

MORPHOMETRIC STUDY OF OCCIPITAL CONDYLES IN NORTH INDIAN SKULLS

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ABSTRACT

Introduction: Occipital condyles are two bony elevations present on either side of foramen magnum in the base of the skull which articulates with the superior articular facet of the atlas vertebra, connecting the skull with the vertebral column.

Objectives: Morphometric analysis of occipital condyles is important for the neuro-surgeons operating for the pathology like degenerative changes of the condyles, neoplasms, and trauma. So the aim of the study was morphometric analysis of the occipital condyles and observe any morphological variations of it.

Materials and Methods: The study was conducted on 60 occipital condyles of 30 dry adult skulls. Length, breadth, height, intercondylar distance were measured. Relations of hypoglossal canal with the condyles were noted.

Results: The mean length, width and height of occipital condyle were found to be 1.99 ± 0.33 (right), 2.23 ± 0.33 (left), 1.31 ± 0.28 (right), 1.37 ± 0.27 (left), 0.62 ± 0.17 (right) and 0.62 ± 0.14 cm (left), respectively. The mean anterior intercondylar distance and posterior intercondylar distance were measured as 1.95 ± 0.34 and 3.66 ± 0.28 cm, respectively. Variations of shape of occipital condyle were kidney like (30%), S-like (23.33%), triangular (16.67%), oval (10.0%), eight like (16.7%) and bipartite condyles (3.33%) respectively. The hypoglossal canal was present related to anterior 1/3 of the occipital condyles in 73.33% case.

Conclusions: The shape and morphometric values of occipital condyles are variable. So the knowledge of these variations may guide neurosurgeons in transcondylar approach in the management of neoplasms and other pathology related to this region.

KEY WORDS: Occipital condyles, Morphometry, Transcondylar approach, condylectomy

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INTRODUCTION

Occipital condyles (OC) are present on either aspect of foramen magnum and are related to many important structures which emerge out

from the surrounding foramen such as jugular foramen, hypoglossal foramen and posterior condylar foramen [1].

It articulates with superior articular facets of

atlas to form atlanto-occipital joint. Occipital condyles are considered to be oval in shape. It is aligned obliquely in such a way that the anterior end of it is closer to each other when compared with the posterior end. On the medial aspect of each condyle a large foramen magnum is present which communicates above with the posterior cranial fossa. It contains lower end of medulla oblongata, meninges, vertebral artery, spinal accessory nerve, apical ligament and tectorial membrane [2].

Space occupying lesions like tumours anterior to the spinal cord at the level of foramen magnum can be surgically reached using a ventral or dorsal approach. The ventral approach has a lot of difficulties and a high rate of morbidity thus dorsal and lateral trans-condylar approach becomes important which requires partial or complete resection of the occipital condyles [3-5]. Knowledge of dimensions of occipital condyles and it's relation with neighbouring foramen is important for the neurosurgeons operating in this region.

MATERIALS AND METHODS

The present study was carried out on 60 occipital condyles of 30 dry adult skulls. Damaged and broken skulls were not included. The following parameters of the occipital condyles were measured on both the sides: (Figure no.1)

- 1) Length : Maximum antero-posterior distance
- 2) Breadth: maximum transverse diameter
- 3) Height: distance between upper and lower margin medially
- 4) Anterior inter condylar distance (AICD): between anterior end of both condyles
- 5) Posterior inter condylar distance (PICD): between posterior end of both condyles
- 6) Distance between anterior tip and basion (DAT-B)
- 7) Distance between posterior tip and basion (DPT-B)
- 8) Distance between anterior tip and opisthion (DAT-O)
- 9) Distance between posterior tip and opisthion (DPT-O)
- 10) Location of hypoglossal canal in relation with OC.

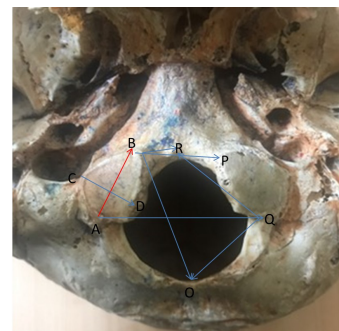
All the measurement were carried three time using vernier calipers and measuring scale and the mean of the three readings was taken as the observed value. The photographs were taken using the digital camera.

The mean and standard deviations were calculated. The comparison of various dimensions of the right and left sides was performed using Student's t-test and p-value was calculated.

RESULTS

The mean length, breadth and height of occipital condyle were found to be 1.99 ± 0.30 , 1.31 ± 0.24 , 0.62 ± 0.17 on the right side and 2.23 ± 0.33 cm, 1.37 ± 0.27 and 0.62 ± 0.14 cm on the left side respectively (Table No.1) (Figure No.1). The mean anterior intercondylar distance and posterior intercondylar distance were measured as 1.95 ± 0.34 and 3.66 ± 0.35 cm, respectively. Variations of occipital condyle shapes were kidney like (30%) (Figure No.4) S-like (23.33%) (Figure No.5), triangular (16.67%) (Figure No.3), rhomboid (8.33%) (Figure No. 2) oval (10.0%), eight like (16.7%) and bipartite condyles (3.33%) (Figure No.6) (Table No.2). The p value was >0.01 . The hypoglossal canal was present related to anterior $1/3$ of the occipital condyles in 73.33% case. In one of the skull occipital condyles of both the sides were having double articular facets and two bony tubercles at the anterior margin of the foramen magnum. (Figure no.6). Articular facet number 1 was roughly oval in shape measuring 2 cm on the right side and 2.3 cm on the left side and articular facet number 2 was round in shape. This was an unusual finding we observed during the study. The movement at the atlanto-occipital joint may be effected due to presence of double articular facet.

Fig. 1: showing measurement of the various dimensions



AB: Length of OC, CD: Breadth of OC, BP: Anterior Intercondylar distance, AQ: Posterior Intercondylar distance, BR: Distance between anterior end and basion, BO: Distance between anterior end and opisthion, QR: Distance between posterior end and basion, QO: Distance between posterior end and opisthion

Fig. 2: showing rhomboidal shape of the occipital condyles.

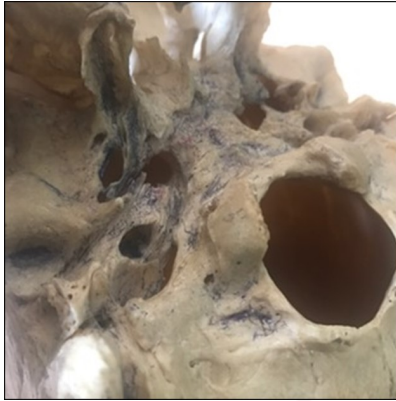


Fig. 3: showing triangular occipital condyles.



Fig. 4: showing kidney shaped occipital condyles.



Fig. 5: showing S shaped occipital condyles.



Fig. 6: showing occipital condyles with double articular facet and 2 bony tubercles at the anterior margin of the foramen magnum.

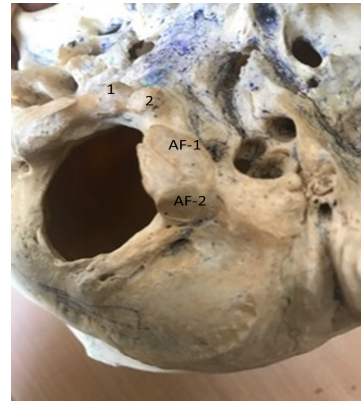


Table 1: Showing various dimensions of the Occipital Condyles (OC).

Parameters		Range (Min-Max) (cm)	Mean (cm)	SD
Length	Right	1.4-2.6	1.99	0.3
	Left	1.7-2.9	2.23	0.33
	Mean	1.4-2.9		
Breadth	Right	0.8-1.7	1.32	0.24
	Left	0.9-1.8	1.37	0.27
	Mean	0.8-1.8		
Height	Right	0.4-1	0.62	0.17
	Left	0.4-0.8	0.62	0.14
	Mean	0.4-1		
Anterior intercondylar distance		1.4-3	1.95	0.34
Posterior intercondylar distance		3.2-4.5	3.66	0.35
Distance between anterior end & basion	Right	0.5-1.2	0.96	0.17
	Left	0.6-1.2	0.98	0.15
	Mean	0.5-1.2		
Distance between anterior end & opisthion	Right	3.4-4.4	3.78	0.24
	Left	3.5-4.5	3.82	0.31
	Mean	3.4-4.5		
Distance between posterior end and basion	Right	2.1-2.8	2.52	0.26
	Left	2-Mar	2.59	0.25
	Mean	2-Mar		
Distance between posterior end and opisthion	Right	2.4-3.4	2.69	0.23
	Left	2.4-3	2.64	0.18
	Mean	2.4-3.4		

Table 2: Showing different shapes of Occipital Condyles (OC) and their percentage.

Shape of OC	Number	Percentage
Oval	6	10%
Kidney shaped	18	30%
S Shaped	14	23.33%
Triangle	10	16.67%
Rhomboid	5	8.33%
8 like	5	8.33%
Bipartite (with double facets)	2	3.33%

Table 3: Showing location of hypoglossal canal with relation to Occipital Condyles (OC) and their percentage.

Location of hypoglossal canal	Number	Percentage
Anterior 1/3 of OC	44	73.33%
Middle 1/3 of OC	16	26.67%
Posterior 1/3 of OC	-	-

Table 4: Showing comparison of present study with the previous studies.

Authors	Year	Population	Length (cm)	Breadth (cm)	Height (cm)
Present Study	2019	Indian	2.2	1.32	0.62
Yu Z et al [10]	2014	Chinese	2.15	-	-
Salih AM et al [11]	2014	Sudanese	2.07	1.3	-
Ozer MA et al [8]	2011	Turkish	2.4	1.13	-
Le TV et al [9]	2011	American	2.24	1.12	0.99
Naderi et al [7]	2005	Turkish	2.36	1.05	0.92

Table 5: Showing comparison of present study with the study done in south Indian skulls.

Parameter in cm	Present Study	Sandeep Saluja et al [6]	Tale AK [12]	Sahoos S [13]	Kalthur SG [14]
Length of OC	2.2	2.23	2.21	2.25	2.2
Breadth of OC	1.32	1.3	1.12	1.27	1.1
Height of OC	0.62	0.92	0.82	-	0.9
AICD	1.95	1.78	2.12	2.03	2.1
PICD	3.66	3.89	4.06	4.17	3.9
DAT-B	0.98	0.97	-	1.1	1.2
DAT-O	3.8	3.77	-	-	3.9
DPT-B	2.54	2.75	-	-	2.7
DPT-O	2.64	2.64	-	2.78	2.8

DISCUSSION

Craniovertebral regions are predisposed to an array of pathologies like fractures, dislocations, benign diseases and malignancy. This area is difficult to approach as there are many important structures present around the occipital condyles. Inadequate knowledge of anatomy of this area can result in potential complications. Treatment of fractures, dislocations, tumours and malignancy involves surgery. Different approaches have been described such as transfacetal approach, transcondylar approach, extreme-lateral transjugular approach and the transtuberular approach [6-9]. Some of these surgeries require partial or complete resection of the occipital condyles. The morphometry of the occipital condyles are different in different populations (Table no.4). The variations in the morphometry of the occipital condyles can be attributed to the genetic constitution of the various populations. The present study aims at providing a reference database of the occipital

condyles of the north Indian population. This will also help in comparison of dimensions of the occipital condyles with other populations [6]. The recent treatment modalities of trauma and tumours such as meningiomas, neurofibroma of this region involves a transcondylar approach. This approach provides a wide surgical exposure and is better than the conventional techniques which are associated with high morbidity. It involves removal of occipital condyles partly or completely along with lateral mass of C1. During the condylar drilling care should be taken of hypoglossal nerve, jugular bulb and internal jugular vein [7].

Naderi et al [7] classified the occipital condyles into three types. Type 1 (Short) condyles with length less than 2cm; Type 2 (Moderate) condyles with length between 2cm to 2.6cm; Type 3 (Long) condyles with length more than 2.6cm. The length of the occipital condyle (OC) in the present study is 2.1 cm which is comparable to the length measured by Le TV et al [9] in the American population. The length of OC in the present study is less than the study conducted by Salih MA et al in Sudanese population [11]. Ozer MA et al [8] and Naderi et al [7] reported length of the OC to be more in the Turkish population than the Indian population. (Table No. 4). Breadth of the OC in the present study (1.32 cm) was comparable to the Sudanese population (1.3 cm). It was less in the American and the Turkish population. Height of the OC in the present study was less (0.62 cm) when compared to the American (0.99 cm) and the Turkish population (0.92). Accurate dimension of occipital condyles is required during the operative interventions in this area.

Operative procedures such as transcondylar approach, lateral transjugular approach requires resection of the condyles. Resection of the condyles depend upon the length, breadth and height of the condyles. If the condyles are long widespread resection can be done but if the condyles are short widespread resection can result in instability of atlanto-occipital joint [6,7]. If the condyles are wider resection becomes more difficult. During occipitocervical screw placement is more successful if the height of the occipital condyles are more [6,15]. Also knowledge regarding the anterior and posterior

intercondylar distance is required for the successful screw placement during occipito cervical fixation. The distance between anterior end and basion (AOCB) and opisthion (AOCO) were less but the distance between posterior end and basion (POCB) and opisthion (POCO) were comparable to the study done by Naderi et al.

A study on south Indian skulls by Kalthur et al [14] observed the length, breadth and height of the occipital condyles as 2.2 cm, 1.1cm and 0.9 cm. Breadth of the occipital condyles in the present study was more whereas the height of the condyles was less. The AICD and PICD were noted to be 2.1 cm and 3.9 cm. The AOCB and AOCO was less in the present study (Table no.5). Figure of 8 shape was most commonly noted in Kalthur et al study. In the present study the most common observed shape of the occipital condyle was kidney shaped (30%). Location of hypoglossal canal was noted in anterior 1/3 of the occipital condyle in both the study in 44 cases (73.33%).

In the present study one occipital condyle with double articular facet and two small bony tubercles were noted to be present on both the side. Articular facet 1 was oval in shape with length 2 cm on right side and 2.3 cm on left side whereas articular facet 2 was round (Figure No.6). The surface was noted to be smooth with no linear bony elevations. Similar case was reported by Srijit Das et al [16] but the surface of the condyles were rough and an incomplete groove was also noted. The antero-posterior diameter and transverse diameter were different on right and left side. Such findings can result in occipitocervical instability. These finding may be due to developmental anomalies. The occipital bone ossifies from 8 centres: one for the basilar part, one for each condylar part, four for the squamous part and one for the posterior margin of the foramen magnum. Each condylar part starts ossification in cartilage in the 8th week of intra-uterine life. The fusion between the condylar part and the squamous parts takes place at the end of two years. Within six years condylar part fuses with basilar part [2]. Presence of extra ossification centres and any deviation in the fusion of these parts may attribute to above observed presence of two articular facets in the occipital condyles with two

bony tubercles at the anterior margin of the foramen magnum.

In humans the neural arch of the pro-atlas divides into anterior and posterior segments. The anterior segment forms the occipital condyles while the posterior segment forms a part of the rostral facets on the atlas vertebrae [17].

CONCLUSION

The present study provided knowledge regarding the morphometry of the occipital condyles in the Indian population which will further help the surgeons operating in this area. There are many important nerves and vessels emerging out of the neighbouring foramina. So, detailed knowledge of the dimensions will prevent damage to these structures. The various dimensions of the Indian populations were compared with other populations. In Indians width of the occipital condyles was more. The observed dimensions may also help in designing customised implants for the Indians.

ABBREVIATIONS

OC - Occipital Condyles

AICD - Anterior inter condylar distance

PICD - Posterior inter condylar distance

DAT-B - Distance between anterior tip and basion

DPT- B - Distance between posterior tip and basion

DAT-O - Distance between anterior tip and opisthion

DPT- O - Distance between posterior tip and opisthion

Conflicts of Interests: None

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