Cadaveric Morphometric Study of Anterior Clinoid Process and Sphenoid Ridge

Dr Pallavan P[1]*, Udhayabharathi G[1], Sadyojata M[1], Mannar Mannan P[2], Balamurugan S[3]

[1] Assistant Professor, Department of Neurosurgery, Government Vellore Medical College, Tamil Nadu, India

[2] Assistant Professor, Department of Neurosurgery, Rajiv Gandhi Government General Hospital, Chennai, Tamil Nadu, India

[3] Associate Professor, Department of Neurosurgery, Government Vellore Medical College, Tamil Nadu, India

*Corresponding author

Address of correspondence

Email: palsortho92@gmail.com

Abstract

Background: Anterior clinoid process and sphenoid ridge are well-studied anatomical structures. However, there is limited research investigating their sexual dimorphism and differences by side. Objectives: To analyse the gender and side variations in anterior clinoid process and sphenoid ridge measurements. The baseline measurements of anterior clinoid process and sphenoid ridge in south Indian population and structural variations were obtained. Methods: This was a prospective human cadaver study conducted at the Department of Forensic Medicine and Department of Neurosurgery, Government Stanley Medical College, Chennai, Tamil Nadu, India between July 2018, and December 2018 among all autopsies that required examination of cranium. The present study included a total of 30 autopsies, consecutively (non-probability sampling technique). Results: The mean (SD) age was 38.60 years (12.31). Majority were between 31 and 40 years of age. Majority of the autopsies were of males (80.0%) and more than two third autopsies (70.0%) had sharp sphenoid ridge. The most common type of anterior clinoid process was type IIIb (66.7%) followed by type II (20.0%). The rarest was type I (3.3%). We found no gender-based variation in the morphometric parameters of anterior clinoid process and sphenoid ridge. However, the parameter values were significantly higher on the right side than the left side ($p < 0.05$) except for the distance between the sphenoid ridge and inner border of superior orbital ridge of frontal bone. Conclusion: The findings of this study can potentially contribute to improving surgical outcomes and developing sex-specific surgical techniques.

Keywords: Anterior clinoid process, sphenoid ridge, morphometry, India neurosurgery

1. Introduction

The study of human anatomy has been an essential aspect of medical research for centuries.(1) An in-depth understanding of anatomical variations can provide valuable insights into the diagnosis and treatment of medical conditions. In recent years, there has been an increasing interest in investigating the sexual dimorphism of various anatomical structures, including the anterior clinoid process and sphenoid ridge.(2) The anterior clinoid process is a bony projection that arises from the sphenoid bone's medial surface, located in the middle cranial fossa. It serves as an attachment site for various structures, including the tentorium cerebelli, oculomotor nerve, and internal carotid artery.(3) The sphenoid ridge, on the other hand, is a bony ridge that extends laterally from the sphenoid bone's body. It forms a crucial landmark for various surgical procedures, including endoscopic skull base surgery and transsphenoidal pituitary surgery. The sphenoid ridge is the posterior border of the lesser and greater wing of sphenoid bone. Its medial end is the anterior clinoid process. The lateral end extends up to the pterion.(4)

Surgeries in the paraclinoid region for the supra clinoid segment of internal carotid artery, periclinoid tumours, sphenoid wing meningiomas, lesions of anterior portion of cavernous sinus, optic nerve related pathology and related surgeries require the removal of anterior clinoid process and sphenoid ridge – to increase the surgical accessibility; to minimise the brain retraction during surgery; and to avoid iatrogenic injury to the important structures around in the region.(5-7)

Anterior clinoidectomy and sphenoid ridge removal are important steps in the procedure and requires knowledge of the anterior clinoid process and sphenoid ridge in standard pterional craniotomy, frontal temporoparietal craniotomy or craniectomy.(8, 9) It is commonly used in trauma neurosurgery for subdural haematoma

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evacuation and medically refractive traumatic brain oedema decompression surgery.(10) The approaches can be orbito zygomatic, sub frontal and lateral sub frontal.(11)

Although the anterior clinoid process and sphenoid ridge are well-studied anatomical structures, there is limited research investigating their sexual dimorphism.(12) Understanding the differences in these structures between males and females can aid in identifying gender-specific anatomical characteristics and improving surgical procedures' safety and efficacy. The findings of this study can potentially contribute to improving surgical outcomes and developing sex-specific surgical techniques.(13)

Against this background, the aim of the present study was to record the morphometry of anterior clinoid process and sphenoid ridge. The specific objectives were to analyse the gender and side variations in anterior clinoid process and sphenoid ridge measurements. The baseline measurements of anterior clinoid process and sphenoid ridge in south Indian population and structural variations (short or long; narrow or broad; sharp or blunt) were also obtained.

2. Materials and methods

This was a prospective human cadaver study conducted at the Department of Forensic Medicine and Department of Neurosurgery, Government Stanley Medical College, Chennai, Tamil Nadu, India between July 2018, and December 2018. The linear measurements were taken bilaterally after removing brain and dura using electronic Vernier callipers for accessible areas. Measurement tape was used for curvilinear measurements and difficult to access areas with regard to this study. The present study sample included all autopsies that required examination of cranium. We excluded autopsy cases of prior cranial surgery, skull base injury, intracranial pathology, and accidental distortion during dissection. The study was approved by Institute Human Ethics Committee, Government Stanley Medical College and Hospital, Chennai, Tamil Nadu, India.

The present study included a total of 30 autopsies, consecutively (non-probability sampling technique). The skull caps were removed first. The brain was then removed along with the brain stem. The duramater was dissected along with the structures passing through it; and striped out from the internal cranial surface. Anterior clinoid process and sphenoid ridge with its entire length up to the lateral most portion of crista alaris near pterion was exposed completely. The field was irrigated with water to wash blood. The measurements were recorded in millimetres.(14) The parameters measured were, medial Length of the anterior clinoid process (ML, from its tip to the lateral margin of the optic canal at its base bilaterally); lateral length of anterior clinoid process (LL, from its tip to the lateral edge where it meets the sphenoid ridge at the base bilaterally); base length of anterior clinoid process (distance between lateral edge of the optic canal and lateral edge of the anterior clinoid process at its base bilaterally); curvilinear distance (T-SR, between the tip of anterior clinoid processes to lateral end of cristal alaris of sphenoid ridge where it meets the inner surface of skull bone, bilaterally); inter clinoidal base to base length (IC B-B); tip to tip distance of bilateral anterior clinoid processes (IC T-T); sphenoid ridge length (SRL); sphenoid ridge external appearance; and the distance between sphenoid ridge point at its apex of the curvature and the internal surface of the superior orbital margin of frontal bone (SR-FB) in the parasagittal plane.(15, 16)

The data collected were entered manually in Microsoft Excel and analysed using SPSS v23. Descriptive analysis – frequency and proportions were calculated for categorical variables; mean (standard deviation) and median (interquartile range) were estimated for continuous variables. Appropriate tables and graphs were made. To identify significant difference between the bivariate samples in paired groups, we used paired sample t-test. Statistical significance was considered if p value was less than 0.05.

3. Results

The present study included a total of 30 autopsies. The mean (SD) age was 38.60 years (12.31). Majority were between 31 and 40 years of age. One in five (20.0%) were either between 21 and 30 or 41 and 50 years of age. Majority of the autopsies were of males (80.0%); one 20.0% were females. More than two third autopsies (70.0%) had sharp sphenoid ridge; and 30.0% presented with blunt sphenoid ridges. The mean (SD) of the various measurements of anterior clinoid process and sphenoid ridge are presented in Table 1.

The anterior clinoid process was divided into four types based on the criteria given by Cecen A et al. (2016).(17, 18) The length was considered short if it was below 10.5 mm and long if it was above 10.5 mm. The breath was narrow if it was below 8.14 mm and wide if it was more than 8.14 mm. Based on these measurements, type I is referred to short and wide anterior clinoid process; type –II refers to long and narrow anterior clinoid process; type-IIIa refers to short and narrow; and type-IIIb refers to long and wide anterior clinoid process. In the present study, most common type of anterior clinoid process was type IIIb (66.7%) followed by type II (20.0%). The rarest was type I (3.3%). The other type, that is, type IIIa was observed in 10.0% of the autopsies (Figure 1).

Table 1: Distribution of study parameters			
Study parameters		n or mean	Percentage (%) or SD
Age (in years)		38.60	12.31
Age (in years)	20 and below	1	3.3
	21 to 30	6	20.0
	31 to 40	13	43.3
	41 to 50	6	20.0
	50 and above	4	13.3
Gender	Female	6	20.0
	Male	24	80.0
Shape of the sphenoid ridge	Blunt	9	30.0
	Sharp	21	70.0
ML LT		11.73	2.12
ML RT		12.47	2.28
LL LT		14.13	2.24
LL RT		15.10	2.07
BW LT		11.37	2.23
BW RT		12.02	2.46
T-SR LT		45.20	4.06
T-SR RT		46.77	4.22
T-SR IC B-B		23.67	2.60
IC T-T		31.68	3.54
SRL LT		45.77	4.39
SRL RT		47.43	4.97
SR – FB LT		42.96	4.59
SR – FB RT		43.78	4.80
ML, medial length of the anterior clinoid process; LL, lateral length of anterior clinoid process; BW, base length of anterior clinoid process; T-SR, curvilinear distance; IC B-B, inter clinoidal base to base length; IC T-T, tip to tip distance of bilateral anterior clinoid processes; SRL, sphenoid ridge length; SR-FB, distance between sphenoid ridge point at its apex of the curvature and the internal surface of the superior orbital margin of frontal bone in the parasagittal plane; LT, left; RT, right			

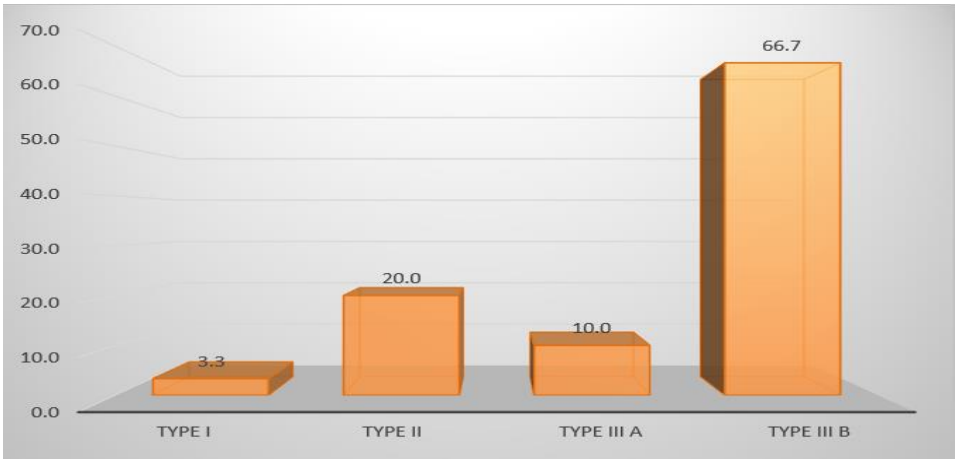

Figure 1: Types of anterior clinoid process

Table 2: Correlation between study parameters, by side				
		N	Correlation	Sig.
Pair 1	ML LT & ML RT	30	.971	<0.001*
Pair 2	LL LT & LL RT	30	.962	<0.001*
Pair 3	BW LT & BW RT	30	.981	<0.001*
Pair 4	T-SR LT & T-SR RT	30	.981	<0.001*
Pair 5	SRL LT & SRL RT	30	.972	<0.001*
Pair 6	SR-FB LT & SR-FB RT	30	.914	<0.001*
ML, medial length of the anterior clinoid process; LL, lateral length of anterior clinoid process; BW, base length of anterior clinoid process; T-SR, curvilinear distance; IC B-B, inter clinoidal base to base length; IC T-T, tip to tip distance of bilateral anterior clinoid processes; SRL, sphenoid ridge length; SR-FB, distance between sphenoid ridge point at its apex of the curvature and the internal surface of the superior orbital margin of frontal bone in the parasagittal plane; LT, left; RT, right *Significant at $p < 0.05$				

The present study found no difference in the measurements of anterior clinoid process and sphenoid ridge, disaggregated by gender ($p > 0.05$). In the analysis of statistical difference by side, we found that medial length of the anterior clinoid

process (MD -0.745, 95% CI -0.951 to -0.539); lateral length of anterior clinoid process (MD -0.967, 95% CI -1.196 to -0.737); base length of anterior clinoid process (MD -0.644, 95% CI -0.835 to -0.453); curvilinear distance (MD -1.567, 95% CI -1.872 to -1.262); sphenoid ridge length (MD -1.667, 95% CI -2.130 to -1.203); and the distance between sphenoid ridge point at its apex of the curvature and the internal surface of the superior orbital margin of frontal bone in the parasagittal plane (MD -0.820, 95% CI -1.551 to -0.089) were significantly different between the right and left sides – right side was slightly higher than the left side ($p < 0.05$). However, the distance between the sphenoid ridge and inner border of superior orbital ridge of frontal bone was not significantly different between the right and left sides ($p > 0.05$).

We also explored the correlation between measurements of anterior clinoid process and sphenoid ridge, by sides. It was found that the measurements had a significant positive strong correlation ($p < 0.05$).

Table 3: Testing for statistical difference, by side

		Paired Differences					p value
		Mean diff.	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		
					Lower	Upper	
Pair 1	ML LT - ML RT	-0.745	0.551	0.101	-0.951	-0.539	<0.001*
Pair 2	LL LT - LL RT	-0.967	0.615	0.112	-1.196	-0.737	<0.001*
Pair 3	BW LT - BW RT	-0.644	0.511	0.093	-0.835	-0.453	<0.001*
Pair 4	T-SR LT - T-SR RT	-1.567	0.817	0.149	-1.872	-1.262	<0.001*
Pair 5	SRL LT - SRL RT	-1.667	1.241	0.227	-2.130	-1.203	<0.001*
Pair 6	SR-FB LT - SR-FB RT	-0.820	1.957	0.357	-1.551	-0.089	0.029*

ML, medial length of the anterior clinoid process; LL, lateral length of anterior clinoid process; BW, base length of anterior clinoid process; T-SR, curvilinear distance; IC B-B, inter clinoidal base to base length; IC T-T, tip to tip distance of bilateral anterior clinoid processes; SRL, sphenoid ridge length; SR-FB, distance between sphenoid ridge point at its apex of the curvature and the internal surface of the superior orbital margin of frontal bone in the parasagittal plane; LT, left; RT, right

*Significant at $p < 0.05$

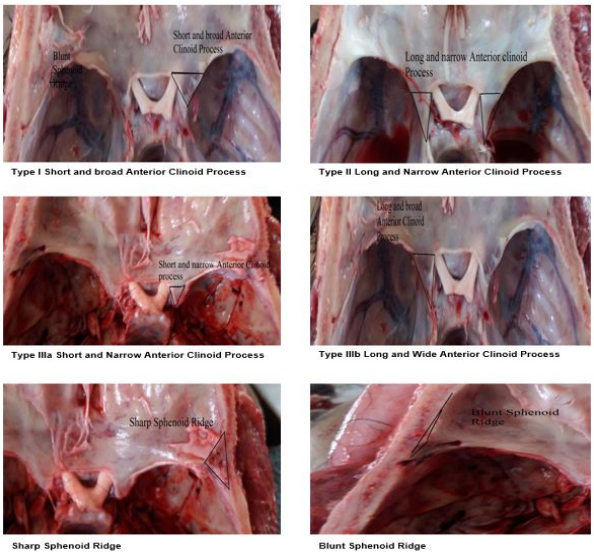

Figure 2: Gallery of pictures in the present study

4. Discussion

Literature evidence highlight that the anterior clinoid process and sphenoid ridge are well-studied anatomical structures. However, there is limited research investigating their sexual dimorphism and differences by side. Understanding the differences in these structures can aid in identifying gender-specific anatomical characteristics and improving surgical procedures' safety and efficacy. The findings of this study can potentially contribute to improving surgical outcomes and developing sex-specific surgical techniques. The aim of the present study was to record the morphometry of anterior clinoid process and sphenoid ridge.

Inoue et al. studied fifty dry skull bones and measured the distance between the tip of anterior clinoid process and the lateral margin of the optic canal.(19) The values ranged between 1.1 and 10.2 mm with an average of 5.4 mm. The measurements in the present study of medial length of anterior clinoid process are 8.10 to 18.00 on left side and 8.12 to 18.42 on the right side. Inoue et al. also documented the distance between the lateral margin of the optic canal and the lateral edge of anterior clinoid process.(19) The values ranged between 2.2 to 8.0 mm with an average of 5.1 mm. In present study, the same measurement done in the name of basal width of anterior clinoid process ranged between 7.50 and 15.32 on the left side and 7.80 to 16.90 on the right side.

Literature evidence showed the distance between the anterior clinoid processes at the level of the lateral margin of the optic canal to range between 18.2 and 30.4 mm with an average of 24.3 mm.(20-22) However, in the present study, similar measurement (referred to in the present study as interclinoidal base to base interval length) ranged between 18.12 mm and 26.72 mm. Inoue et al. reported the distance between the tip of anterior clinoid processes was in the range of 18.0 to 28.0 mm with an average of 22.3 mm.(19) In present study, the same distance ranged between 25.12 and 38.55 mm.

The curvilinear length between the sphenoid ridge

from lateral edge of anterior clinoid process and crista alaris ranged from 40 to 58 mm on the left side and 42 to 60 mm on the right side in this study. Also, the linear distance between the tip of anterior clinoid process and lateral end of sphenoid ridge was 40 to 54 mm on left side and 42 to 57 on right side. The vertical height from highest point of sphenoid ridge to inner border of superior orbital margin was 36.44 to 52.22 mm on left side and 30.44 to 53.12 mm on the right side in this study.

Table 6: Anterior clinoid process dimensions studied in other literature

Study	Population	Length	Width	Methodology
Lee et al. 1997(23)	Korean	9.18 ± 1.55	9.63 ± 1.49	Dry bone measurement Measurement
Gupta et al. 2005(24)	Nepalese	10.74 ± 2.37	10.83 ± 1.20	Dry bone measurement
Hunnargi et al. 2008(25)	Indian	10.68 ± 1.90	12.40 ± 2.58	Dry bone measurement
Kapur et al. 2012(12)	European	9.90 ± 1.60	9.40 ± 1.40	Dry bone measurement Measurement
da Costa et al. 2016(26)	Brazilian	10.31 ± 2.10	7.70 ± 1.73	CT scan
William et al. 2018(27)	Kenyan	10.92 ± 13.17	10.43 ± 1.32	Dry bone measurement

The present study is not without limitations. Firstly, the smaller size. Secondly, being a single centre study. To conclude, the present study found no gender-based variation in the morphometric parameters of anterior clinoid process and sphenoid ridge. However, we found the parameters to be significantly different between the right and left sides – right side was slightly higher than the left side except for the distance between the sphenoid ridge and inner border of superior orbital ridge of frontal bone. The study also found that the most common type of anterior clinoid process in south Indians was type IIIb. The anatomical, radiological, and surgical importance of sphenoid ridge and anterior clinoid process is widely documented. The variations in the morphometric parameters in south Indian population can help the young neurosurgeons in planning surgeries for central skull base pathologies like aneurysms, neoplasms, sellar, supra sellar and para sellar pathologies; primary and secondary bone tumour surgeries.

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