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Morphometric study of jugular foramen in adult South Indian skulls

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ABSTRACT

Introduction: The jugular foramen lies between the occipital bone and the petrosal portion of the temporal bone. It allows the passage of important nervous and vascular vein and inferior petrosal sinus. Glomic tumors, schwannomas, metastatic lesions and infiltrating inflammatory processes are associated with this foramen, which can account for injuries of related structures. Morphometric study of this foramen will serve as guide for imaging and operative procedures in the jugular foramen region.

Material and methods: One hundred and sixteen dry adult skulls of unknown sex of south Indian origin were utilized for this study. Following dimensions of the foramen were measured with the help of a digital vernier caliper: i) Maximum dimension along the long axis; ii) Maximum dimension perpendicular to the long axis; iii) Maximum height of dome of jugular fossa and iv) Distance of stylomastoid foramen from lateral margin of jugular foramen. The minimum distance of stylomastoid foramen from the lateral margin of the foramen was also measured.

Observations: The findings of the present study bring forth some important facts as follows: On an average, all the dimensions measured were more on the right side. The jugular fossa showed great variability ranging from total absence of fossa to deep excavation anterolaterally forming a large fossa with the well-defined roof.

Conclusion: These observations call for further studies on variability of jugular fossa and its possible implications. The distance of the stylomastoid foramen from the jugular foramen will serve as guide for operating surgeons using infratemporal approach during skull base surgeries.

1. Introduction

The jugular foramen (JF) of the human skull is a complex bony canal, which transmits vessels and lower cranial nerves from the posterior cranial fossa through the skull base into the carotid space. This foramen is also difficult to access surgically.[1–7] It is generally said that, although the JF is larger on the right side compared to the left, its size as well as its height and volume vary in different racial groups and sexes.[8,9] The JF is the main route of venous outflow from the skull and is characterized by laterality based on the predominance of one of the sides.[9]

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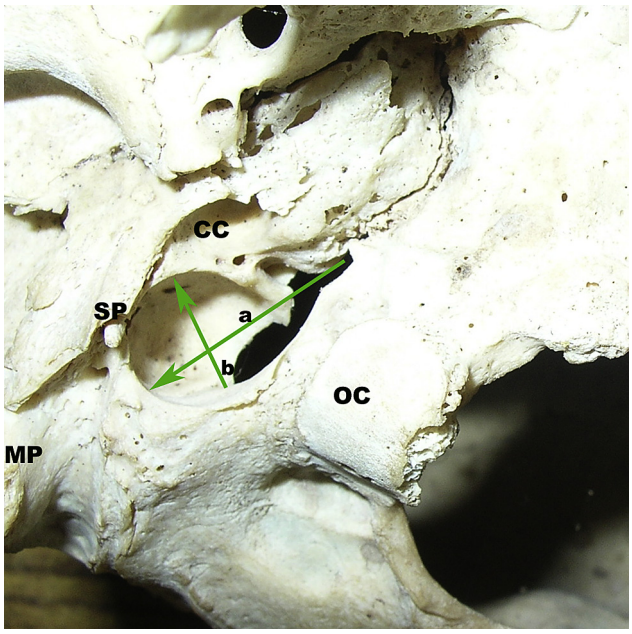

Fig. 1 – Showing jugular foramen from exocranial side. Arrows indicate maximum length along the long axis of the foramen (a) and maximum width perpendicular to the long axis (b). CC – carotid canal; MP – mastoid process; OC – occipital condyle; SP – styloid process.

Irregular shape of the foramen, its formation by two bones, and the numerous nerves and venous channels that pass through it contribute to the complex anatomy of the foramen.

JF may be affected by intracranial and extracranial lesions. Besides tumor like meningiomas, paragangliomas (*glomus jugulare*, from the jugular ganglion of the vagus nerve), and schwannomas; metastatic lesions and infiltrative inflammatory processes from surrounding structures may also affect the JF.[1,10,11] Surgical resection is the treatment of choice in the majority of these cases. Advances in microsurgical techniques have made JF lesions operable.[12] This necessitates the need for familiarity of detailed anatomy of this region for the operating surgeons. Morphometric study of this foramen will serve as guide for imaging and operative procedures in the jugular foramen region.

2. Material and methods

One hundred and sixteen dry adult skulls of unknown sex of south Indian origin were utilized for this study. Following dimensions of the foramen were measured with the help of a digital vernier caliper: i) Maximum length along the long axis; ii) Maximum width perpendicular to the long axis; iii) Maximum height of dome of jugular fossa and iv) Distance of stylomastoid foramen from lateral margin of JF (Fig. 1).

Keeping in view the canal like structure of the foramen, the measurements were calculated from the exocranial side of the foramen. Because of the irregularity of the foramen and its oblique orientation, the dimensions were calculated along the long axis and perpendicular to it. The height of the dome was calculated from the level of extracranial lateral margin of the foramen up to the summit of the fossa. The minimum distance of stylomastoid foramen from the lateral margin of the foramen was also measured.

The observations were statistically analyzed on SPSS-12 for descriptive statistics and paired T-test was performed for comparison of right and left sides.

3. Observations

Table 1 shows dimensions of the jugular foramen on the right and the left side. Although the average length along the long axis was more on the right than the left side; the left foramen was longer in 34 out of 116 skulls, however the difference was not statistically significant ($p = 0.09$). The maximum width measured perpendicular to long axis was located in the region of jugular fossa (posterolateral part of foramen) except in one skull on left side where it was more in anteromedial part of the foramen. On an average, this dimension was more on the right side but in 11 cases it was more on the left side. The difference between the right and the left side was found to be statistically significant ($p = 0.04$). The jugular fossa was observed to be an anterolateral excavation into the petrous temporal bone by the jugular bulb. The jugular fossa showed variable shapes from a well-defined fossa with a roof, to poorly developed fossa (2 rt; 6 lt) and total absence (23 rt; 23 lt) (Figs. 1 and 2).

The height of the dome of jugular fossa could not be measured in 25 skulls on right side and 29 skulls on the left

Table 1 – Showing various dimensions of jugular foramen.

	Right	Left	Statistical significance (p value)
Length along long axis	15.21 mm; ±2.12[a] (9.56–20.07) $n = 113$	13.74 ± 2.3 (8.84–21.02) $n = 114$	0.09
Width perpendicular to long axis	9.38 ± 2.01 (4.74–13.69) $n = 112$	7.16 ± 1.81 (3.93–12.34) $n = 113$	0.04[b]
Height of dome of jugular fossa	11.78 ± 2.41 (5.82–17.31) $n = 91$	9.84 ± 2.08 (4.45–13.76) $n = 87$	0.17
Distance of stylomastoid foramen from the outer margin of jugular foramen	4.72 ± 1.21 (1.87–7.93) $n = 112$	5.87 ± 1.28 (2.43–8.83) $n = 111$	0.15

[a] All values are in mm; figures in the bracket denote the range.
[b] Statistically significant difference between right and left sides.

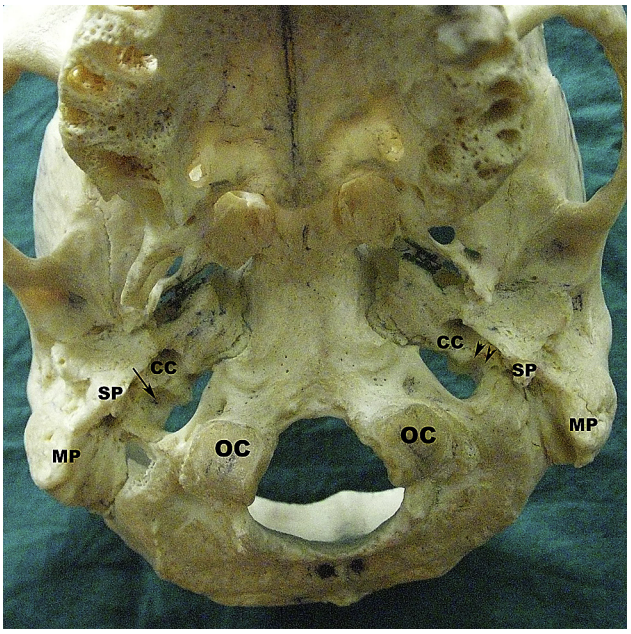

Fig. 2 – Showing partially developed jugular fossa on right side and non developed fossa on the left side. CC – carotid canal; MP – mastoid process; OC – occipital condyle; SP – styloid process.

side due to either total absence or poorly developed fossa. In one skull (rt side) the roof of jugular fossa was perforated. The average of minimum distance of stylomastoid foramen was more on the right side. In one skull the stylomastoid foramen was replaced by three very small foramina.

4. Discussion

The jugular foramen is an irregular canal between the petrous temporal and the occipital bones. The long axis of the foramen is directed obliquely and does not conform to any standard anatomical plane.[13–16] Earlier morphometric studies on the jugular foramen have measured the anterior and transverse dimensions.[5,8,17–19] Authors believe these diameters do not indicate the actual extent of the foramen and hence dimensions along the long axis and perpendicular to it have been measured in the present study. Because of canal like structure of this foramen, it has an endocranial and exocranial opening. These openings differ in size because of presence of jugular fossa exocranially. The present study measured the exocranial openings for two reasons: i) surgeons approach the jugular foramen from the exocranial side and ii) exocranial opening gives an indication of development of jugular bulb. Earlier workers have not taken into consideration these facts.

The average length along the long axis of the foramen was 15.21 ± 2.12 mm on the right side and 13.74 ± 2.3 mm on the left side. The comparable dimensions by other workers, which have been expressed as the sagittal diameters or the length of the foramen, range between 13 and 17 mm in different population groups.[5,8,17–19] The average width perpendicular to the long axis were 9.38 ± 2.01 mm on the right side and 7.16 ± 1.81 mm on left side. The comparable dimensions by other workers which have been expressed as the transverse diameters or width of the foramen range between 7.6 and 10.2 mm.[5,8,17–19] The differences in the results of various studies can be attributed to i) variable reference points used for measurement of different studies or ii) inherent population differences. Differences in size of the right and the left internal jugular veins are reflected in the differences between the sizes of jugular foramina. As has been observed in the present study, the right jugular foramen is usually larger than the left. Similar findings have been reported by earlier workers.[5,8,17–19] The superior sagittal sinus, which drains the major area of cerebral cortex, usually drains into the right transverse sinus. Right transverse sinus continues as sigmoid sinus and forms right internal jugular vein. However, there is a very wide variation in the anatomy of the intracranial venous sinuses,[18,20,21] including the transverse sinus, which accounts for variations in size and shape of the jugular foramen. These variations are reflected in our findings also. Although the average length along the long axis was more on the right side than the left, the left foramen was longer in 34 and wider in 11 out of 116 skulls. The differences in the size of the two internal jugular veins, is already visible in the human embryo at the 23 mm stage (8 week post-conception) and probably results from differences in the pattern of development of the right and left brachiocephalic veins.[22–24]

It is well known that the jugular bulb forms the floor of middle ear cavity.[14,23] The cases of glomus tumors in JF eroding this floor and encroaching the middle ear cavity have also been reported.[3,9,10] The absence of roof of jugular fossa in about 20% cases indicates that the jugular bulb is absent or poorly developed in such cases and may not form the floor of middle ear cavity. This observation is contrary to general belief and needs supportive evidence in the form imaging studies of middle ear cavity (temporal bone).

The average length perpendicular to the long axis varied widely (right 4.74–13.69 mm; left 3.93–12.34 mm) and the difference was also statistically significant. This variability has not been previously reported. This dimension indicates the extent of jugular bulb and its variability reflects the variable development of jugular bulb. Standard text books of anatomy and embryology have not elaborated on the development and size of jugular bulb.[14,23] Paucity of literature concerning the jugular bulb and fossa calls for further studies.

Different surgical approaches have been devised to operate upon the tumors of JF regions. These include transcondylar, infratemporal, transsigmoid, suboccipital and extreme lateral approaches. All these procedures have there own advantages and disadvantages. Among these approaches infratemporal is the more popular but requires re routing of facial nerve.[25,26] Our observations on distance of stylomastoid foramen (from which the facial nerve emerges) from the lateral margin of JF will serve as a guide for operating surgeons, during the procedure of re routing of facial nerve. These dimensions have not been studied and reported earlier.[17] Our findings suggest that the facial nerve lies at a distance about 5 mm and 6 mm respectively from the lateral margins of right and left jugular foramen.

5. Conclusion

The findings of the present study bring forth some important facts as follows:

- Measurement along the long axis of foramen and perpendicular to it were recorded; on an average, all the dimensions were more on right side.
- The jugular fossa showed great variability from total absence of fossa to deep excavation anterolaterally forming a large fossa with the well-defined roof. This observation calls for further studies on variability and its possible implications.
- The distance of the stylomastoid foramen the jugular foramen will serve as guide for operating surgeons for re routing of facial nerve.

Conflicts of interest

All authors have none to declare.

REFERENCES

1. Chong VF, Fan YF. Radiology of the jugular foramen. *Clin Radiol*. 1998;53:405–416.
2. Hovelacque A. *Osteologie*. Paris: G Doin and Cie; 1967:155–156.
3. Katsuta T, Rhoton Jr Al, Matsushima T. The jugular foramen. Microsurgical anatomy. *Neurosurgery*. 1997;41:149–201.
4. Kveton JF, Cooper MH. Microsurgical anatomy of the jugular foramen region. *Am J Otol*. 1988;9:109–112.
5. Lang J, Weigel M. Nerve-vessel relations in the region of the jugular foramen. *Anat Clin*. 1983;5:41–58.
6. Rhoton AL, Buza R. Microsurgical anatomy of the jugular foramen. *J Neurosurg*. 1975;42:541–550.
7. Schwaber MK, Netterville JL, Maciunas R. Microsurgical anatomy of the skull bone. *Am J Otol*. 1990;11:401–405.
8. Navsa N, Kramer B. A quantitative assessment of the jugular foramen. *Anat Anz*. 1998;180:269–273.
9. Wysocki J, Chmielik LP, Gacek W. Variability of magnitude of the human jugular foramen in relation to condition of the venous outflow after ligation of the internal jugular vein. *Otolaryngologia*. 1999;53:173–177.
10. Chong VFH, Fan YF. Jugular foramen involvement in nasopharyngeal carcinoma. *J Laryngol Otol*. 1996;110:897–900.
11. Kanemoto Y, Ochiai C, Yoshimoto Y, Nagai M. Primarily extracranial jugular foramen neurinoma manifesting with marked hemiatrophy of the tongue: case report. *Surg Neurol*. 1998;49:534–537.
12. Tekdemir I, Tuccar E, Aslan A, et al. The jugular foramen: a comparative radioanatomic study. *Surg Neurol*. 1998;50:557–562.
13. Athavale SA. Morphology and compartmentation of jugular foramen in adult Indian skulls. *Surg Radiol Anat*. 2009;32(5):447–553.
14. Standring S, Ellis H, Healy JC, Jhonson D, Williams A. Skull and mandible. In: *Grays Anatomy*. 39th ed. New York: Churchill Livingstone; 2005:461–465.
15. Talbert OR. General methods of clinical examination. In: *Youman's Neurological Surgery*. 3rd ed. W.B.Saunders Company; 1990:21.
16. Van Loveren HR, Liu SS, Pensak ML, et al. Anatomy of the jugular foramen: the neurosurgical perspective. *Oper Tech Otol*. 1996;7:90–94.
17. Ekinci N, Unur E. Macroscopic and morphometric investigation of the jugular foramen of the human skull. *J Anat*. 1997;72:525–529.
18. Lang J. *Skull base and related structures – Atlas of clinical anatomy*. 1995.
19. Deopujari R, Mangalgiri AS, Longia GS. Study of jugular foramen variations in central India. *J Anat Sci*. 2010;18(2):25–30.
20. Browder J, Kaplan M. *Cerebral Dural Sinuses and Their Tributaries*. Springfield: Thomas; 1976.
21. Opuz C, Aydin ME, Kale A, Demir MT, Corumlu U, Kaya AH. The termination of superior sagittal sinus and drainage patterns of the lateral, occipital at confluens sinuum in newborns: clinical and embryological implications. *Surg Radiol Anat*. 2010;32(9):827–833.
22. Hamilton WI, Boyd JD, Mossman HW. *Human Embryology*. 3rd ed. Cambridge: W. Heffer and Son's; 1962.
23. Sadler TW. *Langman's Medical Embryology*. 10th ed. New Delhi: Lippincott Williams and Wilkins; 2006.
24. Padget DH. The development of the cranial venous system in man, from the viewpoint of comparative anatomy. *Contrib Embryol*. 1957;36:81–140.
25. Yop Heon, Jung Hee-Won, Yang Hee Jin. Jugular foramen schwannomas: surgical approaches and outcome of treatment. *Skull Base Surg*. 1999;9(4):243–252.
26. Woodhall B. Anatomy of the cranial blood sinuses with particular reference to the lateral. *Laryngoscope*. 1939;49:966–1010.