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ORIGINAL

Evaluation of the occipital condyles through morphometric and morphological analysis: An examination of bony landmark in the transcondylar approach

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Abstract

Background: On the inferior surface of the occipital bone two bony projections present in the skull are known as occipital condyles. During the surgical approaches like transcondylar, for the harmless occipital condylar resection the anatomical landmarks should be well known. Hence the morpho-logical and the morpho-metric examination of the occipital condyles and their facet become important clinically. **Methods:** 60 human adult dry skulls of unidentified sex were studied for shape, width, length and height of the occipital condyles. Anterior inter-condylar distance, the posterior inter-condylar distance and the distance between the anterior tip and posterior tip of the occipital condyles from basion and the opisthion were recorded. **Results:** Most frequent shape of occipital condyles seen was oval (21.6%) followed by reniform (17.5%), biconvex (15%), S shaped (14.6%), 8 shaped (13%), irregular (9.16%), condyle in two parts (4.2%), quadrangular (2.5%) and triangular (2.5%). All parameters were found to be more on right side except width of the occipital condyles. There was no significant difference observed between right side and left side except distance between the anterior tip of occipital condyles and basion was statistically highly significant. **Conclusion:** For safe occipital condyle resection in various surgeries the morpho-logical and the morpho-metric analysis of occipital condyles becomes utmost important.

Keywords: Morpho-metric, Morpho-logical evaluation, Occipital condyles, Transcondylar approach

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Introduction

Occipital bone largely forms posterior part of the human skull. Two bony projections found on inferior aspect of occipital bone recognized as occipital condyles (OC). These condyles situated lying on each region of foramen magnum at base of skull. Superior articular facade of atlas connects by means of occipital condyles to compose atlanto-occipital joint. Oval in shape, occipital condyles positioned obliquely, with anterior end nearer to the midline than the posterior ending. These structures play a crucial role in maintaining the head in a vertical position and are essential for the steadiness of the craniovertebral junction [1].

It is crucial to have a comprehensive understanding of anatomical foundation of the craniovertebral anomalies while performing surgeries in this specific section. The lateral techniques utilized in craniovertebral surgery necessitate the removal of occipital condyles, while transcondylar approach emphasizes significance of morphometry of these condyles [2-4]. Flexion, extension, and lateral bending movements do not present any challenges in terms of the symmetry of occipital condyles. However, the presence of asymmetrical facets in condyles will result in modified kinematics within the atlantooccipital joint [5]. Numerous individuals who experience closed head injuries face the potential danger of occipital condylar fractures. In order to safely remove the occipital condyle during the transcondylar approach, it is imperative to possess a thorough understanding of the anatomical landmarks [4]. Consequently, the clinical importance is underscored by the morpho-logical and the morpho-metrical assessment of occipital condyles in addition to their facet.

Given aforementioned clinical significance, it is imperative to investigate the typical and altered structure of the occipital condyles. Therefore, this research was conducted to furnish data regarding the occipital condyles and their distances from established anatomical reference points in the dry skulls of adult individuals.

Material and Methods

The current cross-sectional study utilized a sample of 60 human adult dry skulls of unidentified sex. Skulls were obtained from Anatomy Department of two Medical Colleges. Only dry, macerated skulls that were free from physical deformities or abrasions were incorporated in the study. Linear dimensions were taken by means of a digital Vernier caliper with a least count of 0.01 mm. In cases where the Vernier caliper couldn't be used, a steel needle, ruler, silk thread, and divider were employed to measure curved distances and other distances. All measurements

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were conducted with careful consideration of any potential zero error in the instruments. The data was compiled on Excel spreadsheet, statistical assessment performed by means of the SPSS software version 25.0. Statistical assessment was done using chi-square test. Values $p<0.05$ were taken as statistically significant.

Shape, width (transverse maximum distance between medial and lateral borders of OC), length (greatest anteroposterior space between anterior and posterior tips of OC, measured with external jaws of Vernier caliper) and height (vertical maximum distance between superior border and inferior border of medial margin of OC, measured with internal jaws of Vernier caliper) were noted (Fig. 1A).

Anterior inter-condylar distance (AICD) (distance among anterior tip of left and right occipital condyle in horizontal plane, measured with internal jaws of Vernier caliper), posterior inter-condylar distance (PICD) (distance among posterior tip of left and right occipital condyle in horizontal plane, measured with internal jaws of Vernier caliper) were recorded (Fig. 1A).

Distances among anterior tip of OC and basion (AOCB), the anterior tip of OC and opisthion (AOCO), posterior tip of OC and basion (POCB) and the posterior tip of OC and opisthion (POCO) were noted (Fig. 1B).

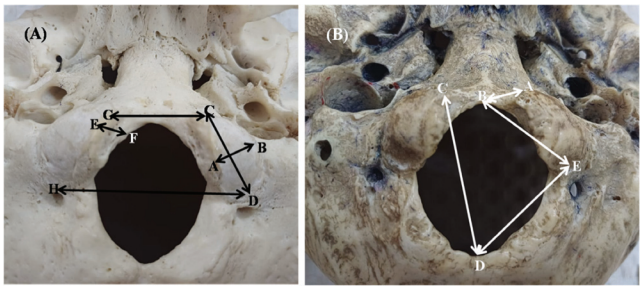

Fig. 1: Morpho-metric parameters of the occipital condyles (A): Width (AB), length (CD), height (EF), anterior inter-condylar distance (CG), posterior inter-condylar distance (DH); (B): Distance between anterior tip of occipital condyle to basion (AB), anterior tip of occipital condyle to opisthion (CD), posterior tip of occipital condyle to basion (EB), posterior tip of occipital condyle to opisthion (ED)

Ethical Consideration

Since the study was based on human dry skulls already present in the departments of anatomy of two Medical Colleges, Ethical consideration was not required for the study.

Results

Most frequent shape of occipital condyles seen be oval (21.6%) followed by reniform (17.5%), biconvex (15%), S shaped (14.6%), 8 shaped (13%), irregular (9.16%), condyle in two parts (4.2%), quadrangular (2.5%) and triangular (2.5%) (Fig. 2). **(Table 1)**

All parameters were found to be more on right side except width of OC, distance AOCB and distance POCB. Between right side and left side no significant difference was observed except distance among anterior tip of OC and basion was calculated to be statistically highly significant.

Mean breadth and length of occipital condyle were 12.10±1.66mm and 23.71±2.95mm respectively, at the same time mean height was found to be 7.52±1.33mm.

Distance among anterior tip of OC and basion was 11.14±2.90mm while the distance among opisthion and anterior tip of OC was 38.25±4.98mm. Mean value of distance among posterior tip of OC and basion was calculated to be 27.44±2.35mm, whereas the distance among posterior tip of OC and opisthion was 28.25±2.28mm. Anterior inter-condylar distance and posterior inter-condylar distance were 18.75±3.09 mm and 42.63±3.21 mm respectively.

All the parameters were found to be more on right side except width of OC, distance between AOCB and distance POCB which were slightly greater on left side and no statistically significant disparity in relation to these parameters on both sides was there. However, the distance among anterior tip of OC and basion was statistically highly significant. **(Table 2)**

Discussion

Previous studies have reported various morpho-logical shapes of the OC in the literature. **(Table 3)** In Egyptian population most common shape reported was reniform shape,[6] in Turkish population it was oval shape,[7] in Greek population it was "S" shaped,[8] while in Brazilian population "8" shape be most common [9].

In the current study, mean value of width of OC were more on left side than right side while other studies reported the reverse [10-12]. This difference could be attributed to the race and the genetic the factors in the different regions of the population. Similarly in current study, mean value of length of occipital condyle reported to be greater on right side which corroborates with the findings of study made by Saluja et al. [10] and Ramkrishna et al. [12] whereas Cheruiyot et al. [11] reported the reverse. In another study on dry skulls, mean value of length of occipital condyle reported to be 23.1 mm [4] which was also comparable to the current study. On comparing mean height of occipital condyle Saluja et al. [10] and Ramkrishna et al. [12] reported values to be greater on right side whereas in another study the values reported were same on both sides [11]. The differences observed could potentially be attributed to distinct approaches in gathering data and the genetic foundation of diverse populations. **(Table 4)**

Mean value of distance from anterior tip of occipital condyle till basion and opisthion were higher in the current study in comparison to that reported by Saluja et al. [10]**.** This difference could be attributed to race and genetic factors in different region of population. Similarly, mean value of distance from posterior end of occipital condyle till basion and opisthion were comparable to study done by Saluja et al. [10]**.** Knowledge of these findings can help avoid harm to the surrounding neurovascular components. **(Table 4)**

Table 1. Shapes of Occipital condyles

No.	Shape of OC	Right N(%)	Left N(%)	Total N(%)
1.	Oval	12 (20)	14 (23.3)	26 (21.6)
2.	Reniform	12 (20)	9(15)	21(17.5)
3.	Biconvex	9 (15)	9(15)	18(15)
4	S Shaped	10 (16.6)	7(11.6)	17(14.6)
5.	8 Shaped	8 (13.3)	8(13.3)	16(13)
6.	Irregular	4 (6.7)	7(11.6)	11(9.2)
7.	Condyle in two part	2(3.3)	3(5)	5(4.2)
8.	Quadrangular	1(1.7)	2(3.3)	3(2.5)
9.	Triangular	2 (3.3)	1(1.6)	3(2.5)

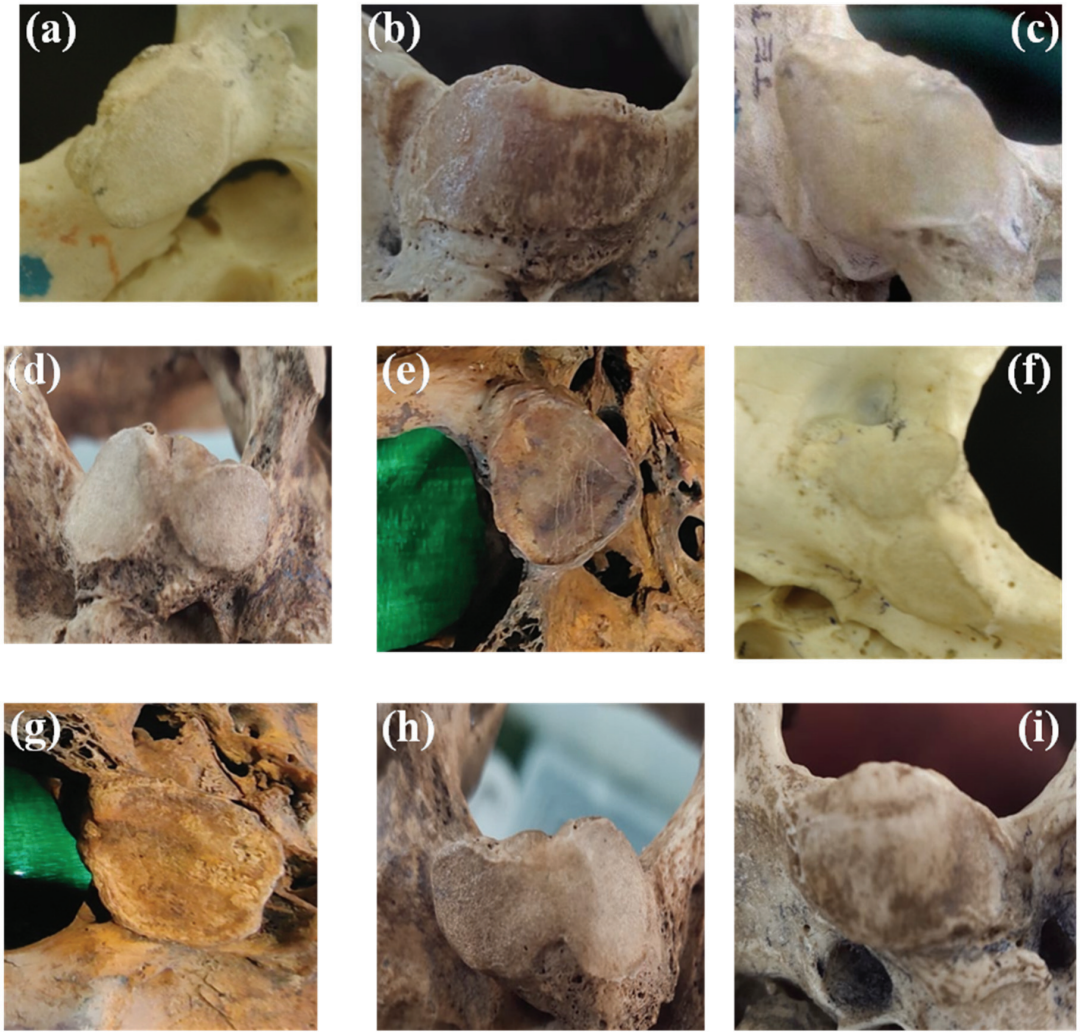

Fig. 2: Various shapes of occipital condyle (a) Oval, (b) Reniform, (c) S shape, (d) 8 shape, (e) Triangular, (f) Condyle in two parts, (g) Quadrangular, (h) Irregular, (i) Biconvex

Table 2: Morpho-metric measurement of the occipital condyles

Parameters	Mean ± SD (mm)			Range Minimum-Maximum (mm)			p-value
	Right	Left	Total	Right	Left	Total	
Width OC	12.02±1.499	12.17±1.8	12.10±1.66	8.42-16.71	9.05-17.24	8.42-17.24	0.42979
Length OC	23.99±2.997	23.43±2.88	23.71±2.95	14.66-29.82	11.08-8.65	14.66-29.82	0.07228
Height OC	7.53±1.42	7.52±1.2	7.52±1.33	4.3-10.82	5.02-9.7	4.3-10.82	0.90114
Dist. AOCB	11±2.91	11.28±2.88	11.14±2.90	4.15-29.65	4.15-29.65	4.15-29.65	**0.04516***
Dist. AOCO	38.28±5.07	38.22±4.88	38.25±4.98	8.53-44.95	10.43-45.46	8.53-45.46	0.66658
Dist. POCB	27.36±2.43	27.52±2.29	27.44±2.35	20.8-32.7	20.8-32	20.8-32.7	0.39907
Dist. POCO	28.4±2.307	28.1±2.47	28.25±2.28	23.66-34.26	22.05-32.7	22.05-34.26	0.21495
Dist. AICD	-		18.75±3.09	-		7.1-51.29	-
Dist. PICD	-		42.63±3.21	-		22.8-51.29	-

Statistical analysis done using chi-square test. Values p< 0.05 were considered Staistically significant. (OC- occipital condyle; AOCB -Distance between the anterior tip of OC and basion; AOCO- Distance between the anterior tip of OC and opisthion; POCB- Distance between the posterior tip of OC and basion; POCO- Distance between the posterior tip of OC and opisthion; AICD- Anterior inter-condylar distance; PICD- Posterior inter-condylar distance)

Table 3: Comparison of the percentage distribution of morpho-logical types of the occipital condyle with prior research findings.

Shape of occipital condyles	Fetouh et al. [6]	Ozer et al. [7]	Natsis et al. [8]	Aragao et al. [9]	Present study
1. Oval	16	59.7	7.6	6.1	21.6
2. Reniform	22	23	6.2	7.9	17.5
3. "S" shaped	19	4	30.7	18.2	14.6
4. "8" shaped	12	4.5	10.6	19.2	13
5. Triangular	6	4.2	16.2	9.3	2.5
6. Ring	7	2.3	4.4	14.5	
7. Condyle in two parts	13	0.3	1.6	4.7	4.2
8. Deformed	-	1.7	5.8	-	-
9. Quadrilateral	5	-	-	8.4	2.5
10. Irregular	-	-	-	3.7	9.16
11.Biconvex	-	-	-	7.9	15

Table 4: Comparison of the morpho-metric measurements of the occipital condyle with prior research findings.

Authors		Saluja et al. [10]	Cheruiyot et al. [11]	Ramkrishna et al. [12]	Present study
Width OC (mm)	Right	12.98±1.62	12.27±1.25	11.03±2.22	12.02±1.49
	Left	12.97±1.46	12.20±1.33	11.01±2.34	12.17±1.8
Length OC (mm)	Right	22.90±3.11	20.51±2.02	21.79±0.09	23.99±2.99
	Left	22.60±2.72	20.59±2.09	21.48±0.87	23.43±2.88
Height OC (mm)	Right	9.32±1.23	8.64±1.10	6.18±1.31	7.53±1.42
	Left	9.12±1.23	8.64±1.07	6.09±1.36	7.52±1.2
AOCB (mm)	Right	9.74±1.78	-	-	11±2.91
	Left	9.56±1.33	-	-	11.28±2.88
AOCO (mm)	Right	37.53±2.26	-	-	38.28±5.07
	Left	37.88±2.5	-	-	38.22±4.88
POCB (mm)	Right	28.16±3.26	-	-	27.36±2.43
	Left	26.93±2.16	-	-	27.52±2.29
POCO (mm)	Right	26.78±1.92	-	-	28.4±2.307
	Left	26.17±2.51	-	-	28.1±2.47
AICD (mm)		17.81±2.93	19.71±2.47	19.41±3.99	18.75±3.09
PICD (mm)		38.91±4.16	39.41±2.73	37.36±4.03	42.63±3.21

(OC- occipital condyle; AOCB -Distance between the anterior tip of OC and basion; AOCO- Distance between the anterior tip of OC and opisthion; POCB- Distance between the posterior tip of OC and basion; POCO- Distance between the posterior tip of OC and opisthion; AICD- Anterior inter-condylar distance; PICD- Posterior inter-condylar distance).

In the current study, mean anterior inter-condylar distance was reported was slightly more than that reported by Saluja et al. [10] and less than Cheruiyot et al. [11] study and Ramkrishna et al. [12]. However in current study**,** mean posterior inter-condylar distance was higher in comparison to other studies [10-12]. The inter-condylar distances, whether anterior or posterior, indicate the alignment and convergence of the OC. This alignment plays a vital role in the precise placement of screws in occipitocervical fixation surgeries. **(Table 4)**

Treatment of craniovertebral region lesions is currently carried out through lateral approaches, such as the transfacetal, partial transcondylar, and complete transcondylar, along with extreme-lateral transjugular and transtubercular. The widely used out of these methods involve the partial or the complete removal of occipital condyle. Size and alignment of OC can affect the selection of surgical approach for various craniovertebral junction lesions [13, 14].

Limitations

Limitations of the study can be considered as the study sample did not include skulls with asymmetries and infant skulls.

Conclussion

In the current study, all parameters were more on right side except width of OC, distance AOCB and distance POCB. No significant statistical difference was observed between two sides except

distance from anterior tip of OC till basion which was statistically highly significant. The assessment of the morphology and the morphometry of occipital condyles play a crucial role in the surgical planning techniques for the skull base, as well as in the excision of occipital condyles in various approaches to the skull base.

Conflict of Interest:	Author declare no COI
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Funding:	No external funding
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