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A PILOT STUDY ON MORPHOMETRIC ANALYSIS OF THE OCCIPITAL CONDYLE

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Abstract

In the present study, the most commonly observed types of occipital condyles were oval, followed by circular and two-portioned shapes. Occipital condyles are small bilateral extensions of the occipital bone that hold crucial implications for neurosurgical practice due to their association with various disease processes affecting the craniovertebral junction. A comprehensive understanding of the bony anatomy and variations in occipital condyles is imperative for optimising neurosurgical approaches. The primary objective of this study is to conduct an in-depth investigation of occipital condyles. We examined 40 dry human skulls, meticulously measuring various parameters such as length, breadth, anterior, and posterior intercondylar distances. The shapes of occipital condyles were classified into distinct types: oval, circular, eight-shaped, kidney-shaped, deformed, two-portioned, oval convex, and pyramid. The documented parameters of occipital condyles and their variations are poised to serve as invaluable guidelines for future surgeons. Possessing a thorough understanding of occipital condyle morphometry can significantly facilitate the instrumentation process, mitigating the risk of neurovascular damage. We firmly believe that the outcomes of our research will establish a comprehensive reference database, aiding in the development of implants and the formulation of optimal surgical approaches tailored to the intricacies of occipital condyles.

Key words: Atlanto-occipital dislocation; Cervical spine injury; Occipital condyle; Morphometric analysis; Comparative morphology; Craniovertebral junction; Neurovascular damage; Cranial landmarks; Craniofacial anatomy**.**

Introduction

In the study of cranial anatomy, the lower surface of the occipital bone reveals two distinct bony protrusions known as occipital condyles. These structures play a crucial role in the articulation of the skull and spine, specifically contributing to the formation of the atlanto-occipital joint. This joint is formed as the upper facet of the atlas bone connects with the occipital condyles, enabling important head movements. These condyles are commonly oval-shaped, contributing to their stability and function.

This study focuses on the initial steps of exploring the dimensions and variations of occipital condyles. By measuring and categorising these variations, we aim to contribute to a better understanding of the intricate details of cranial anatomy.

This research article will further detail our methodology, the specific aspects we measured, and the potential implications of our findings. This pilot study serves as a stepping stone for further investigations into the complexities of occipital condyles, which have implications for various fields including neurosurgery. Through this study, we hope to enhance our knowledge of cranial anatomy and its applications in medical practices.

Objective

The objective of this study was to conduct a morphometric analysis of adult human occipital condyles, encompassing the estimation of sexual dimorphism and the exploration of various shapes they exhibit.

Literature review

Vital responsibilities within the realm of forensic anthropology encompass the evaluation and examination of the bone morphology constituting both the neurocranium and viscerocranium. Kumar and Nagar (2014) assert that these evaluations and analyses hold paramount significance in investigative pursuits aimed at approximating or definitively establishing the sex, age, ethnicity, and stature of unidentified individuals.

The occipital condyles are osseous protrusions located on each side of the foramen magnum, situated at the base of the skull's exterior occipital bone (Kavitha et al., 2013; Natsis et al., 2013). These structures were initially brought to light by the pioneering research of Kavitha et al. and Natsis et al. Both research groups have extensively detailed the characteristics of these formations.

At the atlanto-occipital joint, these structures establish a connection with the spinal column (Kavitha et al., Bayat et al., 2014; Das et al., 2006; Naderi et al., 2005; Ozer et al., 2011; Kizilkanat et al., 2006).

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Naderi et al. and Ozer et al. have revealed that variations in the atlanto-occipital joint are closely associated with disparities in the shape, size, and angle of the occipital condyles. Therefore, safeguarding the structural integrity of the occipital condyles becomes paramount to maintaining the normal and stable craniovertebral connection.

The occipital condyles, as elucidated by Kavitha et al. and Ozer et al., manifest as osseous structures possessing an oval contour, characterised by an angulation wherein the anterior extremity resides more medially than the posterior extremity. This arrangement yields a convex anteroposterior surface. Positioned at the posterior of the skull, the condylar canal lies in close proximity to the occipital condyles. Notably, a pronounced protrusion of the occipital condyles towards the foramen magnum is observable in only a limited number of instances, as highlighted by Muthukumar et al. (2005). According to the research conducted by Kizilkanat and colleagues, this foramen is situated adjacent to the anterolateral border of the hypoglossal nerve canal.

Numerous preceding anatomical investigations have underscored the significance of variations in occipital condyle morphology (Kumar & Nagar, 2014; Kavitha et al.; Natsis et al.; Bayat et al.; Das et al.; Naderi et al.; Ozer et al.; Kizilkanat et al.; Muthukrishnan et al.). The effective execution of neurosurgical procedures via the transcondylar approach mandates a comprehensive grasp of the intricate topography of neurovascular structures situated in the proximity of the occipital condyles. Employing the transcondylar method entails inherent risks for the surgeon due to the intricate proximity to the occipital condyles.

Numerous scholars (Kumar & Nagar, Naderi et al., Ozer et al., Kizilkanat et al., Avci et al.) assert that preoperative decision-making should encompass an extensive exploration of pertinent conceptual frameworks. This perspective aligns with the conclusions drawn by several academicians, including Kumar and Nagar. Despite its paramount importance, the anatomical distinctions inherent to the occipital condyles receive limited emphasis in the majority of textbook explanations (Gardner et al., 1988; Hollinshead, 1991; Drake et al., 2010; Moore et al., 2011). This gap arises due to the fact that these structural variations often manifest within the occipital condyles.

Consequently, this scenario prompts further investigation into the morphometric variations of the occipital condyles. The present study was designed to delve into the distribution of distinct morphological types of occipital condyles. One of our primary objectives was to ascertain the prevalence of different occipital condyle types.

Materials and methods

The study encompassed an examination of 80 occipital condyles, involving forty dried adult human skulls procured from the Anatomy Department of Sree Balaji Medical College and Hospital. Damaged condyles were excluded from the analysis. Sex determination relied upon classic anatomical characteristics.

Distinct shapes were identified in male and female skulls and subsequently tabulated for comparison. Each parameter was measured independently. Precise measurements were executed using Vernier callipers with an accuracy of 0.1mm on both sides of the occipital condyles.

The parameters measured are

- ➔ the length or anteroposterior axis of the occipital condyles which is defined as the longest anteroposterior axis from the anterior end to the posterior end of the condyle.
- ➔ The width or transverse axis of the occipital condyles is the largest diameter from the medial to the lateral border of the condyle.
- ➔ AICD - Distance between anterior tips of right and left occipital condyles
- ➔ PICD - Distance between posterior tips of right and left occipital condyles
- ➔ OCAO - Distance between the anterior tip of occipital condyle and opisthion
- ➔ OCPO- Distance between the posterior tip of occipital condyle and opisthion
- ➔ OCAB- Distance between the anterior tip of occipital condyle and basion
- ➔ OCPB- Distance between the posterior tip of occipital condyle and basion The data of these parameters are collected and tabulated, The mean was calculated.

Result

This research conducted a thorough examination of 40 distinct skulls, with dedicated efforts towards precise sex determination using well-established anatomical criteria.

The detailed morphological variations were diligently documented and vividly presented in Figure I. Additionally, Table I systematically showcased the distribution frequency of these morphological types, classified by gender.

Gender	**Side**	**Kidney**	**Two-Portioned**	**Deformed**	**Oval-convex**	**Triangle**	**Eight**	**Oval**	**Circular**
Female	R	3(15%)	2(10%)	3(15%)	1(5%)	1(5%)	1(5%)	**7(35%)**	1(5%)
	L	2(10%)	3(15%)	1(5%)	1(5%)	1(5%)	2(10%)	**5(25%)**	4(20%)
Male	R		1(5%)		1(5%)		1(5%)	**12(60%)**	4(20%)
	L		1(5%)		1(5%)		2(10%)	**10(50%)**	4(20%)

Table I presents the distribution of various morphological types of occipital condyles, categorised by sex and observed on both the right and left sides.

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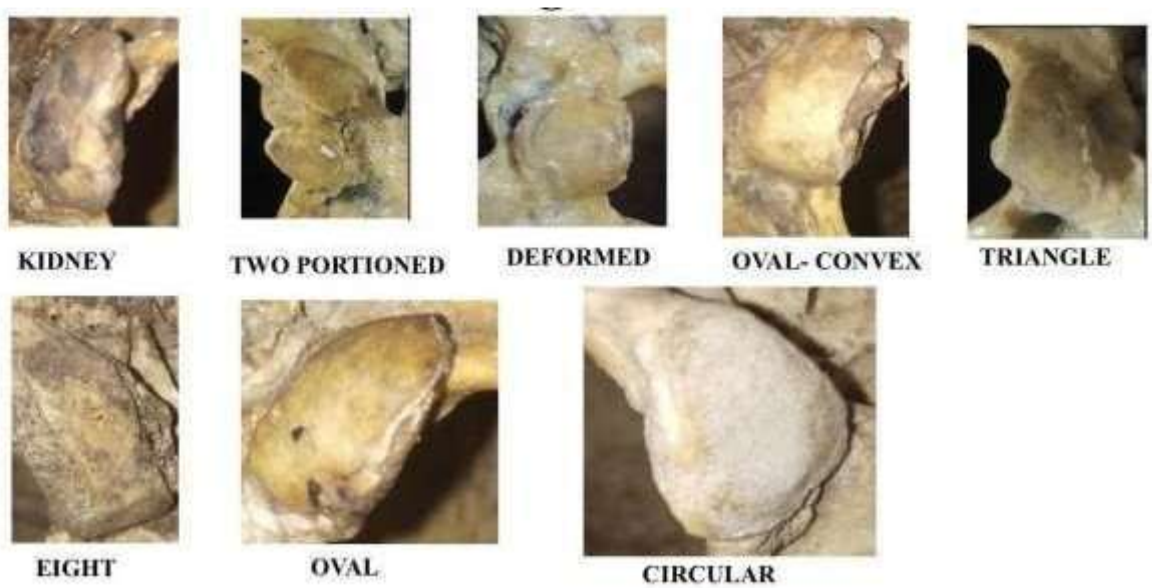

Figure I illustrates a range of occipital condyle morphologies, encompassing kidney-shaped, two-portioned, deformed, oval-convex, triangular, eight-shaped, oval, and circular configurations.

From this detailed analysis, a consistent pattern emerged: the oval morphological type prevailed as the most common, followed closely by the circular and two-portioned variants. These findings hold implications for understanding cranial morphology and its potential functional significance (Table I).

In the realm of cranial dimensions, the average width of the occipital condyle demonstrated slight gender-based differences. Among males, this measurement averaged 1.28 cm, while in females, it averaged 1.21 cm. These subtle distinctions offer intriguing avenues for exploring sexual dimorphism within cranial features (Table II).

Gender	**Side**	**Length(mm)**	**Breadth(mm)**
Female	R	31.64263	12.18211
	L	21.58789	12.84368
Male	R	23.96895	12.81158

Table II displays the mean length and breadth measurements taken from various occipital condyles, accompanied by the analysis of sex-based differences.

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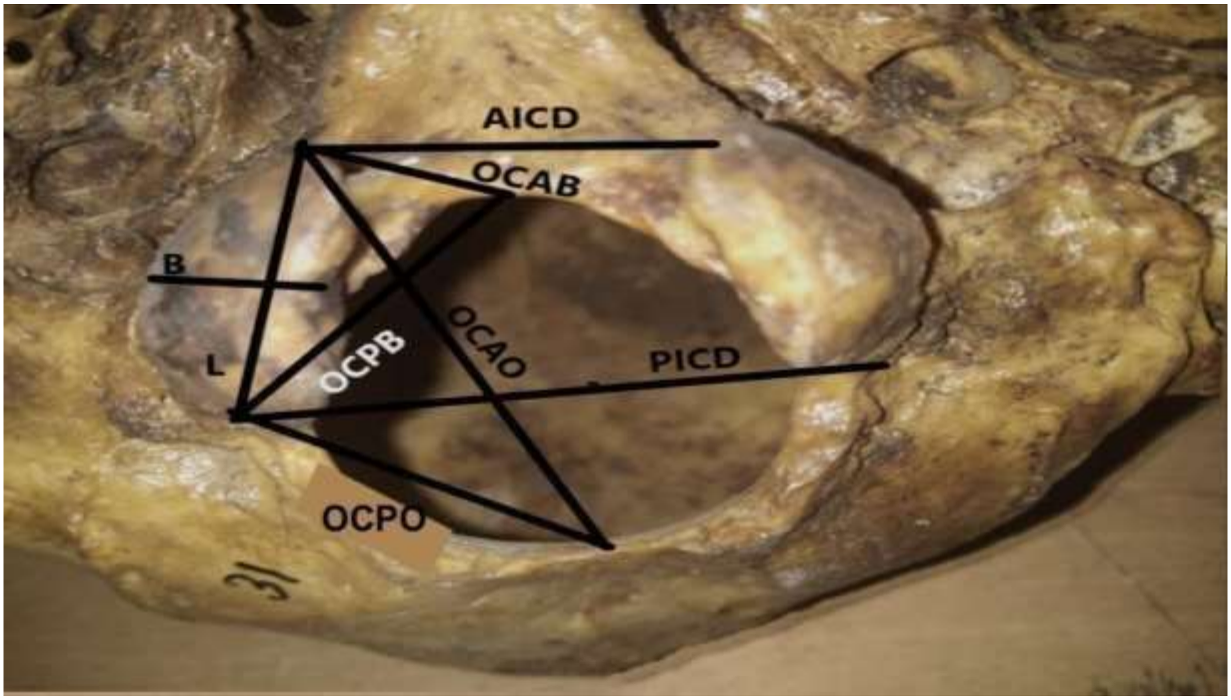

Figure II visually presents the measurement of various dimensions associated with the occipital condyle(OC). These dimensions include: the Distance between the anterior tips of the right and left OC (AICD), the Distance between the posterior tips of the right and left OC (PICD), the Distance between the anterior tip of the OC and opisthion (OCAO), the Distance between the posterior tip of the OC and opisthion (OCPO), the Distance between the anterior tip of the OC and basion (OCAB), and finally, the Distance between the posterior tip of the OC and basion (OCPB).

Gender	**AICD**	**PICD**	**OCAB**	**OCAO**	**OCPB**	**OCPO**
Female	1.684211	3.942105	1.021053	3.8	2.757895	2.768421
Male	1.9	4.321053	0.994737	3.947368	2.989474	0.260388

Table III illustrates the diverse dimensions of the occipital condyle in both male and female specimens.

Likewise, in Table III, The distances between key landmarks, as shown in Figure II, exhibited notable variations. For instance, the anterior intercondylar distance measured 1.9 cm in males and 1.6 cm in females. Similarly, the posterior intercondylar distance demonstrated marginal variability, with measurements of 4.32 cm in males and 3.94 cm in females.

In Table III, when considering the spatial relationships between structures, the distance from the anterior tip of the occipital condyle to the opisthion averaged 3.94 cm in males and 3.8 cm in females. Furthermore, the gap between the posterior tip of the occipital condyle and the basion measured 2.98 cm in males and 2.75 cm in females.

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In summary, this study contributes to an enhanced understanding of occipital condyle morphometrics and their significance within the field of cranial anthropology. The meticulous observations and measurements presented provide a robust groundwork for further research and potential clinical applications, thus facilitating a deeper comprehension of human cranial anatomy. Occipital condyles possess clinical implications as they can restrict the surgical view of lesions positioned anterior to the foramen magnum. Addressing this challenge necessitates the partial resection of the occipital condyle to enhance visibility. Furthermore, the morphometric analysis of occipital condyles plays a pivotal role in surgical planning. It aids in determining the extent of bone to be resected during a transcondylar approach. This comprehensive investigation not only contributes to the field of anatomy but also holds promising potential for improving surgical procedures and patient outcomes.

Discussion

Atlanto-occipital dislocation, a severe cervical spine injury, is often observed in cases of road accidents, typically resulting in a fatality. Unfortunately, such injuries frequently go undiagnosed and are commonly overlooked. In instances of atlanto occipital dislocation, careful radiological assessment becomes imperative, with particular attention to the dimensions and morphology of the occipital condyle.

In this current study, the prevalent occurrence of an oval-shaped condyle on both sides was noted. Similar findings were reported by Naderi et al. (2005) and Avci et al. (2011), who also identified the oval-shaped condyle as the predominant characteristic among specimens.

Moreover, the examination revealed that the anterior intercondylar and posterior intercondylar distances were measured at 1.79 cm and 4.13 cm, respectively. These recorded measurements exhibit comparability, yet deviate from the outcomes documented by Kizikanat et al. (2006).

In conclusion, the investigation underscores the significance of radiological evaluation in cases of atlanto-occipital dislocation, emphasising the distinct oval shape of the condyle and the relevance of specific intercondylar distances. The alignment of our findings with prior studies by Naderi et al. (2005), Avci et al. (2011), and the deviations from Kizikanat et al.'s (2006) findings contribute to the growing body of knowledge in this field.

Conclusion

In summary, the present study has undertaken a comprehensive analysis of sex-related disparities in occipital condyle dimensions and morphological variations. The insights derived from this investigation carry substantial implications, not only for neurosurgeons but also for a broader spectrum of professionals, including anthropologists, morphologists, and clinical anatomists.

The exploration of sex-based variations in occipital condyle characteristics goes beyond the domain of medical practice, plunging into the sphere of anthropology. Anthropologists can leverage these findings to contribute to a deeper comprehension of human skeletal distinctions, potentially illuminating evolutionary facets and population dynamics.

Furthermore, morphologists stand to benefit from the revelations of this study by enhancing their understanding of anatomical intricacies. The intricate interplay of size and shape examined in this research offers valuable insights into the fundamental principles of morphological variations, assisting in the broader interpretation of anatomical diversity.

Clinical anatomists, in turn, can incorporate the study's findings into educational frameworks, enriching medical curricula and enhancing the precision of diagnoses. A nuanced understanding of occipital condyle dimensions and shape variations can empower medical practitioners to provide more accurate assessments and treatments, ultimately elevating patient care.

The implications of this study reverberate not only within the scientific community but also across medical practice, academia, and forensic sciences. By contributing to the collective knowledge of sex-specific anatomical differences, this research serves as a foundational step for future inquiries and potential advancements across multiple disciplines.

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