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Research Article

Anterior Clinoid Process – The Anatomical Landmark to the Parasellar Region

Talia Elza Reegil[1]; Joseph Infant Mithil[2]; Dr. C.S. Janaki[3*]; Dr. A. Kafeel Hussain[4]; Dr. Doni. R. Praveen Kumar[5]

[1]First-year MBBS student, Bhaarath Medical College, Selaiyur, Tambaram.
[2]Second year MBBS student, Bhaarath Medical College, Selaiyur, Tambaram.
[3]Professor in Anatomy, Bhaarath Medical College, Selaiyur, Tambaram.
[4]Professor and Head, Department of Anatomy, Bhaarath Medical College, Selaiyur, Tambaram.
[5]Assistant Professor, Rajalakshmi Medical College, Sriperumbudur.

Corresponding Author:

Dr. C. S. Janaki
Professor in Anatomy, Bhaarath Medical College, Selaiyur, Tambaram

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ABSTRACT

The anterior clinoid process (ACP), a bony prominence located at the posterior edge of the lesser wing of the sphenoid bone, serves as a vital anatomical reference in neurosurgical procedures and craniofacial studies. This investigation was conducted to evaluate the dimensions—namely length, width, and height/thickness—of the ACP. For this purpose, 50 skull specimens from the Indian population were analysed, comprising 34 dry adult skulls and 16 dissected cadaveric specimens. Both sides of the ACP were examined, along with variations in gender and morphology, using established classification systems for the ACP. The findings revealed that the right-sided ACP tended to be marginally larger than the left in terms of length, width, and thickness, with some degree of variation. Type I ACP was the most frequently observed. These results underscore the importance of the anterior clinoid process as a critical anatomical landmark with significant implications for both clinical assessment and surgical intervention.

Keywords*: Anterior clinoid process, Craniofacial studies, Sphenoid bone, Dimensions.*

INTRODUCTION

Previous research has described the anterior clinoid process (ACP) as a bony projection located near the medial end of the sphenoid bone's lesser wing. It is anchored by two roots: the superior root, which forms the roof of the optic canal (OC), and the inferior root, which contributes to the lateral and ventral walls of the canal, as illustrated in Figure 1.[1]

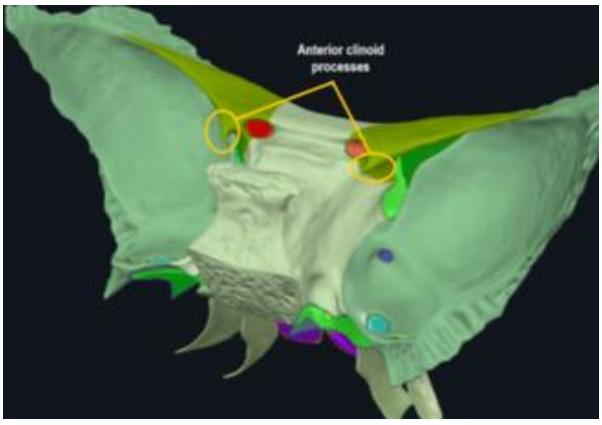

FIGURE 1: ACP STRUCTURE

ACP is positioned medially to the optic nerve, inferolaterally to the oculomotor nerve, and inferomedially to the Internal Carotid Artery (ICA) and its ophthalmic branch. [1,2] The ACP constitutes a section of the anterior roof of the cavernous sinus (CS).[3] Various ways of accessing the parasellar and suprasellar areas encounter challenges due to the ACP, which obstructs direct visualization of critical neurovascular systems.[4]

A previous study has demonstrated that the morphology of the anterior clinoid process (ACP) shows considerable dimensional variability, which can be applied for classification and for determining the most appropriate surgical approach during anterior clinoidectomy (A-CLD).[5] This variation improves the visualization of structures surrounding the optic nerve (ON), allowing for safer manipulation of the internal carotid artery (ICA) and ON while reducing the need for extensive brain retraction.[6,7] Given the scarcity of research on this topic within the South Indian population, the present study was undertaken to investigate whether geographical factors contribute to new morphological variations on both sides.

AIM

To assess the length, width, height/ thickness of ACP.

MATERIALS & METHODS

An observational study was carried out on 50 adult skull specimens, including 34 dry skulls and 16 obtained from dissected cadavers, at the Department of Anatomy, Bhaarath Medical College and Hospital. The study was conducted following approval from the Institutional Ethics Committee, as depicted in Figure 2.

FIGURE 2: DIFFERENT SKULLS USED

The Carotico-Clinoid Foramen (CCF) was identified within the middle cranial fossa (MCF). Its presence or absence in the skull specimens was assessed using a pair of sliding Vernier calipers, as illustrated in Figure 3

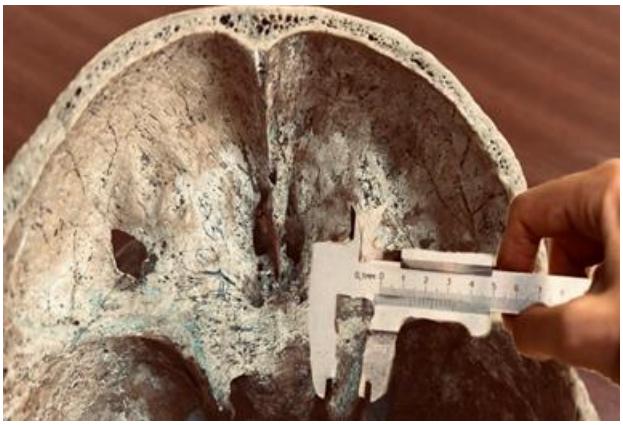

FIGURE 3: VERNIER CALIPER FOR MEASURING ACP.

All measurements were recorded in millimeters. The length and width were determined at the base of the anterior clinoid process (ACP) tip, with the length being measured from its base. These reference points were adopted based on the methodology described by Souza et al. in 2016.[8] The thickness of the ACP was measured using an adjustable compass in combination with a ruler. Additionally, the ACP was classified into four distinct types through dimensional analysis, applying a modified version of the classification criteria proposed by Cecen et al. in 2016.[9]
The Classification of ACP was as follows.

A. Length

- **Type I**: Short (≤ 8.14 mm)
- **Type II**: Long (> 10.5 mm) and narrow (≤ 10.5 mm)

B. Width

- Width greater than 8.14 mm

Inclusion Criteria:

1. Adult dry skulls exhibiting the carotico-clinoid foramen (CCF)
2. Dissected cadavers

Exclusion Criteria:

1. Damage to the parasellar region
2. Damage to the middle cranial fossa (MCF)

STATISTICAL ANALYSIS

The data were analysed using SPSS version 21.1 (IBM SPSS Statistics). Descriptive statistical measures, including the mean, standard deviation, and range, were computed to interpret the results.

RESULTS

The shape of the ACP was found to be variable.

Length

LENGTH	MEAN ±SD	RANGE
Mean Length	8.5±1.8mm	5.0-13.0mm

TABLE 1: MEAN LENGTH

As presented in Table 1, the mean length of the anterior clinoid process was 8.5 ± 1.8 mm, with a range spanning from 5.0 to 13.0 mm. A minor variation was observed between the sides, with the right ACP being slightly longer than the left.

Width

WIDTH	MEAN ±SD	RANGE
Base width	6.5±1.2 mm	4.5 - 9.0mm
Tip width	3.2 ± 0.8 mm	2.0 - 4.5mm

TABLE 2: WIDTH MEASUREMENT

In Table 2 of our study, it was observed that the width varied across different regions.

Height/ Thickness

HEIGHT/THICKNESS	MEAN ±SD	RANGE
Mean height	5.2 ± 1.1 mm	3.5 – 8.0 mm
Base thickness	6.1 ± 1.3mm	-
Tip thickness	2.8 ± 0.7mm	-

TABLE 3: MEASUREMENT OF HEIGHT

In Table 3, we have found that the height/ thickness average had variations.

S.NO.	TYPE	SHAPE	OCCURRENCE	AVERAGE LENGTH
1.	I (pointed)	Sharp, Triangular Projection	45-50%	9.0mm
2.	II(Flat)	Blunt, Rectangular Shape	30-35%	7.5mm
3.	III(Curved)	Hook-like appearance	15-20%	8.2mm

TABLE: SHAPE VARIATION

In Table 4, at different positions, different structures, and shape occurrences are present with varying average length.

DISCUSSION

Previous studies have reported that critical neurovascular structures are at risk of injury during anterior clinoidectomy (A-CLD).[10] Moreover, the anterior clinoid process (ACP) is connected to the middle clinoid process (MCP) via the carotico-clinoid ligament (CCL) [11,12], which may ossify and form the carotico-clinoid foramen (CCF).[13] Understanding morphological variations is therefore essential to reduce the risk of iatrogenic injury.[14]

In the present study, the mean length of the ACP was 8.5 ± 1.8 mm, ranging from 5.0 to 13.0 mm. A slight asymmetry was noted, with the right ACP being marginally longer than the left. The width differed between the base and tip, with measurements of 6.5 ± 1.2 mm and 3.2 ± 0.8 mm, respectively. The thickness also showed variation, with the mean height at 5.2 ± 1.1 mm, base thickness at 6.1 ± 1.3 mm, and tip thickness at 2.8 ± 0.7 mm across adult dry skulls and cadaveric specimens.

Comparable studies conducted in various regions have reported differing measurements. Lee et al. (1997) in Korea recorded a mean length of 9.18 ± 1.55 mm, width of 9.63 ± 1.49 mm, and thickness of 5.32 ± 1.07 mm. [15] Gupta et al. (2005) in Nepal found measurements of 10.74 ± 2.37 mm (length), 10.83 ± 1.20 mm (width), and 5.13 ± 1.03 mm (thickness). [16] Hunnargi et al. (2008) in India reported values of 10.68 ± 1.90 mm, 12.40 ± 2.58 mm, and 6.88 ± 1.09 mm, [17] respectively. Kapur and Mehic et al. (2012) in Europe found length and width values of 9.90 ± 1.60 mm and 9.40 ± 1.40 mm, [18] using dry bone specimens. In contrast, da Costa et al. (2016) in Brazil, employing CT imaging, [19] reported a length of 10.31 ± 2.10 mm and width of 7.70 ± 1.73 mm. In another study, female patients comprised 56.5% of the sample, with ages ranging from 38.6 to 90 years. The width and base length were each 7.7 ± 1.73 mm and 10.31 ± 2.1 mm, respectively. [20] Anatomical variations were present in 38.7% of the scans, with CCF and sella turcica bridging observed in 14.2% and 14.4% of cases, while ACP pneumatization appeared in 25.5%.

Further research by Dhakal et al. (2019) found the right ACP measured 9.88 ± 1.36 mm in length, 8.72 ± 1.50 mm in width, and 5.21 ± 1.83 mm in thickness, while the left side measured 10.30 ± 1.47 mm, 8.73 ± 1.71 mm, and 5.33 ± 1.60 mm, respectively, with no significant asymmetry. Similarly, Sibuor et al.[21] (2018) in Kenya reported right-sided measurements of 11.12 ± 2.83 mm (length), 10.52 ± 2.68 mm (width), and 5.38 ± 2.11 mm (thickness), and left-sided measurements of 10.72 ± 2.77 mm,10.34 ± 2.69 mm, and 5.47 ± 1.95 mm, with no significant differences between sides. In our study, type I morphology was predominant, observed in 45–50% of cases, characterized by a sharp and triangular projection with an average length of 9.0 mm. Type II, exhibiting a blunt and rectangular shape with an average length of 7.5 mm, was seen in 30–35% of cases, while type III, showing a hook-like appearance with an average length of 8.2 mm, accounted for 15–20%.

Additionally, previous studies have emphasized the anatomical connections between the sellar, suprasellar, and parasellar regions with critical structures such as the pituitary gland, internal carotid artery (ICA),[22,23] cavernous sinus (CS) and its contents, optic nerve (ON), and ophthalmic artery. Adequate exposure of these areas is essential for performing safe surgical procedures in cases involving lesions in these regions. However, this remains challenging due to surrounding bony prominences. Safe surgical intervention requires precise visualization, especially in conditions involving tumors, aneurysms, or vascular complications. The pneumatization of the ACP is particularly relevant, as it has been associated with the formation of the CCF and should be confirmed through radiological assessment.[24]

CONCLUSION

The clinical implications of our study suggest that variations in the size of the anterior clinoid process impact factors such as the amount of bone that must be removed, the dimensions of the surgical pathway, and the accessibility of deeper anatomical structures. Furthermore, differences in shape influence surgical considerations, including drilling strategies, the potential for bone fracture, and the choice of operative techniques. Therefore, a thorough preoperative evaluation of the ACP's anatomical characteristics is essential for neurosurgeons to ensure safe and effective surgical planning.

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