

## ORIGINAL ARTICLE

# A Study on the Anatomical Variations of Occipital Condyles in the Dry Adult Human Occipital Bones

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## ABSTRACT

**Objective:** The aim of the study is to describe the morphological and morphometric variations of bilateral Occipital condyles (OC) present in dry adult human occipital bones which are anatomically and surgically important structures.

**Methodology:** 150 dry adult occipital bones were studied for the presence of protrusion of the OC into the Foramen Magnum (FM). The length and width of the OC along with the distance of its posterior end from opisthion, distance of its anterior end from basion and the distance of the hypoglossal canal (HC) from its posterior end were measured bilaterally. Presence of posterior condylar foramen (PCF) was noted. Results were analysed statistically and compared with the results of previous studies.

**Results:** Of 150 cases 119 (79.33%) were found to have bilaterally protruded occipital condyles and 11 (7.33%) showed protrusion at either side (p value < 0.0001). Comparison between variables gives statistically significant difference between right and left distance of anterior end of occipital condyles from the basion (P value = 0.0305). PCF was found to be present in 90 out of 150 cases (60%) on the right side, 113 cases (75.33%) on the left side.

**Conclusion:** Since there is a wide variation in the anatomy of occipital condyles all over the world, the neurosurgeons, anatomists, morphologists and anthropologists should be familiar with the morphology and morphometry of the same in our part of the country. It will help in performing surgeries with minimal damage. Furthermore, the result of the study can be used for teaching and research purposes.

**Key words:** Far lateral transcondylar approach, Posterior condylar foramen, Hypoglossal canal

## INTRODUCTION

The posterior part of the cranial base is largely formed by the occipital bone. The occipital condyles (OC) are related medially to the foramen magnum, laterally to jugular foramen, behind to condylar fossa which may sometimes be traversed by posterior condylar canals/foramen (PCF) and above by the hypoglossal canal. Below it articulates with the atlas to form atlano-occipital joint.<sup>1</sup> Being an integral component of craniovertebral region it is predisposed to a variety of traumatic, degenerative and neoplastic diseases which require surgical interventions for successful management.<sup>2</sup>

Advances in skull base approaches have improved surgical exposure leading to better and wider access for successful surgery. Lateral approaches are being increasingly used to access lesions ventral to the brainstem and cervico-medullary junction. Different forms of lateral approaches include the transfacetal approach, the partial or complete transcondylar approach, the extreme-lateral transjugular approach and

the transtubercular approach. Most of these approaches require complete or partial resection of the occipital condyles which are related to a number of important vessels and nerves. Special attention has to be given to the presence of PCF which if present changes the anatomy of important vessels and nerves present in the surrounding area.

The dimensions and orientation of the occipital condyle may influence the choice of surgical approach for correction of the lesions of the afore-mentioned area. The purpose of the present study was to conduct a morphometric analysis of the occipital condyle as it pertains to the transcondylar approach and being an important part of the cranio-vertebral junction, connecting the cranium to the upper cervical spine.

## MATERIALS AND METHODS

A descriptive morphometric study was performed over 150 dry adult occipital bones collected from the

department of Anatomy of different medical colleges in Kolkata and Burdwan, West Bengal. Malformed, non-ossified or broken bones were excluded. The presence or absence of protrusion of the OC into the Foramen Magnum (FM) was noted. The length (distance between the most anterior and the most posterior points) and width (transverse distance at the maximum width) of the OC, distance of its posterior end from opisthion, distance of its anterior end from basion and the distance of the hypoglossal canal (HC) from its posterior end were measured bilaterally. Presence of PCF was also noted. All measurements were done with Vernier slide calipers. The mean value of the three observations was taken in each case to avoid observational bias. Data of various morphometric parameters was expressed with the mean, standard deviation, 25th, 75th, 10<sup>th</sup>, 90<sup>th</sup>, 5th and 95th percentile value. Categorical data was summarized as counts and percentages. Key variables were expressed with the 95% confidence intervals. Right and left were compared by t-test or Mc Ne-

mar's Chi-square test with the help of Statistica version 6 [Tulsa, Oklahoma: StatSoft Inc., 2001] and MedCalc version 11.6 [Mariakerke, Belgium: MedCalc Software 2011]. All variables were normally distributed by Kolmogorov-Smirnoff goodness of fit test.

**RESULTS**

Mean values ± SD and 95% confidence interval of all the measurements are given in Table 1. Of 150 cases, 119 (79.33%) had bilaterally protruded occipital condyles, 11 show protrusion at either side. Fisher's exact t-test p value = 0.0001 (Table 2). Comparison between variables give statistically significant difference between right and left side distance of anterior end of occipital condyles from the basion (Paired t- test p value = 0.0305) (Table 3). PCF was found to be present in 90 out of 150 cases (60%) on the right side, 113 cases (75.33%) on the left side. (McNemar's Chi-square test p value=0.005) (Table 4)

**Table 1: Descriptive statistics of study related dimensions – Whole cohort [n = 150]**

Parameters	Range	Mean ±SD	95% CI
Length of occipital condyle (right)	16.38 – 28.88	22.69 ± 2.54	22.28 – 23.09
Length of occipital condyle (left)	17.50 – 28.52	22.50 ± 2.49	22.10 – 22.91
Width of occipital condyle (right)	9.18 – 18.90	12.65 ± 1.98	12.33 – 12.97
Width of occipital condyle (left)	8.54 – 17.10	12.69 ± 2.04	12.36 – 13.02
Distance of anterior end of occipital condyle from basion (right)	5.80 – 16.88	9.89 ± 2.21	9.54 – 10.25
Distance of anterior end of occipital condyle from basion (left)	4.72 – 14.10	9.55 ± 2.01	9.22 – 9.87
Distance of posterior end of occipital condyle from opisthion (right)	19.56 – 32.40	26.70 ± 2.46	26.30 – 27.10
Distance of posterior end of occipital condyle from opisthion (left)	20.30 – 31.84	26.52 ± 2.30	26.15 – 26.89
Distance of hypoglossal canal from posterior end of occipital condyle (rt)	6.60 – 16.49	10.05 ± 2.23	9.69 – 10.41
Distance of hypoglossal canal from posterior end of occipital condyle (lt)	5.90 – 15.78	10.20 ± 1.97	9.88 – 10.52

**Table 2. Comparison between categorical variables**

	Occipital condylar protruberance (left) present	Occipital condylar protruberance (left) absent
Occipital condylar protruberance (right) present	119	8
Occipital condylar protruberance (right) absent	3	20

P value < 0.0001

**Table 3: Comparison between numerical variables**

Parameters	Right (m±sd)	Left (m±sd)	P value
Length of occipital condyle	22.68 ± 2.54	22.50 ± 2.49	0.210
Width of occipital condyle	12.65 ± 1.98	12.69 ± 2.04	0.7134
Distance of posterior border of occipital condyle from opisthion	26.69 ± 2.46	26.52 ± 2.30	0.3441
Distance of anterior border of occipital condyle from basion	9.89 ± 2.21	9.55 ± 2.01	0.0305
Distance of hypoglossal canal from posterior border of occipital condyle	10.05 ± 2.23	10.20 ± 1.97	0.2793

**Table 4: Comparison between categorical variables**

	Posterior condylar foramen (left) present	Posterior condylar foramen (left) absent
Posterior condylar foramen (right) present	71	19
Posterior condylar foramen (right) absent	42	18

P value = 0.005

## DISCUSSION

Avci E et al in 2011 stated that protrusion of the OC into FM, especially in the ovoid type may indicate more extensive bony removal during surgery.<sup>3</sup>In present study protrusion is found in 84.67% cases on right side and 81.33% on left side. Table 5 shows the result of the present study was close to that done by Natsis K. et al in 2013 where they found 86.7% protrusion bilaterally.<sup>4</sup>

According to Down et al., for visualizing the contralateral jugular tubercle, the average length of the OC necessary for resection was minimum 17mm.<sup>5</sup> Average OC length in the present study is found to be  $22.69 \pm 2.539$ mm and  $22.50 \pm 2.489$ mm for right and left sides respectively. Comparative values of different parameters among different studies are given

**Table 5. Comparison of protrusion of OC**

Study name	Right side present	Right side absent	Left side present	Left side absent
Muthukumar N. et al (2005) <sup>8</sup>	20%	80%	20%	80%
Avci E. et al (2011) <sup>3</sup>	57%	43%	57%	43%
Chethan P. et al (2012) <sup>15</sup>	20.7%	79.3%	20.7%	79.3%
Natsis K. et al (2013) <sup>4</sup>	86.7%	13.3%	86.7%	13.3%
<b>Present study</b>	<b>84.67%</b>	<b>15.33%</b>	<b>81.33%</b>	<b>18.67%</b>

**Table 7: Comparison of frequency of Posterior Condylar Foramen between different Studies**

Study name	Present in right side	Absent in right side	Present in left side	Absent in left side
Muthukumar N et al (2005) <sup>8</sup>	92%	8%	68%	32%
Pereira G.A.M. et al (2012) <sup>13</sup>	58.5%	41.5%	65.9%	34.1%
Present study	60%	40%	75.33%	24.67%

Hypoglossal nerve which passes through the hypoglossal canal (HC), if damaged may lead to an alteration in the tongue movement and speech later on.<sup>1</sup> Hence the knowledge of the distance between HC and the posterior end of OC is important to avoid its damage during the surgery. The mean distance of HC from posterior end of OC that we found (Rt side:  $10.05 \pm 2.228$ mm, Lt side:  $10.20 \pm 1.974$ mm) is close to that found by Avci et al<sup>3</sup> and Pereira et al<sup>13</sup> (Table 6)

Hollinshead has mentioned that the posterior condylar canal opens at the groove for sigmoid sinus, posterolateral to the jugular foramen in the posterior cranial fossa.<sup>11</sup> PCF maybe the additional route of drainage of intracranial veins into extracranial veins. Posterior condylar veins leave the skull through the posterior condylar canal and it is an alternative source in a dysfunction of the venous drainage of the sigmoid-jugular complex.<sup>12</sup> Damage to this vein during surgery may lead to excessive bleeding which if not foreseen may lead to fatality. Table 7 shows that in present study there is predominance of PCF on left side as is also reported by Pereira et al<sup>13</sup> and Bayat P et al<sup>14</sup>. Muthukumar et al on the other hand reports left side PCF predominance.<sup>8</sup> Our study as well as

in Table 6. Mean length of OC of left side seems similar to that reported by Kavitha S et al while that of right side is found closer to Fetouh F.A. et al.<sup>6,7</sup> It is seen that the mean of width of OC of both sides in present study is very similar to that of Avci E et al.<sup>3</sup>

Muthukumar N et al mention that the distance of the posterior end of OC from opisthion is important because a longer corridor provides a wider space for a far lateral transcondylar approach.<sup>8</sup> This distance on both the sides in the present study corresponds with that of Naderis et al<sup>9</sup> (Table 6). The mean distance of anterior end of OC from basion on right side is closer to that found by Avci E. et al than on the left side<sup>3</sup> (Table 6). No third occipital condyle was found in our study as found by Saralaya VV et al in 2012.<sup>10</sup>

studies done by Muthukumar et al and Pereira et al mention that most of the bones studied show presence of PCF rather than its absence which is contradicted by Bayat P et al study done in 2014. Left side results of our study also correspond with Muthukumar et al and Pereira et al.

## CONCLUSION

A significant number of cases in the present study were found to have bilaterally protruded occipital condyles. The difference between right and left distance of anterior end of occipital condyles from the basion was also found to be statistically significant. The presence of PCF on either side was also not a chance finding. Overall morphometry of OC is found to differ from that reported in the studies from different parts of the world as well as within the country. These variations may be attributed to the different methods by which the data were collected in different studies &/or to the different genetic and environmental factors affecting the different populations.

**Table 6: Comparison between different parameters among different studies [Values are in millimeter (Mean ± S.D)] (part a and b)**

**Part a**

Parameter (part A)	Length of OC		Width of OC		Distance of anterior end of OC from basion	
	Right	Left	Right	Left	Right	Left
Present study	22.69±2.54	22.50±2.4489	12.65±1.98	12.69±2.04	9.89±2.21	9.55±2.01
Naderi S. et al (2005) <sup>9</sup>	23.6±2.5	23.2±2.4	10.6±1.4	10.6±1.4	10.5±1.5	11.1±1.5
Fetouh F.A. <sup>7</sup>	23.5±2.53	23.75±2.5	13.58±1.82	13.62±1.71	11.1±2.1	11.3±2.1
Barut et al (2009) <sup>16</sup>						
Avci E. et al (2011) <sup>3</sup>	23.7±2.6	24±2.7	12.2±1.2	12.4±1.5	9.9±1.9	10.0±2.00
Pereira G.A.M. et al (2012) <sup>13</sup>	24.0+/-3.6	23.3±2.6	13.4±1.4	16.4±1.6		
Natsis K. et al (2013) <sup>4</sup>	25.60±2.91	25.60±2.70	13.09±1.99	13.01±1.98		
Bayat P et al (2014) <sup>14</sup>	9.21±1.97	9.40±1.87	9.21±1.97	9.40±1.87		
Kavitha S. et al (2014) <sup>6</sup>	21.97	22.34				
Melissa et al (2014) <sup>17</sup>					10.81±0.31	11.36±0.25
Tale AK et al (2016) <sup>18</sup>	21.83±2.99	22.19±3.31	11.07±2.41	11.42±2.31		

**Part b**

Parameter (part b)	Distance of posterior end of OC from opisthion		Mean distance of HC from posterior end of OC	
	Right	Left	Right	Left
Present study	26.70±2.46	26.52±2.30	10.05±2.23	10.20±1.98
Naderi S. et al (2005) <sup>9</sup>	26.7±2.4	26.2±2.2		
Fetouh F.A. <sup>7</sup>	27.87±3.37	27.94±3.21		
Barut et al (2009) <sup>16</sup>			12.5	12.6
Avci E. et al (2011) <sup>3</sup>	26.6±1.8	27.1±2.6	9.8±1.1	9.9±1.4
Pereira G.A.M. et al (2012) <sup>13</sup>			10.3±2.5	11.3±2.1
Natsis K. et al (2013) <sup>4</sup>				
Bayat P et al (2014) <sup>14</sup>				
Kavitha S. et al (2014) <sup>6</sup>				
Melissa et al (2014) <sup>17</sup>				
Tale AK et al (2016) <sup>18</sup>				

The data obtained in the present study will be of help to the neurosurgeons in analysing the morphological anatomy of cranio-vertebral junction. Surgeons, specially those from our part of country will be benefited as the study gives an idea about the amount of bone that can be safely removed without violating the HC and giving a wide exposure on far lateral transcondylar approach. The findings are also useful for the clinical anatomists, morphologists and anthropologists for the purpose of teaching and further research work.

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