Website: www.aijournals.com/journals/aanat/ **DOI: 10.21276/aanat.2016.2.2.7**

ORIGINAL ARTICLE ISSN: 2455-5274

Variant Anatomy of the Jugular Foramen: An Osteological Study

Faith Bonareri Aseta[1], Philip Maseghe Mwachaka[2], Pamela Idenya Mandela[3], Julius Ogeng'o[4]

[1]*Department of Human Anatomy, University of Nairobi.*

[2]*Department of Human Anatomy, University of Nairobi.*

[3]*Department of Human Anatomy, University of Nairobi.*

[4]*Department of Human Anatomy, University of Nairobi.*

Date of Submission: ***29-08-2016***

Date of Acceptance: ***07-11-2016***

Date of Publishing: ***20-12-2016***

ABSTRACT

Background: Jugular foramen lesions are among the major complications of skull base surgery. Morphological variations in the structure are pertinent during interpretation of skull base radiographs and in surgical procedures within the foramen. This study therefore aimed at describing the morphology of the jugular foramen in a Kenyan population. **Methods:** One hundred and five adult skulls from the Nairobi National Museums were used. Jugular foramen septation, dome and dimensions were studied extracranially. Statistical analysis was performed using SPSS (Version 21.1 IBM). **Results:** Septation was present in 202 (96.2%) jugular foramina, type I partial septation being the most common (78.7%). A dome was observed in 81 (38.6%) jugular foramina. Respectively, the mean right and left anteroposterior dimensions were 11.17 ±2.05mm vs.8.88 ±2.30mm (p <0.001), mediolateral dimensions 17.47 ±2.18mm vs. 15.30 ±2.53mm (p <0.001), jugular dome depth 12.38 ± 2.64 mm vs. 11.25 ± 2.15 mm (p=0.054), posterior wall thickness7.95 ± 2.20mm vs. 9.68 ± 1.98mm (p <0.001) and medial wall thickness 3.73 ± 1.10 mm vs. 3.73 ± 0.98mm (p = 0.992). **Conclusion:** Partial septation, asymmetry in dimensions and a wide range in the dome depth of the jugular foramen were frequent. Preoperative imaging of jugular foramen morphology is therefore recommended to avoid inadvertent injury to its contents and surrounding structures owing to variability.

Keywords: *Jugular foramen, septation, jugular dome, jugular foramen dimensions.*

INTRODUCTION

The jugular foramen (JF) transmits the internal jugular vein (IJV), inferior petrosal sinus, meningeal branch of ascending pharyngeal artery, glossopharyngeal, vagus and spinal accessory nerves.[1] Lesions including para-gangliomas, schwannomas, meningiomas, high jugular bulb and trauma may occur in the foramen, constituting one of the major challenges experienced in skull base surgery.[2-4]

Name & Address of Corresponding Author
Faith Bonareri Aseta
Department of Human Anatomy
University of Nairobi, Nairobi, Kenya.
E mail: bonareri.aseta@gmail.com

Knowledge of variations in its anatomy is important to minimize complications in diagnosis and surgical access to foramina lesions.[3,5] The morphology of the foramen shows population-specific variations.[6-10] There is however paucity of data from the African population and lacking altogether among Kenyans. Additionally, the wall thickness, which may be important during access to the foramen has barely been described in literature. This study therefore set out to describe the morphology of the jugular foramen in a Kenyan population, with regards to septation, dome, anteroposterior dimension, mediolateral dimension and wall thickness.

MATERIALS AND METHODS

In this descriptive cross sectional study one hundred and five skulls (n=210 JF) obtained from the Nairobi National Museums of Kenya were studied. The museum osteological collection was from central Kenya (1950 - 1960). Approval for use of cadaveric material is provided in the Human Anatomy Act Cap 249(1967) and the Human Tissues Act Cap 252(1968) of the Laws of Kenya.

Skulls with normal morphology and those with erupted third molars (adults) were selected. The JF was identified extracranially. Presence or absence of septae - bony structures dividing JF into compartments and jugular dome - transverse bony plate within JF, were documented. When present the septation or bridging was classified as type I(one bridge), II(two bridges), III (three bridges) or IV(atypical fusion of intraforamina processes) according to Athavale.[11] Morphometric data were taken using a pair of digital Vernier calipers (Sealey Professional Tools ™, accurate to 0.01 mm) and a pair of adjustable compasses with a ruler for smaller measurements. Data were collected by a single observer. Intra-observer error was minimized by taking each measurement thrice and obtaining the average.

The measurements taken were: Anteroposterior (AP) dimension, the maximum sagittal dimension of JF; mediolateral (ML) dimension, the maximum transverse dimension of JF; depth of jugular dome, the height from the margin of the JF to the central part of the dome; medial wall thickness, the thickness of the osseous bar between JF and the hypoglossal canal and posterior wall thickness, the thickness of the jugular process at the level of the occipital condyles.

Data analysis was performed using SPSS version 21.1 (SPSS IBM). Means, standard deviations and range were obtained. The paired Student's t test was used to determine the statistically significant differences in means between the right and left jugular foramina dimensions. $P \leq 0.05$ was considered statistically significant at 95% confidence interval.

RESULTS

The jugular foramen varied in terms of septation types, presence of dome and side differences in wall thickness, anteroposterior and mediolateral dimensions.

Septation: Bony septation was present in 202 (96.2%) JF. Of these, type I partial septation was present in 159 (78.7%), type II partial septation in 8 (4%), type I complete septation in 28 (13.9%), type II complete in 1 (0.5%) and type II mixed septation in 5 (2.5%). Type IV or atypical septation was observed in only 1 (0.5%) JF. Bilateral septation was observed in 97 skulls of which type I partial was observed in 66 skulls (71%), type I complete in 7 (7.5%), type II partial in 2 (2.2%) while 22 skulls (22.7%) showed different septation types on the right and left sides [Figure 1].

Dome: Jugular dome was present in 81 (38.6%) of the jugular foramina. Unilaterally, right dome was observed in 32 skulls (30.5%) [Figure 2A] and left dome in 7 skulls (6.7%) [Figure 2B]. Bilateral presence of the dome was seen in 21 skulls (20%) [Figure 2C] and bilateral absence in 45 skulls (42.9%). The dome was always posterolateral in the foramen. The mean depth of the right dome was 12.38 ± 2.64 mm and the left 11.25 ± 2.15mm (P = 0.054). A wide range in the depths was obtained, the maximum depth being 18.6mm and the minimum depth 6.11mm.

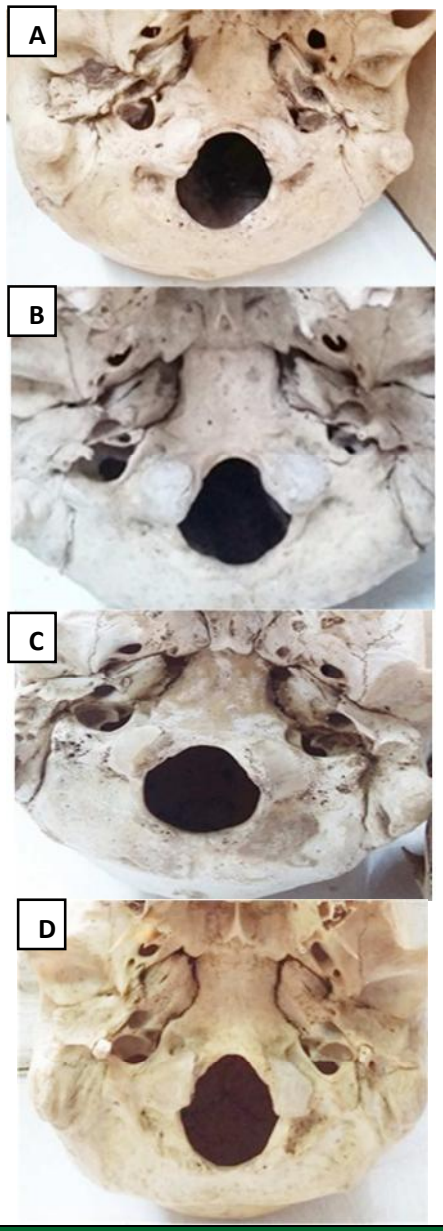

Figure 1: Photographs showing various jugular foramen septation types. (A) shows Right JF Type II mixed septation and left JF Type I partial septation, (B) Bilateral Type I complete JF septation with the right superficial and the left more deeply seated, (C)Bilateral type I partial septation and (D)bilateral type I complete septation both deeply seated.

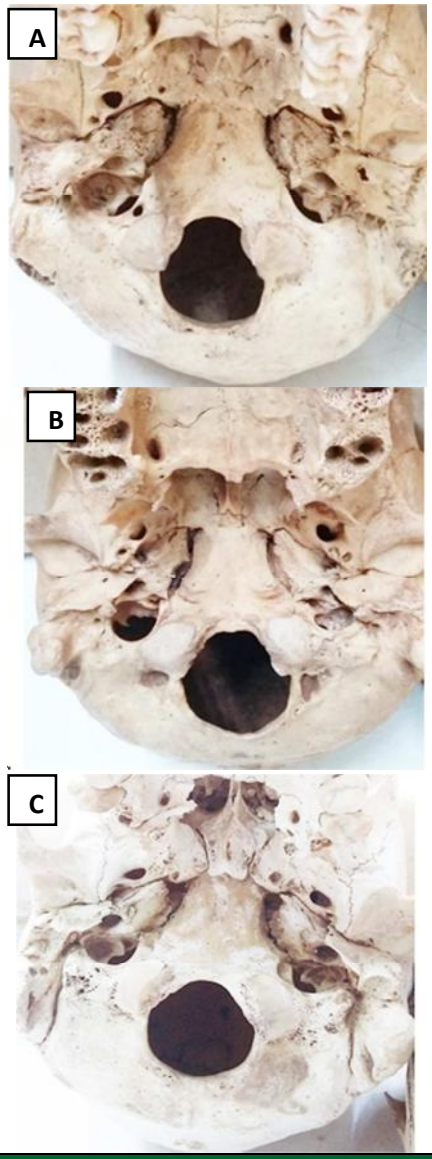

Figure 2: Photographs showing jugular foramen dome. (A) represents right JF dome, (B) left JF dome and (C) bilateral JF dome.

Anteroposterior and mediolateral dimensions: Both mean AP and ML dimensions were greater for the right JF than the left JF. The mean AP dimension was 10.03 ± 2.46mm, right and left JF 11.17 ± 2.05mmand 8.88 ± 2.30 mm respectively (p< 0.001). The mean ML dimension was 16.38 ± 2.59mm, right and left JF 17.47 ± 2.18mmand 15.30 ± 2.53mm respectively (p< 0.001) [Figure 3]. The right JF showed larger dimensions than the left JF in 86 skulls (81.9%) for the AP dimension and 82 skulls (78.1%) for the ML dimension.

Posterior and medial wall thicknesses: The mean posterior wall thickness was greater in the left JF than the right JF with the difference being statistically significant (9.68 ± 1.98mm vs. 7.95 ± 2.20mm, p< 0.001). The mean thickness of the medial wall for the right and left JF was 3.73 ± 1.10mm and 3.73 ± 0.98mm respectively (P=0.992) [Figure 3].

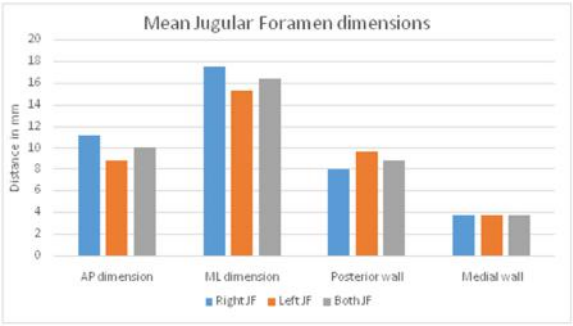

Figure 3: Bar graph showing mean jugular foramen dimensions.

DISCUSSION

The jugular foramen was bilaterally present in all cases as conventionally described [1]. The foramina septation, dome and dimensions showed variations from some populations, which may be of clinical relevance.

Septation

The high prevalence (96.2%) of JF septation is concordant with Kumar et al [10]but at variance from other literature [Table 1]. The most common type is partial septation, in agreement with reports from other populations.[7,10,12,13] Data on complete septation is close to the findings of Kumar et al [10] and Roma et al[13] but differs largely from other studies.[7- 9,12] Complete septation was higher in the left compared to the right JF as opposed to the results of Kumar,[10]Hatiboğlu[12] and Roma et al.[13] Likewise, partial septation was higher in the left than right JF, similar to some reports in literature.[7,10,12]The variations in frequency of septation are genetic or developmental.[6, 14]For foramina with partial septation, they may be completed in the living by a fibrous septum.[15] Compartmentation may have implications during surgical access to the lesions within the foramen.[16]The high frequency of septation calls for prudence during planning to ensure safe access and accurate interpretation of posterior cranial fossa radiographs.[3]

Dome

The 30.5% frequency of unilateral right JF dome is akin previous descriptions [7,10,13] but differs from

Hatiboğlu et al [12] among the Turkish [Table 2]. The 6.7% frequency of unilateral left dome is similar to the studies by Sturrock[7] and Hatiboğlu et al. Bilateral presence of dome showed a lower frequency (20%) similar to the findings of Roma et al,[13] while bilateral absence was highest for the present study [Table 2]. The mean depth of jugular foramen dome is comparable to the results of Singla et al [17]who studied skulls in an Indian population and obtained 11.11 mm and 11.04 mm for the right and left JF respectively. Gupta et al [18] reported a depth of 11.75 mm for the right JF and 11.13 mm for the left JF, these too correspond to the present study. The ranges of the depths do not exhibit such a wide population difference compared to other JF dimensions. A study by Anson et al [19]nevertheless seems to differ from this. They reported most of the domes being less than 7mm in depth. The difference may be methodological.

Table 1: Jugular foramen septation in different study populations.

Study	Population	Sample size	Complete Septation (%)		Partial Septation (%)	
			R	L	R	L
Sturrock (1988)	British	156	3.2	3.2	1.3	10.9
Hatiboğlu et al (1992)	Turkish	300	5.6	4.3	2.6	19.6
Idowu (2004)	Nigerian	20	7.5		_	_
Pereira et al (2010)	Brazilian	111	0.9		0.9	
Kumar et al (2014)	Indian	68	16.17	8.82	83.82	91.2
Roma et al (2014)	Indian	100	16	14	29	25
Present Study	Kenyan	105	13.3	14.3	75.2	83.8

Table 2: Jugular foramen dome in different study populations.

Study	Population	Sample size	Bilateral(%)	Right JF dome (Unilateral) (%)	Left JF Dome (Unilateral) (%)	Absent (%)
Sturrock (1988)	British	156	53.9	30.1	6.4	9.6
Hatiboğlu et al (1992)	Turkish	300	49	36	6	10.3
Pereira et al (2010)	Brazilian	111	68.5	_	_	4.5
Kumar et al (2014)	Indian	68	57.35	29.4	8.82	4.41
Roma et al (2014)	Indian	100	23	30	11	36
Present Study	Kenyan	105	20	30.5	6.7	41.9

The bilateral differences in presence of a dome may be attributed to difference in size between the right and left superior jugular bulbs the larger forming a dome.[20]The population differences are genetic or ethnic based.[10,18,21]Jugular dome suggests a prominent superior jugular bulb which should not be mistaken for a tumor or a mass during radiography. Where the dome is so high that it reaches above the internal acoustic meatus, it is indicative of a high riding jugular bulb.[22,23] During preoperative planning for inner ear surgeries, presence of a dome with its jugular bulb should be considered as an important relation since injury to the bulb can be devastating.[24]The wide range of depth obtained in the current study (6.1mm - 18.6 mm) suggests variable positions of the superior jugular bulb which should be considered during surgery.

Anteroposterior and mediolateral dimensions

The present study demonstrated larger AP and ML dimensions for the right JF compared to the left JF in line with literature reports.[9,17,25-27] Idowu obtained a similar trend for the AP dimension but had almost equal left and right ML dimension.[8]The11.17 mm and 8.88 mm right and left AP dimensions from the current study are comparable with most literature[8,9,17,27]but differ largely from those reported by Saheb[25] and Sundika[26] et al [Table 3]. The 17.47 mm and 15.3 mm right and left ML dimensions are akin to findings among Nigerians[27]and Brazilians[9] and are at variance from the other reports [Table 3].

The right dimensions were larger than the left dimensions in about 80% of the skulls, a value higher compared to about 67% reported as standard literature.[28] This observation however corresponds to that by Singh et al [21]who reported a high of 88.3% larger right than left JF. The AP and ML dimensions of JF are indicative of the size of the IJV. The larger superior sagittal sinus preferentially drains into the right sigmoid sinus and therefore the right IJV is larger than the left IJV.[29]Intracranial variations in venous sinuses, different developmental patterns, genetic or

ethnic differences contribute to the asymmetry.[30] Knowledge of jugular foramen dimensions may be important in the diagnosis of JF stenosis or widening. The right JF dimensions are greater than the left's, suggestive of right IJV 'dominance' in most of the study population. This may provide guidance in selecting the IJV to ligate or catheterize.[31,32]

Table 3: A-P and M-L dimensions from different study populations.

Study	Population	Sample Size	AP Dimension (mm)		ML Dimension (mm)	
			R	L	R	L
Idowu (2004)	Nigerian	20	10.22 ± 2.67	9.57 ± 1.84	13.90 ± 1.48	14.11 ± 3.13
Pereira et al (2010)	Brazilian	111	9.21 ± 1.95	8.65 ± 1.57	15.82 ± 2.67	15.86 ± 2.64
Saheb et al (2010)	S. India	125	7.83 ± 1.36	6.83 ± 1.63	23.62 ± 2.29	22.86 ± 3.13
Singla et al (2012)	N.W.Indian	50	9.32 ± 2.04	7.34 ± 2.04	8.99 ± 1.92	7.54 ± 2.07
Osunwoke et al (2012)	S. Nigeria	120	9.34 ± 2.00	7.54 ± 2.17	15.76 ± 2.36	13.39 ± 2.5
Sundika et al (2014)	South African	73	6.43	5.39	12.89	12.12
Present study	Kenyan	105	11.17± 2.05	8.88 ± 2.30	17.47 ± 2.18	15.3 ± 2.53

Posterior and medial wall thicknesses

The thicker left than right JF posterior wall may be related to the presence of a smaller left JF compared to right JF. The medial wall separating JF from the hypoglossal canal was a thin plate (3.73 mm) with no significant side differences. To the best of our knowledge, there is paucity of data on these dimensions from the available literature. Variability in posterior wall dimension may be crucial in the posterior approach to the jugular foramen by drilling the jugular process.[33] A very thin process may result in inadvertent injury to JF structures. Image guided procedure is therefore imperative. For the medial wall, the thin bony plate is prone to laceration when resecting lesions within the jugular foramen. Caution is therefore essential during such procedures to avoid penetration of the osseous septum and inadvertent injury to the hypoglossal nerve in the adjacent hypoglossal canal.

CONCLUSION

Partial septation, asymmetry in dimensions and a wide range in the depth of jugular dome were a frequent occurrence. Preoperative imaging of jugular foramen morphology is therefore recommended to avoid inadvertent injury to its contents and surrounding structures owing to variability.

Limitation: Most of the skulls were not sex-categorized.

Acknowledgements

We acknowledge the Osteology Department, National Museums of Kenya and Human Anatomy Department, University of Nairobi for their unwavering support.

REFERENCES

1. Standring S.S.P. Gray's Anatomy: The Anatomical Basis of Clinical Practice, Expert Consult- Online and Print, 40th edition. ed. Churchill Livingstone, Edinburgh. 2008. p. 415, p. 424.
2. Kanno T., Nobuo K., Manjila V. Microsurgical anatomy of the retroauricular, transcervicomastoid infralabyrinthine approach to jugular foramen. Neuroanatomy. 2003;2: 28-34.
3. Vogl T., Bisdas S. Differential diagnosis of jugular foramen lesions. Skull Base. 2009; 19: 003–016.
4. Rayappa C. Jugular Foramen Tumors. Otorhinolaryngology Clinics: An International Journal. 2011; 3: 15-23.
5. Keskil S., Gözil R., Calgüner E. Common surgical pitfalls in the skull. Surg. Neurol. 2003; 59: 228–231.
6. Dodo Y.A population study of the jugular foramen bridging of the human cranium. Am. J. Phys. Anthropol. 1986; 69: 15–19.
7. Sturrock R.R. Variations in the structure of the jugular foramen of the human skull. J. Anat. 1988; 160: 227–230.
8. Idowu O.E. The jugular foramen -a morphometric study. Folia Morphol. 2004; 63: 419–422.
9. Pereira GAM., Lopes PTC., Santos AMPV. and Krebs WD. Morphometric aspects of the jugular foramen in dry skulls of adult individuals in Southern Brazil. J. Morphol. Sci , 2010; 27: 3-5.
10. Kumar A., Ritu D., Akhtar M.J., Kumar A. Variations in jugular foramen of human skull. Asian J. Med. Sci. 2014; 6: 95-98.
11. Athavale S.A. Morphology and compartmentation of the jugular foramen in adult Indian skulls. Surg. Radiol. Anat. 2009; 32: 447–453.
12. Hatiboğlu M.T., Anil A. Structural variations in the jugular foramen of the human skull. J. Anat. 1992; 180 (1): 191–196.

13. Roma P., Mehta C.D. Morphometric study of jugular foramen at base of the skull in the South Gujarat region. IOSR- JDMS. 2014; 13: 58-61.
14. Shapiro R. Compartmentation of the jugular foramen. J. Neurosurg.1972; 36: 340–343.
15. Tubbs R.C.G. Dural septation on the inner surface of the jugular foramen: An anatomical study. J. Neurol. Surg. Part B Skull Base.2015; 76: 214-217.
16. Khanday S, Ramesh Kumar, Melani R., Ashfaq U., Sajad H. Morphological and morphometric study of jugular foramen in South Indian population.Int. J. Anat. Res. 2013;1: 122-27.
17. Singla A., Sahni D., Anjali A., Tulika G., Harjeet K. Morphometric study of the jugular foramen in Northwest Indian Population. J. Postgrad. Med. Educ. Res.2012; 46: 165-171.
18. Gupta C., Kurian P., Seva K.N., Kalthur S.G., D'Souza A.S. A morphological and morphometric study of jugular foramen in dry skulls with its clinical implications. J. Craniovertebral Junction Spine. 2014; 5: 118–121.
19. Anson B.J. Critical distances in the middle and inner ear and in posterior cranial fossa. Trans. Am. Acad. Ophthalmol. Otolaryngol. 1972; 76: 108-29.
20. Ichijo H, Hozawa J, Ota S, Miyano K. Anatomical study of the superior jugular bulb by use of high-resolution computed tomography. Nihon Jibiinkoka Gakkai Kaiho. 1989; 92: 1934–8.
21. Singh S., Suman P., Panigrahi A.K. Morphometric Variation of Jugular Foramen in dry adult skulls of South Indian Population and its clinical implications. Int. J. Health. Sci. Res. 2015; 5: 215–219.
22. Sasindran V., Abraham S., Hiremath S., Joseph A. High-riding jugular bulb: A rare entity. Indian J. Otolaryngol. 2014; 20: 129.
23. Roche P.-H., Moriyama T., Thomassin J.-M., Pellet W. High jugular bulb in the translabyrinthine approach to the cerebellopontine angle: anatomical considerations and surgical management. Acta Neurochir.2006; 148: 415–420.
24. Jovanović I., Ugrenović S., Stojanović V., Krstić M., Trandafilović M., Čukuranović J. Morphometric characteristics of jugular foramen and sigmoid sinus groove: their possible connections with high jugular bulb presence. Facta Univ., Med. Biol. 2014; 16: 12-17.
25. Saheb S., Mavishetter G. F., Thomas S. T, Prasanna L.C., Muralidhar P. A morphometric study of the jugular foramen in human adult skulls of south India. J Biomed Sci Res. 2010; 2: 240-243.
26. Sundika I.P.P. An osteometric evaluation of the jugular foramen. Int. J. Morphol.2014; 33 : 251-254.
27. Osunwoke E.A, Oladipo G.S, Gwunireama I.U, Ngaokere J.O. Morphometric analysis of the foramen magnum and jugular foramen in adult skulls in southern Nigerian population. Am.J. Sci.Ind. Res. 2012; 3(6): 446-448.
28. Caldemeyer K.S., Mathews V.P., Azzarelli B., Smith R.R. The jugular foramen: a review of anatomy, masses, and imaging. Radiogr. Rev. Publ. Radiol. Soc. N. Am. Inc. 1997; 17: 1123-39.
29. Naidich T.P., Castillo M., Cha S., Smirniotopoulos J.G. Imaging of the brain: Expert Radiology Series. Elsevier Health Sciences. 2012: 111-112.
30. Sethi R., Kaul N., Singh V. Morphological variations of jugular foramen in North Indian human adult skulls. Indian J. Otolaryngol. 2011; 17: 14.
31. Wysocki J., Chmielik L.P., Gacek W. Variability of magnitude of the human jugular foramen in relation to conditions of the venous outflow after ligation of the internal jugular vein. Otolaryngol. Pol. 1999; 53: 173–177.
32. Lichtenstein D, Saïfi R, Augarde R, Prin S, Schmitt JM, Page B, et al. The internal jugular veins are asymmetric. Usefulness of ultrasound before catheterization. J Intensive Care Med.2001; 27:301–305.
33. Komune N, Matsushima K, Matsushima T, Komune S, Rhoton AL. Surgical approaches to jugular foramen schwannomas: an anatomic study. Head Neck. 2015; 38:56-9.

How to cite this article: Aseta FB, Mwachaka PM, Mandela PI, Ogeng'o J. Variant Anatomy of the Jugular Foramen: An Osteological Study. Acad. Anat. Int. 2016;2(2):38-43.

Source of Support: Nil, **Conflict of Interest:** None declared.