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An Anatomical Outlook of Foramen Magnum and Occipital Condyles with Its Clinical Implication in Transcondylar Approach

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A B S T R A C T

Background: The skull base serves as a critical landmark in both anatomical studies and surgical procedures. Foramen Magnum is an oval opening situated at the base of the skull. The inferior margin of foramen magnum has an oval curved articular facet (occipital condyle) on each side of its anterolateral surface. Understanding the bony anatomy of the condylar region is important for transcondylar approach in neurosurgical practices, which is an optimal approach to resect lesions which are ventral to the brainstem and cervico medullary lesions.

Aims and Objectives: The aim of this study was to conduct a morphometric analysis of occipital condyles and foramen magnum as it pertains to transcondylar approach.

Methodology: 100 adult skulls were studied from the department of Anatomy. Skulls with a damaged or broken foramen magnum were excluded from this study. Intercondylar distances at anterior, middle and posterior parts were measured. Length and width of occipital condyles on both the sides was also measured using digital vernier caliper.

Results: The mean anterior intercondylar distance was 18.76 ± 4.33 mm, mean middle intercondylar distance 24.22 ± 4.53 mm & mean posterior intercondylar distance was 31.58 ± 3.67 mm. The mean axial length of the occipital condyle was found to be 23.82 ± 3.69 mm on the right side and 23.98 ± 4.36 mm on the left side. The mean axial width was 14.51 ± 3.61 mm and 15.63 ± 3.82 mm on right and left side of the occipital condyles respectively.

Keywords- Morphometry, Foramen magnum, intercondylar distance, occipital condyles

INTRODUCTION

The skull base serves as a critical landmark in both anatomical studies and surgical procedures. Central to this region is the foramen magnum (FM) which allows passage for the medulla oblongata, surrounding meninges, spinal roots of the accessory nerve and the vertebral arteries. The occipital condyles (OC) are anterolateral to the foramen magnum and participate in the articulation of the skull with the cervical vertebral column [1].

The morphology of foramen magnum and occipital condyles play a pivotal role in formulating the transcondylar approach in neurosurgical practices. This approach is particularly effective for resecting lesions located ventral to the brainstem and within the cervico-medullary regions. Transcondylar approach is an extension of basic far lateral approach. The procedure entails a meticulous dissection of the muscles along posterolateral aspect of craniocervical junction, identification of vertebral artery, suboccipital craniectomy with removal of at least half of the posterior arch of atlas and additional resection of posterior portion of occipital condyle (not done is basic far lateral approach). Consequently, the drilling of the condyle and identification of vertebral artery emerge as pivotal steps in this transcondylar extension of far lateral approach. An understanding of the length and width of the occipital condyle along its long axis is instrumental in safely resecting the posterior third of the condyle [2,3].

Anatomical variations in intercondylar distances and occipital condyle measurements have been documented in several studies. For instance, consistent variations in these measurements were observed in a study conducted by Goel and Desai et al. [3], which emphasized the need for an understanding of these variations during surgical planning. Similarly, a comprehensive analysis by Bhatia et al. [4] highlighted the significance of individual anatomy in relation to surgical outcomes and complications. These studies indicate that knowledge of the dimensions at the base of the skull is essential, not just for surgical approaches but also for the development of preoperative imaging strategies and patient-specific surgical templates [4].

With this background this study was designed to perform a morphometric analysis of foramen magnum and occipital condyle, two most prominent structures of cranial base.

MATERIALS AND METHODOLOGY

This study was conducted on hundred adult skulls and occipital condyles obtained from department of Anatomy from various colleges of Mumbai. According to tooth eruption of the skulls, they were accepted as adults. Skulls with a damaged or broken foramen magnum were excluded from this study. All craniometrical measurements of the foramen magnum and occipital condyles were performed by means of a digital vernier caliper with precision of 0.01 mm.

Following parameters were studied:
Intercondylar distance: measured as distance between medial margins of occipital condyles at anterior, middle and posterior parts.
a) Anterior Intercondylar Distance: Distance between anterior tips of right and left occipital condyles
b) Middle Intercondylar Distance: Distance between the most prominent points on the medial borders of the condyles
c) Posterior Intercondylar Distance: Distance between posterior tips of right & left occipital condyles

Occipital condyle dimensions:
a) Length of occipital condyles: Distance between anterior & posterior tips of occipital condyles
b) Width of occipital condyles: Maximum distance along the transverse plane of occipital condyles
Descriptive statistical methods like mean, standard deviation, range were used for depicting and analyzing data. Microsoft word and excel were used to generate graphs and tables.

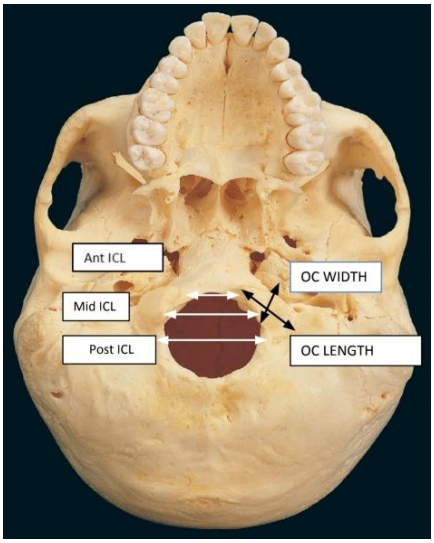

Figure 1: Illustrations showing measurements of intercondylar distances and length and width of occipital condyles
(Ant ICL-Anterior Intercondylar Length, Middle ICL-Middle Intercondylar Length and Posterior ICL-Posterior Intercondylar Length)

RESULTS

Parameters related to foramen magnum were measured in 100 dry adult human skulls of undetermined gender in the present study. Length and width of 100 right and 100 left adult occipital condyles were also measured in present study. All the measurements and observations are mentioned as follows:

Table 1: Measurements of intercondylar distance (mm)

Parameter	Min.	Max.	Mean	S.D.
Anterior Intercondylar Distance	13	33	18.76	± 4.33
Middle Intercondylar Distance	15	39	24.22	± 4.53
Posterior Intercondylar Distance	25	43	31.58	± 3.67

Table 2: Measurements of Occipital Condyles of right and left side (mm)

Parameter	Mean	SD
Rt OC Length	23.82	± 3.69
Lt OC Length	23.98	± 4.36
Rt OC Width	14.51	± 3.61
Lt OC Width	15.63	± 3.82

DISCUSSION

Transcondylar surgical techniques aim to minimize morbidity while maximizing exposure to the critical neurovascular structures within the foramen magnum and lower cranial fossa. The effectiveness and safety of these procedures heavily depend on the surgeon's understanding of cranio-cervical anatomy, including the precise measurements of intercondylar distances. Variations in these dimensions can affect the trajectory of surgical instruments and the positioning necessary for optimal access to deep-seated lesions. Consequently, to enhance surgical techniques and ensure safe access to the skull base, a comprehensive morphometric analysis of the relevant anatomy should be conducted and evaluated.

Knowledge of condylar anatomy helps the surgeon in making important decisions regarding the extent and direction of condylar drilling and minimizing injury and retraction of neural structures [2].

Comparison of our results and results reported in literature regarding length and width of occipital condyle:

Table 3: Comparison of length and width of occipital condyles with previous studies

Sr No.	Study	Year	Length of OC Rt. side	Length of OC Lt. side	Width of OC Rt. side	Width of OC Lt. side
1.	Nadera et al [5]	2005	23.70	23.20	10.60	10.60
2.	Gaurav Agnihotri [2]	2011	22.61	22.36	13.72	13.96
3.	Avic E et al [6]	2011	23.70	24.0	12.20	12.40
4.	S. Kavitha et al [7]	2013	21.97	22.34	13.05	13.03
5.	Archana K. Tale et al [8]	2015	21.83	22.19	11.07	11.42
6.	V. Jasuja et al [9]	2016	22.72	22.86	-	-
7.	Present study	2022	22.82	23.98	14.51	15.63

When compared with findings of Nadera et al. [5] and Gaurav Agnihotri et al. [2] the width of occipital condyles in our sample was somewhat greater. Such variations raise awareness about the potential influence of environmental factors, nutritional status, and genetic backgrounds in shaping cranial anatomy among different populations.

Avic et al. [6] in Turkey conducted a comparative analysis on occipital condyles revealed that width was slightly less and length was slightly greater on both sides than our study. These discrepancies could be attributed to variations in sample populations, including geographic, ethnic, or demographic differences, suggesting that cranial dimensions can exhibit considerable variability between different groups. Vishal Jasuja et al. [9] found axial length measurements comparable to ours but noted a significantly large range of variability.

The differences and similarities noted across these studies emphasize the need for a comprehensive understanding of occipital condyle dimensions, particularly in surgical contexts where precise anatomical knowledge is critical. It is also

vital to consider that variations in the data may also arise from differences in measurement techniques, sample sizes, and the inclusion and exclusion of variables

Comparison of our results with results reported in literature regarding anterior, middle and posterior intercondylar distance.

Table 4: Comparison of Anterior, Middle and Posterior Intercondylar distance with previous studies

S.rN.	Study	Year	Anterior Intercondylar distance	Middle Intercondylar distance	Posterior Intercondylar distance
1.	Nadera et al [5]	2005	21.0 ± 2.8	-	41.6 ± 2.9
2.	Harisudha et al [10]	2010	20.2	-	± 35.8
3.	Anil Kumar et al [11]	2014	17.63	-	± 42.02
4.	Archana K. Tale et al [8]	2015	21.28	-	± 40.61
5.	V. Jasuja et al [9]	2016	18.59 ± 2.96	-	-
6.	Arora et al [12]	2017	17.25 ± 1.91	21.64 ± 2.26	30.66 ± 1.97
7.	Present study	2022	18.76 ± 4.33	24.22±4.53	31.58±3.67

The present study has measured the intercondylar distances, reporting a mean anterior intercondylar distance of 18.76 ± 4.33 mm, a mean middle intercondylar distance of 24.22 ± 4.53 mm, and a mean posterior intercondylar distance of 31.58 ± 3.67 mm. These dimensions are particularly relevant in the context of transcondylar surgical approaches, which are increasingly utilized for accessing the cranio-cervical junction and managing pathologies such as tumors, trauma, and congenital anomalies.

In comparing our findings with previously published studies, several patterns emerge. For instance, Nadera et al. [5] reported anterior and posterior intercondylar distances of 21.0mm and 41.6 mm, respectively. The dimensional data presented by V. Jasuja et al. [9] closely correlates with our results, indicating a developing consensus on cranio-cervical anatomy. This alignment is crucial for enhancing transcondylar techniques. As neurosurgery advances, possessing precise and detailed information about anatomical variations can significantly enhance surgical accuracy and minimize the risk of complications.

It is essential to acknowledge the limitations of this study. The sample size, though substantial, is limited to dry adult skulls, which may not represent living populations. Additionally, variations due to age, sex, and ethnic background were not assessed in this study, and these factors could influence the intercondylar and condylar dimensions. Future research could benefit from a more diverse sample and explore these dimensions in living subjects through imaging techniques such as CT or MRI.

CONCLUSION

The present study gives a morphometric reference of occipital condyle dimensions & intercondylar distance in anterior, middle and posterior part. The data obtained may serve as an aid to neurosurgeons in assessing the morphology of craniovertebral junction in lateral transcondylar surgical approaches for reaching lesions in the middle and posterior part of cranial base. The findings are also enlightening for the anesthetist, radiologists, forensic experts, anatomists and anthropologists. Prospective studies will help surgeons with a proper reference value for determining feasibility of transcondylar surgical approaches.

Conflict of Interest: NIL

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