Original Article

Morphometric Analysis of the Optic Strut in Adult Human Dry Skulls: An Anatomical Study with Surgical Implications

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Abstract

Background: The optic strut is a small but anatomical important bone structure that joins lesser wing of the sphenoid to body of the sphenoid and forms the lower border of the optic canal. The optic strut is in close proximity to the optic nerve, the internal carotid artery and cavernous sinus and is therefore critical for safe surgical navigation of skull-base surgery and thus essential for precise morphometric knowledge. The morphometric data of optic strut in human population is so far limited to Indian population. The aim is to describe and analyse the morphometry of the optic strut in dry skulls of adult human remains and assess the clinical importance of this structure. **Material and Methods:** 30 adult dry human skulls were obtained from the Department of Anatomy, Sawai Man Singh Medical College, Jaipur and a descriptive cross-sectional study was carried out on them. Optic strut anteroposterior (AP) and transverse diameters were bilaterally measured with a digital Vernier calipers and bisector. The measurements are all in millimetres (mm). Mean ± standard deviation (SD) was used to express descriptive statistics; and the paired Student's t-test was used for bilateral comparison. The p value was used as a threshold for significance at < 0.05. **Results:** The mean anteroposterior diameter of the optic strut was 5.70 ± 6.68 mm on the right and 6.22 ± 7.51 mm on the left, while the mean transverse diameter measured 6.76 ± 6.65 mm on the right and 7.44 ± 7.39 mm on the left. The left optic strut demonstrated larger mean dimensions than the right, indicating a trend toward left-sided dominance. The findings also revealed considerable inter-individual variability in optic strut morphology. **Conclusion:** The present study demonstrates significant morphometric variability of the optic strut in the Rajasthan population, with relatively larger dimensions on the left side. These findings provide valuable population-specific anatomical reference data that may facilitate pre-operative planning, improve radiological interpretation, and enhance the safety of anterior clinoidectomy, optic nerve decompression, and other skull-base surgical procedures.

Keywords: Optic Strut, Morphometry, Optic Canal, Sphenoid Bone, Skull Base, Anterior Clinoidectomy, Dry Human Skull, Neurosurgery.

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INTRODUCTION

The optic strut (OS) is a small but anatomically important bony bridge extending from the lesser wing of the sphenoid to the body of the sphenoid. It forms the inferior boundary of the optic canal and separates the optic canal from the superior orbital fissure [Figure 1]. Owing to its close anatomical relationship with the optic nerve, ophthalmic artery, internal carotid artery, cavernous sinus, and anterior clinoid process, the optic strut serves as a critical surgical landmark during skull-base procedures. Precise anatomical knowledge of this structure is essential to minimize neurovascular injury during anterior clinoidectomy, optic nerve decompression, and surgeries involving the parasellar region.[1–3]

Advances in microsurgical and endoscopic skull-base approaches have increased the need for accurate morphometric information on the optic strut. Surgical management of pituitary adenomas, tuberculum sellae meningiomas, paraclinoid aneurysms, craniopharyngiomas, and lesions involving the optic canal frequently requires drilling of the optic strut to improve exposure of the optic nerve and paraclinoid segment of the internal carotid artery. Variations in the size and morphology of the optic strut may alter the surgical corridor and increase the risk of complications if not identified pre-operatively.[2,4]

Previous anatomical studies have demonstrated considerable variability in the dimensions of the optic strut among different populations. Boyan et al. described morphometric variations of the optic strut and anterior clinoid process and emphasized their importance in skull-base surgery.[5] Kapur and Mehic reported anatomical variability without consistent bilateral asymmetry,[6] while Vaidya et al. documented smaller optic strut dimensions in a North Indian population with no significant side dominance.[7,8] Despite these reports, morphometric data from the Rajasthan population are lacking, and regional anatomical variations remain inadequately documented.

The present study was therefore undertaken to evaluate the

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morphometry of the optic strut in adult dry human skulls from the Rajasthan population by measuring its anteroposterior and transverse diameters bilaterally. The findings are expected to provide population-specific reference data that may aid anatomists, radiologists, and neurosurgeons in pre-operative planning and contribute to safer skull-base surgical interventions.

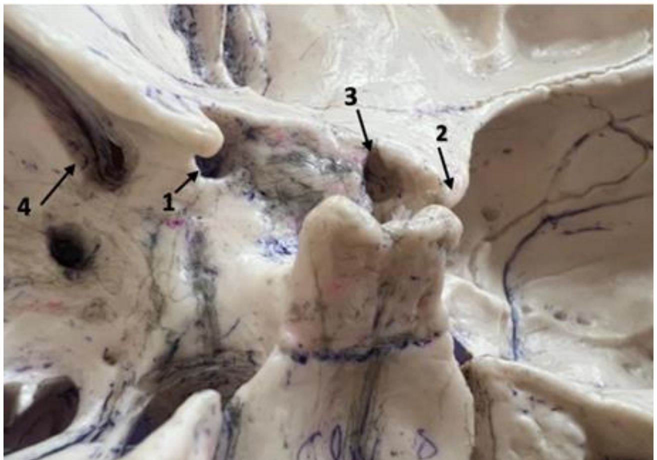

Figure 1: Sellar and perasellar region (1-optic strut, 2- Anterior clinoid process, 3- optic canal, 4- superior orbital foramen)

Materials and Methods

In the cross-sectional cadaveric study present, the Department of Anatomy, Sawai Man Singh Medical College, Jaipur, Rajasthan, India was used. The study included 30 "adult" dry human skulls of unknown age and sex available in the departmental osteology museum. To choose only well-preserved skulls that had intact sphenoid bones and well-preserved optic struts were clear on either side, all of the skulls were inspected. All skulls were inspected to select only those with intact sphenoid bones and clearly identifiable optic struts on both sides. Skulls with fractures, deformities, congenital anomalies or pathological changes of the optic canal and the sphenoid bone were not included in the study. Permission from the institutions was received before the study was conducted.

The bilateral morphometric measurements of the optic strut were taken using a digital Vernier calliper, having accuracy of 0.01 mm. Anteroposterior (AP) diameter (maximum distance between anterior and posterior margins of the optic strut) and the transverse diameter (maximum mediolateral width) were measured. Measurements were taken in millimetres (mm). For each parameter, three measurements were taken by the same observer, in the same conditions, and the average was taken for statistical analysis in order to reduce measurement error. The collected data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), with minimum and maximum values. Bilateral comparisons between the right and left sides were performed using the paired Student's t-test, and a p-value <0.05 was considered statistically significant.

Results

A total of 30 adult dry human skulls were included in the present study. Morphometric evaluation of the optic strut was performed bilaterally by measuring the anteroposterior (AP) diameter and transverse diameter, with all measurements recorded in millimetres (mm).

The mean AP diameter of the optic strut measured 5.70 ± 6.68 mm (range: ... mm) on the right side and 6.22 ± 7.51 mm (range: ... mm) on the left side. Similarly, the mean transverse diameter was 6.76 ± 6.65 mm (range: ... mm) on the right side and 7.44 ± 7.39 mm (range: ... mm) on the left side. The left optic strut exhibited greater mean dimensions than the right in both parameters, indicating left-sided dominance. The paired Student's t-test demonstrated statistically significant bilateral differences ($p < 0.05$) (Table 1).

Overall, considerable morphometric variation of the optic strut was observed among the studied skulls. These findings suggest individual anatomical variability in the sellar and parasellar region and provide baseline morphometric data for the Rajasthan population that may be useful during skull-base surgical procedures.

Table 1: Observations–Morphometric Analysis of the Optic Strut

Parameter	Right Range (mm)	Right Mean ± SD	Left Range (mm)	Left Mean ± SD
Anteroposterior Diameter	2 – 17.7	5.70 ± 6.68	2 – 19.7	6.22 ± 7.51
Transverse Diameter	3 – 18.7	6.76 ± 6.65	3.1 – 20.7	7.44 ± 7.39

Discussion

The optic strut is one such anatomical landmark in skull-base surgery since it constitutes the lower part of the optic canal and is in close proximity to the optic nerve, ophthalmic artery, cavernous sinus and paraclinoid segment of the internal carotid artery. Knowing the morphometry of this structure can ease the surgeon's way in performing anterior clinoidectomy, decompression of the optic nerve, and in the endonasal and endocranial approaches with the goal of avoiding injury to the neurovascular structures.[1–3]

From the results of the present study, it may be concluded that optic strut was dominant on the left side in terms of both anteroposterior and transverse diameters. This result contrasts with Vaidya et al. (2022) who found optic strut dimensions that were relatively smaller with no significant bilateral difference. Similarly, Boyan et al. (2011) and Kapur and Mehic (2012) reported that there was considerable morphometric variation in the optic strut, and no consistent side dominance. Asymmetrical findings noted in the present study could be due to the population specific anatomic differences in the population under study and thus the regional morphometric databases are of significance in the surgical planning.

The great inter-individual differences found in the present study are in keeping with earlier anatomical research that showed that craniofacial morphology is both ethically and genetically, as well as environmentally influenced. These differences can affect surgical approach to the surgical corridor around the optic canal and the amount of bone to be removed during anterior clinoidectomy. Pre-operative evaluation with high resolution computed tomography or magnetic resonance imaging, therefore, along with detailed anatomical knowledge, is crucial to reduce operative complications and to maintain adjacent neurovascular structures unharmed.[4-7]

The present study provides needed baseline morphometric information, but some limitations need to be noted. There were a relatively small number of samples and the ages and sex of the skulls were unknown. Further detailed understanding of optic strut morphology and its surgical implications could be gained through future studies using larger number of patients, radiological correlation and three-dimensional imaging techniques.

Conclusion

The present study has shown that there is a great morphometric variation of the optic strut in the adult dry skulls of the population of Rajasthan. We found anatomical asymmetry in the sellar region with a relatively larger left-sided optic strut in both anteroposterior and transverse dimensions. These population-specific morphometric data are of value for any anatomists, radiologists and neurosurgeon as reference data and may help in the safe pre-operative planning and improved surgical outcome in case of anterior clinoidectomy, optic nerve decompression and other skull-base surgeries.

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Conflicts of interest

There are no conflicts of interest.

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