Original Article

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A Study on the Morphometry of Occipital Condyles and Suboccipital Muscles in Human Dry Skulls and its Clinical Significance

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Abstract

Introduction: The base of the human skull presents Occipital condyle which articulates with the atlas vertebra forming Atlanta-Occipital joint. Keeping the head in inclined posture to engage in actions may play major role in architecture of facet. Maintenance of a particular posture demands more activity from muscles concerned. In this context the role of muscles in terms of traction to maintain a desired posture cannot be ruled out. More anatomical facts on the condyle facets will play an additional boon for the day to day surgeries. *Materials & Methods:* One hundred adult South Indian skulls were examined using the scale, divider and the transparent centimeter reticule in the present study. The shape, size, the anterior-posterior diameter (length) and transverse diameter (width), surface area of occipital condyles on both sides were estimated. The location and number of extra facets were also noted. The surface area of suboccipital muscles were measured in search of the functional relation. *Results:* Mean anteroposterior (length) and transverse diameter(width) of occipital condyles were 2.12cm & 1.1 cm on right side and 2.2 cm & 1.2 cm on left respectively. Mean Surface areas of the facet were 1.76 square centimeter (sq cm) on right and 1.9 sq cm on left which was significant. 22 extra facets were present maximally on the posteromedial aspect of the left occipital condyles. Its mean anteroposterior and transverse diameter were 0.52cm & 0.44 cm on right side and 0.45 cm &0.36 cm on left respectively. Mean surface areas (sq cm) of suboccipital muscles - rectus capitis minor, rectus Capitis major and Obliquus Capitis Superior were 4.9, 5.05 and 10.56 on left side and 4.96,5.37 and 10.82 on right side respectively. Statistically the valued proved to be significant. *Conclusion:* The present study provides anatomical knowledge on the measurements of the occipital condyles serves as a guide in various head and neck procedures for the Neurosurgeons and the Orthopaedicians. The incidence of the facets and the measurements of impressions of the suboccipital muscles on the occipital bone mentions the tilting posture of the humans on one side.

Keywords: Occipital Condyles; Extra Facets; Suboccipital Muscles.

Introduction

Occipital condyles are normally oval in shape and placed in the oblique manner so that anterior end is nearer to midline [1]. The condyles of occipital bone is unique in nature as it connects cranium to the vertebral column. Occipital condyle with the atlas forms the Atlanto- occipital joint, a true synovial joint. Its main movement is flexion and extension of the head which is innervated by C1 ventral ramus [2]. The joint also involved with postural maintenance, balance & weight transmission. The development of bone runs parallel to the stresses imposed on them [3]. Later it is appended that these stresses are transmitted from one bone to other through joints, which may bring about changes in morphology of articular surfaces [4].

In humans the neural arch of pro-atlas divides it into anterior and posterior segments which form occipital condyles and rostral facets on the atlas vertebra [5]. Developmentally abnormal immigration and lack of separation of the features of the cervical vertebrae and base of the skull leads to formation of Occipital Condyle. Precondylar facets develop in response to the primordial dens or odontoid process failing to move down from its primordial position with the foramen magnum, leaving tip of the dens and the atlas anterior border articulating with the rim of the occipital bone [6].

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Two canals anterior and posterior condylar canals are related to occipital condyle which transmits important structures. Anterior condylar canal or hypoglossal canal transmits rootlets of hypoglossal nerve. Posterior condylar canals transmit largest emissary vein to the sigmoid sinus, nerves and meningeal branches of occipital artery. During transcondylar approach the condyles should be resected partially or completely to protect these neurovascular structures.

The direction, angle and position of the instruments should be manipulated in various procedures depending on the morphometric measurements of the occipital condyles. Transcondylar surgeries in cranio-vertebral junction requires anatomical knowledge of occipital condyles. Hence prior knowledge of these condyles is compulsory before intervention. So, present study adds a light on the anatomical knowledge of the occipital condyles and the facets.

Posture of the head is maintained by the tension of the extensor muscles. Here study has been made on the surface area of the suboccipital muscles in search of the correlation with the straight / tilted postures of the head.

Materials & Methods

One hundred adult south Indian skulls of unknown age and sex were examined using the scale, divider and the transparent centimeter reticule in the present study. The shape, size, the anterior-posterior diameter and transverse diameter, surface area of occipital condyles on both sides were estimated.

Anterior- posterior diameter (length) is measured between the anterior tip to posterior tip of occipital condyle. Transverse diameter (width) is measured between the midpoint of the left and right margins of the condyles. It is measured using a divider and scale and measured in millimeters (mm) (Fig. 1).

Fig. 1: Measurement using scale and divider

Results

Articular surface areas were calculated using a superimposed square centimeter transparent reticule. 1&>1 sq = 1 UNIT. (Fig. 2)

Statistical analysis was done using unpaired tests on mean and standard deviation results.p value is calculated.

Mean Anteroposterior and transverse diameter of occipital condyles were 21.2mm & 11 mm on right side and 22 mm & 12 mm on left respectively. Mean Surface areas of the facet were 1.76 sq cm on right and 1.9 sq cm on left which was significant (Table 1).

22 extra facets were present maximally on the posteromedial aspect of the left occipital condyles (Fig. 5). Its mean Anteroposterior and transverse diameter were 5.2cm & 4.4 mm on right side and 4.5mm & 3.6 cm on left respectively (Table 3). p value was significant on the left side.

Table 1: Mean Diameter and Surface Area of Occipital condyles

	Anteroposterior (length) [mm]	Transverse (width) [mm]	Surface Area [in sq mm]
Right	21.2	11	17.6
Left	22	12	19

p <0.01, highly significant on left side

Table 2: Mean Diameter of extra facets in mm

	AP diameter	Transverse diameter
Right	5.2	4.4
Left	4.5	3.6

Two different shapes of occipital condyles- globular and hour-glass shaped were observed (Fig. 3,4).

Mean surface areas (sq cm) of suboccipital muscles -rectus capitis minor, rectus Capitis major and Obliquus Capitis Superior were 4.9, 5.05 and 10.56 on left side and 4.96,5.37 and 10.82 on right side respectively (Fig. 6). p valve was highly significant on the right side.

Observations were also made on the number, location and surface area of additional facets.

Our study showed 22 extra facets, 12 on left side and 10 on right Side. Its position was onpostero-medial aspect (20) and 2 were located medially. Measurements were made on these extra facets which showed more values on right side (Table 3).

Table 2: Comparision of occipital condyles paramaters with other studies

Sl. No	Author	Year	Occipitalcondyles								
			No. of occipital condyles	Length		Width		Height		AICD (anterior intercondylar distance)	PICD = (posterior intercondylar distance)
				Rt	Lt	Rt	Lt	Rt	Lt		
1.	Present study	2018	200	21.2	22	11	12	---	---	---	---
2	Divya P[10]	2017	110	22.9	22.8	12.7	12.3			19.2	39.3
3	Deepa Somanath et al.[11]	2017	100	24.9	23.9	11.4	10.1	5.3	4.5	15.22	7.7
4	Sandeep Saluja[25]	2016	228	22.90	22.60	9.32	12.97	9.32	9.12	17.81	38.91
5	Anil kumar et al. [26]	2014	100	23.88	24.99	12.97	14.11	8.64	9.32	17.63	42.02
6	S. Kavitha et al. [27]	2013	290	21.97	22.34	13.05	13.30	---	---	---	---
7	Avic.E et al.[28]	2011	60	23.7	24	12.2	12.4	9.6	9.5	9.9	26.7
8	Divya Mahajan et al.[29]	2011	300	22.61	22.36	13.72	13.96	7.01	6.95	---	---
9	Archana et.al.[30]	2016	200	21.83	22.19	11.07	11.42	8.25	8.19	21.28	40.61
10	Naderi et al.[12]	2005	404	23.6	23.3	10.6	10.6	9.2	9.2	21	41.6

Fig. 2: Measurement using Transparent reticule

Fig. 4: Shape of the condyle – Globular

Fig. 3: Shape of the condyle – Hourglass

Fig. 5: Shape and position of the extra facets

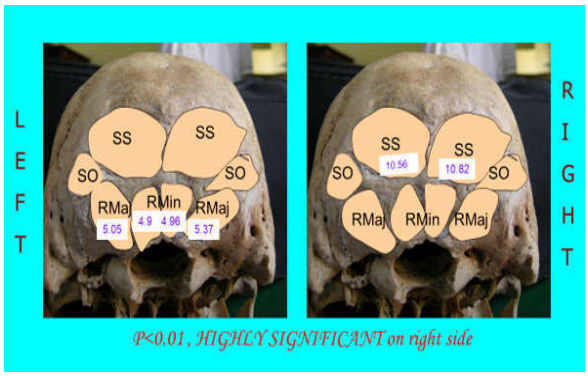

Fig. 6: Mean Surface area of muscles (In cms2)

Discussion

The entire weight of the head falls on the atlanto occipital joint. Any variation in the shape and size will disturb this function. The condylar parts of occipital bone flank the foramen magnum. Lesions closeto foramen magnum can be approached through transcondylar approach which is performed by piercing occipital condyles above occipital junction [7]. Dorsal aspect is most preferred at craniovertebral junction [8]. It is important to plan and calculate the bone extent to be resected [9].

Most of the researchers conducted morphometry of occipital condyles in dry skulls, though a few investigators studied cadaveric specimens and CT scans which can yield variable results. A comparative study has been done with our findings (Table 3). In our study mean length of occipital condyles were found 21.2mm right and 22.2 mm left which are in accordance with the findings of other authors with a difference range of 1-2 mm. The values were found more on the left side which is in conformity with the length reported by other authors except Divya. P [10] and Deepa Samarth [11], Naderi Mahajan et al.[12] mentioned more on right side of measurement 1-2 mm (Table 3). Mean width of occipital condyles in our studies revealed 11 mm on right and 12 mm on left side. The values were almost same with other authors with a variable range of 1-2mm. Comparatively, higher values were found on the left side which are coinciding with the findings of other authors with a exception of findings of Deepa Samarth and Divya. P where the difference is about 1-2mm more (Table 3). Probably the slight difference of measurements among the authors may be due to racial variations and the difference in the methodology. Naderi [12] classified length of occipital condyles as Type-1. Short Condyles- shorter than 20mm, Type-2. Moderate Condyles- between 20–26 mm and Type-3. Long Condyles longer than 26mm.

Based on the above classification, the occipital condyles in the present study falls in Type-2. moderate condyles.

Most of the cranio-vertebral approaches necessitate either partial or complete resection of occipital condyles [13].

Our study showed 70% globular shaped and 30% hourglass shapedoccipital condyles in South Indian population. This was different from other previous studies done by Fetou H [14] and Parvindokht [15] which showed reniform shaped in Egypt population and in Iran population respectively. Jose study showed S and 8 types to be more common in Brazilian population [16].

The suboccipital region is one the most complicated anatomical areas of human body [17]. The sub-occipital muscles act to functionally maintain the stability of the head while allowing delicate control of movement of atlanto-occipital and atlanto-axial joint with a weak sustained force [18]. Unilateral contraction of these muscles results in head rotation, were as bilateral contraction results in head extension [19].

Muscle strength is proportional to cross sectional area of muscle fibres [10]. Our study showed the values of surface areas of suboccipital muscle to be highon the right side compared to left side (Fig. 6). This shows that the muscle strength is more on right side. Cross-sectional areas of neck muscles is proportional to height and weight of an individual [21].

The proprioceptive inputs from the cervical musculature play an important role in head-eye co-ordination and postural process [22]. Atrophy of sub-occipital muscles following whiplash is involved in marked, chronic neck pain and reduced standing balance [23]. Hence association between these muscles and headache cannot be ruled out. Our study on surface areas of these muscles provides clinical significance in relation to the headache and neck pain.

Xiao-Ying Yuan et al. investigated the existence of second termination originating from sub-occipital muscles and relation between various types of To Be Named Ligament (TBNL) [24].

Extra facets were observed in 10-12% skulls studied. Majority of them were located posterior to occipital condyles.

The above findings perhaps suggest an adaptation for tilted head posture on the left side.

Conclusion

This study provides anatomical data on occipital condyles and the accessory facets. These morphometric parameters will be helpful for planning the appropriate surgical approach.

12% of the skulls showed extra facets posteriorly. Probably this suggests a "secondary adaptation" to maintain the erect posture of the head countered by the tonus of extensor muscles (sub occipital muscles). More surface area on the right side may probably due to tilted head.

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