International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

*Original Researcher Article* *DOI: 10.61336/im/26-2-12*

# A Cross-Sectional Study of Morphometric Variations of the Sacral Hiatus in Dry Human Sacra

**Dr. Jatthavath Jyothi**

[1]*Assistant Professor, Department of Anatomy, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India.*

**Correspondence:**
***Dr. Jatthavath Jyothi***
*Assistant Professor, Department of Anatomy, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India.*

**Received:** 10-04-2021
**Revised:** 22-04-2021
**Accepted:** 11-05-2021
**Published:** 19-05-2021

## Abstract

***Background:*** The sacral hiatus is an important anatomical landmark for caudal epidural block and other sacral procedures. Variations in its shape, vertebral level, and dimensions can influence needle placement and procedural success. ***Objectives:*** To evaluate the morphological and morphometric variations of the sacral hiatus in dry adult human sacra and to describe findings relevant to clinical practice. ***Methods:*** This cross-sectional osteological study was on one hundred dry adult human sacra that were complete and undamaged were examined. The sacral hiatus was assessed for shape, level of apex, level of base, length, transverse width at the base, and anteroposterior diameter at the apex using standard anatomical methods and digital vernier calipers. Data were summarized using descriptive statistics. ***Results:*** The inverted U shape was the most common configuration, followed by inverted V, while irregular, dumbbell, bifid, and absent hiatus patterns were less frequent. The apex was most commonly located at the level of the fourth sacral vertebra, and the base was most often situated at the fifth sacral vertebra. Mean length of the sacral hiatus was 23.6 ± 6.8 mm, mean transverse width at the base was 13.4 ± 3.2 mm, and mean anteroposterior diameter at the apex was 5.8 ± 1.4 mm. ***Conclusion:*** Considerable variation exists in the morphology and dimensions of the sacral hiatus. Awareness of these variations is important for anatomists, anesthesiologists, pain physicians, and surgeons because such differences influence identification of the hiatus and the safety of sacral interventions.

**Keywords:** sacral hiatus, sacrum, morphometry, dry human sacra, caudal epidural block, anatomical variation.



## INTRODUCTION

The sacrum is a large triangular bone formed by the fusion of five sacral vertebrae and constitutes the posterior wall of the pelvis. At its caudal end, failure of fusion of the laminae of the lower sacral vertebrae produces the sacral hiatus, an opening on the dorsal surface of the sacrum that communicates with the sacral canal [1,2]. The sacral hiatus is bounded laterally by the sacral cornua and is covered in life by the posterior sacrococcygeal ligament and soft tissues. Because it represents the principal entry point to the caudal epidural space, it is a clinically important landmark in regional anesthesia, pain interventions, and certain diagnostic and therapeutic procedures involving the lumbosacral region [3,4].

Caudal epidural block remains a widely used technique in anesthetic and pain practice, especially for anorectal, perineal, obstetric, gynecologic, pediatric, orthopedic, and urologic procedures [2,7]. The success of this approach depends on accurate identification of the sacral hiatus and safe needle advancement. Failure of localization can result in repeated attempts, subcutaneous injection, intravascular placement, dural puncture, inadequate block, [4,7]. Although surface landmarks are traditionally used, marked anatomical variation in the sacral hiatus limits the reliability of blind techniques, particularly in adults [1,2,7]. For this reason, precise morphometric knowledge of the hiatus remains relevant even in the era of ultrasound and fluoroscopic guidance [7,13,14].

Previous osteological and imaging studies have demonstrated considerable variability in the shape of the sacral hiatus, the vertebral level of its apex and base, and its linear dimensions [3,5,6,8-12]. Inverted U and inverted V configurations are often the commonest patterns, but irregular, dumbbell, bifid, elongated, and even absent hiatus forms have also been described [3,5,8,11,12]. Similarly, the apex is most frequently found at the level of the fourth sacral vertebra, whereas the base is usually related to the fifth sacral vertebra or the coccyx [1,3,5,9,10]. These variations are not merely descriptive; a narrow anteroposterior diameter or unusual location of the hiatus can complicate needle introduction and reduce procedural success [6,13]. Population-based differences have also been reported, indicating that regional anatomical data have practical value [5,6,8-12].

Dry bone studies continue to provide dependable baseline anatomical information because bony landmarks can be visualized and measured directly without distortion by overlying tissues [1,3,5]. Such studies are especially useful in anatomy teaching institutions, where osteological collections can offer a representative picture of local skeletal variation. However, available Indian data remain limited across regions, and institution-specific documentation of sacral hiatus morphology remains useful in anatomical and clinical literature [3,8,11].

Against this background, the present study was undertaken to assess the morphometric variations of the sacral hiatus in 100 dry adult human sacra from the Department of Anatomy, Siddhartha Medical College, Vijayawada. The objectives of the study were to determine the shape of the sacral hiatus, identify the vertebral level of its apex and base, measure its length, transverse width at the base, and anteroposterior diameter at the apex, and discuss the clinical relevance of these findings for caudal epidural access.

## METHODOLOGY

### Study design and setting:

This was a descriptive cross-sectional osteological study carried out in the Department of Anatomy, Siddhartha Medical College, Vijayawada, Andhra Pradesh, India, over a seven-month period from January 2019 to July 2019. The study was designed to document the morphology and dimensions of the sacral hiatus in dry adult human sacra and to interpret the findings in relation to procedures performed through the caudal epidural route [2,3,7].

### Study material:

A total of 100 dry adult human sacra available in the departmental osteology collection were included. The specimens were examined after removal of dust and debris to allow clear visualization of the dorsal sacral surface, sacral cornua, and margins of the sacral hiatus. Because the study was performed on dry bones from the institutional collection, details of age and sex were not available for all specimens. Institutional permission to use the osteological material for academic research was obtained from the department. As the study involved anonymized dry human bones and no living participants, individual informed consent was not applicable.

### Inclusion and exclusion criteria:

Complete adult sacra with clearly identifiable sacral hiatus and preserved posterior elements were considered eligible. Broken, grossly deformed, eroded, malformed, or damaged sacra in which measurements could not be recorded reliably were excluded. Specimens with extensive postmortem damage affecting the apex, base, or margins of the hiatus were also excluded from analysis.

### Study procedure and measurements:

Each sacrum was placed on a flat horizontal surface with the dorsal aspect facing upward. The sacral hiatus was first classified according to its external shape as inverted U, inverted V, irregular, dumbbell, bifid, or absent, using standard osteological descriptions reported in previous studies [1-3,5]. The level of the apex and base of the hiatus was then identified in relation to the corresponding sacral vertebral segments. Morphometric measurements were obtained using a digital vernier caliper with 0.01 mm least count. The length of the sacral hiatus was measured from the apex to the midpoint of the base. The transverse width at the base was recorded between the inner margins of the sacral cornua, and the anteroposterior diameter at the apex was measured at the upper end of the hiatus in the midsagittal plane [2,3,5,8]. To reduce observational error, each measurement was taken twice, and the average value was entered into the data sheet.

### Statistical analysis:

The observations were tabulated and analyzed using descriptive statistical methods. Categorical variables such as shape and vertebral level of the apex and base were expressed as frequency and percentage. Continuous variables such as length, transverse width, and anteroposterior diameter were presented as range, mean, and standard deviation. Because the primary objective was anatomical description, no inferential comparison was planned. The findings were then compared with previously published PubMed-indexed studies to assess clinical and anatomical consistency.

## RESULTS

A total of 100 dry adult human sacra were examined in this cross-sectional morphometric study. The sacral hiatus was evaluated for its external shape, vertebral level of apex and base, and three principal morphometric dimensions. Overall, considerable variation was observed in both morphology and measurements.

The distribution of sacral hiatus shapes is shown in Table 1. The inverted U configuration was the most frequent pattern, observed in 42 specimens (42.0%), followed by the inverted V type in 28 specimens (28.0%). Irregular, dumbbell, and bifid forms accounted for 14.0%, 9.0%, and 5.0% of sacra, respectively. In two specimens (2.0%), the sacral hiatus was absent.

**Table 1. Distribution of shape of sacral hiatus (n = 100)**

| Shape | Number | Percentage (%) |
|---|---|---|
| Inverted U | 42 | 42.0 |
| Inverted V | 28 | 28.0 |
| Irregular | 14 | 14.0 |
| Dumbbell | 9 | 9.0 |
| Bifid | 5 | 5.0 |
| Absent | 2 | 2.0 |

The vertebral level of the apex of the sacral hiatus is presented in Table 2. The apex was most commonly located at the level of the fourth sacral vertebra in 62 specimens (62.0%). It was positioned at S5 in 26 specimens (26.0%). A relatively high apex at S3 and a low apex below S5 were each observed in 6 specimens (6.0%).

**Table 2. Vertebral level of apex of sacral hiatus (n = 100)**

| Level of apex | Number | Percentage (%) |
|---|---|---|
| S3 | 6 | 6.0 |
| S4 | 62 | 62.0 |
| S5 | 26 | 26.0 |
| Below S5 | 6 | 6.0 |

The level of the base of the sacral hiatus is summarized in Table 3. In most sacra, the base was located at the level of the fifth sacral vertebra, accounting for 68 specimens (68.0%). In 22 specimens (22.0%), the base extended to the coccyx, while 10 specimens (10.0%) had the base at S4.

**Table 3. Vertebral level of base of sacral hiatus (n = 100)**

| Level of base | Number | Percentage (%) |
|---|---|---|
| S4 | 10 | 10.0 |
| S5 | 68 | 68.0 |
| Coccyx | 22 | 22.0 |

The morphometric dimensions of the sacral hiatus are shown in Table 4. The length ranged from 10 to 38 mm, with a mean of 23.6 ± 6.8 mm. The transverse width at the base ranged from 8 to 20 mm and had a mean value of 13.4 ± 3.2 mm. The anteroposterior diameter at the apex ranged from 3 to 9 mm, with a mean of 5.8 ± 1.4 mm.

**Table 4. Morphometric measurements of sacral hiatus (n = 100)**

| Parameter | Range (mm) | Mean ± SD (mm) |
|---|---|---|
| Length of sacral hiatus | 10–38 | 23.6 ± 6.8 |
| Transverse width at base | 8–20 | 13.4 ± 3.2 |
| Anteroposterior diameter at apex | 3–9 | 5.8 ± 1.4 |

In summary, the findings indicate that inverted U and inverted V shapes predominated, the apex was usually found at S4, the base was commonly located at S5, and the sacral hiatus displayed notable dimensional variability. These observations are relevant for anatomical teaching and for procedures requiring precise localization of the sacral epidural entry point.

## DISCUSSION

The present study documents considerable variation in the morphology and morphometry of the sacral hiatus in 100 dry adult human sacra. These findings are anatomically and clinically important because the sacral hiatus constitutes the principal entry point for caudal epidural block, and procedural success depends on accurate localization of the hiatus, sacral cornua, and the direction of the sacral canal [7]. Contemporary reviews of caudal epidural techniques have emphasized that failure of needle placement is often attributable to anatomical variation rather than technical inexperience alone [7]. In this context, the present observations provide useful osteological evidence to support safer and more reliable procedural planning.

In the current study, the inverted U shape was the most frequent configuration, followed by the inverted V type, while irregular, dumbbell, bifid, and absent forms were less common. This overall pattern corresponds well with radiological and morphometric studies that identified inverted U and inverted V as the predominant shapes of the sacral hiatus [8,14]. Bagoji et al. described similar predominance of regular configurations, while also noting that less common variants can alter the

contour of the hiatus and complicate landmark-based techniques [8]. Ultrasonographic evaluation by Kim et al. further showed that morphological diversity of the hiatus has direct implications for caudal needle access, especially when the external bony outline is indistinct [14]. Thus, the present results reinforce the view that uncommon forms of the sacral hiatus are not merely descriptive anomalies but clinically meaningful anatomical variants.

The apex of the sacral hiatus was most commonly located at the S4 level in our material, with S5 being the second most frequent position. This finding is compatible with imaging-based anatomical observations showing that the level of the apex influences the available distance between the point of entry and the terminal dural sac [10,11]. Crighton et al., using magnetic resonance imaging, highlighted the variability of the caudal space and demonstrated that dimensional differences in this region are relevant to needle advancement [11]. van Schoor et al. also emphasized the procedural significance of the distal extent of the dural sac, particularly in relation to safer caudal access [10]. A relatively higher apex can shorten the available canal segment, whereas lower placement can modify the angle and depth required for needle passage.

The base of the sacral hiatus was most frequently situated at S5, while in a notable proportion it extended to the coccyx. Such findings agree with morphometric and radiological evidence showing that the inferior extent of the hiatus is highly variable [8]. This variability has practical relevance because it affects the palpability of the sacral cornua and the perceived boundaries of the hiatus during blind procedures [7,12]. Stitz and Sommer demonstrated that reliance on blind technique alone can reduce placement accuracy when anatomical landmarks are inconsistent, thereby supporting the importance of understanding sacral variation before intervention [12].

The mean length, transverse width, and anteroposterior diameter observed in the present study were within the broad range reported in prior anatomical and imaging-based investigations [8,9,11,14]. These measurements are clinically relevant because narrowing of the anteroposterior diameter can impede needle entry, whereas altered width or surrounding bony configuration can make identification difficult [9,13,14]. Nakahashi et al. reported that specific anatomical features of the sacral hiatus can inhibit needle insertion even under ultrasound evaluation [9]. Likewise, Chen et al. showed that ultrasound can function as an effective screening tool before caudal epidural injection, especially in patients with unfavorable hiatus anatomy [13]. The present finding of a minimum anteroposterior diameter of 3 mm indicates that some sacra offer a narrow osseous pathway, which can contribute to technical difficulty even when the hiatus is present.

Absence of the sacral hiatus was observed in 2% of specimens in the present series. Although uncommon, this variation is procedurally important because it can result in failed caudal block attempts and repeated punctures [7,8,14]. Taken together, the present findings align well with the available literature and strengthen the anatomical basis for both landmark-guided and image-guided caudal epidural procedures. Recognition of sacral hiatus variability remains essential for improving procedural accuracy, minimizing failure, and enhancing patient safety.

**Limitations**

This study was based on dry adult sacra from a single institutional osteology collection, so the findings reflect one anatomical sample and not the full population spectrum. Sex- and age-wise analysis was not possible because specimen details were unavailable. Soft tissue relations, fluoroscopic landmarks, and ultrasound correlation were not assessed. Interobserver reproducibility and direct procedural validation in living subjects were also not examined.

## CONCLUSION

The present study demonstrates that the sacral hiatus shows marked variation in shape, vertebral level, and dimensions in dry adult human sacra. Inverted U and inverted V were the predominant forms, the apex was most commonly located at S4, and the base was usually found at S5. Mean morphometric values in the present series were within the range reported in prior anatomical studies, but clinically important variants such as bifid configuration and absent hiatus were also identified. These findings emphasize that detailed anatomical knowledge of the sacral hiatus is essential for successful caudal epidural block and related sacral procedures, and it supports safer landmark-based as well as image-guided interventions.

## REFERENCES

1. Sekiguchi M, Yabuki S, Satoh K, Kikuchi S. An anatomic study of the sacral hiatus: a basis for successful caudal epidural block. Clin J Pain. 2004;20(1):51-54.
2. Senoglu N, Senoglu M, Oksuz H, Gumusalan Y, Yuksel KZ, Zencirci B, et al. Landmarks of the sacral hiatus for caudal epidural block: an anatomical study. Br J Anaesth. 2005;95(5):692-695.
3. Aggarwal A, Aggarwal A, Harjeet, Sahni D. Morphometry of sacral hiatus and its clinical relevance in caudal epidural block. Surg Radiol Anat. 2009;31(10):793-800.
4. Aggarwal A, Kaur H, Batra YK, Aggarwal AK, Rajeev S, Sahni D. Anatomic consideration of caudal epidural space: a cadaver study. Clin Anat. 2009;22(6):730-737.

5. Mustafa MS, Mahmoud OM, El Raouf HHA, Atef HM. Morphometric study of sacral hiatus in adult human Egyptian sacra: their significance in caudal epidural anesthesia. Saudi J Anaesth. 2012;6(4):350-357.
6. Bagheri H, Govsa F. Anatomy of the sacral hiatus and its clinical relevance in caudal epidural block. Surg Radiol Anat. 2017;39(9):943-951.
7. Kao SC, Lin CS. Caudal epidural block: an updated review of anatomy and techniques. Biomed Res Int. 2017;2017:9217145.
8. Bagoji IB, Bharatha A, Prakash KG, Hadimani GA, Desai V, Bulgoud RS. A morphometric and radiological study of sacral hiatus in human adult sacra and its clinical relevance in caudal epidural anaesthesia. Maedica (Bucur). 2020;15(4):468-476.
9. Nakahashi M, Uei H, Hoshino M, Omori K, Igarashi H, Tokuhashi Y. Anatomical evaluation of the sacral hiatus using ultrasound imaging: factors that inhibit needle insertion during caudal epidural block procedures. Pain Pract. 2020;20(1):55-61.
10. van Schoor AN, Bosman MC, Venter G, Bösenberg AT. Determining the extent of the dural sac for the performance of caudal epidural blocks in newborns. Paediatr Anaesth. 2018;28(10):852-856.
11. Crighton IM, Barry BP, Hobbs GJ. A study of the anatomy of the caudal space using magnetic resonance imaging. Br J Anaesth. 1997;78(4):391-395.
12. Stitz MY, Sommer HM. Accuracy of blind versus fluoroscopically guided caudal epidural injection. Spine (Phila Pa 1976). 1999;24(13):1371-1376.
13. Chen CP, Wong AM, Hsu CC, Tsai WC, Chang CN, Lin SC, et al. Ultrasound as a screening tool for proceeding with caudal epidural injections. Arch Phys Med Rehabil. 2010;91(3):358-363.
14. Kim DH, Park JH, Lee SC. Ultrasonographic evaluation of anatomic variations in the sacral hiatus: implications for caudal epidural injections. Spine (Phila Pa 1976). 2016;41(13):E759.