Rizvi SSA et al. GAIMS J Med Sci 2025;5(1) (Jan-June):101-108
Online ISSN: 2583-1763

Original Research Article

Morphometric Analysis of Human Occipital Condyle and its Clinical Significance

Shaheen Sajid Abbas Rizvi*, Sharadkumar Pralhad Sawant

Department of Anatomy, K. J. Somaiya Medical College, Somaiya Ayurvihar, Eastern Express Highway, Sion, Mumbai, India
* Correspondence: Dr Shaheen Sajid Abbas Rizvi (rizvishaheen68@gmail.com)

ABSTRACT

Background: There are several approaches to operate on brainstem and craniovertebral lesions and involve a resection of occipital condyles (OC). Morphological assessment of occipital condyles, aids in determining the extent and direction of condylar drilling, helping to prevent occipito-cervical destabilization and accidental damage to the neurovascular structures related here.

Aim: To analyze the morphometry of occipital condyles and the frequency of occurrence of different morphological types of occipital condyles and its clinical significance.

Materials and Methods: 100 dry human skulls were studied in the Department of Anatomy, K. J. Somaiya Medical College, Mumbai. The dimensions of the occipital condyles, including their length, width, height and shape were measured. In addition to this, the anterior and posterior intercondylar distances and the distance from the posterior end of the occipital condyle to the hypoglossal canal were recorded using digital Vernier calipers. Paired 't' test was used for significance between the length, width and height of occipital condyles with that of its sides (right and left respectively).

Results: The mean measurements of the occipital condyles in terms of length, width, and height were identified as 23.52, 23.13 and 9.49 mm respectively. As the value of p was less than 0.05, the differences between right and left side were insignificant. The average anterior intercondylar distance and posterior intercondylar distance was found to be 21.16 mm and 43.35 mm respectively. Commonest shape seen was oval in 38% of skulls followed by "S" shaped condyle in 22% skulls. On an average, the hypoglossal canal was positioned 8.78 mm from the posterior end of the occipital condyles.

Conclusions: These results confirm the variability in different parameters of occipital condyles. The safest area of the occipital condyles to be resected is maximum up to 12mm from the posterior end because there is no location for the hypoglossal canal orifice.

Key Words: Craniovertebral lesions, Hypoglossal canal, Intercondylar distance, Occipital Condyles

INTRODUCTION

The occipital condyles (OC) are two prominent, distinctive bony projections at the base of the skull, just anterolateral to the foramen magnum. They form the only articulation between skull and vertebral column by articulating with the superior articular facets on the lateral masses of the atlas as Atlantooccipital joint. Each occipital condyle is angled obliquely, with its anterior end positioned proximal to the midline and presents a convex anteroposterior surface.[1] The hypoglossal nerve canal is positioned obliquely at the anterolateral margin of the foramen magnum, near the caudal end of the medulla oblongata. The inferior vermis, and the tonsils of the cerebellum are located in proximity to the occipital condyles. Also 9th to 12th cranial nerves and important blood vessels such as the vertebral artery, some dural venous sinuses, emissary veins and internal jugular

veins are also closely related to it. The stability of the atlantooccipital joint is influenced by morphological features of the occipital condyles such as their shape, size and angle. The stability is maintained by congruency of the articular surfaces along with the capsulo-ligamentous factors which permit flexion and extension.[2] Information of the neurovascular structures situated in the vicinity of the occipital condyles is indispensable while conducting neurosurgical procedures. Morphometric analysis of the occipital condyles is useful in decisions regarding extent and direction of condylar drilling to avoid occipito-cervical destabilization and inadvertent injury to the neurovascular structures of the hypoglossal canal. Concepts of this knowledge should be one of the main issues to be analyzed during the preoperative decision-making process.[3] Most of the descriptions found in textbooks do not deal with anatomical variations of the occipital condyles. Numerous anatomical studies in the literature highlight the significance of morphometric variations in the occipital condyles and radiological studies have also been conducted.[4] But very few studies have been done on the Indian population. To minimize morbidities during transcondylar, supracondylar, and para-condylar surgical approaches for lesions ventral to brainstem, it is imperative to understand the linear measurements of the occipital condyles.[5] This suggests that further research on the morphological variations of the occipital condyles is still necessary.

AIMS AND OBJECTIVES

To analyze the morphometry of occipital condyles and the frequency of occurrence of different morphological types of occipital condyles and its clinical significance.

MATERIAL AND METHODS

In the present study 100 dry human skulls were studied in the Anatomy Department, Karamshi Jethabhai Somaiya Medical College & Research Centre, Sion, Mumbai. The skulls with any pathology or damage in the region of occipital condyles were excluded. The dimensions of the occipital condyles, including their length, width, height and shape were measured. In addition to this, the anterior and posterior intercondylar distances and the distance from the posterior end of the occipital condyle to the hypoglossal canal were recorded using digital Vernier calipers. The configuration of the occipital condyles was also observed and recorded. All the data was recorded on to MS excel and statistical analysis compared the measurements between the right and left sides. The average mean and standard deviation were calculated for every measurement. Paired t test was used for significance of the length, width and height of occipital condyles with that of its sides (right and left respectively).

RESULTS

The mean measurements of the occipital condyles in terms of length and width were identified as 23.52 mm ± 2.34 (right) and 23.13 mm ± 1.83 (left) respectively. The mean height was determined to be 9.08 mm ± 1.52 on the right and 9.90 mm ± 1.56 on the left. As the value of p was less than 0.05, the differences between right and left side were insignificant. The anterior intercondylar distance and posterior intercondylar distance was found to be 21.16 mm ± 2.64 and 43.35 mm ± 3.36 respectively. The values obtained are summarized in Table-1 and Figure-1. Also, longer and wider occipital condyles were observed in 42% of skulls, shorter condyles were observed in 26% and moderate sized condyles were observed in the remaining 32% skulls. The occipital condyles were observed to be of varied shapes, convex downward and long axes directed forward and medially. Types of shapes of occipital condyles and their percentage of occurrence have been given in Table-2. Commonest shape was oval seen in 38% of skulls followed by "S" shaped condyle observed in 22% skulls. The hypoglossal canal was located at an average distance of 8.85 mm (Range= 5.5 to 12.2 mm) on the right side and 8.72 mm (Range = 5.2 to 11.79 mm) on the left side from the posterior tip of the occipital condyles.

Table-1: Showing the linear measurements of all dimensions of the occipital condyles

Dimensions	Side	Mean ± SD	Range	t-test
Length of occipital condyle	Right	23.52 mm ± 2.34	14.4-29.32	0.915
	Left	23.13 mm ± 1.83	13.37-28.63	
Width of occipital condyle	Right	12.11 mm ± 1.55	7.6-16.8	0.913
	Left	11.88 mm ± 1.62	7.25-16.10	
Height of occipital condyle	Right	8.36 mm ± 1.52	6.05-12.0	0.891
	Left	8.50 mm ± 1.56	6.52-12.37	
Anterior intercondylar distance	-	21.16 mm ± 2.64	14.29-25.18	-
Posterior intercondylar distance	-	43.35 mm ± 3.36	35.52-49.13	-
Posterior tip of occipital condyles to hypoglossal canal	Right	8.85 mm ± 1.6	5.8-12.0	0.046
	Left	8.72 mm ± 1.5	5.9-11.79	

Table-2: Percentage of distribution of shape of occipital condyles

Types of shape	Percentage distribution
Oval	38
'S' shaped	21
Ring	13
Reniform/Kidney shaped	11
Deformed	8
Figure of '8' shaped	7
2 - portioned	2
Total	**100**

DISCUSSION

Outcomes of this study reveal a variability in the morphometry of occipital condyles. In our study of the Indian population, the most commonly observed shape of the occipital condyles was oval (38%) followed by "S" shape (21%) and least common is two-portioned (2%), results summarized in Table-2. Our findings align with those of Naderi et al., who reported that oval-shaped occipital condyles were the most common type, observed in 50% of skulls. In contrast, Fetouh and Awadalla et al. identified kidney-shaped condyles as the most prevalent type, accounting for 22% of their study population. The shape of the occipital condyles is genetically determined but may also be influenced by the use of the atlantooccipital joint, which can vary according to age, gender, and occupation.[6] Our study found that the length of the occipital condyles ranged from 13.37 to 28.63 on left side and 14.4 to 29.32 mm on right side which was similar to the measurements observed in studies of other authors, Dowd et al[7] reported a length of 30 mm. Naderi et al[8] classified occipital condyles according to the length as follows: Type 1 (short): Condyles shorter than 20 mm. Type 2 (moderate): Condyles between 20–26 mm. Type 3 (long): Condyles longer than 26 mm. The width of the occipital condyle in our study ranged from 7.25 to 16.10 mm on left side and 7.6 to 16.8 mm on right side. It was comparable with results from other studies. The length and width of the occipital condyle are essential factors required for occipital condylar resection.[9] Occipital condyles that were longer and wider were observed in 42% of skulls, which could be gender determined as males have larger condyles as compared to females.[10] The height of the occipital condyles varied from 6.52 to12.37 on the left and 6.05 to12.0 on the right. This is consistent with the findings reported by Naderi et al, Fetouh and Awadalla et al[11] and Oliver et al.[12] The anterior intercondylar distance ranged from 14.29 to 25 and posterior intercondylar distance ranged from 35.52 to 49.13 in our study. The intercondylar distances, both anterior and posterior exhibit a wide difference due to a convergence in the anterior part of occipital condyles. These measured distances are similar to distances obtained by Naderi et al and findings of Fetouh and Awadalla. This result is significant during neurosurgeries as extensive bony removal during condylectomy may become essential owing to the anteroposterior alignment and a narrow intercondylar space. Wider intercondylar distances provide more advantages for accessing the foramen magnum without being detrimental to vital structures. The larger the distance, more the space available for posterolateral approaches.[13] Dowd et al proposed that the intercondylar distances, both anterior and posterior could be used in gender determination of unknown skulls due to the higher significant values in males than females, in their sample.[7] In the present study, the hypoglossal canal was found to be located at an average distance of 8.85 mm ± 1.6 mm on the right and 8.72 mm ± 1.5 mm on the left with a range between 5.9 to 12 mm. A study by Issac et al (2018)[14] on the Kenyan Population showed a distance of 9.62 mm. Higher distances up to 12.2 mm have been reported by Muthukumar et al., 2005[15] on Indian population, Pereira et al, 2012[16] on Brazilian population and Saeid et al, 2015[17] on Iranian population. The optimal area for resection of the occipital condyle is a maximum of 12 mm from the posterior end, as this region does not contain the opening of the hypoglossal canal. This will aid in minimizing hypoglossal nerve palsies.[18] The findings of this study align with those of previous research focusing on cranio-vertebral junction anatomy and particularly on occipital condyle anatomy. These results confirm the variability in occipital condyle parameters like length, width, height, anterior and posterior inter condylar distances and shape of occipital condyles (Table-3 and Graphs 1-4).

Table-3: Comparison of Data in different studies

	Length	Width	Height	AID	PID
Oliver (1975)	23.7	11.5	8	-	-
Naderi (2005)	23.6	10.5	9.2	21.6	41.6
Kizilkanat (2006)[19]	24.51	13.11	-	22.6	44.2
Fetouh (2009)	23.62	13.6	9.57	-	-
Anilkumar (2014)[20]	24.4	13.54	8.98	17.67	42.02
Roopashree (2019)[21]	21.64	10.06	6.15	19.41	37.36
Present (2023)	23.32	11.99	8.44	21.16	43.35

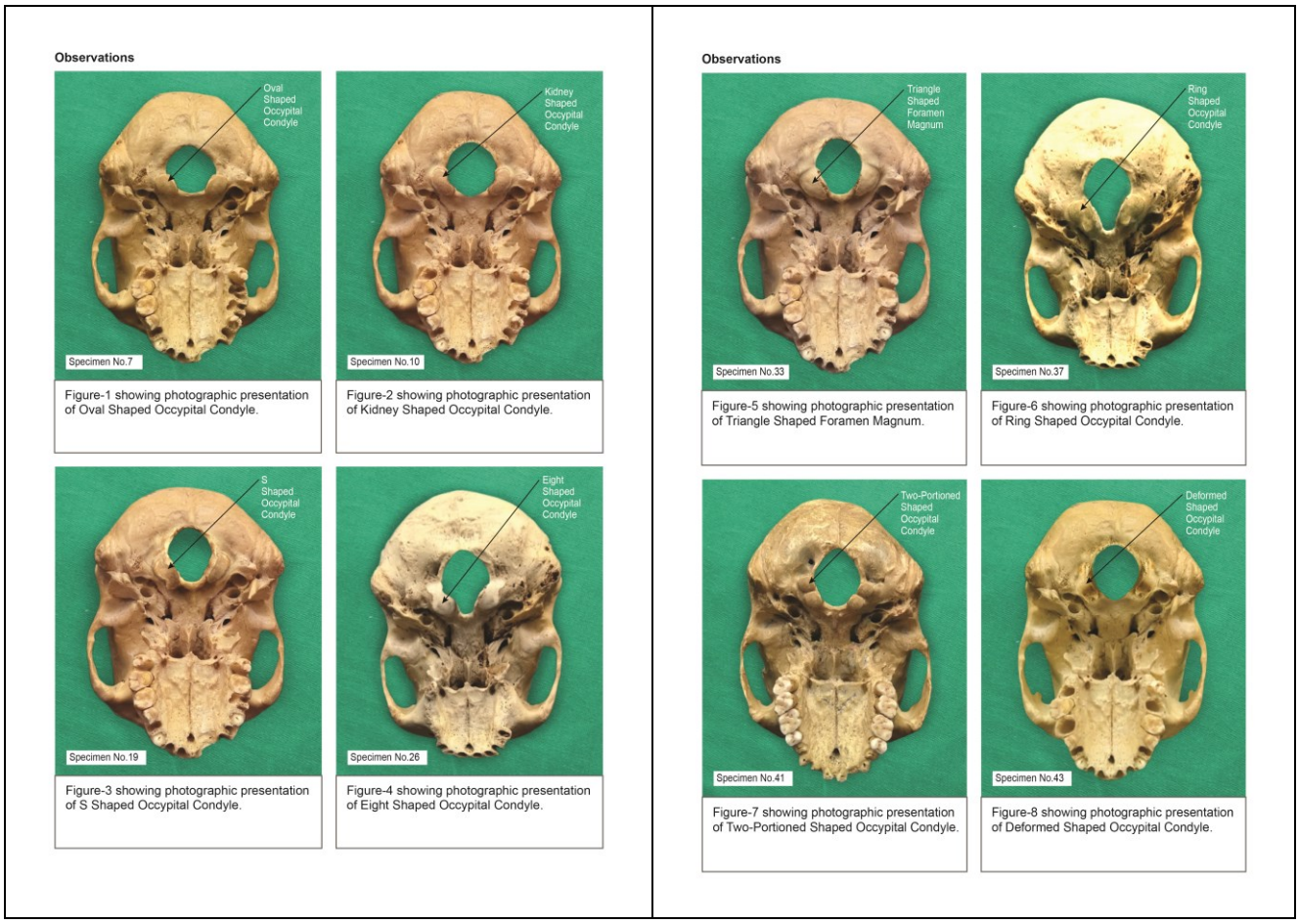
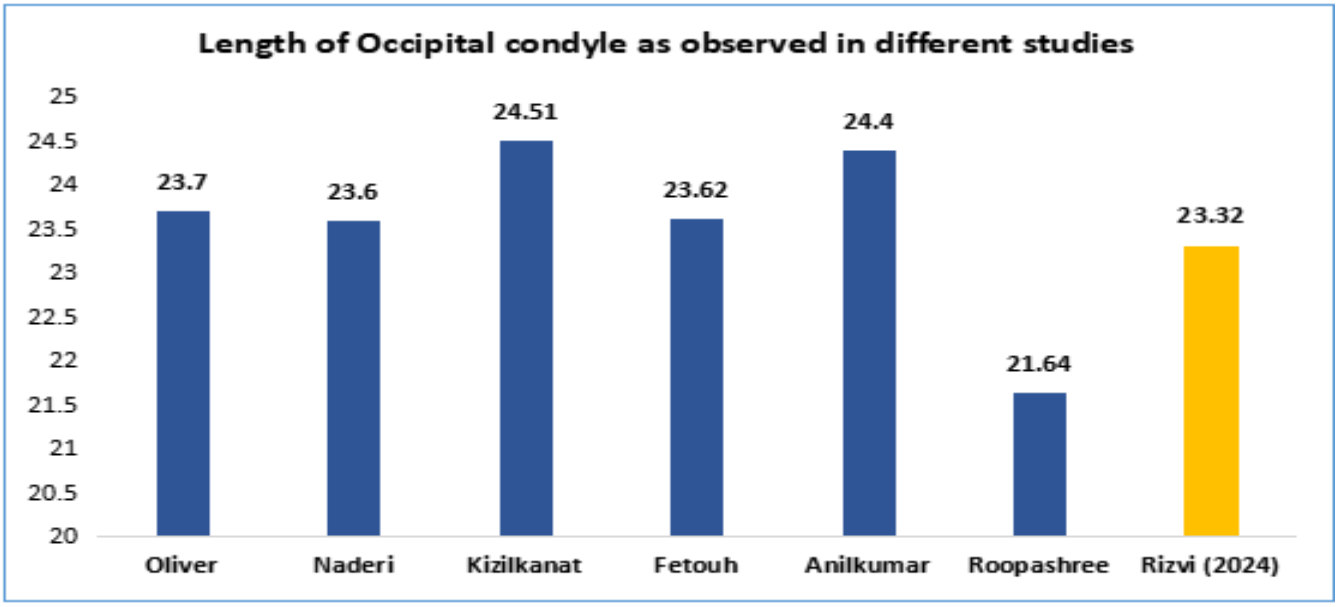
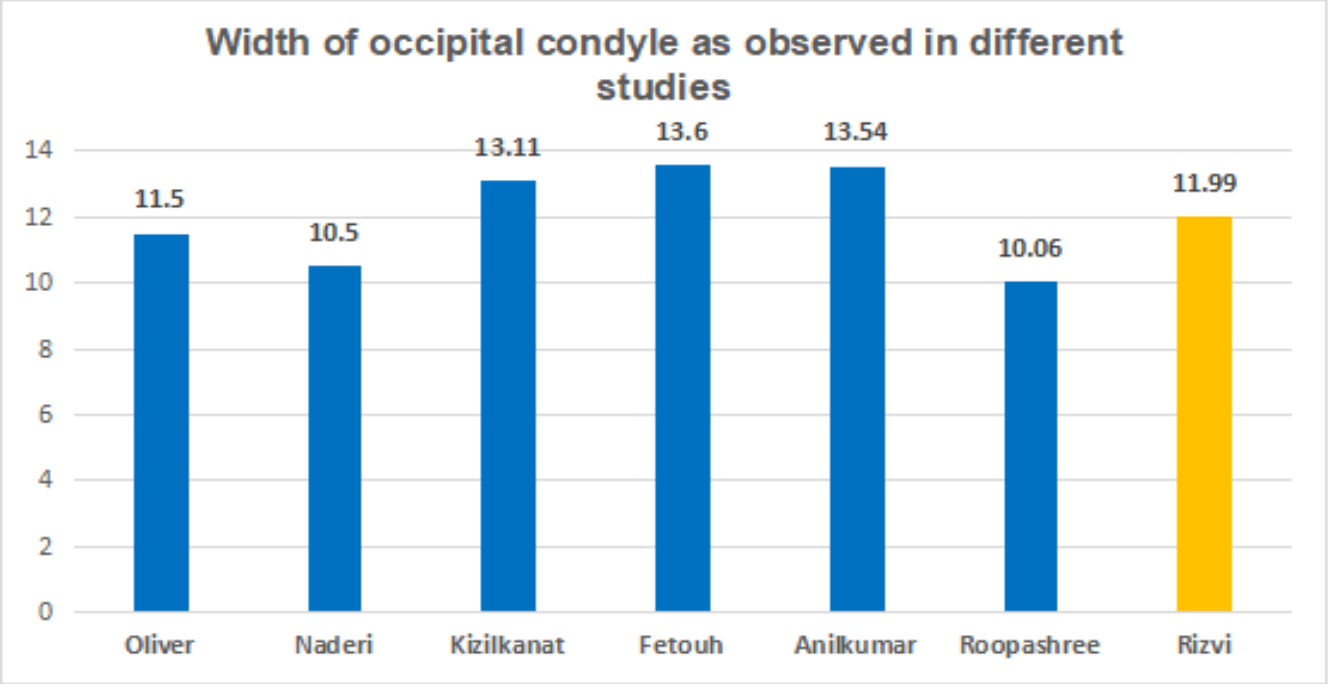


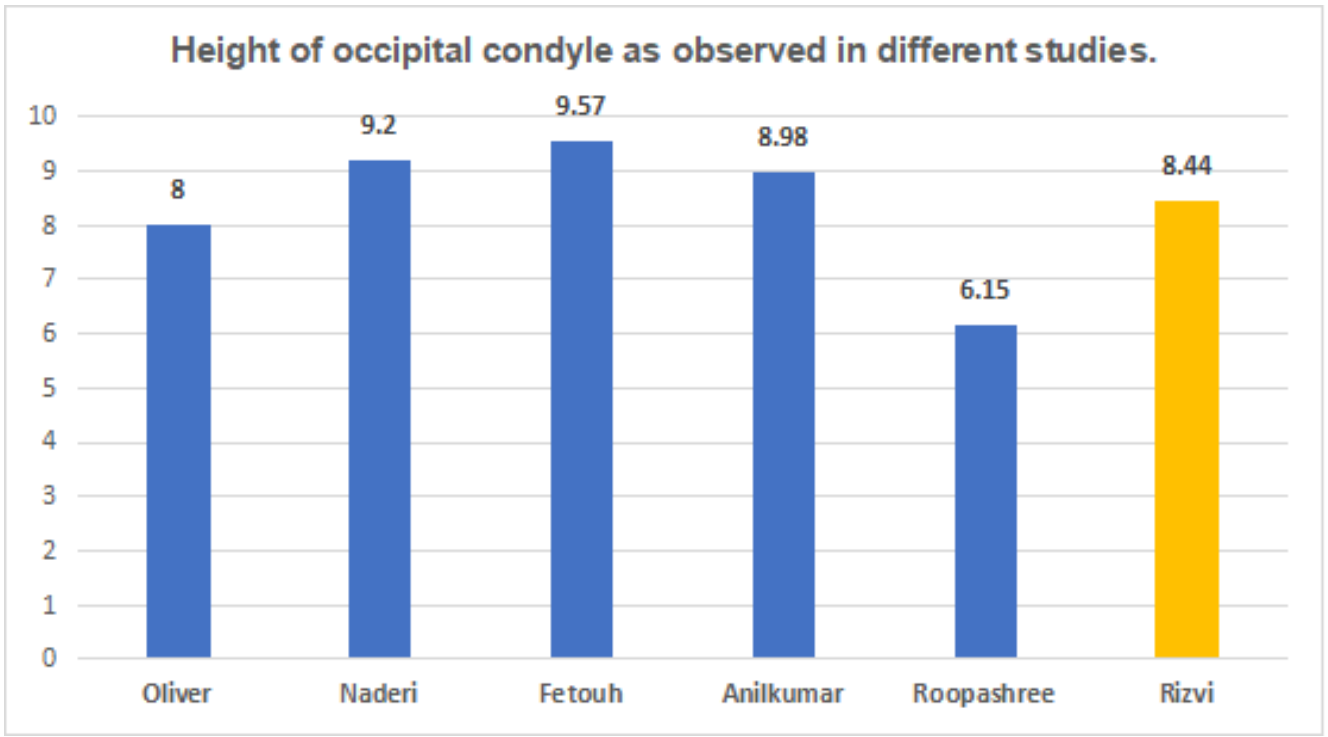
Figure-1: Photographic presentation of shape of occipital condyles



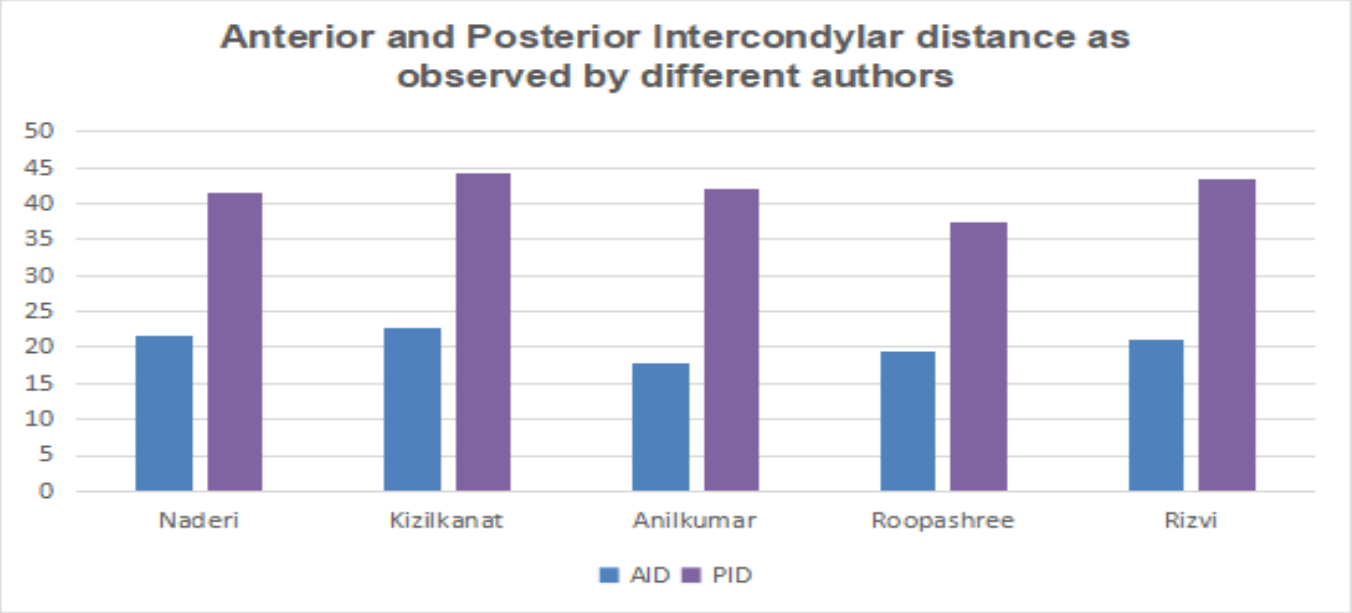
Graph-1: Length of occipital condyles (mm) as observed in literature



Graph-2: Width of occipital condyles (mm) as observed in literature



Graph-3: Height of occipital condyles (mm) as observed in literature



Graph-4: The distances between the anterior and posterior condyles (mm) as observed in literature

CLINICAL SIGNIFICANCE

Extradural and intradural tumors and vascular malformations such as meningioma, schwannoma, brainstem gliomas, subarachnoid cysts, and vertebral artery aneurysms frequently found at the base of the skull, near the foramen magnum. Craniovertebral area is a complex area associated with significant mortality and morbidity rates during surgery and in the postoperative period. There are several approaches to operate on brainstem and craniovertebral lesions, like trans-facetal, partial transcondylar, complete transcondylar, extreme lateral trans-jugular, retro-condylar, trans-tubercular. For all these approaches a morphological assessment of occipital condyles would become very vital as they involve a resection of occipital condyles.[22] Transcondylar approach (TA), which involves partial condylectomy by drilling the posterior region of the occipital condyle is increasingly being used to access brainstem lesions because it expands the surgical field of view and minimize nerve tissue retraction.[23] Relatively longer or wider condyles require greater resection to enhance visualization of the ventral portion of the brainstem during the transcondylar approach. Smaller the occipital condyles, probability of occipito-cervical instability may increase following resection.[24] For pre-planning of transcondylar approach an adequate information of the morphometry of the condyles is critical to avert damage to neurovascular structures related to it. Occipital condylectomies can also be the source of hypoglossal nerve injuries owing to varied extent of the occipital condyles and location of the hypoglossal canal in relation to the posterior end of occipital condyles. Understanding the measurement and shape of the occipital condyles and the location of the hypoglossal canal may offer valuable insights for determining the extent and direction of condylar drilling so as to evade occipito-cervical destabilization and unintentional damage to the neurovascular structures of the hypoglossal canal.[25,26] Analyzing the morphology of the bones that form the neurocranium and viscero-cranium is important in forensic anthropology and is vital for determining the sex, age, ethnicity, and height of unidentified individuals.[27]

CONCLUSIONS

These findings validate the variability in the dimensions of the occipital condyles like length, width, height, anterior and posterior inter condylar distances and shape of occipital condyles. Craniovertebral area is a complex area involving significant mortality and morbidity rates during surgeries and postoperatively. There are several approaches to operate on brainstem and craniovertebral lesions, involving a resection of occipital condyles, hence a morphological assessment of occipital condyles is vital to avert damage to neurovascular structures related here. The safest region of the occipital condyles for resection extends up to 12 mm from the posterior end, as there is no hypoglossal canal orifice in that area.

REFERENCES

1. Williams PL. Gray's Anatomy. The Anatomical Basis of Medicine and Surgery. 38th ed. London: Churchill Livingstone; 1995. p. 582-5.

2. Frazer JE. The Anatomy of Human Skeleton. 4th ed. London: J. and A. Churchill Ltd.; 1946. p. 173.

3. Mahajan, D. Agnihotri, G. Sheth, A. & Brar, R. (2013). An anatomical perspective of human occipital condyles and foramen magnum with neurosurgical correlates. Anatomy, 7 (1), 29-33. DOI: 10.2399/ana.11.141.

4. Noble ER, Smoker WR. The forgotten condyle: the appearance, morphology, and classification of occipital condyle fractures. AJNR Am J Neuroradiol. 1996 Mar;17(3):507-13. PMID: 8881246; PMCID: PMC8337992.

5. Faisal Siddiqui H, Cardona JJ, Chaiyamoon A, Gilkes A, Rajaram-Gilkes M, Keshavarzi S, Iwanaga J, Dumont AS, Tubbs RS. Angulation Between the Occipital Condyle and the Hypoglossal Canal: An Anatomical Study with Application in Transcondylar Approaches and Occipital Condyle Screw Placement. Cureus. 2022 Dec 8;14(12):e32326.

6. Bello SS, Zagga AD, Kalale SB, Usman JD, Bello A, Abdulhameed A. 2013. Measurements of occipital condyles using computerised tomography from Sokoto State, Nigeria. Int J Health Med Inf.2:10-7.

7. Dowd GC, Zeiller S, Awasthi D. Far lateral transcondylar approach: Dimensional anatomy. Neurosurgery. 1999; 45:95–9.

8. Naderi S, Korman F, Citak G, Guvencer M, Arman C, Senoglu M, Tetik S, Arda MN. Morphometric analysis of human occipital condyle Clin Neurol Neurosurg. 2005;107(3):191–99.

9. Gökce C, Cicekcibasi AE, Yilmaz MT, Kiresi D. 2014. Morphometric analysis of bone structures in major subjects' skull base live by multidetector computed tomography. International Journal of Morphology, 32:812–821.

10. Cicekcibasi AE, Murshed KA, Ziylan T, et al. morphometric evaluation of some important bony landmarks on the skull base related to sexes. Turk J Med Sci. 2004; 34: 37–42.

11. Fetouh F A, Awadalla AM. Morphometric analysis of the occipital condyle and its surgical implications in transcondylar approach Skull base. 2009:19–A023

12. Oliver G. Biometry of the human occipital bone J Anat. 1975; 120: 507–518.

13. D. Refai, J. H. Shin, C. Iannotti, and E. C. Benzel. Dorsal approaches to intradural extramedullary tumors of the craniovertebral junction. J. of Craniovertebr. Junction and Spine 2010;1(1): 49-54.

14. Isaac Cheruiyot, Phillip Mwachaka, Hassan Saidi; Morphometry of occipital condyles: Implications for transcondylar approach to craniovertebral Junction lesions; Anatomy Journal of Africa. 2018. Vol 7 (2): 1224 – 1231.

15. Muthukumar N, Swaminathan R, Venkatesh G, Bhanumathy SP. 2005. A morphometric analysis of the foramen magnum region as it relates to the transcondylar approach. Acta Neurochirurgica, 147:889–895.

16. Pereira GAM, Lopes PTC, Santos AMPV, Duarte RD, Piva L, and Pozzobon A. 2012. A morphometric analysis related to the transcondylar approach in dry skulls and computed tomography. International Journal of Morphology, 30(2):399-404.

17. Saeid B, Parvindokht B, Rez D. 2015. Morphometric analysis of hypoglossal canal of the occipital bone in Iranian dry skulls. Journal of Craniovertebral Junction and Spine, 6:111.

18. Barut N, Kale A, Turan Suslu H, et al. Evaluation of the bony landmarks in transcondylar approach. Br J Neurosurg. 2009; 23(3): 276–281.

19. Kizilkanat E. D, Boyan N, Soames R, Oguz O. Morphometry of the hypoglossal canal, occipital condyle and foramen magnum. Neurosurg.Q.,2006;16(3):121-5.

20. Anil Kumar, Mahindra Nagar. Human adult occipital condyles: morphometric study. Research and Review: Journal of Medical and health sciences., 2014;3(4):112-116.

21. Roopashree Ramakrishna, Azra Mubeen, Adil Ahmed Karnul, Balachandra N. Morphometric analysis of the occipital condyles and their correlation with hypoglossal canal in dry skulls of South Indians. Int J Anat Res 2019;7(1.2):6154-6160.

22. Shima and Islam. Morphometric Study of Human Adult Occipital Condyle, Hypoglossal Canal and Foramen Magnum in Dry Skull of Modern Egyptians. International Journal of Clinical and Developmental Anatomy, 2018;4(1):19-26.

23. Sahoo S, Giri SK, Panda SK, Panda P, Sahu MC, Mohapatra C. 2015. Morphometric analysis of the foramen magnum and the Occipital condyles. International Journal of Pharmaceutical Sciences Review and Research, 33:198–204.

24. Bayat P, Bagheri M, Ghanbari A, Raoofi A. Characterization of occipital condyle and comparison of its dimensions with head and foramen magnum circumferences in dry skulls of Iran. Int. J. Morphol., 2014;32(2):444-8.

25. Banerji D. 1999. Extreme lateral transcondylar approach to the skull base. Neurology India, 47:22–30.

26. Guidotti A. Morphometrical consideration on occipital condyles. Anthropol Anz. 1984; 42:117–19.

27. Bozbuga M, Ozturk A, Bayraktar B, Ari Z, Sahinoglu K, Polat G. Surgical anatomy and morphometric analysis of the occipital condyles and foramen magnum Okajimas Folia Anat Jpn. 1999; 75:329–34.

Source of support: Nil

Conflict of interest: None declared

How to cite: Rizvi SSA, Sawant SP. Morphometric Analysis of Human Occipital Condyle and its Clinical Significance. GAIMS J Med Sci 2025;5(1):101-108.

https://doi.org/10.5281/zenodo.14498881