Morphometric evaluation of occipital condyles for a safe transcondylar approach through skull base

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Abstract

Aims and Objectives: Occipital condyle is an important landmark in transcondylar approach for surgery of lesions ventral to the brainstem, hence it is imperative to understand the anatomical aspects of occipital condyle. The aim of the present study is to analyse the morphometrical aspects of occipital condyle and to highlight its importance in surgical resection. Materials and method: Hundred occipital condyles of fifty dry skulls were used for this study. Twenty-six parameters were measured. The measurements were made separately for right and left sides. Results: The mean length of occipital condyle was found to be 22.92mm. The distance between the intracranial orifice of the hypoglossal canal and the posterior margin of occipital condyle was 12.55±0.05mm. The commonest location of intracranial orifice and extracranial orifice of hypoglossal canal was found to be at location 3 and location 2 respectively. Occipital condyle was oval in most skulls. Conclusion: Occipital condyle can be safely drilled for a distance of 12 mm from the posterior margin before encountering the hypoglossal canal. Surgeons operating in this area must consider the variations of parameters of south Indian skulls.

Keywords: occipital condyle; transcondylar approach; hypoglossal canal

Introduction

Occipital condyle with lateral mass C1, is the only articulation between the occiput and atlas. Its integrity contributes to the stability of craniovertebral junction. In recent years most of the studies have focused on some aspect of occipital condyle and have come out with different surgical procedures. It is a challenging task for the surgeons to resect the lesion ventral and ventrolateral to the foramen magnum.

The occipital condyle is frequently drilled during transcondylar surgical approaches. The tumors on the ventral aspect of the brainstem can be directly visualized after condylar resection. However, the extent of the bone resection necessary is not properly reported in previous studies. Three modified approaches are possible through occipital condyle, they are – transcondylar approach, paracondylar approach and supracondylar approach. The topographic relation between the tumors and the neurovascular structures is the most important feature in selection of surgical treatment. Localization of such features will be a guidance for the surgeon in the selection of the surgical approach. Due to its extreme importance in neurosurgery, a morphometric analysis of occipital condyle has been carried out in the present study for determining the incidence of variations in south Indian skulls and also to decide the safer extent of condyle resection needed to be in transcondylar approach.

Materials & methods

The measurements were performed on 100 occipital condyles of 50 adult human dry skulls of unknown age and sex obtained from south Indian population. The study was carried out in the Department of Anatomy, Sri Ramachandra Medical College and Research Institute, Chennai, Sri Manakula Vinayagar Medical College, Puducherry and Saveetha Dental College, Chennai. The following eight measurements related to occipital condyle and the hypoglossal canal were made using a vernier caliper, measuring scale, divider and protractor. The measurements were made nearest to 0.1 mm.

1. The occipital condyle length, width, height on both sides
2. Anterior and posterior intercondylar distance [distance between anterior and posterior tips of right & left occipital condyles]
3. Distance between the anterior tip of occipital condyle and basion – on both sides
4. Distance between the anterior tip of occipital condyle and opisthion – on both sides
5. Distance between the anterior tip of occipital condyle and intracranial orifice of hypoglossal canal - on both sides
6. Distance between the posterior tip of occipital condyle and intracranial orifice of hypoglossal canal - on both sides
7. Location of intracranial and extracranial orifices of hypoglossal canal on both sides
8. Distance between the basion and opisthion
9. The head circumference

The height of the occipital condyle was measured by taking the centre of the condyle [Fig.1] as the intersection of the midpoint of largest antero-posterior axis and midpoint of the transverse line dividing condyle. The condyle was divided into four equal portions along its antero-posterior axis. The location of intracranial and extra cranial orifice of hypoglossal canal was determined with reference to the subdivisions of the condyle [Fig. 2].

Localization of the hypoglossal canal with reference to occipital condyle was done as follows:
Location 1- Anterior 1/4\textdegree  of occipital condyle; Location 2- Junction of first & second 1/4\textdegree  of occipital condyle;Location 3- Second 1/4\textdegree  of occipital condyle; Location 4- Junction of second & third 1/4\textdegree  of occipital condyle; Location 5- Third 1/4\textdegree  of occipital condyle; Location 6- Junction of third & fourth 1/4\textdegree  of occipital condyle; Location 7- Fourth 1/4\textdegree  of occipital condyle

**Results**

The results obtained are presented in the Table 3, the mean length, width, height of occipital condyle were found to be 22.9 ± 1.82 mm [right], 23.08 ± 2.02 mm [left], 12.98 ± 1.95 mm [right], 13.24 ± 2.28 mm [left], and 7.48 ± 1.05 mm [right], 7.68 ± 1.15 mm [left] respectively. The mean anterior intercondylar distance and posterior intercondylar distance were measured as 22.48 ± 2.16 mm and 40.52 ± 2.75 mm respectively. The distance between the anterior tip of occipital condyle and basion was found to be 12.74 ± 1.48 mm [right] and 11.4 ± 1.26 mm [left] respectively. The distance between the posterior tip of occipital condyle to basion was found to be 27.4 ± 1.95 mm [right] and 27.76 ± 1.89 mm [left] respectively. The distance between the anterior tip of occipital condyle and opisthion was 40.34 ± 2.46 mm [right] and 39.8 ± 2.44 mm [left], the distance between the posterior tip of occipital condyle and the opisthion was found to be 29.3 ± 2.3 mm [right] and 28.7 ± 1.86 mm [left] respectively. The distance between the basion and opisthion was found to be 34.88 ± 2.4 mm. The head circumference was found to be 495.9 ± 1.66 mm.

In the present study, a weak positive correlation between the anterior intercondylar distance and posterior intercondylar distance [r=0.046, P=0.042] was observed. A strong positive correlation between the anterior intercondylar distance and the basion-opisthion distance [r=0.39, P=0.028] also between the anterior intercondylar distance and the head circumference [r=0.3, P=0.07] was also observed.

The location of intracranial and extracranial orifice of the hypoglossal canal along with its incidence are listed below [Table 2]. The intracranial orifice of hypoglossal canal was found to be in location 3 in 56% on right and 72% on left side [Fig. 3]. The extracranial orifice was found in location 2 in 25% on right and 25% on left side respectively [Fig. 4]. The intracranial orifice was not observed in location 1 in any of the specimens.

The distance between the anterior tip of occipital condyle and the intracranial orifice was found to be 10.54±1.89 mm [right], 10.64±1.78 mm [left] respectively. The distance between the posterior tip of occipital condyle and the intracranial orifice was found to be 12.5 ± 1.65 mm [right] and 12.6 ± 1.71 mm [left] respectively.

Shapes of occipital condyles could be classified into five types: Oval, Kidney shape, S-shape, Two-
Table 1: The statistical analysis of the parameters

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Mean ±SD</th>
<th>Range</th>
<th>P value</th>
<th>Measurements</th>
<th>Mean ±SD</th>
<th>Range</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>OCL [r]</td>
<td>22.92 ± 1.82</td>
<td>18-27</td>
<td>0.18</td>
<td>PTOC-B[r]</td>
<td>27.4 ± 1.95</td>
<td>22-32</td>
<td>0.35</td>
</tr>
<tr>
<td>OCL [l]</td>
<td>23.08 ± 2.02</td>
<td>20-32</td>
<td></td>
<td>PTOC-B[l]</td>
<td>27.76 ± 1.89</td>
<td>22-32</td>
<td></td>
</tr>
<tr>
<td>OCW [r]</td>
<td>12.98 ± 1.95</td>
<td>8-19</td>
<td>0.53</td>
<td>PTOC-O[r]</td>
<td>29.5 ± 2.3</td>
<td>25-34</td>
<td>0.16</td>
</tr>
<tr>
<td>OCW [l]</td>
<td>13.24 ± 2.28</td>
<td>8-20</td>
<td></td>
<td>PTOC-O[l]</td>
<td>28.7 ± 1.86</td>
<td>24-33</td>
<td></td>
</tr>
<tr>
<td>OCH [r]</td>
<td>7.48 ± 1.05</td>
<td>6-10</td>
<td>0.36</td>
<td>ATOC-JCO[r]</td>
<td>10.54 ± 1.89</td>
<td>6-14</td>
<td>0.78</td>
</tr>
<tr>
<td>OCH [l]</td>
<td>7.68 ± 1.15</td>
<td>5-10</td>
<td></td>
<td>ATOC-JCO[l]</td>
<td>10.64 ± 1.78</td>
<td>7-15</td>
<td></td>
</tr>
<tr>
<td>Ant.Intercond. dist.</td>
<td>22.4 ± 8.216</td>
<td>18-26</td>
<td></td>
<td>PTOC-JCO[r]</td>
<td>12.5 ± 1.65</td>
<td>7.9-17.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Post.Intercond. Dist.</td>
<td>40.52 ± 2.75</td>
<td>36-50</td>
<td></td>
<td>PTOC-JCO[l]</td>
<td>12.6 ± 1.71</td>
<td>8.3-16.4</td>
<td></td>
</tr>
<tr>
<td>ATOC-B [r]</td>
<td>12.74 ± 1.48</td>
<td>9-15</td>
<td>0.00</td>
<td>Basion-opisthion</td>
<td>34.88 ± 2.44</td>
<td>29-41</td>
<td></td>
</tr>
<tr>
<td>ATOC-B[l]</td>
<td>11.4 ± 1.26</td>
<td>10-15</td>
<td></td>
<td>Head circumference</td>
<td>495.9 ± 1.66</td>
<td>455-530</td>
<td></td>
</tr>
<tr>
<td>ATOC-O[r]</td>
<td>40.34 ± 2.46</td>
<td>35-57</td>
<td>0.27</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>ATOC-O[l]</td>
<td>39.8 ± 2.44</td>
<td>33-46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: OC: occipital condyle; ATOC: anterior tip occipital condyle; PTOC: posterior tip occipital condyle; B: basion; O:opisthion; r: right; l: left; ICO: intracranial orifice; S.D: standard deviation.

Table 2: The location of intracranial and extracranial orifice of hypoglossal canal with reference to the occipital condyles

<table>
<thead>
<tr>
<th>Location</th>
<th>Intracranial orifice</th>
<th>Extracranial orifice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>left</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>2 [4%]</td>
<td>5 [10%]</td>
</tr>
<tr>
<td>3</td>
<td>28 [56%]</td>
<td>36 [72%]</td>
</tr>
<tr>
<td>4</td>
<td>17 [34%]</td>
<td>6 [12%]</td>
</tr>
<tr>
<td>5</td>
<td>2 [4%]</td>
<td>1 [2%]</td>
</tr>
</tbody>
</table>

Table 3: Occurrence of different shapes of occipital condyle

<table>
<thead>
<tr>
<th>Type</th>
<th>Right</th>
<th>Left</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. [%]</td>
<td>No. [%]</td>
<td>No. [%]</td>
</tr>
<tr>
<td>1</td>
<td>23 [23]</td>
<td>27 [27]</td>
<td>50 [50]</td>
</tr>
<tr>
<td>4</td>
<td>1 [1]</td>
<td>0 [0]</td>
<td>1 [1]</td>
</tr>
</tbody>
</table>

Discussion

Far-lateral transcondylar approach has been recognized as an optimal approach to resect lesions ventral and ventrolateral to foramen magnum because it improves the surgical exposure to the ventrolateral clivus and anterior foramen magnum. The advantage of the approach is that the procedure enhances exposure of the brainstem while markedly reducing the brain retraction. The occipital condylar drilling is an important procedure in transcondylar approach.

Sait did the morphometric analysis of 404 human occipital condyles in detail. The length, width, height

partitioned, Deformed [Fig. 5]. Most common type was

Oval and the most unusual type was the deformed one.
Fig. 1: Methods of important measurements:

Fig. 2: Location of intracranial and extracranial orifice of hypoglossal canal

Fig. 3: Intracranial orifice at location 3

Fig. 4: Extracranial orifice at location 2

Fig. 5: Different shapes of occipital condyles noted in the study – oval, kidney shaped, S-like condyle, two-portioned condyle and deformed condyle
were found to be 23.4 mm, 10.6 mm, and 9.2 mm respectively. The length and the transverse distance were found to be 23.6 mm and 14.72 mm on 50 dry skulls whereas another study on 30 dry skulls reported the long axis of the condyle ranged from 18.19 to 30.30 mm, the average length was 24.47 ± 3.32 left and 25.16 ± 2.39 right. In the present study, the length of occipital condyle was 22.92 ± 1.82 on right side, 23.08 ± 2.02 on left side. These findings are comparable to Lang and Hornung [22.9 mm], Bozbuga et al [23.1 mm], and Naderi et al which ranges between 16.7 and 30.6 mm [mean 23.6 mm].

Width in the present study was much greater when compared to the results reported by Naderi, Bozbuga and Oliver. In contrast, the height is smaller than the results reported by Naderi and Oliver. The width was reported as 11.9 mm [right] and 11.7 mm on [left] in a study done on 56 dry skulls, this was more close to present study.

The occipital condyle is placed below the foramen magnum anteroposteriorly, more converging ventrally. The anterior intercondylar distance and posterior intercondylar distance are important as wider the distance, more the space for reaching the ventral foramen magnum. Naderi et al reported the measurements as 21 and 41.6 mm respectively. Whereas in present study the measurements of anterior intercondylar distance was 22.48 and posterior intercondylar distance was 40.52 mm which were very close to the previous study.

The distance between the posterior tip and opisthion is also an important landmark. Posterolateral approach will be easier if the distances are larger. The distance between the anterior and posterior tip of occipital condyle and opisthion was 40.07 mm and 29 mm respectively. This was slightly higher than the results given by Naderi [anterior: 39 mm and 26.4 mm]. The distance between anterior and posterior tip of occipital condyle and basion were measured as 12.07 mm and 27.58 mm. This was comparable with the results reported by Naderi.

Hypoglossal canal passes from a posteromedial to anterolateral direction. The two orifices of hypoglossal canal namely intracranial orifice is located medial to the occipital condyle and extracranial orifice is located lateral to the occipital condyle. The location of the intracranial orifice and extracranial orifice is important during condylar resection as hypoglossal nerve passes through it. In a study done by Naderi et al the intracranial orifice was found in location 4 in more than 55% specimens, extracranial orifice was found in more than 90% of specimens in location 1 and 2. In the present study, the intracranial orifice and hypoglossal canal was found to be in location 3 as commonest, right side 56% and left side 72%. The intracranial orifice was found to be more common in location 2, right side 25% and left side 25%. The location of intracranial orifice and hypoglossal canal limit the condylectomy procedure and avoid hypoglossal nerve injury.

The measured values and its variations, help us to determine the maximum amount of drillable condyle without opening the posterior border of the hypoglossal canal. Wen et al reported that the distance between the posterior margin of occipital condyle and hypoglossal canal was nearly 8.4 mm and added that condylar resection of 8.4 mm [nearly 1/3rd occipital condyle] was sufficient for surgical exposure. In another study, the distance between the posterior border of occipital condyle and hypoglossal canal was found mainly as 12.5 mm at the right side and 12.6 mm at the left one, the occipital condyle length was determined as 23.3 mm at the right side and 22.9 mm on the left side. The author stated that by drilling bone 12 mm from the posterior border of occipital condyle does not harm the hypoglossal canal and concluded that by resecting nearly ½ of occipital condyle [12.55 ± 0.05 mm] the border of the hypoglossal canal can be reached. Hence, in transcondylar approach, the posterior 1/3rd or half of the long axis of the occipital condyle is the maximum amount of drillable condyle without opening the posterior border of hypoglossal canal.
Another similar study also concluded that the occipital condyle could be resected with a 12 mm safe zone, without touching the hypoglossal canal and its contents. In present study, the distance between the posterior tip of the occipital condyle and the hypoglossal canal was determined as 12.5 mm on right and 12.6 mm on left which was very much comparable with the study of Nehir Barut. Hence by resecting 1/2 of the occipital condyle [12.55 ± 0.05 mm], the border of hypoglossal canal can be reached which would definitely prevent the injury to the hypoglossal nerve traversing hypoglossal canal.

Shapes of occipital condyle also play a significant role in the surgical approach as it may affect the condylectomy. The knowledge of different shapes are important as the extent of condylectomy varies by different shapes. As more extensive condylectomy is required for kidney-like and deformed type of occipital condyle. Many authors have classified according to the shapes. Oliver classified it as 1. normally constricted and 2. subdivided, whereas Bozbuga classified as two semicircles type, oval type, rhombus type, bean shaped, prismatic types, flattened types, convex types, flat convex types, flat types, short and broad types, flat and long types, small and convex types.

Based on the, systematic and detailed classification of its shapes the occurrence of oval-like shape was more than 50% in present study. These morphometrical variations in the parameters and shapes of occipital condyle, confers for a thorough radiological investigation before the surgical approach. The major limitation of the study was the lack of knowledge about the gender of the skull.

**Conclusion**

The results obtained in this study can be useful in cranial base surgeries, a careful radiological study is a pre-requisite for a cranial base surgeries. The knowledge of the variations and the safe zone transcondylar approach reported in this study contributes to the knowledge of the surgeons operating in this area.


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