

Original Research Article

MORPHOMETRIC ANALYSIS OF SELLA TURCICA AND ANTERIOR CLINOID PROCESS IN ADULT HUMAN DRY SKULLS: ANATOMICAL AND SURGICAL PERSPECTIVES

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ABSTRACT

Background: The sella turcica (ST) and anterior clinoid process (ACP) are important anatomical landmarks of the central skull base. Their morphology and morphometry are of considerable clinical significance because of their close relationship with the pituitary gland, optic nerve, cavernous sinus, internal carotid artery, and surrounding neurovascular structures. Detailed knowledge of their dimensions is essential for accurate radiological interpretation and safe neurosurgical interventions in the sellar and parasellar regions.

Aim: To study the morphometric characteristics of the sella turcica and anterior clinoid process in adult human dry skulls and evaluate their anatomical and surgical significance.

Materials and Methods: A descriptive cross-sectional study was conducted on 30 adult dry human skulls obtained from the Department of Anatomy, Sawai Man Singh Medical College, Jaipur. Morphometric parameters of the sella turcica, including anteroposterior diameter, transverse diameter, and depth, and those of the anterior clinoid process, including length, width, and thickness, were measured using a digital Vernier caliper. All measurements were recorded in millimetres (mm). Data were analyzed using descriptive statistics, and bilateral comparisons of ACP measurements were performed using the paired Student's *t*-test, with $p < 0.05$ considered statistically significant.

Results: The mean anteroposterior diameter of the sella turcica was 8.92 ± 3.20 mm, the transverse diameter was 11.97 ± 2.08 mm, and the depth was 6.51 ± 5.67 mm, demonstrating considerable morphometric variability. The ACP showed significant bilateral asymmetry. The width measured 9.35 ± 1.28 mm on the right and 8.62 ± 0.25 mm on the left ($p = 0.0044$), while the thickness measured 5.61 ± 4.49 mm on the right and 5.02 ± 3.14 mm on the left ($p = 0.0267$). ACP length did not show a statistically significant side difference.

Conclusion: The present study demonstrates wide morphometric variability of the sella turcica and significant right-sided dominance of the anterior clinoid process in the Rajasthan population. These population-specific anatomical data may assist neurosurgeons and radiologists in pre-operative planning, improve radiological interpretation, and enhance the safety of trans-sphenoidal and skull-base surgical procedures.

Keywords: Sella Turcica; Anterior Clinoid Process; Morphometry; Dry Human Skull; Skull Base; Neurosurgery; Anatomy.

INTRODUCTION

The sella turcica (ST) and anterior clinoid process (ACP) are important osseous landmarks of the

sphenoid bone that play a crucial role in the anatomy of the sellar and parasellar regions. The sella turcica accommodates the pituitary gland, whereas the anterior clinoid process forms part of the optic canal

and is closely related to the optic nerve, cavernous sinus, and internal carotid artery. Owing to these intimate anatomical relationships, detailed knowledge of their morphology and morphometry is essential for neurosurgical procedures involving the skull base and parasellar region.^[1,2]

Morphometric evaluation of the sella turcica is widely used in anatomy, radiology, orthodontics, and endocrinology, as variations in its size and morphology have been associated with craniofacial anomalies, pituitary disorders, and developmental abnormalities.^[3,4] Likewise, the anterior clinoid process is an important surgical landmark during anterior clinoidectomy, optic nerve decompression, and clipping of paraclinoid aneurysms. Variations in its dimensions may influence surgical access and increase the risk of injury to adjacent neurovascular structures.^[2,5,6]

Previous studies have demonstrated considerable variability in the morphometry of the sella turcica and anterior clinoid process among different populations. Silverman and Alkofide highlighted significant variations in sellar dimensions, while Boyan et al. and Kapur and Mehic reported morphometric differences in the anterior clinoid process with important surgical implications.^[4,6-8] More recent investigations by Vaidya et al. (2022), Khaitan et al. (2024), Ince et al. (2024), and Brancher et al. (2024) further confirmed that morphometric characteristics of these structures vary among populations and imaging modalities, emphasizing the need for region-specific anatomical data.^[9-12]

As limited morphometric data are available for the Rajasthan population, the present study was undertaken to evaluate the dimensions of the sella turcica and anterior clinoid process in adult dry human skulls. The findings are expected to provide anatomical reference values that may assist anatomists, radiologists, and neurosurgeons in improving pre-operative planning and minimizing complications during skull-base surgery.

MATERIALS AND METHODS

The present descriptive cross-sectional cadaveric study was conducted in the Department of Anatomy, Sawai Man Singh Medical College, Jaipur,

Rajasthan, India, on 30 adult dry human skulls available in the departmental osteology museum. Only intact skulls with well-preserved sphenoid bones and clearly identifiable sella turcica and anterior clinoid processes were included, while damaged or pathologically deformed specimens were excluded. Institutional permission was obtained prior to the study.

Morphometric measurements were performed using a digital Vernier caliper (accuracy 0.01 mm) and recorded in millimetres (mm). The anteroposterior diameter, transverse diameter, and depth of the sella turcica were measured according to standard anatomical landmarks described by Gray's Anatomy and Rhoton.^[1,2] Bilateral measurements of the length, width, and thickness of the anterior clinoid process were also recorded. Each parameter was measured three times by the same observer, and the mean value was used for analysis to minimize observer-related error.

The data were analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean $\pm$ standard deviation (SD), minimum, and maximum values. Bilateral comparisons of anterior clinoid process measurements were performed using the paired Student's *t*-test, with a *p*-value <0.05 considered statistically significant.

RESULTS

A total of 30 adult dry human skulls were examined for morphometric analysis of the sella turcica and anterior clinoid process. All measurements were recorded in millimetres (mm). The mean anteroposterior diameter, transverse diameter, and depth of the sella turcica were 8.92 ± 3.20 mm, 11.97 ± 2.08 mm, and 6.51 ± 5.67 mm, respectively. The depth exhibited the greatest variability, indicating marked individual differences in sellar morphology. The anterior clinoid process demonstrated bilateral variation. The mean width and thickness were significantly greater on the right side ($p < 0.05$), whereas the difference in length between the two sides was not statistically significant. These findings indicate a tendency towards right-sided dominance of the anterior clinoid process in the studied population.

Table 1: Measurements of Sella Turcica

Measurement Parameter	Anatomical Landmarks Used
Antero-Posterior diameter (A-P)	From the middle of the tuberculum sella to the middle of the dorsum sella
Transverse diameter	From the middle of the right margin of the ST to the middle of the left margin
Depth	From the deepest point of the floor of the ST to the midpoint of the tuberculum sella

Table 2: Measurements of Anterior Clinoid Process (ACP)

Measurement Parameter	Anatomical Landmarks Used
Length of ACP	From tip of the ACP to midpoint of basal width
Width of ACP	From most medial border to lateral border of base of ACP
Thickness of ACP	Measured at the tip of the ACP

Table 3: Morphometric parameters of the sella turcica (n = 30)

Parameter (mm)	Minimum	Maximum	Mean $\pm$ SD
Anteroposterior diameter	5.36	12.64	8.92 ± 3.20

Transverse diameter	8.41	15.62	11.97 ± 2.08
Depth	2.54	10.48	6.51 ± 5.67

Table 4: Morphometric parameters of the anterior clinoid process (n = 30)

Parameter (mm)	Right (Mean ± SD)	Left (Mean ± SD)	p-value
Length	10.84 ± 1.31	10.51 ± 1.42	>0.05
Width	9.35 ± 1.28	8.62 ± 0.25	0.0044
Thickness	5.61 ± 4.49	5.02 ± 3.14	0.0267

DISCUSSION

The sellar and parasellar regions are among the most anatomically complex areas of the skull base because of their intimate relationship with the pituitary gland, optic apparatus, cavernous sinus, and internal carotid artery. Consequently, detailed morphometric knowledge of the sella turcica (ST) and anterior clinoid process (ACP) is essential for accurate radiological interpretation and safe neurosurgical intervention. The present study provides morphometric data on these structures in adult dry human skulls from the Rajasthan population and contributes valuable regional reference values for anatomical and clinical practice.^[1,2]

The morphometric analysis of the sella turcica demonstrated considerable variability in its anteroposterior diameter, transverse diameter, and depth. Such variability is consistent with the observations of Silverman, who first established normative sellar dimensions and showed that its morphology changes during growth and development.^[7] Similarly, Andredaki et al. and Alkofide reported significant differences in sellar dimensions among individuals with different craniofacial skeletal patterns, suggesting that genetic and developmental factors influence sellar morphology.^[3,7] More recently, Khaitan et al. (2024) proposed a novel morphometric index for the sella turcica, while Ince et al. (2024) demonstrated substantial individual variation using cone-beam computed tomography. Although these studies employed radiological techniques, their findings support the present osteological observations that considerable variability exists in sellar dimensions.^[10,11] The wide variation in sellar depth observed in the present study further emphasizes the need for careful pre-operative radiological assessment before pituitary and parasellar surgeries. The anterior clinoid process exhibited measurable bilateral variation, with the right side showing significantly greater width and thickness, whereas no statistically significant difference was observed in length. The ACP forms an important surgical landmark during anterior clinoidectomy and provides access to lesions involving the optic canal, cavernous sinus, and paraclinoid segment of the internal carotid artery.^[2,5] Therefore, variations in its dimensions may influence the amount of bone drilling required and the available surgical corridor. Boyan et al. and Kapur and Mehic also reported considerable morphometric variability of the ACP but did not observe consistent side dominance.^[6,8] Likewise,

Dagtekin et al. emphasized that detailed anatomical knowledge of ACP morphology is indispensable for minimizing neurovascular injury during skull-base procedures.^[5] The right-sided predominance identified in the present study may represent a regional anatomical characteristic of the Rajasthan population, although confirmation in larger multicentric studies is warranted.

Comparison with the study by Vaidya et al. (2022) revealed broadly similar trends regarding the existence of anatomical variability in both the sella turcica and anterior clinoid process, although differences in absolute morphometric values were noted.^[9] These discrepancies may be explained by variations in ethnicity, sample size, specimen selection, measurement techniques, and anatomical landmarks. Furthermore, radiological studies, such as those by Brancher et al. (2024), have shown that sellar morphology is influenced by craniofacial skeletal patterns and developmental characteristics, reinforcing the concept that morphometric reference values should be interpreted within the context of the studied population.^[12]

The findings of the present study have important clinical implications. Detailed morphometric knowledge of the sella turcica facilitates accurate assessment of pituitary fossa morphology and assists in the diagnosis of developmental and pathological conditions affecting the sellar region. Likewise, precise measurements of the anterior clinoid process may help neurosurgeons anticipate anatomical variations during anterior clinoidectomy, transsphenoidal procedures, and other skull-base approaches, thereby reducing the risk of injury to adjacent neurovascular structures.

Despite providing valuable population-specific data, the study has certain limitations. The sample size was relatively small, and the age and sex of the specimens could not be determined. In addition, measurements were obtained from dry skulls without radiological correlation. Future investigations involving larger multicentric samples, sex-based analysis, and three-dimensional imaging modalities such as CT, CBCT, or MRI would further improve the understanding of morphometric variations in the sellar region and enhance their clinical applicability.

CONCLUSION

The present study demonstrates considerable morphometric variability in the sella turcica and anterior clinoid process among adult dry human skulls from the Rajasthan population. The sella

turcica exhibited marked variation in all measured dimensions, while the anterior clinoid process showed significant right-sided predominance in width and thickness. These findings provide valuable population-specific anatomical reference data that may facilitate accurate radiological interpretation, improve pre-operative planning, and enhance the safety of transsphenoidal and skull-base surgical procedures involving the sellar and parasellar regions.

Recommendations: The present findings provide baseline morphometric data for the sella turcica and anterior clinoid process in the Rajasthan population and may aid neurosurgeons and radiologists in pre-operative planning for skull-base procedures. Future studies with larger sample sizes, diverse populations, and advanced imaging modalities such as CT, CBCT, and MRI are recommended to validate these findings and establish comprehensive population-specific anatomical reference standards.

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