

Morphometric Analysis of Anterior Clinoid Process and Optic Strut: A Cadaveric Study

SHARADA B MENASINKAI¹, V SAVITHA²

ABSTRACT

Introduction: Anterior Clinoid Process (ACP) is a bony projection on the posterior border of lesser wing of sphenoid. It is related to optic nerve, internal carotid and ophthalmic arteries. Optic strut (OS) is a bony formation located between upper side of body and lesser wing of sphenoid bone.

Aim: To observe the variations in length, width of ACP and location of optic strut on right and left side in dry skulls among South Indian population.

Materials and Methods: An observational study was done in the Department of Anatomy, Adichunchanagiri Institute of Medical Sciences, Mandya, Karnataka, India, from August 2021 to December 2021. Total 37 dry skulls were collected from department and also from bone sets from first year MBBS (Bachelor of Medicine and Bachelor of Surgery) students. Various parameters (length, width of ACP, distance from tip of

ACP and OS, distance between tips of ACP) were measured on both sides using digital vernier callipers. Independent t-test was applied to compare the means of different groups.

Results: Mean width of ACP was 14.86 ± 4.47 mm on right side and 12.71 ± 3.13 mm on left side (p -value 0.019). Mean length was 12.45 ± 2.85 mm on right side and 12.05 ± 3.11 mm on left side ($p > 0.05$). Mean distance from tip of ACP to optic strut was 9.48 ± 2.86 mm on right side and 9.31 ± 3.03 mm on left side (p -value > 0.05). Distance between the tips of ACP ranged from 27.09 ± 28.89 mm and mean was 26.29 ± 3.77 mm. Optic strut was located at anterior two-fifth of ACP on right side in 17 (45.95%) and on left side in 14 (37.83%) of skulls.

Conclusion: There was variation in mean width of ACP on right and left side. The knowledge will help in preoperative planning and preventing unnecessary injury to neurovascular structures present in vicinity of anterior clinoid process and optic strut.

Keywords: Carotico-clinoid ligament, Internal carotid artery, Sphenoid bone

INTRODUCTION

Anterior Clinoid Process (ACP) is a bony projection located on the medial end of lesser wing of the sphenoid bone [1,2,3]. It is connected to the body of sphenoid by two roots. Superior root forms roof of the optic canal and continues as jugum sphenoidale and inferior root forms lateral and ventral wall of optic canal [1]. ACP is related medially to the optic nerve, inferolateral to oculomotor nerve and infero medially to Internal Carotid Artery (ICA) [1,2]. ACP is a part of the anterior roof of cavernous sinus [3]. In different approaches used to access parasellar and suprasellar regions, ACP pose difficulties for safe exposure by obscuring direct visualisation of important neurovascular structures [4].

Optic strut (OS) is a bony formation located between upper side of body and lesser wing of sphenoid bone. Optic strut separates optic canal from the superior orbital fissure and is closely related to significant structures such as cavernous sinus, ICA, optic nerve, pituitary gland [5].

The morphology of the ACP shows significant population specific variations in dimensions. The dimensions are used to determine the types of ACP, and choice of surgical technique employed during anterior clinoidectomy [6]. During operations for tumours or aneurysms in the sellar region, the ACP and optic strut are often removed from the lesser wing of sphenoid bone [3]. Anterior clinoidectomy provides improved exposure of structures in and around the optic nerve, and enhances mobilisation of the ICA and optic nerve with less brain retraction [7,8]. Since there are few studies reported in South Indian population [9,10,11], tip of Anterior Clinoid Process (ACP) and the Optic Strut (OS) the present study was taken with an aim to observe the variations in length, width of ACP and location of optic strut in relation to tip of ACP on right and

left side and to measure the distance between the tips of ACP in dry skulls among South Indian population.

MATERIALS AND METHODS

An observational study was done in the Department of Anatomy Adichunchanagiri Institute of Medical Sciences Mandya, Karnataka, India, from August 2021 to December 2021. Total 37 dry skulls were collected from department museum and also from bone sets from first year MBBS students irrespective of gender.

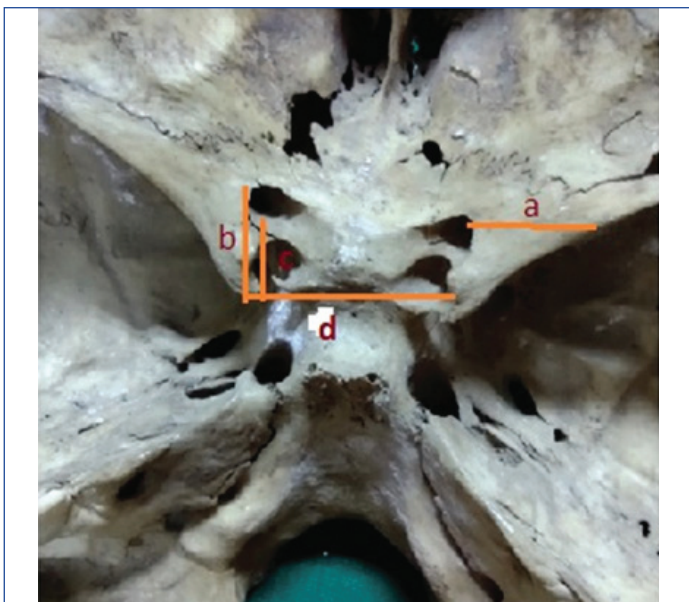
Inclusion criteria: Skulls with erupted third molars, without any obvious deformities in paraclinoid region.

Exclusion criteria: Damaged skulls in paraclinoid region.

The location of ACP was identified on both sides. Position of OS was determined based on relation between the length of ACP and the distance measuring from OS to the tip of ACP as shown in [Table/Fig-1] labelled 'c'. The position of OS in relation to length of ACP was calculated as anterior one-fifth, anterior two-fifth, anterior three-fifth, anterior four-fifth, at tip of ACP. Following parameters of ACP were measured on both sides using digital vernier callipers as shown in [Table/Fig-1].

- Width was measured at the base of ACP, from lateral margin of optic canal to lateral margin of ACP.
- Length was measured from base (medial point) to tip of ACP.
- Distance from tip of ACP to posterior margin of optic strut.
- Distance between the tips of ACP.

We followed a study reported by Sibuur W et al., for reference points and classification of ACP based on dimensions [6]. All the measurements were recorded in mm and classified as four types based on length and width.



[Table/Fig-1]: Measurements a-width, b-length, c-distance between tip and OS, d-inter ACP.

Classification of ACP [6]:

- **Type I**-short (<10.5 mm) and wide (>8.14 mm)
- **Type II**-long (>10.5 mm) and narrow (<8.14 mm)
- **Type III a**- short (<10.5 mm) and narrow (<8.14 mm)
- **Type III b**- long (>10.5 mm) and wide (>8.14 mm)

The data was collected by a single observer and each measurement was taken thrice and arithmetic average was taken to minimise the intra-observer bias.

STATISTICAL ANALYSIS

The mean and standard deviation were calculated for all variables and measurements. Data was entered in Microsoft excel and analysed using Statistical Package for Social Sciences (SPSS) software version 20.0. Independent t-test was applied to compare the means of different groups. All statistical analyses were carried out at 5% level of significance and p-value <0.05 was considered significant.

RESULTS

Mean width of ACP was 14.86±4.47 mm on right side and 12.71±3.13 mm on left side. The p-value was significant [Table/Fig-2]. Mean distance between the tips of ACP was 26.29±3.77 mm (range 27.09-28.89 mm).

Optic strut was located at anterior two-fifth of ACP on right side in 45.95% and on left side in 37.83% of skulls [Table/Fig-3].

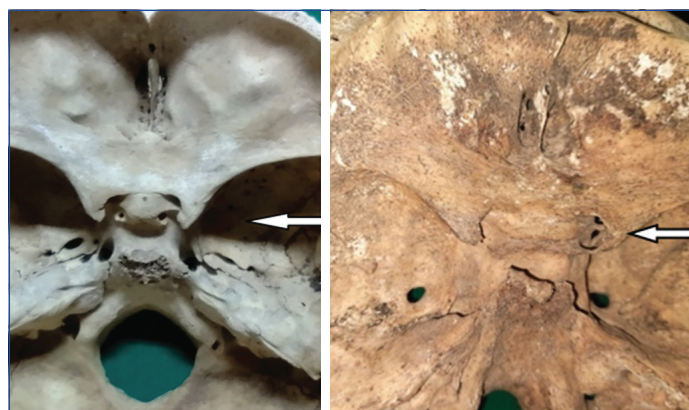
Parameters (mm)	Right	Left	p-value
	Mean±SD	Mean±SD	
Width of ACP	14.86±4.47	12.71±3.13	0.019
Length of ACP	12.45±2.85	12.05±3.11	0.559
Tip of ACP to optic strut	9.48±2.86	9.31±3.03	0.805

[Table/Fig-2]: Width, length of ACP on right and left side and distance from tip of ACP to optic strut on both sides.

Distance from tip of ACP	Right side	Left side
Root of ACP	2 (5.4%)	2 (5.4%)
Anterior one-fifth of ACP	10 (27%)	14 (37.83%)
Anterior two-fifth of ACP	17 (45.95%)	14 (37.83%)
Anterior three-fifth of ACP	4 (10.8%)	6 (16.21%)
Anterior four-fifth of ACP	4 (10.8%)	1 (27.02%)

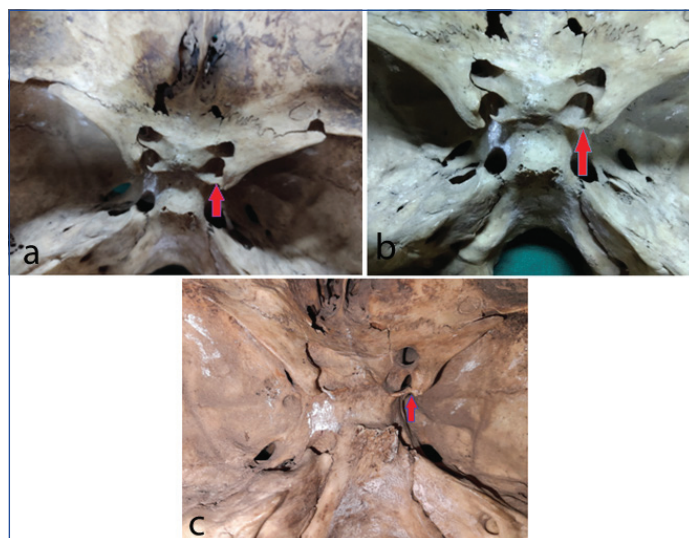
[Table/Fig-3]: The location of Optic strut in relation to ACP. Total N=37 in both sides

According to the classification based on dimensions, 26 (70%) skulls belonged to type III b (long and wide) [Table/Fig-4] 8 (21.6%) skulls type I (short and wide), 2 (5.4%) skulls type II (long and narrow) and 1 (2.7%) skull type III a (short and narrow). There were 3 skulls with ossified carotico clinoid ligament on left side [Table/Fig-5,6(a-c)].



[Table/Fig-4]: Skull showing wide and long anterior clinoid process.

[Table/Fig-5]: Skull showing left short ACP with ossified carotico-clinoid ligament. (Images from left to right)



[Table/Fig-6]: Different skulls showing ossified carotico-clinoid ligament- a, b and c.

DISCUSSION

The present study was done by collecting data from skulls that belonged to South Indian population. Morphologically the most common type of ACP in the present study was type III b, 26 (70%) and least type was type III a, 1 (2.7%). Cecen A et al., [7]. reported a study done in Istanbul (Turkey) during 2016, on 121 Computed Tomography (CT) scans of (57 males, 64 females) and they compared the ACP measurements with that of 27 dry skulls. Regarding the type of ACP, 65.7% belonged to type III, 17.8% type II and 16.5% type I. Sibuur W et al., [6]. reported a study in 2018 by collecting 51 dry skulls that belonged to Kenyan population, most common type of ACP was type III b seen in 48 (47.1%) and least common type was III a, 8 (7.8%). This could be due to racial variations.

The mean length of ACP was 9.7 and 9.6 mm on right and left side while the mean width of ACP on right and left side was 7.3 mm and 7.2 mm respectively, in a study by Akture E and Baskaya MK [4] [Table/Fig-7,8] [3-11].

In 2013, Lee HW et al., [1]. reported a study done on 10 formalin fixed specimens of cadaveric heads that belonged to Korean population. The length was 7.65±1.64 mm and 7.58±1.35 mm right and left side respectively and width was 10.7±2.11 mm, 10.93±1.46 mm on right and left side respectively. Hunnargi S et al., [10]. reported a study in 2008 by collecting and studying 25 skulls that belonged to South Indian population. The length of ACP was 10.68±1.19 mm on right side and 9.96±1.71 mm on left side

S. No.	Author	Place of study	Year	Sample size	ACP (mm)		p-value
					Right	Left	
1	Akture E and Baskaya MK, [4]	Turkey	2014	25	9.7	9.6	-
2	Kapur E and Mehić A, [5]	Bosnia	2012	200	9.9±1.6	9.3±1.6	<0.05
3	Sibuor W et al., [6]	Kenya	2018	51	11.12±2.8	10.72±2.77	0.184
4	Lee HY et al., [3]	Korea	1997	60	9.26±1.43	9.09 ±1.67	<0.05
5	Cecen A et al., [7]	Turkey	2016	27	10.9±3.75	13.46±3.41	-
6	Gupta N et al., [8]	India	2005	35	10.74±2.47	9.91±1.5	-
7	Souza AD et al., [9]	India	2016	27	12.07±1.77	12.46±1.39	-
8	Hunnargi S et al., [10]	India	2008	25	10.68±1.9	9.96±1.71	-
9	Swetha S, [11]	India	2015	60	12.61±2.59	12.99±2.58	-
10	Present	India	2022	37	12.45±2.85	12.05±3.11	>0.05

[Table/Fig-7]: Comparison of length of ACP (mean in mm) on right and left side [3-11].

S. No.	Author	Place of study	Year	Sample size	ACP (mm)		p-value
					Right	Left	
1	Akture E and Baskaya MK, [4]	Turkey	2014	25	7.3	7.2	<0.05
2	Kapur E and Mehić A, [5]	Bosnia	2012	200	9.4±1.4	9.1±1.7	-
3	Sibuor W et al., [6]	Kenya	2018	51	10.52±2.68	10.34±2.69	0.186
4	Lee HY et al., [3]	Korea	1997	60	9.97±1.58	9.29 ±1.39	<0.05
5	Cecen A et al., [7]	Turkey	2016	27	10.53±1.83	11.17±2.49	>0.05
6	Gupta N et al., [8]	India	2005	35	10.83±1.2	11.0±1.12	-
7	Souza AD et al., [9]	India	2016	27	10.30±1.93	11.23±1.57	<0.05
8	Hunnargi S et al., [10]	India	2008	25	12.4±2.58	11.12±1.81	-
9	Swetha S, [11]	India	2015	60	11.38±1.31	11.59 ±1.66	-
10	Present	India	2022	37	14.86±4.47	12.71±3.13	<0.05

[Table/Fig-8]: Comparison of width of ACP (mean in mm) on right and left side [3-11].

[Table/Fig-7]. The width of ACP was 12.4±2.58 mm on right side and 11.12±1.81 mm on left side [Table/Fig-8]. Sella turcica is an important area, due to the anatomical relations with the cavernous sinus and contents, sphenoid sinus, pituitary gland. In the superior approach to the cavernous sinus, radical removal of tumours and paraclinoid aneurysms, complete or partial removal of ACP is an important step. Removal of ACP combined with completely ossified Carotico-clinoid Foramina (CCF) may have high risk [7].

Lone M et al., reported a study on 50 skulls harvested from formalin fixed specimens in Maharashtra population, where the inter ACP distance was 22.9±1.9 mm (20-27 range) [12]. Akture E and Baskaya MK, reported the distance between tips of ACP mean 24.1 mm (range 19-29.3 mm) [4]. In the present study, inter ACP distance was 26.29 mm (range 27.09-28.89 mm). Following [Table/Fig-9] shows that in 42%-47% the location of optic strut was in anterior 2/5 in studies done by Lee HY et al., and Kapur E and Mehić A [3,5]. The findings of the present study are comparable with these two studies.

Attachment site	Lee HY et al., [3] Korea 1997		Kapur E and Mehić A, [5] Bosnia 2012		Present study India 2022	
	Right	Left	Right	Left	Right	Left
At the root of ACP	1.4%	4.3%	1.4%	4.3%	5.4%	5.4%
Anterior one-fifth of ACP	11.6%	14.5%	11.6%	14.5%	27%	37.83%
Anterior two-fifth of ACP	42.0%	47.8%	42.0%	47.8%	45.95%	37.83%
Anterior three-fifth of ACP	37.7%	27.5%	37.7%	27.5%	10.8%	16.21%
Anterior four-fifth of ACP	4.3%	5.9%	4.4%	5.0%	10.8%	27.02%
Posterior one-fifth of ACP	2.9%	0%	-	-	-	-

[Table/Fig-9]: Comparison of location of optic strut with other studies [3,5].

Complete or partial removal of optic strut can lead to injury to optic nerve or ICA. The strut is placed latero-caudal to optic nerve and optic strut need to be removed before ACP so the process could be completely released [3].

Knowing the precise size and location is important while analysing CT images, since it represent valuable landmark in proper evaluation and differentiation of optic canal, superior orbital fissure and ACP on coronal and axial scans [3].

Limitation(s)

There is possibility of subjective errors while taking measurements.

CONCLUSION(S)

The present study contributes to the knowledge of variable morphology of anterior clinoid process and optic strut in Indian population. It is of clinical importance to neurosurgeons operating in parasellar region. The knowledge will help in preoperative planning and preventing unnecessary injury to neurovascular structures present in vicinity of anterior clinoid process and optic strut.

REFERENCES

- [1] Lee HW, Park HS, Yoo KS, Kim KU, Song YJ. Measurement of critical structures around paraclinoid area: A cadaveric morphometric study. J Korean Neurosurg Soc. 2013;54(1):14.
- [2] Sharma A, Rieth GE, Tanenbaum JE, Williams JS, Ota N, Chakravarthi S, et al. A morphometric survey of the parasellar region in more than 2700 skulls: Emphasis on the middle clinoid process variants and implications in endoscopic and microsurgical approaches. Journal of Neurosurgery. 2017;129(1):60-70.
- [3] Lee HY, Chung IH, Choi BY, Lee KS. Anterior clinoid process and optic strut in Koreans. Yonsei Med J. 1997;38(3):151-54.
- [4] Akture E, Baskaya MK. Microsurgical anatomy and variations of the anterior clinoid process. Turk Neurosurg. 2014;24(4):484-93.
- [5] Kapur E, Mehić A. Anatomical variations and morphometric study of the optic strut and the anterior clinoid process. Bosn J Basic Med Sci. 2012;12(2):88.
- [6] Sibuor W, Cheruiyot I, Munguti J, Kiger J, Gikenye G. Morphology of the anterior clinoid process in a select Kenyan population. Anatomy Journal of Africa. 2018;7(1):1132-37.

- [7] Cecen A, Celikoglu E, Is M, Kale AC, Eroglu BT. Pre-operative measurement of the morphometry and angles of the anterior clinoid process (ACP) for aneurysm surgery. *International Journal of Morphology*. 2016;34(4):1333-38.
- [8] Gupta N, Ray B, Ghosh S. A study on anterior clinoid process and optic strut with emphasis on variations of caroticoclinoid foramen. *Nepal Medical College Journal: NMCJ*. 2005;7(2):141-44.
- [9] Souza AD, Ankolekar VH, Nayak N, Hosapatna M, Souza AS. Morphometric study of anterior clinoid process and optic strut and the ossification of carotico-clinoid ligament with their clinical importance. *J Clin Diagn Res*. 2016;10(4):AC05.
- [10] Hunnargi S, Ray B, Pai SR, Siddaraju KS. Metrical and non-metrical study of anterior clinoid process in South Indian adult skulls. *Surg Radiol Anat*. 2008;30(5):423-28.
- [11] Swetha S. Metrical and non-metrical study of anterior clinoid process in adult Indian skulls. *Surg Radiol Anat*. 2015;7(9):708.
- [12] Lone M, Rajgopal L, Telang A. Morphometry of anterior clinoid process: A cadaveric study. *Int J Anat Res*. 2016;4(4):3237-41.

PARTICULARS OF CONTRIBUTORS:

1. Professor and Head, Department of Anatomy, Adichunchanagiri Institute of Medical Sciences, Affiliated to Adichunchanagiri University, B.G. Nagara, Mandya, Karnataka, India.
2. Assistant Professor, Department of Anatomy, Adichunchanagiri Institute of Medical Sciences, Affiliated to Adichunchanagiri University, B.G. Nagara, Mandya, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Sharada B Menasinkai,
Professor and Head, Department of Anatomy, Adichunchanagiri Institute of
Medical Sciences, Affiliated to Adichunchanagiri University, B.G. Nagara,
Mandya, Karnataka, India.
E-mail: drsharadabmenasinkai@bgsaims.edu.in

PLAGIARISM CHECKING METHODS: [\[Jain H et al.\]](#)

- Plagiarism X-checker: Jan 28, 2022
- Manual Googling: May 05, 2022
- iThenticate Software: May 11, 2022 (11%)

ETYMOLOGY: Author Origin**AUTHOR DECLARATION:**

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval Obtained for this study? NA
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Jan 24, 2022**Date of Peer Review: **Feb 23, 2022**Date of Acceptance: **May 05, 2022**Date of Publishing: **Oct 01, 2022**