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ORIGINAL ARTICLE

AN ANATOMICAL PERSPECTIVE OF HUMAN OCCIPITAL CONDYLES AND FORAMEN MAGNUM WITH NEUROSURGICAL CORRELATES

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ABSTRACT: AIMS: Knowledge of condylar anatomy helps the surgeon in making important decisions regarding extent and direction of condylar drilling and minimizing injury and retraction of neural structures. Important preoperative information includes length, width, axis/directions and overriding of occipital condyle in foramen magnum, relationships of condyles to foramen magnum and to hypoglossal canal. The antero-posterior and transverse diameters of foramen magnum and amount of overriding of occipital condyle in foramen magnum are useful in calculating area of surgical field. The present study aims to provide important anatomical parameters for the far lateral transcondylar approach. **METHODS AND MATERIAL:** The morphometric analysis of human occipital condyles and foramen magnum in 126 dried human skulls and 50 separated occipital bones was performed. The parameters significant to the far lateral transcondylar approach were measured using a digital vernier caliper. In addition, morphometric analysis was also done on 40 patients using thin section CT scans. The paired't' test was performed. **RESULTS:** The difference between the measurements for the right side and left side and those done on CT scans and using Vernier calipers on bones came out to be statistically insignificant($p>0.05$). **CONCLUSION:** The far lateral transcondylar approach provides better exposure of the ventrolateral foramen magnum and inferior clivus. Lesion removal from this site can be considerably made easier by utilizing a shorter and widened angle of exposure. Pre-operative assessment using CT imaging facilitates the far lateral transcondylar approach without damage to vital functional structures.

KEYWORDS: Morphometry, occipital condyles, foramen magnum.

INTRODUCTION: Resection of lesions in lower brain stem and ventral surface of cranio-cervical junction is extremely challenging. A number of surgical access routes to this region are currently in use. Immediate and optimal exposure to foramen magnum, cranio-cervical junction, clivus and front of lower brain stem is possible using either anterior or lateral/ postero-lateral approach methodology.[1, 2] Far lateral transcondylar approach is recognized as an optimal approach to access this region.[3-6] The transcondylar approach is an extension of basic far lateral approach.[7, 8]

Basic far lateral approach includes dissection of muscles of back and suboccipial triangle, adequate exposure of C1 transverse process and posterior arch of atlas, identification of vertebral artery above the posterior arch of atlas and a suboccipital craniotomy with removal of at least half of posterior arch of atlas.[8] Transcondylar extension of far lateral approach in addition includes the condylar drilling. It increases the area of surgical exposure and provides access to the lower clivus and premedullary area.

The important anatomical consideration for condylar drilling includes relationships of occipital condyles to foramen magnum, hypoglossal canal and vertebral artery. The study was done to provide the important morphometric parameters useful for the far lateral transcondylar approach.

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The foramen magnum is a vital component of skull base and its morphological considerations are imperative for anatomists, clinicians, forensic and anthropological experts.[9, 10]

MATERIAL AND METHODS: The morphometric analysis was performed on 126 dried skulls and 50 occipital bones (separated) of North Indian subjects (Table 1). In addition, certain morphometric parameters were measured from 40 cases of thin section CT scans (Table2). The study was conducted in Dr. H .S judge Institute of Dental Sciences & Hospital, Punjab University, Chandigarh. All the measurements taken with digital vernier caliper (Least Count 0.01 mm).

RESULTS: The measurements on occipital condyles and skulls were done using vernier calipers and the parameters for CT scans were taken from the monitor. The results have been depicted in table 3 and Table 4 respectively. The difference between the measurements for the right side and left side and those done on CT scans and using Vernier calipers on bones was statistically insignificant($p>0.05$).

DISCUSSION: 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. The important preoperative information includes length, width, axis/directions and overriding of occipital condyle in the foramen magnum, the relationships of the condyles to the foramen magnum and the relationship of condyles to important structures such as hypoglossal canal Condylar drilling is an important step in the transcondylar extension of the far lateral approach. The knowledge of length of the occipital condyle along its long axis and width of condyle helps the resection of the posterior 1/3rd of the occipital condyle safely. The long axis of occipital condyles ranged between 15.24-28.7 mm, which was consistent with the measurement taken on CT scans ie.16.2-27.3 mm. The average length found by Wen[7] was 21 mm and the range was 18-24mm.

The removal of approximately the posterior 1/3rd of occipital condyle is required to reach the lateral aspect of the intracranial end of the hypoglossal canal. This is located about 5mm below the jugular tubercle and 5mm above the junction of posterior and middle third of the occipital condyle. The extracranial end of hypoglossal canal is located immediately above the junction of anterior and middle third of occipital condyle and medial to the jugular foramen[6]. The posterior 2/3rd of the occipital condyle can be sacrificed as the direction of the canal is anterolateral, implying thereby that further drilling should be done anteriorly and laterally. The distances of inner and outer openings of hypoglossal canal from the mid-point of medial border of occipital condyle ought to be an important surgical guide in extension of condylar drilling. In our study, the distance of outer and inner foramen of hypoglossal canal from the midpoint of medial border was ranging between 7.43-18.42 mm and 8.37-11.56 mm. Wen[7] has mentioned about the distance from the posterior edge of occipital condyle to posterior edge of hypoglossal canal which was 8.4 mm and range between 6-10 mm.

The antero-posterior and transverse diameters of foramen magnum and the amount of overriding of occipital condyle in the foramen magnum would help in calculating the area of surgical field We have observed that the size, shape and overriding of occipital condyle in to the foramen magnum can alter the area of surgical field. The overriding of occipital condyle can range from 0-10.1 mm.eg. A patient with small foramen magnum and relatively large occipital condyles would definitely require condylar drilling and transcondylar approach would be a safer approach.

The distances from the posterior midline of foramen magnum to the posterior border and midpoint of occipital condyle represent the width of surgical exposure in suboccipital craniotomy and

50% condylar drilling respectively. The lateral exposure is increased in 50% drilling as compared to suboccipital craniotomy. Our study showed an average increase of exposure by 5 mm (22 %) for 50% condylar resection. Wanebo & Chicoine[11] found an increase in exposure by 7mm (30%) for 50 % transcondylar resection. The distances from the anterior midline of foramen magnum to the posterior border and midpoint of occipital condyle represent the angle of exposure in suboccipital craniotomy and 50% condylar drilling respectively. Wanebo & Chicoine[11] found values of 54.3±5.7° for 50 % transcondylar resection.

The recognition and understanding of the correlations among these important structures and an understanding of the possible variations helps to distinguish the normal from the potentially abnormal and consequently avoid misinterpretations during surgery.[12]

CONCLUSION: The far lateral transcondylar approach provides better exposure of the ventrolateral foramen magnum and inferior clivus. The removal of lesions from this site is made easier through a shortened and widened angle of exposure. Morphometric parameters measured can be used for the estimation of extent of condylar removal and to perform transcondylar approach without harming functional structures. These parameters can be assessed pre-operatively by CT imaging.

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Length of long axis and width of the occipital condyles (1a & 1b)
Antero-posterior & transverse diameters of foramen magnum (2 a & 2 b)
Overriding of medial border of occipital condyle into the foramen magnum(3)
Distances from the anterior midline of foramen magnum to posterior end and the midpoint of medial border of occipital condyles. (4a & 4b)
Distances from the posterior midline of foramen magnum to posterior end and the midpoint of medial border of occipital condyles (5a & 5b)
Distance of outer foramen and inner foramen of hypoglossal canal to midpoint of medial border of occipital condyle (6a & 6b)

Table 1: Parameters measured on bones

Length of long axis and width of the occipital condyles (CT 1a & 1b)
Antero-posterior & transverse diameters of foramen magnum (Ct 2 a & 2 b)
Distances from the anterior midline of foramen magnum to posterior end and the midpoint of medial border of occipital condyles. (CT 4a & 4b)
Distances from the posterior midline of foramen magnum to posterior end and the midpoint of medial border of occipital condyles (Ct 5a & 5b)

Table 2: Parameters measured on CT Scans

Parameter	Side	Mean ±SD (mm)	Range (mm)
1 a	Right	22.61±2.3	18.51-28.7
	Left	22.36±2.3	15.24-27.43
1b	Right	13.72±1.56	10.4-17.2
	Left	13.96±1.82	10.8-16.8
2a		32.83±2.62	26.06-39.59
2b		27.47±2.25	21.65-34.83
3	Right	7.01±1.92	0-10.1
	Left	6.95±1.65	0-9.47
4a	Right	26.07±2.00	20.16-31.16
	Left	25.75±2.18	19.79-31.66
4b	Right	14.87±1.42	11.32-16.37
	Left	14.63±1.39	11.19-15.74
5a	Right	23.57±2.6	18.3-30.98
	Left	23.04±2.6	17.05-29.75
5b	Right	28.78±3.0	28.78±3.0
	Left	28.32±2.6	21.4-35.4
6a	Right	13.31±1.82	7.43-17.48
	Left	14.01±2.06	7.59-18.42
6b	Right	9.92±0.92	8.48-11.56
	Left	9.69±0.54	8.37-10.5

Table 3: Measurement values for bones as taken by vernier calipers

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Parameter	Side	Mean ±SD (in mm)	Range (in mm)
CT1a	Right	21.96±1.2	18.8-27.3
	Left	22.84±1.92	16.2-26.6
CT1b	Right	13.2±1.68	10.8-16.7
	Left	13.38±1.71	11.7-16.1
CT2a		33.4±2.91	27.2-38.2
CT2b		28.12±1.74	22.4-33.6
CT 4a	Right	26.42±2.32	21.2-32.6
	Left	25.94±2.68	19.2-32.4
CT 4b	Right	15.2±1.38	11.4-17.2
	Left	14.9±1.52	11.2-16.1
CT 5a	Right	23.57±2.6	23.04±2.6
	Left	23.04±2.6	17.05-29.75
CT 5b	Right	28.2±2.6	22.4-35.2
	Left	28.6±2.2	22.6-34.6

Table 4: Measurement values for parameters measured on CT scans

Figure 1: Parameters as measured on skulls and occipital bones.

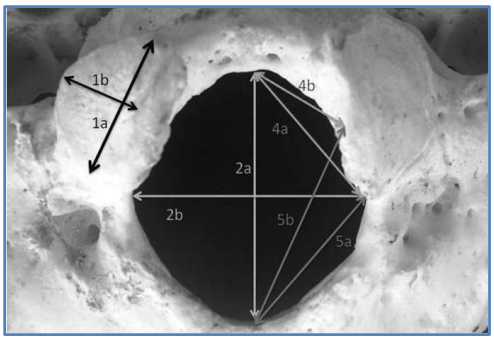

Figure 1

Figure 2: Occipital condyles as seen from inner aspect of foramen magnum.

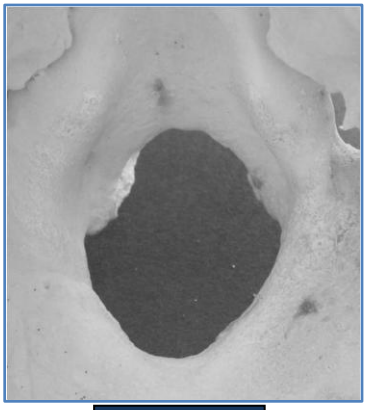

Figure 2

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Figure 3: Length and width of occipital condyle (CT 1a & CT 1b).

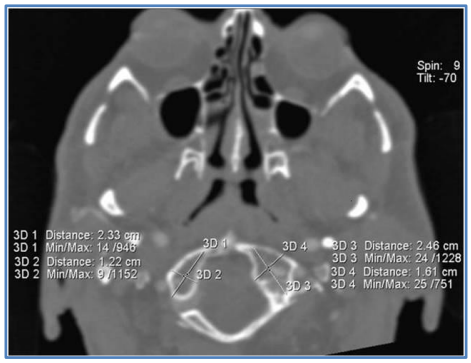

Figure 3

Figure 4: Anterior margin of foramen magnum to posterior end and midpoint of medial border of occipital condyles (CT 4a & CT 4b).

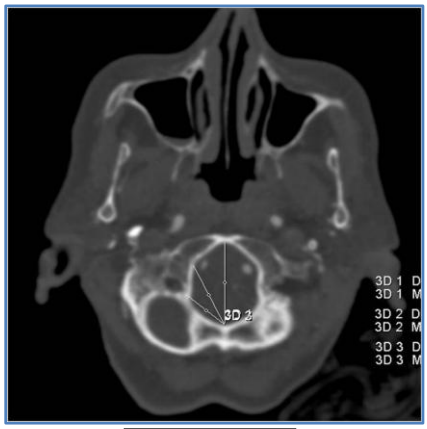

Figure 4

Figure 5: Anteroposterior and transverse diameters of foramen magnum (CT 2a & CT2b).

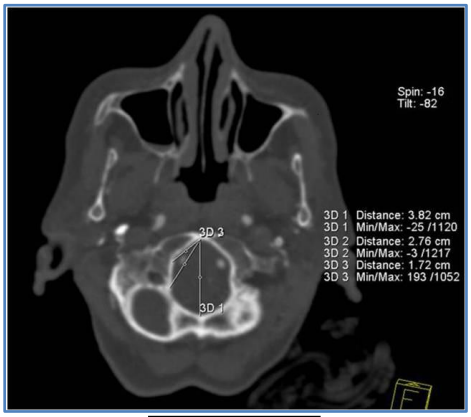

Figure 5

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Figure 6: Posterior margin of foramen magnum to posterior ends and midpoint of medial border of occipital condyles (CT 5a & CT 5b).

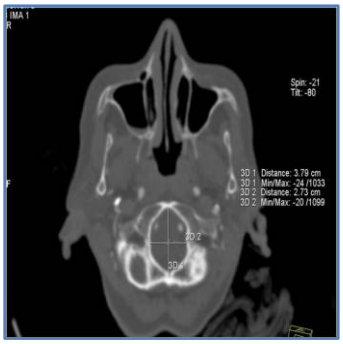

Figure 6

Figure 7: A probe passing through hypoglossal canal, showing direction of canal. Direction of probe shows medially posterior 1/3rd and laterally posterior 2/3rd of occipital condyle can be removed safely.

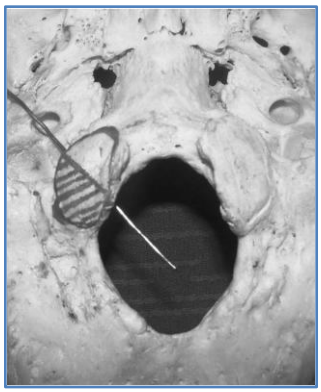

Figure 7

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