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Anatomical Analysis of Occipital Condyle (OC) at the Posterior Part of the Base of the Skull in Dried Skull Bone

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KEYWORDS

Occipital condyle (OC), Skull, morphology, morphometry, shape.

ABSTRACT:

Background: Most anatomical and biomechanical studies on the craniovertebral junction have involved morphological or morphometric analysis on the occipital condyles. Some of these studies have provided important findings based on different surgical procedures. The shape, size and angle of the occipital condyles and the locations of the intracranial and extracranial orifices of the hypoglossal canal are highly important because they may affect the lateral approaches to the craniovertebral junction.

Aim: To morphologically analyze the adult human occipital condyle, estimate the bilateral differences, sexual dimorphism and compare with the available data.

Methodology: A total 150 (86 male and 64 female) dry skulls of adult human being were studied. Anteroposterior diameters (APD) and transverse diameters (TD) of occipital condyle (OC) were calculated using vernier caliper and shapes were visually assessed. Additionally, the area and index of Occipital condyle (OCI)were also calculated using formulae (OCI =Length/Width).

Results: The anteroposterior diameter in right-side Occipital Condyles is 23.1±1.2mm &21.1±1.5mm, in male & female respectively and anteroposterior diameter in right-sideOccipital Condyles is 23.23±1.2mm &21.9±1.5mm, in male & female respectively. Oval shape of right-side Occipital Condyles was commonly seen (32.7%). This was followed by Kidney (20.7%), foot shaped (14.7%), eight shape (10.0%), Quadrangular Shape (6.7%), S-shape (4.7%). The distribution of shape of OC insignificantly distributed in both male and female groups ($p>0.05$). Right-sided Occipital Condyles Anteroposterior Diameter was noted significantly higher in oval, Kidney, Foot Shape, Eight Shapes, S-Shape, and Round Shape in male skulls; while in case of Triangular Shape, Two Portioned and Irregular shape it was lower significantly in male skulls in compare to female skulls.

Conclusion: Our study results will serve as an aid to neurosurgeons in evaluating the morphology of carnio-vertebral junction in lateral transcondylar surgical procedures in case of lesions in the middle and posterior part of cranial base. Our findings are also

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informative for the anatomists, radiologists, orthopaedic surgeon, anaesthetist, forensic experts and anthropologists.

Introduction:

The occipital condyle (OC) is a bony structure lying anterolateral to foramen magnum and connects the cranium to the vertebral column [1]. It articulates with superior articular facets on lateral masses of atlas, forming the atlanto-occipital joint. Stability of this joint is important and is maintained by congruency of the articular surfaces together with capsulo-ligamentous factors. Hypoglossal canal (HC), which runs deep to each condyle, is where the meningeal branch of ascending pharyngeal artery & the hypoglossal nerve (HGN) are transmitted [1, 2]. While performing craniovertebral procedures, the OC's morphology is crucial, especially when accessing lesions including HGN schwannomas, foramen magnum meningiomas, and cervico-medullary hemangioblastomas that are ventral to the brainstem or at the cervico-medullary junction [3]. Because it maximises the surgical field of view and reduces nerve tissue retraction, the transcondylar technique (TA), which comprises partial condylectomy by drilling the posterior portion of the OC, is becoming more and more popular for accessing these lesions [4, 5]. Occipital condylectomies may however complicate with the hypoglossal nerve injuries, or the atlanto-occipital joint instabilities [6. 7]. This been attributed to the variations in dimensions of OC in addition to position of HC relative to posterior tip of OC [8], which might lead to severing of HGN due to perforation of the posterior cortex of HC [5]. Therefore, information on the morphometry of OC and the location of HC may be helpful in determining the amount and direction of the condylar drilling to prevent occipital-cervical destabilisation and unintentional damage to the neurovascular systems of the HC [9]. Convex anteroposterior surface is presented by the occipital condyles, which are oval-shaped bone structures positioned obliquely such that anterior extremity more medial than the posterior extremity [10, 11]. The occipital condyles are situated posterior to the condylar canal. The occipital condyles may occasionally protrude noticeably in direction of the foramen magnum [12]. The canal of hypoglossal nerve located at anterolateral margin of foramen [13]. Rating importance of the morphometric variations of occipital condyles, [10, 11, 12, 12, 14, 15] and the radiological studies also been conducted [16, 17, 18]. When performing neurosurgical procedures (transcondylar approach) and getting excellent outcomes, it is crucial to understand the topography of the various neurovascular systems around the area of occipital condyles. One of the primary things to be examined throughout the preoperative decision-making process should be notions about this knowledge [11, 13, 14, 16].

Therefore, the occipital condyles, located in the posterior region of the skull base in dried skull bone, are the subject of the current study's anatomical examination. It is hoped that the information would be helpful, especially for radiologists, orthopaedicians, and neurosurgeons when making preoperative decisions.

Aim: To analyse morphology & morphometric parameters of occipital condyle (OC) at base of dry human skulls anatomically in male and female skulls for the determination of sex.

Material & Methods

The present morphometric observational study conducted in Department of Anatomy, Index Medical College, Hospital and Research Centre Indore MP, India from January 2022 to December 2023 after approval of Institutional Ethical committee. The study included 150 dry human skulls (86 males and 64 females). Dry fragile Skulls, incomplete or damaged skulls, congenital deformities with the skulls, any pathological changes in skulls and fetal, neonatal & children's skulls, etc. excluded from the study.

The following parameters were measured:

Occipital Condyle

- Different Shapes of the Occipital Condyles were observed while working, 1-Kidney shaped, 2-Oval, 3-Quadrangular, 4-'S' shaped, 5-Two portioned, 6 Eight shaped, 7-Triangular, 8-Round, 9-Deformed, 10-foot Shape.

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- Length of OC (right and left): From its anterior tip to posterior tip.
- Width of OC (right and left): Maximum transverse distance measured at right angles to line joining anterior & posterior tip.

Index of Occipital Condyle: The index was calculated for right and left occipital condyle respectively by dividing length of occipital condyle by width of occipital condyle (Length/Width).

Statistical Analysis

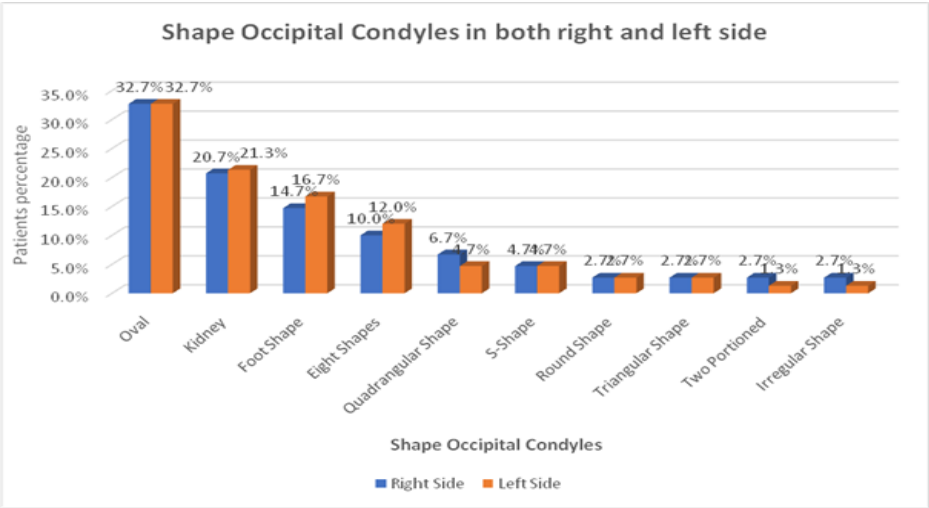
Data was analysed using Statistical Package for Social Sciences, version 20 (SPSS Inc., Chicago, IL). Results for continuous variables was presented as mean±standard deviation, whereas results for categorical variables was presented as frequency/number (percentage). Continuous two independent groups were compared by parametric independent Student's t test. Discrete (categorical) groups were compared by chi-square ($\chi 2$) test. The level $P < 0.05$ was considered as the cutoff value or significance.

Observation & results

The present research is related to physical and morphometric assessment of the human skull base. The study was focused on foramen magnum & occipital condyles, study was carried-out on one hundred fifty dry adult human skulls (86 males and 64 females) i.e., One hundred fifty foramen magnum and three hundred occipital condyles were observed.

In our study, oval shape of right-side Occipital Condyles was commonly seen (32.7%). This was followed by Kidney (20.7%), foot shaped (14.7%), eight shape (10.0%), Quadrangular Shape (6.7%), S-shape (4.7%), but Round Shape, Triangular Shape, Two Portioned and irregular was 2.0% of each type shape. In left side it was also common oval shape seen in 32.7%, followed by Kidney (21.3%), foot shaped (16.7%), eight shape (12.0%), Quadrangular Shape (4.7%), S-shape (4.7%), Round Shape (2.7%), Triangular Shape (2.7%), Two Portioned (1.3%) and irregular (1.3%).

Figure 1: Distribution of Shape Occipital Condyles in right side left side



In the present research the commonest shape of left-side Occipital Condyles is oval shape the percentage is 32.6% in males and 32.8% in females which is almost equal in both male and female groups. Followed by second common shape of FM is kidney shape the percentage is 20.9% in males and 21.9% in females and foot shape the percentage is 16.3% in males and 17.2% in females, Eight Shapes shape the percentage is 10.5% in males and 14.1% in females, which was higher than the values of males. In our study Quadrangular Shape, S-Shape, Round Shape, Triangular Shape, Two Portioned and irregular shape of the left-side Occipital Condyles is less common in both male and female. The distribution of shape of OC insignificantly distributed in both male and female groups ($p>0.05$).

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Table 1: Comparison of the different shapes of OCs of present research of male & female skulls with other researchers.

	Present Study				**KalthurSG et al [19] (%)**		**Asra et al [20] (%**	
	Right Side		**Left Side**					
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Oval	31.4%	34.4%	32.6%	32.8	21.8%	22.5%	40.0%	34.6%
Kidney	20.9%	20.3%	20.9%	21.9	11.8%	11.3%	2.8%	3.7%
Foot Shape	14.0%	15.6%	16.3%	17.2	--	--	--	--
Eight Shapes	10.5%	9.4%	10.5%	14.1	29.0%	22.5%	15.1%	11.1%
Quadrangular Shape	7.0%	6.3%	5.8%	3.1	--	--	5.5%	--
S-Shape	4.7%	4.7%	5.8%	3.1	13.6%	14.8%	2.7%	12.4%
Round Shape	3.5%	1.6%	2.3%	3.1	--	1.4%	1.4%	7.4%
Triangular Shape	1.2%	4.7%	3.5%	1.6	9.0%	10.6%	11.0%	7.4%
Two Portioned	3.5%	1.6%	1.2%	1.6	2.7%	4.9%	2.5%	4.4%
Irregular Shape	3.5%	1.6%	1.2%	1.6	11.8%	11.3%	2.7%	3.7%

In present study, mean anteroposterior diameter of right-side Occipital Condyles was 22.30±1.66mm and mean transverse diameter 12.93±1.12mm. The index of the right-side Occipital Condyles observed was found to be 1.74±0.18. The mean anteroposterior diameter of left-side Occipital Condyles was 22.50±1.66mm and mean transverse diameter 13.23±1.12mm. The index of the left-side OCs observed was found 1.71±0.17.

Table 2: Antero-posterior diameter of OCs in male and female skulls:

Antero-posterior Diameter (mm)	**Right Side**		**Left Side**	
	Male	**Female**	**Male**	**Female**
Oliveira OF et al [21] (2013)	26.74±2.96	25.45 ± 3.21	26.85 ± 2.97	24.65 ± 3.23
Anil Kumar et al [14] (2014)	23. 88±1.5	22.6±1.30	24. 99±1.82	24. 20±1.62
Kalthur et al [19] (2014)	22.8±0.25	21.4±0.29	22.9±0.24	21.6±0.26
Sholapurkar et al [22] (2017)	22.95±2.98	21.07±3.09	22.34±3.35	20.25±2.65
Asra Anjum et al [20] (2021)	23.5±2.71	22.44±2.01	23.34±3.06	22.62±2.41
Present Study	23.1±1.2	21.1±1.5	23.23 ± 1.2	21.9±1.5

The anteroposterior diameter in right-sideOccipital Condyles is 23.1±1.2mm &21.1±1.5mm, in male & female respectively, there is a significant higher APD observed in male & females ($p<0.05$). The anteroposterior diameter in right-sideOccipital Condyles is 23.23±1.2mm &21.9±1.5mm, in male & female respectively, there is a significant higher APD observed in male & females ($p<0.05$).

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Table 3: Transverse diameter of occipital condyles in male & female skulls:

Transverse Diameter (mm)	Right Side		Left Side	
	Male	**Female**	**Male**	**Female**
Oliveira et al [21] (2013)	13.51±1.38	12.68 ± 1.56	13.79 ± 1.39	12.71 ± 1.75
Anil Kumar et al [14] (2014)	12. 97±1.43	12.65±1.33	14. 11±1.01	13.85±1.02
Kalthur et al [19] (2014)	10.5±0.18	12.0±0.23	10.8±0.24	12.2±0.26
Sholapurkar et al [22] (2017)	11.36±1.77	11.43±1.67	11.99±1.31	11.94±1.75
Asra Anjum et a[20] (2021)	12.19±1.53	11.46±1.56	12.29±1.47	11.87±1.45
Present Study	13.0± 1.48	12.7±1.0	13.56 ± 1.74	13.1±1.0

The transverse diameter is 13.0±1.48mm &12.7±1.0mm, in male & female respectively, there is an insignificant higher TD observed in male & females ($p>0.05$). But the index is 1.78±0.17 &1.70±0.17 male & female respectively the value is statically analyzed ($p<0.05$). The transverse diameter is 13.56±1.74mm &13.1±1.0mm, in male & female respectively, there is a insignificant higher TD observed in male & females ($p>0.05$). But the index is 1.73±0.16 &1.68±0.16 male & female respectively the value is statically analyzed p-value is less than ($p<0.05$). **Bayat P et al [15]** found19.43±3.27 (right), 19.28±3.57 (left), 9.21±1.97 (right) 9.40±1.87 (left), 7.21±1.9 (right) and 7.33±2.74 mm (left), respectively. There were significant differences between bilateral occipital condyles in their study.**lhan P et al[23]**observed that the antero posterior and the transverse diameters of FM were 35,17±2,94mm and 29,73±2,53mm, respectively. The intercondylar measures were 41,54±3,78mm for the posterior and 22,47±2,98mm for the anterior. The diameters of OC measured antero posteriorly were 23,47±2,44 mm and transversely were 11,40±1,41 mm. The right side's sagittal intercondylar angle was 31,72±3,48 degrees, whereas the left side's was 33,29±3,25 degrees.**Cheruiyot I et al**[24] reported that AID and PID were 19.66±2.70 mm and 38.52±3.09 mm, respectively, while the mean occcipital condyle length (OCL), width (OCW), and height (OCH) were 20.59±2.05 mm, 12.23±1.28 mm, and 8.65±1.08 mm, respectively.The OC type was primarily moderate in males and short in females ($p=0.001$).**Parmar A, Patel D[25]**observed that the occipital condyles' length, breadth, and height were 23.97 mm, 12.27 mm, and 9.26 mm for the right condyle and 23.36 mm, 12.57 mm, and 9.09 mm for the left.

In present study right-sided Occipital Condyles Anteroposterior Diameter was noted significantly higher in oval, Kidney, Foot Shape, Eight Shapes, S-Shape, and Round Shape in male skulls; while in case of Triangular Shape, Two Portioned and Irregular shape it was lower significantly in male skulls in compare to female skulls. But for Quadrangular Shape of right-sided Occipital Condyles it was showing insignificant differences in both male and female groups. In present study left-sided Occipital Condyles Anteroposterior Diameter was noted higher significantly in oval, Kidney, Foot Shape, Eight Shapes, S-Shape, Round Shape, Two Portioned and Irregular Shape in male skulls; while in case of Triangular Shape, it was lower significantly in male skulls in compare to female skulls. But in case of Quadrangular Shape of left-sided Occipital Condyles it was showing insignificant differences in both male and female groups. In present study right-sided Occipital Condyles Transverse Diameter was noted significantly higher in oval, Eight Shapes, S-Shape, Triangular Shape, and Two Portioned in male skulls; while in case of Quadrangular Shape, Round Shape, and Irregular shape it was lower significantly in male skulls in compare to female skulls. But in case of Kidney and Foot Shape right-sided Occipital Condyles it was showing insignificant differences in both male and female groups. In present study left-sided Occipital Condyles Transverse Diameter was noted significantly higher in Eight

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Shapes, S-Shape, Triangular Shape, and Two Portioned in male skulls; while in case of Quadrangular Shape, Round Shape, and Irregular shape it was lower significantly in male skulls in compare to female skulls. But in case of oval, Kidney and Foot Shape left-sided Occipital Condyles it was showing insignificant differences in both male and female groups. **Bayat P et al [15]**reported that the occipital condyle variations included kidney-like (34.4%), S-like (25.6%), oval (10.0%), ring-like (7.8%), eight-like (6.7%), and malformed (2.2%) morphologies, in that order. 60% of dry skulls had the condylar fossa, 24% had the right side and 36.0% the left, and 60.0% specimens under study had the condylar foramen. While **Aragao JA et al [26]**reported that the "8" and "S" shaped occipital condyles were the most common forms. Right side of male skulls had a higher prevalence of the "S" form compared to the "8" shape. These two categories were bilaterally distributed in the female skulls.

Our study noted that there was a positive significant correlation of APD with both left and right-side Occipital Condyle index; while transverse diameter was showing a negative significant correlation with right-side Occipital Condyle index. But there was insignificant correlation between APD and transverse diameter of right-side Occipital Condyle.

Conclusion:

The mean APD and TD of the occipital condyles are greater in males as compare to the females in both right and left side. Results indicate that expression of sexual dimorphism in the occipital condylar region within the Indian population is demonstrable. Therefore, the use of morphometric values of the occipital condyles in North Indian skeletal populations may be considered in cases of fragmented cranial bases when no other morphogenetic or morphometric method can be utilized for sex determination.

Reference

1. Sinnatamby CS. 2006. Last's anatomy. Regional and Applied. Edinburgh, Churchill Livingstone, 12th Edition, Page 419
2. Standring S, Borley NR, Collins P, Crossman AR, Gatzoulis MA, et al. Gray's Anatomy 40th Ed, London: Elsevier Ltd., 2008. 415,420,424,711
3. Suhardja A, Agur AMR, Cusimano MD. Anatomical basis of approaches to foramen magnum and lower clival meningioma: comparison of retrosigmoid and transcondylar approaches. Neurosurgery Focus, 2003; 14:e9
4. Sahoo S, Giri SK, Panda SK, Panda P, Sahu MC, Mohapatra C. Morphometric Analysis of the Foramen Magnum and the Occipital condyles. Int. J. Pharm. Sci. Rev. Res., July – August 2015; 33(2):198-204
5. Pereira GAM, Lopes PTC, Santos AMPV, Duarte RD, Piva L, and Pozzobon A. A morphometric analysis related to the transcondylar approach in dry skulls and computed tomography. International Journal of Morphology, 2012; 30(2):399-404
6. Sen C, Shrivastava R, Anwar S, Triana A. Lateral transcondylar approach for tumors at the anterior aspect of the craniovertebral junction. Neurosurgery, 2010; 66:104–112
7. Lynch JC, Temponi V, Emmerich JC, Pereira CE, Gonçalves MB. Foramen magnum meningioma: To drill or not to drill the occipital condyle? A series of 12 patients. Surgical Neurology International, 2013; 1(4):73
8. Naderi S, Korman E, Çıtak G, Güvençer M, Arman C, Şenoğlu M, Tetik S, Arda MN. Morphometric analysis of human occipital condyle. Clinical Neurology and Neurosurgery, 2005; 107:191–199
9. Mahajan D. An anatomical perspective of human occipital condyles and foramen magnum with neurosurgical correlates. International Journal of Experimental and Clinical Anatomy, 2013; 6(7):29–33
10. Kavitha S. Chandrasekaran, S.; Anand, A. & Shanthi, K. C. Morphometric study of occipital condyles in adult human skulls. IJCRR,2013; 5(15):31 4
11. Ozer MA, Celik S, Govsa F, Ulusoy MO. Anatomical determination of a safe entry point for occipital condyle screw using three-dimensional landmarks. Eur. Spine J., 2011; 20(9):1510-7
12. Muthukumar N, Swaminathan R, Venkatesh G, Bhanumathy SP. A morphometric analysis of the foramen magnum region as it relates to the transcondylar approach. Acta Neurochir. (Wien), 2005;147(8):889-95

13. Kizilkanat ED, Boyan N, Soames R, Oguz O. Morphometry of the hypoglossal canal, occipital condyle, and foramen magnum. Neurosurg. Q., 12006; 6(3):121-5
14. Kumar A, Nagar M. Human adult occipital condyles: A morphometric analysis. Res. Rev. J. Med. Health Sci., 2014; 3(4):112-6
15. 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
16. Avci E, Dagtekin A, Ozturk AH, Kara E, Ozturk NC, Uluc K, et al. Anatomical variations of the foramen magnum, occipital condyle and jugular tubercle. Turk Neurosurg, 2011; 21:181–190
17. Le TV, Dakwar E, Hann S, Effio E, Baaj AA, Martinez C, et al. Computed tomography-based morphometric analysis of the human occipital condyle for occipital condyle-cervical fusion. J. Neurosurg. Spine, 15(3):328-31, 2011
18. Hong JT, Takigawa T, Sugisaki K, Espinoza Orías AA, Inoue N, An HS. Biomechanical and morphometric evaluation of occipital condyle for occipitocervical segmental fixation. Neurol. Med. Chir. (Tokyo), 51(10):701-6, 2011
19. Kalthur SG, Padmashali S, Gupta C, Antony S. Dsouz Anatomic study of the occipital condyle and its surgical implications in transcondylar approach Journal of Craniovertebral Junction and Spine 2014, 5:15
20. Asra A, Gayathri P, Supriya G, Naveen B , Hajera R, Divya P. Morphology and morphometric study of occipital condyles International Journal of Anatomy and Research, Int J Anat Res 2021, Vol 9(1.3):7905-11
21. Oliveira OF, Tinoco RLR, Daruge JE, Araujo LG, Silva RHA, Paranhos LR. Sex determination from occipital condylar measyrements by baudoin index in forensic porpoises. Int. J. Morphol. 2013,31 (4),1297-1300
22. Sholapurkar VT, Virupaxi RD, Desai SP. Morphometric Analysis of Human Occipital Condyles for Sex Determination in Dry Adult Skulls. International Journal of Anatomy and Research, Int J Anat Res 2017, Vol 5(1):3318-23
23. Pelin I, Busekayhan, Mete E, Gulgun S. Morphological analysis of occipital condyles and foramen magnum as a guide for lateral surgical approaches.MOJ Anat. & Physiol. 2017; 3(6): 00117
24. Cheruiyot I, Mwachaka P, Saidi H. Morphometry of Occipital Condyles: Implications for Transcondylar Approach to Craniovertebral Junction Lesions. Anatomy Journal of Africa. 2018. Vol 7 (2): 1224 – 1231
25. Parmar A, Patel D. Morphometric study of occipital condyle in dry human skull and its clinical importance in Gujarat region. Indian Journal of Clinical Anatomy and Physiology 2019; 098
26. Aragao JA, de Santana GM, da Cruz de Moraes RZ, Sant'Anna Aragão IC, Sant'Anna Aragão FM, Prado Reis F. Morphological Analysis on the Occipital Condyles and Review of the Literature. Int. J. Morphol., 2017; 35(3):1129-1132