27
		Left	3.78-7.24	5.08±1.18	
	PLW	Right	4.56-8.95	7.07±1.29	0.04
		Left	2.42-8.54	5.51±2.25	
	L	Right	9.84-16.11	13.25±1.56	0.90
		Left	10.08-14.84	12.26±1.33	
	PMF-PIJ (T)	Right	1.83-10.45	6.38±2.24	0.73
		Left	3.96-8.61	6.09±1.44	
	PMF-PIJ (O)	Right	2.18-9.83	6.62±2.08	0.56
		Left	3.55-8.8	6.18±1.90	
SSG	Right	5.25-9.91	8.16±1.35	0.14	
	Left	5.44-9.53	7.15±1.14		
Exo-cranial	AP	Right	4.84-14.96	9.37±2.61	0.03
		Left	4.36-9.77	6.88±1.72	
	MW	Right	8.31-18.18	13.72±2.70	0.65
		Left	10.18-16.4	13.07±2.09	
	Depth JF	Right*	8.44-16.23	12.54±2.59	0.77
		Left**	10.32-15.53	8.72±1.86	
	WJF	Right*	10.08-4.69	7.25±1.82	0.04
		Left**	8.11-4.44	5.88±1.31	
	SMJF	Right	7.95-2.1	4.76±1.82	0.64
		Left	7.99-2.97	5.13±1.61	

*n=110, **n=99. SMJF - Stylo mastoid foramen to the lateral margin of jugular foramen; WJF - Maximum width of jugular fossa; JF - Jugular fossa; MW - Maximum width; AP - Maximum length perpendicular to the long axis; PMF-PIJ (T) - Peak of the intrajugular process of the temporal bone; PMF-PIJ (O) - Peak of the intrajugular process of the occipital bone; PLW - Width of posterolateral; AMW - Maximum width of anteromedial; SD - Standard deviation; L - Maximum length along the long axis; SSG - Sigmoid sinus groove

population suggesting an oval shape of the jugular foramen with its long axis along the anteroposterior diameter. In contrast, our study reported mean AP diameter to be 9.37 mm and 6.88 mm and MW diameter to be 13.72 mm and 13.07 mm on the right and left side, respectively, suggesting an oval shape of the jugular foramen with its long axis along the mediolateral diameter. This finding in our study was also similar to other studies done in other populations. This difference between the long axes of the jugular foramen could be due to different origin of the south Indian population, i.e. Dravidians as compared to the whole adult Indian population which is a mixture of Aryans and Dravidians origin. Singla *et al.*^[8] found statistically significant difference between mean right (9.32 mm) and left (7.34 mm) AP diameter and mean right (8.99 mm) and left (7.54 mm) WJF distance on the exocranial aspect. Our study also found significant differences in the above-mentioned parameters. These diameters indicate the size of jugular bulb and its variability reflects the variable development of superior jugular bulb.

Vlajkovic *et al.*^[2] reported statistically significant difference between mean right (7.11 mm) and left (5.86 mm) PMF-PIJ (T) and mean right (7.78 mm) and left (6.42 mm) PLW distance on the endocranial aspect. However, our study reported

only statistically significant difference only in the mean right (7.78 mm) and left (6.42 mm) PLW distance on the endocranial aspect.

The greater mean width of the groove for the sigmoid sinus (SSG) at the level of the posterior margin of the right jugular foramen (8.16 mm) as compared to left (7.15 mm) obtained in our study evidently indicates a larger caliber of the right sigmoid sinus. This is comparable to other studies and is interpreted as a larger superior sagittal sinus draining into the right transverse sinus and then through the right sigmoid sinus into the right internal jugular vein, which leads to a larger right jugular foramen.^[2,20,21]

Females had greater maximum length along the long axis (L), distance between the posterior margin of the jugular foramen and the peak of the intrajugular process of the temporal bone (PMF-PIJ [T]), and distance between the posterior margin of the jugular foramen and the peak of the intrajugular process of the occipital bone (PMF-PIJ [O]). The significant sexual difference in maximum length along the long axis (L) as reported in this study indicated that the jugular foramen on the endocranial aspect in females was more long oval shaped than males on both the sides. In females, statistically significant greater measurements of PMF-PIJ (T) on the left

Table 2: Gender differences in morphometric measurements of jugular foramen

Cranial surface	Parameters	Right/left (n=114)	Gender	Range minimum-maximum (mm)	Mean±SD (mm)	Significance (P)
Endo-cranial	AMW	Right	Male	2.01-5.58	4.37±1.47	0.93
			Female	3.27-5.6	4.31±0.84	
		Left	Male	4.13-6.2	5.22±0.93	0.72
			Female	3.78-7.24	4.93±1.48	
	PLW	Right	Male	4.56-8.95	7.37±1.68	0.51
			Female	5.93-8.2	6.78±0.85	
		Left	Male	2.42-8.54	5.61±2.50	0.89
			Female	2.94-8.04	5.41±2.26	
	L	Right	Male	9.84-13.6	12.43±1.49	0.04
			Female	13.38-16.11	14.36±1.05	
		Left	Male	10.08-12.2	11.43±1.00	0.03
			Female	11.8-14.84	13.09±1.11	
	PMF-PIJ (T)	Right	Male	1.83-7.18	5.86±2.26	0.50
			Female	4.84-10.45	6.90±2.35	
		Left	Male	3.96-6.23	5.08±0.97	0.02
			Female	5.55-8.61	7.10±1.09	
	PMF-PIJ (O)	Right	Male	2.18-8.75	6.12±2.45	0.48
			Female	5.14-9.83	7.12±1.76	
		Left	Male	3.55-7.43	5.25±1.98	0.13
			Female	5.49-8.8	7.11±1.42	
	SSG	Right	Male	7.68-9.91	8.54±0.92	0.41
			Female	5.25-9.68	7.78±1.70	
		Left	Male	5.44-9.53	7.29±1.47	0.74
			Female	6.07-7.97	7.02±0.85	
Exo-cranial	AP	Right	Male	9.14-14.96	10.77±2.38	0.04
			Female	4.84-10.97	7.97±2.19	
		Left	Male	5.09-9.77	7.29±1.66	0.48
			Female	4.36-8.41	6.47±1.86	
	MW	Right	Male	8.31-18.18	13.69±3.95	0.98
			Female	12.24-14.63	13.75±0.90	
		Left	Male	10.18-15.25	12.73±2.02	0.63
			Female	10.47-16.4	13.42±2.34	
	Depth JF	Right	Male	9.62-15.85	13.16±2.30	0.49
			Female	8.44-16.23	11.91±3.20	
		Left	Male	10.87-15.53	13.39±7.52	0.75
			Female	10.32-13.56	9.40±5.45	
	WJF	Right	Male	4.69-9.95	7.29±1.92	0.95
			Female	5.03-10.08	7.21±1.93	
		Left	Male	4.95-7.79	6.17±1.24	0.52
			Female	4.44-8.11	5.59±1.44	
	SMJF	Right	Male	4.01-7.95	5.23±1.74	0.45
			Female	2.1-6.1	4.30±1.96	
		Left	Male	3.98-7.99	5.86±1.64	0.16
			Female	2.97-5.99	4.40±1.35	

SMJF - Stylo mastoid foramen to the lateral margin of jugular foramen; WJF - Maximum width of jugular fossa; JF - Jugular fossa; MW - Maximum width; AP - Maximum length perpendicular to the long axis; PMF-PIJ (T) - Peak of the intrajugular process of the temporal bone; PMF-PIJ (O) - Peak of the intrajugular process of the occipital bone; PLW - Width of posterolateral; AMW - Maximum width of anteromedial; SD - Standard deviation; L - Maximum length along the long axis; SSG - Sigmoid sinus groove

side than males were also found. This suggests that the posterolateral compartment in females has a greater length along its anterior boundary of left jugular foramen. In males, the maximum length perpendicular to the long axis (AP) on exocranial aspect of right jugular foramen was statistically greater as compared to females. This suggests that the right

jugular foramen along exocranial aspect has a larger area in males than females. Alternatively, we can say that right jugular foramen in females is smaller in area which may be a risk factor for compression of neurovascular structures passing through the jugular foramen in cases of tumors invading this region. Overall, these gender differences in

Table 3: Incidence of presence of dome of jugular fossa

Dome of JF	Side	n (%)	Significance (P)	Gender	n (%)	Significance (P)
Presence of dome of JF (n)	Right (114)	110 (96.49)	0.008	Male	61 (96.83)	0.76
	Left (114)	99 (86.84)		Female	49 (96.08)	
Bilateral presence of dome of JF		71 (62.3)		Male	53 (84.13)	0.5
				Female	46 (90.2)	
				Male	38 (60.32)	0.78
				Female	33 (64.71)	

JF - Jugular fossa

Table 4: Comparison of septation of jugular foramen with previous studies

References	Population and year	n*	Unilateral partition (%)								Bilateral partition (%)			
			2 compartment				3 compartment				2 compartment		3 compartment	
			Complete		Incomplete		Complete		Incomplete		Complete	Incomplete	Complete	Incomplete
			Right	Left	Right	Left	Right	Left	Right	Left				
Sturrock ^[14]	British; 1988	156	3.2	3.2	-	-	-	-	-	-	-	-	-	
Hatiboglu and Anil ^[15]	Turkish; 1992	300	5.6	4.6	-	-	-	-	-	-	-	-	-	
Patel and Singel ^[16]	Western India; 2007	91	23.1	17.6	-	-	-	-	-	-	-	-	-	
Vlajkovic et al. ^[2]	Serbian; 2010	50	55	60	-	-	45	40	-	-	-	-	-	
Singla et al. ^[8]	Northwest Indian; 2011	50	4	-	-	-	-	-	-	4	-	6	-	
Shruthi et al. ^[13]	South Indian; 2015	250	23.2	19.2	44	56.8	-	-	-	-	-	-	-	
Present study	Indian; 2016	114	-	7	3.5	11.4	-	-	-	-	2.6	-	-	

*n - Sample size (number of skulls)

the measurements of jugular foramen cannot be overlooked as slightest error in measurements in neurosurgeries in this region can be detrimental. This gender data in the present study could not be compared as these sexual differences were not reported earlier in previous studies.

Furthermore, in our study, domed jugular fossa was present in 96.49% (96.83% in males and 96.08% in females) of cases on the right and in 86.84% (84.13% in males and 90.2% in females) of cases on the left side, which indicates the existence of well-expressed superior jugular bulb of internal jugular vein (statistically significant more on the right side). No statistically significant gender differences were reported in the presence of dome of jugular fossa. Bilateral dome of jugular fossa was present in 62.3% (60.32% in males and 64.71% in females) of cases which is approximately equal to the finding by Singla et al.,^[8] i.e. 66%. Thus, in total, 8.44% of the jugular fossa showed the absence of dome bony roof. Kotgirwar and Athavale^[3] reported a higher incidence (20%) of absence of roof of jugular fossa. No bilateral absence of domed jugular fossa was observed in our study which was in contrast to other previous studies which found 9.6%–25.2% bilateral

absence of dome of jugular fossa.^[8,14-16] The jugular fossa along with superior jugular bulb forms the floor of middle ear cavity.^[11,3] Many cases of glomus jugulare tumors eroding this floor and penetrating into the middle ear cavity have been reported.^[22,23] The absence of domed bony roof indicates that the superior jugular bulb is poorly developed or absent in such cases and may not form the floor of middle ear cavity. Thus, there is less risk of penetration of these tumors into the middle ear in these cases.

The mean depth of right jugular fossa (12.54 mm) was higher as compared to the left (8.72 mm). Males demonstrated a greater depth of jugular fossa as compared to females (statistically nonsignificant). A higher jugular fossa may cause conductive hearing loss because of its contact with the tympanic membrane, thus affecting ossicular chain integrity. It may also cause complications during cochlear implantation.^[24,25] Higher jugular fossa is a risk factor during surgery for vestibular schwannomas as it lies very close to the internal acoustic meatus.^[26]

Different surgical approaches have been developed to operate upon the tumors of jugular area. These include

Table 5: Comparison of various morphometric parameters of jugular foramen with other osteological studies

Parameters*	Right/ left	Present study, 2016	Idowu 2004 ^[5]	Pereira <i>et al.</i> , 2010 ^[18]	Vlajkovic <i>et al.</i> , 2010 ^[2]	Singla <i>et al.</i> , 2011 ^[8]	Osunwoke <i>et al.</i> , 2012 ^[19]	Kotgirwar and Athavale 2013 ^[3]	Gupta <i>et al.</i> , 2014 ^[10]
		Indian	Nigerian	Southern Brazilian	Serbian	Northwest Indian	Southern Nigerian	South Indian	South Indian
AMW	Right	4.34	-	-	4.21	-	-	-	-
	Left	5.08	-	-	4.34	-	-	-	-
PLW	Right	7.07	-	-	7.78	-	-	-	-
	Left	5.51	-	-	6.42	-	-	-	-
L	Right	13.25	-	-	14.21	-	-	-	-
	Left	12.26	-	-	13.24	-	-	-	-
PMF-PIJ (T)	Right	6.38	-	-	7.11	-	-	-	-
	Left	6.09	-	-	5.86	-	-	-	-
PMF-PIJ (O)	Right	6.62	-	-	8.34	-	-	-	-
	Left	6.18	-	-	7.60	-	-	-	-
SSG	Right	8.16	-	-	7.77	-	-	-	-
	Left	7.15	-	-	6.86	-	-	-	-
AP	Right	9.37	10.02	9.21	-	9.32	15.76	15.21	11.22
	Left	6.88	9.57	8.65	-	7.34	13.39	13.74	9.52
MW	Right	13.72	13.9	15.82	-	15.67	9.34	9.38	16.52
	Left	13.07	14.11	15.86	-	14.85	7.54	7.16	16.02
Depth JF	Right	12.54	-	-	-	11.11	-	11.78	11.75
	Left	8.72	-	-	-	11.04	-	9.84	11.13
WJF	Right	7.25	-	-	-	8.99	-	-	6.83
	Left	5.88	-	-	-	7.54	-	-	5.69
SMJF	Right	4.76	-	-	-	-	-	4.72	-
	Left	5.13	-	-	-	-	-	5.87	-

*Mean in millimeters have been considered for all parameters. SMJF - Stylomastoid foramen to the lateral margin of jugular foramen; WJF - Maximum width of jugular fossa; JF - Jugular fossa; MW - Maximum width; AP - Maximum length perpendicular to the long axis; PMF-PIJ (T) - Peak of the intrajugular process of the temporal bone; PMF-PIJ (O) - Peak of the intrajugular process of the occipital bone; PLW - Width of posterolateral; AMW - Maximum width of anteromedial; L - Maximum length along the long axis; SSG - Sigmoid sinus groove

infratemporal, transcondylar, suboccipital, transsigmoid, and extreme lateral approaches. Among these approaches, infratemporal is the more popular but requires rerouting of the facial nerve.^[27,28] 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 serve as a guide for neurosurgeons, during the procedure of rerouting of facial nerve. Our study shows that the facial nerve lies at a mean distance of 4.76 mm and 5.13 mm from the lateral margins of right and left jugular foramen, respectively. This side difference in the distance of facial nerve from jugular foramen was statistically nonsignificant. These dimensions are comparable to the earlier study by Kotgirwar and Athavale^[3] Overall, males showed greater length of SMJF than females but were also not statistically significant.

In our study, we observed complete left bipartite compartmentalization in 8 cases (5 in males and 3 in females; total 7%), incomplete right and left bipartite compartmentalization in 4 (3 in males and 1 in females; total 3.5%) and 13 (7 in males and 6 in females; total 11.4%) cases,

respectively. These data were comparatively less than the earlier studies done on other ethnic population [Table 4]. Three cases (2 in males and 1 in females; total 2.6%) of bilateral incomplete bipartite compartmentalization were also noticed which has not been reported in previous studies. These bridging or compartmentalization patterns can compress the structures passing through the jugular foramen, thereby mimicking the clinical presentations of glomus jugulare tumor; it can produce multiple cranial nerve palsies, i.e., jugular foramen syndrome (Vernet's syndrome). Furthermore, by looking at the above-mentioned data, it is clear that bridging is more common in males than females. Therefore, males are at a higher risk of these presentations than females.

Conclusion

The present study concludes that there is a significant gender difference between the size of jugular foramen of the right and left side. The morphometric data and variations observed in the present study are of enormous value to neurosurgeons and ENT surgeons while performing middle ear surgeries for

various jugular foramen tumors. Furthermore, the variable compartmentalization patterns in both sexes can cause compression of the structures passing through this foramen, hence mimicking the clinical presentations of glomus jugulare tumor.

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Conflicts of interest

There are no conflicts of interest.

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