

Original Article

Osseomorphometric Study of Jugular Tubercle in Dry Human Skull

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Background : Occipital bone is unique in respect to its relation with brainstem as it rests on clivus and pass-through Foramen Magnum to continue as spinal cord. Any pathological lesion in anterior or antero-lateral location of brainstem approached surgically through transcondylar plane. Most common obstructions in this process are Occipital Condyle (OC) and Jugular Tubercle (JT). Familiarity with the anatomical configurations of these structures is important for a safe and uncomplicated outcome of the surgeries.

Aims and Objective : Measurement of length, width and height of Jugular Tubercle (JT) of dry human occipital bone and to find out presence of bilateral dimorphism if any in West Bengal population.

Materials and Methods : In the present study authors measured different parameters in 150 available dry human occipital bones; preserved in Anatomy departments of different Medical Colleges of Kolkata over last one year. Measurement of length, width and height were taken by slide callipers and analysed.

Result : In the present study mean values of the parameters of JT were: length 13.79 ± 2.0 mm (right) and 13.85 ± 1.7 mm (left), width 10.15 ± 1.4 mm (right) and 10.15 ± 1.6 mm (left), height 7.57 ± 1.8 mm (right) and 8.32 ± 1.9 mm (left). In present study only height shown statistically significant difference between right and left side.

Conclusion : Measurement of different parameters of JT of occipital bone can be useful for neurosurgeons during pre and intraoperative transcondylar surgical intervention. In addition, it would contribute to anthropometric data available for JT in different population.

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Key words : Jugular Tubercle, Transcondylar Approach, Occipital Condyle, Hypoglossal Canal.

Intra or extra dural any brainstem lesion is a medical emergency and need definite medical attention and intervention when necessary. Surgical exposure of the brainstem is a challenging step for neurosurgeons as Foramen Magnum (FM) is guarded by thick bony prominences and closely related to important neurovascular structures pass through it. Different surgical approaches like lateral transcondylar and its modifications, supracondylar approach, Endoscopic Endonasal Transclival Approach and Extreme Lateral Infrjugular Transcondylar Transtuberular Exposure (ELITE) are being introduced for last few years. These approaches are effective in decreasing the depth of the surgical field and improving visualization by resection of the Occipital Condyle (OC), Jugular Tubercle (JT) and preferably articular facets of the C1 and C2¹⁻⁶. In ELITE, drilling the Jugular Tubercle (JT) can maximise the extent of exposure and removal of JT is critical for optimising access to the inferior and midclival areas, Vertebro-basilar Artery Junction, ventral aspect of pons and medulla⁷.

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Editor's Comment :

- By drilling or removing of Jugular Tubercle (JT), Extreme Lateral Infrjugular Transcondylar Transtuberular Exposure (ELITE) can maximise the exposure of lesions of the brainstem region or nearby neuro-vascular structures like vertebra-basilar arterial junction during surgery. Hence, knowledge of morphometric variations of JT can decrease morbidity of patients after surgery.
- This study measured bilateral height, width and length of JT among the West Bengal population and found a statistically significant difference between height of right and left side.
- The data obtained may be useful to the neurosurgeons as well as for the anthropologists, morphologists and clinical anatomists.

Modified endo scopic transclival approach allows direct access to ventrolateral lesions in the infraclival or petroclival region without brain or cranial nerve retraction. Supracondylar approach is a new addition in this field which is minimally invasive extradural approach to the Hypoglossal Canal (HC) with low risk of morbidity, where the Occipital Condyle (OC) and the lateral osseous circumference of the Foramen Magnum are preserved and drilled extradurally and dorsal parts of the JT are removed. Angle of visualization of ventral aspect of brainstem and it surrounding improved by far-lateral approach. Principal obstacle in the far-lateral approach is Jugular Tubercle, especially when pathology is located in vertebra or in Vertebro-basilar Junction (VBJ)⁸⁻¹².

Additional 2-4mm increase in the operative field from the Foramen Magnum toward the clivus is possible by removal of JT¹³.

Hence, detailed regional anatomical orientation and knowledge of variations of the JT increase safety and reduces rate of morbidity by allowing adequate neurovascular decompression during the surgical approaches.

The purpose of this study is to measure the dimensions of JT, describe its structural variations and pursue a morphometrical analysis of the collected data.

MATERIAL AND METHODS

An observational descriptive morphometric study was performed on 150 dry healthy adult occipital bones collected from the department of Anatomy of different Medical Colleges in Kolkata after getting Institutional Ethical Committee clearance letter. Malformed, unossified or broken bones were excluded. The length, width and height of JT were measured bilaterally with Vernier slide callipers (with the minimum division on the vernier scale measuring 0.02mm. The zero mark on the vernier scale coincided with the zero mark on the main scale, so no correction factor has been used for the vernier scale). Each measurement was taken thrice and the mean value of the three was taken to avoid observer bias. Data was summarized by routine descriptive statistics. Data of various morphometric parameters were expressed with the mean, Standard Deviation, 25th, 75th, 10th, 90th, 5th and 95th percentile value. Key variables were expressed with the 95% confidence intervals. Bilaterality was compared by t-test or Mc Nemar's Chi-square test with the help of Statistica version 6 (Tulsa, Oklahoma: StatSoft Inc, 2001) and MedCalc version 11.6 (Mariakerke, Belgium: MedCalc Software 2011). All variables are normally distributed by Kolmogorov-Smirnoff goodness of fit test (Figs 1-3).

RESULTS

Range, mean ±SD and 95% confidence interval is given in Table 1. Bilateral difference in length and width of JT were found statistically insignificant, whereas show highly significant bilateral variation (paired sample t-test, P<0.0001) in height. Table 2 shows percentile value of JT.

DISCUSSION

Lateral transcondylar

approach is a complicated skull base approach used to access anterior and anterolateral region of brainstem, FM and associated joints. Though different terminologies used for different approaches, but main aim is early exposure of vertebral artery, lateral craniotomy and resection of OC and JT. Extent of resection of the bony parts depends on location of pathology and structural variation in bony prominences in and around FM region⁵.

Dowd, *et al*¹⁴, Spektor, *et al*¹⁵ and Goel A, *et al*¹⁶ reported increase in visual angle for the petroclival region by resection of OC in their research studies. Wu A, *et al* in 2010¹⁷ mentioned about JT Angle (JTA). The angle was measured in a cadaveric study of condylar fossa exposure and 3D CT study. They concluded that if JT and OC were not prominent (JTA>180°) greater petroclival or brainstem exposure was found by condylar fossa approach than transcondylar approach¹⁷. It has also established in various studies that both extra and intradural resection of JT can be performed for management of lesions of the brainstem to gain a wider exposure for which the dimensions of JT will help neurosurgeons a lot¹⁸⁻²⁰.

In the present study length, width and height of JT were measured. Specific bony landmarks for measurement would be helpful to get a reliable assessment by different researchers. In 2006, evaluation of individual structural variations of JT in 100 split occipital bones was done by Mintelis, *et al*. Authors measured the length of JT between the posterior condylar canal and basilar part of the clivus⁷. However, reliability of these landmarks was questionable as condylar canal was not a constant feature of occipital bone. Muthukumar, *et al*²¹

Table 1 — Measurement of Jugular Tubercle (JT) – Whole cohort [n = 150] and bilateral comparison by paired sample t-test

Parameters	Side	Range (Minimum - maximum)	Mean ± SD	95% Confidence Interval (lower limit – upper limit)	P value between group comparisons
Length	Right	9.90 - 18.52	13.79 ± 1.960	13.47 - 14.11	0.7009
	Left	8.18 - 17.12	13.85 ± 1.776	13.56 - 14.13	
Width	Right	6.38 - 13.80	10.15 ± 1.435	9.92 - 10.38	0.9688
	Left	5.60 - 15.00	10.15 ± 1.569	9.90 - 10.40	
Height	Right	4.00 - 11.60	7.57 ± 1.796	7.28 - 7.86	<0.0001
	Left	4.20 - 12.20	8.32 ± 1.867	8.02 - 8.62	

Table 2 — Percentile values of Jugular Tubercle (JT)

Parameter	Side	5th Per	10th Per	25th Per	50th Per	75th Per	90th Per	95th Per
Length	Right	11.64	11.75	12.10	13.42	15.12	16.58	17.82
	Left	10.80	11.67	12.66	14.23	15.02	15.86	16.62
Width	Right	7.26	8.52	9.24	10.23	10.82	12.00	12.26
	Left	7.82	8.42	9.24	10.17	11.06	11.86	12.28
Height	Right	4.94	5.60	6.20	7.29	8.68	10.06	11.18
	Left	5.12	6.00	6.92	8.41	9.24	11.31	11.46



Fig 1 — Measurement of length of Jugular Tubercle (JT)

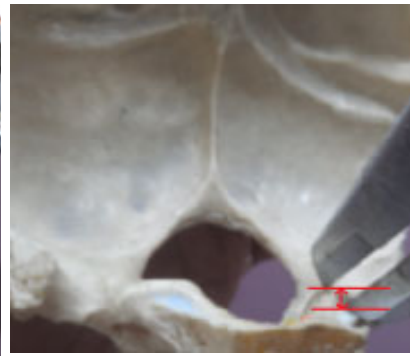


Fig 2 — Measurement of width of Jugular Tubercle (JT)



Fig 3 — Measurement of height of Jugular Tubercle (JT)

demonstrated that presence of condylar canal was only in 60% in their study specimens. Wu A, *et al* also reported absence of posterior condylar foramen in 27% of specimen unilaterally and in 17% bilaterally in their research work in 2010. So, instead of taking this as a reference point they took measurement of the JT length between the anterior and posterior regions where the prominence of tubercle flattens¹⁷. In the present study we followed author Wu A, *et al*¹⁷ at the time of measurement of the same.

The thickness or height was measured according to the points of the imaginary lines drawn perpendicular to the width and the length by Avci E, *et al*⁶. Mintelis and his colleagues⁷ measured the JT width as the maximum distance between the anterior border of the hypo-glossal canal and the anterior infrajugular point. Above mentioned same procedures were followed in present study for the measurements of mentioned parameters.

Avci E, *et al*⁶ in 2011 observed on thirty dry skulls (dried specimens, 60 sides) and ten formalin-fixed cadaveric heads with perfused vessels, were carried out to define the microsurgical anatomy of the FM region. Morphometric analysis and variations of the FM, OC, JT and Hypoglossal Canal (HC) were noted. Radiological assessment (3D-computed tomography) of the OC, JT, HC were also conducted on dry skulls. The short and long OC were demonstrated in 5% and 33% of the specimens, respectively. Flat formation of the JT was determined in 10% and tall JT was found in 23% of the specimens. The comparison of the anatomical measurements and the correspondent radiological mean values did not achieve statistical significance. The OC and JT are the main bony prominences obstructing the anterolateral surface of the brainstem. Neurosurgeons should be familiar with

variations of the structures surrounding the FM in order to perform the safest and widest exposure possible⁵.

Result of the Study by Mintelis, *et al*⁷ showed mean length of the JT was 1.65 ± 0.36 cm (range 1.2–3 cm); its mean width was 1.15 ± 0.16 cm (range 0.7–1.7 cm); and its mean thickness was 0.61 ± 0.15 cm (range 0.2–1 cm). The authors analysed the difference in morphometric data with regard to right and left sides and found no statistically significant difference between the two sides. Furthermore, data from the morphometric study were compared with the results of 20 measurements obtained from three-dimensional computed tomography (3D CT) scans. Accordingly, the mean length of the JT was 1.35 ± 0.15 cm (range 1–2.8 cm); the mean width, 1.10 ± 0.12 cm (range 0.8–1.3 cm); and the mean thickness, 0.51 ± 0.18 cm (range 0.2–1 cm). they concluded that morphometric data on the JT contribute significantly to the neurosurgeon's task of skull base drilling. The 3D CT scans were useful in the preoperative planning⁷.

Table 3 shows that mean values are different in each study for JT. length of JT is higher in study by Mintelis A, *et al*⁷ than other studies but width and height were showing lower value in comparison to others. The above table shows that mean height of JT of right side of present study is close to that of done by Avci E, *et al*⁶. But, in their study bilateral difference was non-significant whereas, in present study the mean of left side is much higher (8.32mm with SD 1.867) than that of the right side (7.57mm with SD 1.796). and was found statistically significant difference in height ($P < 0.0001$).

Table 3 — Comparison of measurements of Jugular Tubercle (JT) explored in studies (Anatomical) conducted in different countries

Parameters (mm)	Mintelis A, <i>et al</i> (2006)	Avci E, <i>et al</i> (2011)		p-value	Present study (2022)		p-value
		Right	Left		Right	Left	
Length of JT	16.5±3.6	15.4±1.24	15.3±1.32	0.8004	13.79±2.0	13.85±1.7	0.7009
Width of JT	11.5±1.6	9.6±1.2	9.5±1.2	0.8965	10.15 ±1.6	10.15± 1.4	0.9688
Height of JT	6.1±1.5	7.8±2.3	7.6±2.2	0.5447	7.57± 1.8	8.32± 1.9	0.0001

CONCLUSION

Different surgical approaches are being increasingly used to access lesions ventral to the brainstem and cervico-medullary junction. Majority of these approaches demand resection of the JT partially or completely. The dimensions and orientation of the JT may influence the surgical approach in the lesions of craniovertebral junction. So, a sound knowledge and understanding of the bony anatomy and variations of this region is important for these approaches. The purpose of the present study was to conduct a morphometric analysis of the JT. Present study found statistically significant difference between right and left side in height of JT ($P < 0.0001$).

Different investigators reported variable morphometry of JT. These variations may be due to different sample and methods of data assimilation and also genetic endowment of different populations. The data obtained may be of useful to the neurosurgeons. The data can give us idea about the amount of bone that can safely be removed without disturbing the hypoglossal canal and giving a wide exposure on different approaches. The findings are also enlightening for the anthropologists, morphologists and clinical anatomists.

The major limitation of this study is the lack of knowledge regarding the age and gender of the bony specimens. So, gender dimorphism could not be elicited if any. Present study was based on dry bone specimen with limited sample size. In future there is a scope for extension of this study with larger sample size and comparison of the data with cadaveric specimen as well as radiological specimens to get more precise and complete result.

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