Research Article

Morphometric analysis of occipital condyles with occipitalization of atlas vertebrae

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Abstract

Objective: The human occipital condyle is the unique bony structure connecting the cranium and the vertebral column. This study aims to document the dimensions of occipital condyles and its variations which are of paramount importance to neurosurgeons, orthopaedic surgeons and radiologist when dealing with Transcondylar surgical approaches and condylectomies. **Material and Method:** In 150 dried human skulls the shapes of the occipital condyles were observed and the measurements like length, and breadth were measured. **Results:** The length and width of the occipital condyle were found to be 22.5 mm and 10.5 mm. The anterior and posterior intercondyler distances are 22.0 mm and 41.5 mm respectively. The shape of occipital condyles was classified into eight types as followings—type 1: oval-like condyle; type 2: kidney-like condyle; type 3: S-like condyle; type 4: eight-like condyle; type 5: triangle condyle; type 6: ring-like condyle; type 7: two-portioned condyle and type 8: deformed condyle. **Conclusion:** The documented parameters of the occipital condyles and its variations will serve as a guide line for surgeons in future.
Keywords: Condyles, shape, occipital bone.

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INTRODUCTION

The posterior part of the human skull is largely formed by the occipital bone. Adjoining the foramen magnum the occipital condyles are present. The occipital condyles are small, bilateral inferior extensions of the occipital bones and form a portion of the lateral aspect of the foramen magnum. The superior articular facet of the atlas articulates with the occipital condyles to form the atlanto occipital joint. The occipital condyles are oval in shape and placed in an oblique manner so that its anterior end lies closer to the midline than its posterior end[8]. Occipital condyles are important element to maintain the head vertically. It is necessary for the stability of the craniovertebral junction. Occipital condylar fractures are a dangerous proposition due to the intimacy of the occipital condyles to the neurovascular structures abutting it[14]. In humans, the neural arch of the pro-atlas divides it into anterior and posterior segments, and the anterior segment forms the occipital condyles while the posterior segment forms apart of the rostral facets on the atlas vertebra[11]. Several types of anomalies and traumas are associated with the occipital condyles. The condyles articulate with the lateral masses of the atlas vertebral body. This unique anatomical feature results in a unique biomechanical characteristic. Its integrity is of vital importance for the stability of the craniovertebral junction. They are intimately related to the other osseous structures at the foramen magnum and skull base by a number of ligamentous attachments. Understanding the anatomical basis of craniovertebral anomalies is important when carrying out surgeries in the region. Lateral approaches during craniovertebral surgery require resection of the occipital condyles and In the Transcondylar approach, the Morphometry of the occipital condyles is a must [6, 14]. Symmetry of the occipital condyles does not pose any difficulty in flexion, extension and lateral bending but asymmetrical facets will give rise to altered kinematics in the atlanto occipital joint

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[4]. Many patients who suffer a closed head injury are at risk for occipital condylar fractures [8]. Hence the Morphometric analysis of occipital condyles and their facet is important clinically. So the present study will serve as a guideline for the dimensions of occipital condyles and their morphological variations in dry adult human skulls.

MATERIALS AND METHODS

The study was conducted after ethical clearance was obtained from the Institutional Ethics committee. A total of 150 dry human skulls with intact occipital condyles were selected from the museum of anatomy department of GMERS Medical College Gotri Vadodara and Government Medical College Bhavnagar and from the students. All skulls were regular in shape, without obvious evidences of deformities.

The equipments used for the purpose of study were
- Vernier callipers,
- Measuring scale
- Digital photography equipment

Measurements will be based on following bony landmarks on the skull:

- Basion
- Opisthion
- Anterior tip of right occipital condyle
- Posterior tip of right occipital condyle
- Anterior tip of left occipital condyle
- Posterior tip of left occipital condyle

The following parameters were measured on both right and left sides

1. The OC shapes bilaterally. Naderi *et al*. (2005) classified the shape of occipital condyles in eight types as follows - type 1: S-like condyle; type 2: kidney-like condyle; type 3: triangle condyle; type 4: square condyle; type 5: eight like condyle; type 6: oval-like condyle; type 7: two-portioned condyle and type 8: foot condyle [14]
2. The length of right and left occipital condyle (Figure-1)
3. The width of right and left occipital condyle
4. Distance between the anterior tip of right occipital condyle and basion
5. Distance between the anterior tip of left occipital condyle and basion
6. Distance between the anterior tip of right occipital condyle and opisthion
7. Distance between the anterior tip of left occipital condyle and opisthion
8. Distance between the posterior tip of right occipital condyle and basion
9. Distance between the posterior tip of left occipital condyle and basion
10. Distance between the posterior tip of right occipital condyle and opisthion
11. Distance between the posterior tip of left occipital condyle and opisthion
12. The Anterior intercondyler distance between the anterior OC tips bilaterally.
13. The Posterior intercondyler distance between the posterior OC tips bilaterally.
14. The OC protrusion into the FM.
15. Occipitalization of atlas vertebrae.
16. Presence of partition or grooves on the articular surface of occipital condyle.

RESULTS

Of the 150 skulls studied the shape of the occipital condyles varied and the commonest shapes were oval shapes on both sides (Table-1). The mean length and width of occipital condyle were found to be 23.5mm± 2.5mm (right), 23.1mm ± 2.5mm (left), 10.5mm ± 1.3mm(right), 10.2mm ± 1.6mm (left), 9.0mm± 1.1mm (right), 9.5mm ±1.2mm (left), respectively. The mean anterior intercondyler distance and posterior intercondyler distance were measured as 22.0mm ± 2.5mm and 41.5mm ± 2.4 mm, respectively. The distance between the anterior tip of occipital condyle and basion was found to be 10.1mm ± 1.2mm and 11.0mm ± 1.1mm in the right and left, respectively. The distance between the anterior tip of occipital condyle and opisthion was found to be 35.9mm±2.9mm and 34.1mm±3.0mm in the right and left, respectively. The distance between the posterior tip of occipital condyle and basion was found to be 28.5 mm± 2.5mm and 27.1mm ± 2.5mm in the right and left, respectively. The distance between the posterior tip of occipital condyle and opisthion was found to be 26.5mm±2.2mm and 26.1mm±2.5mmin the right and left, respectively.

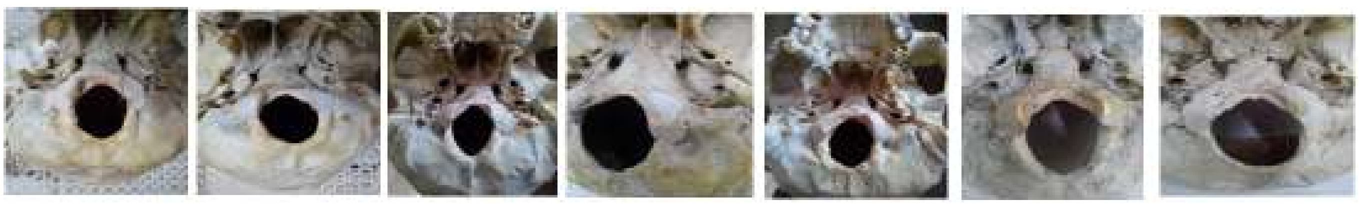
Table 1

Shape	Rt	Lt
S-shape	13(8.66%)	12(8%)
Kidney	22(14.66%)	23(15.33%)
Triangle	12(8%)	11(7.33%)
Square	15(10%)	12(8%)
Eight	18(12%)	19(12.66%)
Oval	43(28.66%)	44(29.33%)
Two portioned	07(4.66%)	08(5.33%)
Foot	20(13.33%)	21(14%)
Total	**150**	**150**

In the present study in one skull a tight bony fusion between the anterior arch of the atlas, the left portion of the posterior arch, the lateral masses of the atlas, and the occipital bone was observed. Hence, the left and right superior articular facets of the atlas were fused with the corresponding occipital condyles. The anteroposterior dimension of both inferior articular facets was the same (22 mm), while the transverse diameter of the right one was considerably smaller (11 mm). The transverse diameter of the left inferior articular facets was 18 mm. The right and the left transverse process of the atlas were normally developed, each of them contained transverse foramen, and they were not fused with the occipital bone. The circumference of the foramen magnum was minimally diminished by the osseous structures of the atlas fused to the occipital bone (occipitalization of atlas vertebrae Figure-3).

Statistical Analysis

Standard deviation, mean values and the range were calculated from the obtained results and parameters measured were evaluated by the paired sample t test to differentiate between the right and the left sides. The resultant p value was < 0.05 making it statistically significant. The mean, standard deviation (SD) were assessed. Epi info 7.0.8.0 Atlanta USA software was used for data analysis.



1.Foot 2.Oval 3.Triangle 4.Eight 5.S -Like 6. Kidney shape 7. Square with groove

Figure 1: Various Shapes of OC

Figure 2: Groove on surface

Figure 3: Occipitalization of atlas vertebrae

DISSCUSSION

The occipital condyle is an important of the Craniovertebral junction. It is the only articulation between occiput and atlas. It has ball- pivot relation with lateral mass of the atlas. This unique anatomical feature results in a unique biomechanical characteristic. It integrity is of vital importance for the stability of the Craniovertebral junction[7]. Sait et.al have analysed the occipital condyle in detail. 404 occipital condyles of 202 dry skulls were used for his study. The average length, width and height of the occipital condyle were found to be 23.4mm, 10.6mm, and 9.2mm respectively[14]. Muthukumar et.al has measured 100 occipital condyles in 50 dry skulls and the average anterioposterior length of occipital condyle was 23.6 mm. Xiang Jain et.al have measured 30 dry skulls and the average length of occipital condyle is 24.47mm±3.32mm (left) and 25.16mm± 2.39 mm (right)[18]. The surgical treatment for any space-occupying lesion is usually performed at the level of the foramen magnum, through a ventral or dorsal approach[6]. It has been found that the ventral approach is usually associated with more morbidity; hence the dorsal approach is usually advocated for all surgeries. Most of the surgical approaches, such as the lateral transjugular approach, transtubercular approach and transcondylar approach, require resection of the condyles[17]. Understandably, surgical resection of the occipital condyles requires thorough anatomical knowledge for preoperative planning. In the present case, the articular surfaces of the facets of the occipital condyles were rough and serrated, and this may have caused disturbance to the stability and movements of the atlanto-occipital joint. Thorough anatomical knowledge of the anomalies of the occipital condyles may be important while performing surgery and Interpreting neuroinvestigative procedures. The dimensions of the occipital condyles in this study are significant and comparable with other studies of similar parameters. Atlanto occipital dislocation is a common cause of road accidents which are usually fatal, are undiagnosed and often not considered[12]. In such cases the dimensions of the occipital condyles and its shape will play an important role during a radiological assessment.

A few research studies have documented the evidence of partition in the facets[7]. In the present study condyles showed such partition. A partitioned occipital condylar facet can be mistaken for fracture in an X-ray. Such morphological variations can produce clinical symptoms [7]. In space occupying lesions of the posterior condylar fossa the preferred mode of approach is the dorsal approach through the foramen magnum. This surgical approach requires a thorough knowledge of occipital condyles and their adjoining structures. Other surgical approaches like transcondylar and the transjugular approach require surgical removal of occipital condyles [6, 7]. If occipital condyles have to be surgically removed, the geometrical configuration of the atlanto occipital joint will be disturbed and result in instability giving rise to clinical symptoms. Resection of condyles requires an in depth idea of measurements on how much to resects or how much to be left. An incomplete longitudinal groove and a transverse groove were observed on the facets of the occipital condyles on the left and right sides respectively and were rough and serrated, and this may have caused a disturbance in the stability and movements of the atlanto-occipital joint (Figure-2). The presence of bony elevations on the facet may have exerted pressure upon the alar ligaments, thereby altering the biomechanics of the atlanto-occipital articulation. The presence of bony projections and grooves provide morphological evidence of possible developmental defects[4]. The skull showed erosion of the occipital condyles. The occipital left condyle and the left border of the foramen magnum appear distorted and scalloped, and are irregularly shaped (Fig. 3). The articular surfaces are pitted and rough, and seem as though the epiphyseal cartilages had been separated by maceration. The erosion of bone also extended into the right occipital condyle. These joint disorders can be broadly classified in pathogenetic categories, non-inflammatory and inflammatory. The non-inflammatory category includes degenerative joint disease, traumatic joint disease, and developmental, dietary, metabolic, and neoplastic arthropathies. The inflammatory category includes infectious (bacterial, viral, fungal, protozoal) and non-infectious (immunologic, crystal-induced) arthritis. Differentiating between the non inflammatory and inflammatory types of joint disorders can be complex, since non-inflammatory disorders may be accompanied by secondary inflammation, and inflammatory disorders commonly result in secondary, often severe degenerative changes. A variety of disease processes may affect the craniovertebral junction. In the population, abnormalities may be either congenital (Arnold-Chiari malformations) or acquired (posttraumatic, inflammatory, and neoplastic) (Stroobants *et al*., 1994; Binatli *et al*., 1995)[2, 16]. In individuals, acquired lesions involving the craniovertebral junction and foramen magnum may be the result of trauma (occipital condyle fractures related to axial loading injuries in association with ipsilateral flexion, avulsion fractures from a combination of head rotation and contralateral head flexion) (Anderson and Montesano, 1988; Deeb *et al*., 1988)[1,5]. Inflammatory disorders such as rheumatoid arthritis and metabolic disorder such as Paget's disease, and hyperparathyroidism may result in basilar invagination (Johnson and Smoker, 1994)[8]. The cranial base and endocranial base are directly affected by the cervical vertebrae, which play a substantial role in the development and modification of the foramen magnum. Congenital and developmental osseous abnormalities and anomalies affecting the craniovertebral junction complex can result in neural compression. Clinical and osteological research suggests that malnutrition or non-specific systemic stress is strongly correlated with the incidence of vertebral anomalies (Bergman, 1993; See *et al*., 2008)[3, 15]. See *et al*. (2008) documented numerous vertebral anomalies in the offspring of vitamin A-deficient rats, including cleft neural arches, occipital vertebrae, vertebral blocks etc. In addition, over 80% of the offspring exhibited basioccipital malformation of some variety (See *et al*., 2008). In occipitalization of atlas vertebrae the asymmetrical anatomy of the superior and inferior articular facets of the atlas give rise to speculation that movement in the atlantoaxial joint was disturbed by assimilation with the occipital bone. In the present study we had not find out 3rd occipital condyle. The third occipital condyle (condylus tertius or median occipital condyle) was first described by J.F. Meckel in 1815, as a bony process in the anterior midline of the foramen magnum[10]. It is always present in reptiles; in humans it is found in approximately 0.5% of the population and may exist as a discrete condyle or an isolated osseous element. It may serve as an articulation with the tip of the dens or with the anterior atlantic arch. The third occipital condyle is a vestige of proatlas (a derivative of the 4th occipital and 1st cervical sclerotome). The variations of the anatomic appearances of the third condyle can be explained by the different degrees of persistence. An isolated, articulated condylus tertius, located in the median-sagittal plane and the anterior margin of the foramen occipitale magnum represents the highest degree of persistence.

CONCLUSION

The occipital condyle is an important part of the craniovertebral junction, connecting the cranium to the upper cervical spine. Several anatomical parameters such as shape, size, orientation of occipital condyle and the location of hypoglossal canal should be taken into consideration during posterior and lateral approaches to the craniovertebral junction. The determined variability reported in this study require a careful radiological analysis of occipital condyle before craniovertebral junction surgery. There are several developmental variations in the region of the craniocervical junction, many of which can resemble deformities. Some variations are minor anatomic abnormalities but they can cause severe diagnostic problems. A reliable and exact radiologic diagnosis requires knowledge of the morphologic features of the variations and the appearance of their characteristic features in the common radiologic procedures[8]. The major limitation of this study is the lack of knowledge regarding the age and gender of the subjects whose condyles were studied.

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