

# Morphometric study of jugular foramen in adult North Indian skulls

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## ABSTRACT

**Introduction:** Jugular foramen in the posterior cranial fossa is located between the temporal and occipital bones at the posterior end of petro-occipital fissure, above and lateral to the foramen magnum. Several important structures surround the jugular foramen and knowledge of their spatial relationship is the key in understanding the potential clinical effects of nearby lesions.

**Materials and Methods:** The material for the present study comprised of 60 adult human dry skulls of unknown sex. Morphometric parameters of jugular foramen and jugular fossa were noted. Presence or absence of intrajugular process, jugular tubercle, mastoid canaliculus, cochlear canaliculus and tympanic canaliculus were noted.

**Results:** All parameters of jugular foramen from posterior cranial fossa were greater on right side except anteromedial width of JF which was slightly higher on left side. All parameters of jugular foramen from base of skull were greater on right side and difference was found to be statistically highly significant. Mastoid canaliculus, cochlear canaliculus and tympanic canaliculus were seen bilaterally in 68.33% skulls, 95% skulls and 95% skulls respectively.

**Discussion:** Various pathological lesions, tumors involving jugular foramen and nearby structure require microsurgical approaches to enter into this region. Hence, a detailed knowledge of the jugular foramen is needed to all the neurosurgeons while doing surgery in this region.

**Keywords:** Morphometric study; Jugular foramen; North Indian skulls

## INTRODUCTION

Jugular foramen (JF) is a bony canal in the posterior cranial fossa, located between the temporal and occipital bones at the posterior end of petro-occipital fissure, above and lateral to the foramen magnum.<sup>1,2</sup> Several important structures surround the JF and knowledge of their spatial relationship is the key in understanding the potential clinical effects of nearby lesions. Anterosuperiorly is the inner ear complex, continuing from the internal acoustic meatus located superior to the JF. The mastoid process and parotid gland are located on the lateral aspect extracranially. Moving medially from the mastoid process, sandwiched between it and the JF, is the external opening of the stylomastoid foramen from which the facial nerve exits. Intracranially, the tentorium cerebellum lies above the JF, and inferiorly is the parapharyngeal space.<sup>3</sup> On the exocranial, anterior edge of the JF is part of five attachment site of the prevertebral fascia, which also attaches laterally to the mastoid. The prevertebral fascia contains the vertebral column and surrounding musculature.<sup>2</sup> Metastatic cancers can represent up to 36% of lesions affecting the foramen, most arising from the breast, lung, or kidney. If a patient with confirmed diagnosis of such a cancer begins to experience craniofacial pain, it is highly suggestive of cranial base metastasis, so further imaging is indicated. In addition to symptoms of Vernet's syndrome, patient can also experience headache, mastoid pain, ear pain, vertigo, vomiting, gait instability, and signs of Horner's syndrome.<sup>4</sup> Tumors affecting structures in the vicinity of jugular foramen such as

paragangliomas, otherwise known as glomus jugular tumors also a common cause of JF obstruction 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.<sup>5</sup> The jugular foramen has constantly fascinated ENT, radiologists and neurosurgeons because of modern advances in surgical procedure involving skull base and middle ear. Tumors in this area such as schwannoma, intracranial meningioma, glomus jugulare and chordoma can produce multiple cranial nerve palsies, i.e., jugular foramen syndrome (Vernet's syndrome). Most of the approaches for resection for these tumors such as retro-sigmoid, trans-jugular craniotomy require partial petrosectomy traversing the jugular fossa.<sup>6,7</sup>

The diverse anatomy of the jugular foramen, the relationship 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. Thus the knowledge of anatomical details and dimensions of jugular foramen would be a great help to the surgeons during the surgical procedures.

#### **MATERIAL AND METHODS**

The material for the present study comprised of 60 adult human dry skulls of unknown sex available in the Department of Anatomy, Government Medical College and Rajindra Hospital Patiala in collaboration with the Department of Anatomy, Government Medical College and Hospital, Sector-32, Chandigarh.

Morphometric parameters of jugular foramen were recorded as anteroposterior length (maximum anteroposterior length along long axis) [Fig. 1a], maximum width of antero-medial parts of jugular foramen (maximum width of antero-medial parts of jugular foramen) [Fig. 1b], and maximum width of postero-lateral parts of jugular foramen (maximum width of postero-lateral parts of jugular foramen) [Fig. 1c] with a pair of dividers and then distance between the divider's tips were measured with internal jaws of Vernier caliper.

Vertical diameter of jugular fossa (maximum vertical diameter of jugular fossa) [Fig. 2a], width of jugular fossa (maximum width of jugular fossa) [Fig. 2b], and lateromedial diameter of jugular foramen (diameter between most lateral and medial most point of the jugular foramen) [Fig. 2c], were noted with a pair of dividers, and then distance between the divider's tips was measured with internal jaws of Vernier caliper.

Morphological parameters included noting whether an intrajugular process [Fig. 1d] and whether a jugular tubercle [Fig. 1e] was present or absent. Mastoid canaliculus (runs through the lateral wall of the jugular fossa)

whether present or absent was noted.

Cochlear canaliculus (found medially at the apex of the notch on the upper boundary of the jugular foramen) [Fig. 2d] and tympanic canaliculus (lies on the ridge between the jugular fossa and the opening of the carotid canal) [Fig. 1e] were noted whether present or absent.

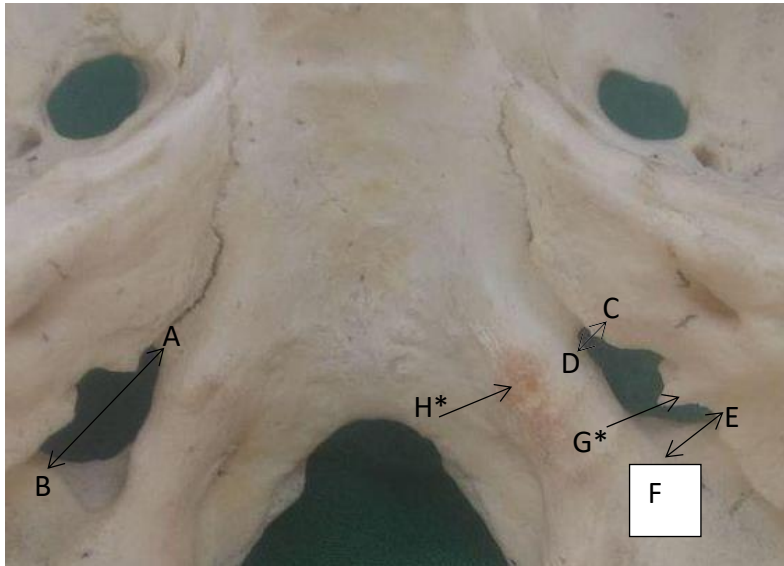


Fig.1 Morphometric parameter of jugular foramen: (a) Anteroposterior diameter of jugular foramen (AB); (b) Anteromedial width of jugular foramen (CD); (c) Posteromedial width of jugular foramen(EF); (d) Intrajugular process (G\*); (e) Jugular tubercle (H\*)



Fig. 2 Morphometric parameter of jugular foramen from base of skull (a) Vertical diameter of jugular fossa (AB); (b) Width of jugular fossa (CD); (c) Lateromedial diameter of jugular foramen (EF); (d) Cochlear canaliculus (H\*); (f) Tympanic canaliculus (G\*)

**RESULTS**

Morphological and morphometrical parameters of posterior cranial fossa and jugular foramen of both left and right side were recorded. The mean of anteroposterior length (AP) of jugular foramen was  $14.46 \pm 1.55$  mm. The mean maximum width of anteromedial (AMW) part and of posterolateral (PLW) part of jugular foramen were  $4.31 \pm 0.89$  mm and  $8.07 \pm 1.77$  mm respectively. [Table 1]

**Table 1:** Morphometric measurement of Jugular foramen

Parameters	Mean $\pm$ SD (mm)			Range Minimum-Maximum (mm)			p-value
	Right	Left	Total	Right	Left	Total	
AP	$14.64 \pm 1.538$	$14.28 \pm 1.54$	$14.46 \pm 1.55$	12 - 20	11-20	11-20	<b>0.0383*</b>
AMW	$4.28 \pm 0.91$	$4.34 \pm 0.957$	$4.31 \pm 0.89$	2.4 - 6.7	2.6-7	2.4-7	0.4802
PLW	$8.25 \pm 1.854$	$7.9 \pm 1.673$	$8.07 \pm 1.77$	3.5 - 12	3.6-11	3.5-12	0.1572

The mean maximum width of jugular fossa was  $10.66 \pm 2.03$  mm whereas the mean of latero-medial width of JF was  $16.97 \pm 2.48$  mm. The mean of vertical diameter of jugular foramen was  $8.94 \pm 1.88$  mm. [Table 2] A solitary skull with a slit like jugular foramen on right side with vertical and lateromedial diameter of 3.64 and 17.44 mm respectively was found [Fig. 3].

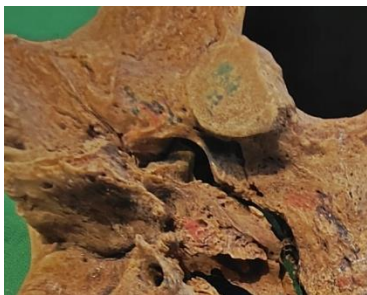


Fig. 3 Slit like jugular foramen

**Table 2:** Morphometry of the jugular foramen and jugular fossa from the base of skull

Parameters	Mean $\pm$ SD			Range Minimum-Maximum			p-value
	Right	Left	Total	Right	Left	Total	
Width of jugular fossa	$11.12 \pm 1.66$	$10.19 \pm 2.256$	$10.66 \pm 2.03$	6.75-15.8	4.91-15.6	4.91-15.8	<b>0.001602**</b>
Latero-medial width of jugular fossa	$17.21 \pm 2.461$	$16.73 \pm 2.493$	$16.97 \pm 2.48$	8.7-22.87	10.6-23.7	8.7-23.7	0.09448 871
Vertical	$9.67 \pm 2.64$	$8.21 \pm 5.42$	$8.94 \pm 2.64$	3.64	5.42	3.64	

Jugular tubercle was present in 112(93.3%) skulls and absent in 8 (6.7%) skulls while intrajugular process was present in 98 (81.7%) skulls and absent in 22 (18.3%) skulls. [Table 3]

**Table 3: Incidence of Intrajugular process and jugular tubercle**

Structures		Intrajugular process	Jugular tubercle
Present	Right	49(81.7%)	56(93.3%)
	Left	49(81.7%)	56(93.3%)
	Total	98(81.7%)	112(93.3%)
Absent	Right	11 (18.3%)	4(6.7%)
	Left	11(18.3%)	4(6.7%)
	Total	22(18.3%)	8(6.7%)

**Table 4: Incidence of Mastoid canaliculus, Cochlear canaliculus and Tympanic canaliculus from the base of the skull**

Canal	Bilateral	Unilateral			Absent		
		Right	Left	Total	Right	Left	Total
Mastoid canaliculus	41 (68.33%)	4 (6.76%)	2 (3.33%)	6 (5%)	15 (25%)	17 (28.5%)	32 (26.76%)
Cochlear canaliculus	57 (95%)	1 (1.66%)	-	1 (0.83%)	2 (3.33%)	3 (5%)	5 (4.25%)
Tympanic canaliculus	57 (95%)	-	2 (3.33%)	2 (1.66%)	3 (5%)	1 (1.6%)	4 (3.33%)

## DISCUSSION

In the present study, the mean anteroposterior length of jugular foramen from posterior cranial fossa on right and left side was  $14.64 \pm 1.538$  mm and  $14.28 \pm 1.54$  mm. Our findings were comparable with studies done by Das SS et al. (2016)<sup>7</sup> and Vljakovic et al. (2010)<sup>8</sup> and. Similarly, the findings of current study were comparable with these two studies for the mean anteromedial width (AMW) and the mean posterolateral width (PLW) of jugular foramen. [Table 5]

**Table 5: Comparison of various morphometric parameters of jugular foramen with other osteological studies on posterior cranial fossa**

Parameters	AP Length (mm)		Antero-medial width (AMW) (mm)		Postero-lateral width (PLW) (mm)	
	Right	Left	Right	Left	Right	Left
Vlajkovic et al. (2010) <sup>8</sup>	14.21	13.24	4.21	4.34	7.78	6.42
Das SS et al. (2016) <sup>7</sup>	13.25±	12.26±	4.34±	5.08±	7.07±	5.51±
	1.56	1.33	1.13	1.18	1.29	2.25
Present study	14.64±	14.28±	4.28±	4.34±	8.25±	7.9±
	1.538	1.54	0.91	0.957	1.854	1.673

The size of jugular foramen is related to size of internal jugular vein and presence or absence of a prominent superior bulb. Standard anatomical textbook described that the superior sagittal sinus drains into the right transverse sinus, thus the right jugular foramen is expected to be larger than left.<sup>9</sup> The differences in the size of right and left internal jugular veins is evident in the human embryo at the 23mm stage (8 weeks post-conception) which might result from the different development of the right and left brachiocephalic veins. Many authors have also reported larger diameter of the right jugular foramen as compared to the left on both endocranial and exocranial aspects in various ethnic groups.

The mean width of jugular fossa on right and left side of present study were in accordance to the studies done by Das SS et al. (2016)<sup>7</sup>, Gupta C et al. (2014)<sup>10</sup> and Jain SR et al. (2018)<sup>11</sup>. Similarly the mean latero-medial width of jugular fossa was found to be greater on right side when compared with these studies. [Table 6] However study done by Kotgirwar et al. (2013)<sup>12</sup> on South Indian population reported values were greater on left side. This difference may be because they have done a study in different region. On comparing the mean vertical diameter of jugular fossa higher values were reported by Das SS et al. (2016)<sup>7</sup>, Gupta C et al. (2014)<sup>10</sup> and Jain SR et al. (2018)<sup>11</sup> which were in concordance to present study. Contrast results were reported by Kotgirwar et al. (2013)<sup>12</sup> (values were greater on left side). [Table 6]

**Table 6: Comparison of various morphometric parameters of the jugular foramen from base of skull with previous studies**

Authors	Width of jugular fossa (mm)	Lateromedial width of jugular fossa (mm)	Vertical diameter of jugular fossa (mm)

	Right	Left	Right	Left	Right	Left
Kotgirwar et al. (2013) <sup>12</sup>	-	-	7.16	9.38	13.74	15.21
Gupta C et al. (2014) <sup>10</sup>	11.22± 2.47	9.52± 1.55	16.52± 2.03	16.02± 2.20	6.83± 1.50	5.69± 1.60
Das SS et al. (2016) <sup>7</sup>	7.25± 1.82	5.88± 1.31	13.72± 2.70	13.07± 2.09	9.37± 2.61	6.88± 1.72
Jain SR et al. (2018) <sup>11</sup>	8.99± 1.92	7.54± 2.07	15.67± 2.28	14.85± 2.89	9.32± 2.04	7.34± 2.04
Present study	11.12± 1.66	10.19± 2.25	17.21± 2.461	16.73± 2.49	9.67± 1.91	8.21± 1.54

Tumors involving jugular foramen and nearby structure require microsurgical approaches to enter into this region.<sup>13</sup> In most of the cases, we have to drill the nearby bones around the jugular foramen for proper exposure. And the tumor tends to alter the normal anatomy of the foramen by eroding and invading it. Therefore, it is not possible to have correct anatomic visualization of the foramen in presence of such pathologies. Hence, a detailed knowledge of the jugular foramen is needed to all the neurosurgeons while doing surgery in this region.

## CONCLUSION

All parameters of jugular foramen from posterior cranial fossa were greater on right side except anteromedial width of JF which was slightly higher on left side. All parameters of jugular foramen from base of skull were greater on right side and difference was found to be statistically highly significant. Mastoid canaliculus, cochlear canaliculus and tympanic canaliculus were seen bilaterally in 68.33% skulls, 95% skulls and 95% skulls respectively. Various pathological lesions, tumors involving jugular foramen and nearby structure require microsurgical approaches to enter into this region. Hence, a detailed knowledge of the jugular foramen is needed to all the neurosurgeons while doing surgery in this region.

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