Section: Anatomy

Original Research Article

MORPHOLOGIC AND MORPHOMETRIC ANALYSIS OF SACRAL HIATUS AND ITS CLINICAL IMPLICATION IN CAUDAL ANESTHESIA

Dhiren M Rathod[1], Shailesh M Patel[2], Manju Vala[3], Dwiti S. Patel[4]

[1]3rd year resident doctor, Department of Anatomy, GMC Bhavnagar, Gujarat, India
[2]Professor & Head, Department of Anatomy, GMC Bhavnagar, Gujarat, India
[3]Tutor, Department of Anatomy, GMC Bhavnagar, Gujarat, India
[4]Tutor, GMC Bhavnagar, Gujarat, India

Received : *21/12/2024*
Received in revised form : *12/02/2025*
Accepted : *27/02/2025*

Keywords:
Sacrum, Sacral hiatus, Caudal epidural anaesthesia, Anatomical variation.

Corresponding Author:
Dr. Dhiren M Rathod,
Email: drdhirenrathod@gmail.com

DOI: 10.47009/jamp.2025.7.1.213

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2025; 7 (1); 1095-1100

Abstract

Background: The sacral hiatus serves as a crucial landmark for administering a caudal epidural block. For performing epidural anaesthesia, we must have knowledge about exact location and variation of sacral hiatus and its level of opening. Our objective was to perform morphologic and morphometric analysis of the sacral hiatus. **Materials and Methods:** The current cross-sectional study analysed 48 human dry sacra of unknown sex and age from the Government Medical College in Bhavnagar. We examined parameters of the sacral hiatus such as various shapes like inverted U, inverted V, dumbbell, irregular, and bifid. The apex of the sacral hiatus opens at the S3, S4, and S5 vertebrae level, while the base opens at the S5 and coccyx level. The length of hiatus was measured from the apex to the midpoint of the base of the sacrum, with the width defined as the distance between the two sacral cornua and also depth of the hiatus at the apex level. **Result:** Out of 48 dry human sacra, the inverted U shape was the most prevalent (45.83%) form of the sacral hiatus, opening of the apex and base was most commonly found at S4 (50%) and S5 vertebrae 47.91% respectively. The average length and width of hiatus was 24.70mm (SD= 7.88mm) and 12.52mm (SD=3.9mm) respectively. The mean depth of the hiatus was 8.1mm (SD=2.72mm). **Conclusion: :** Findings of this study revealed that inverted U was most common shape of sacral hiatus, with common apex opening at S4 and base opening at S5 vertebrae.

INTRODUCTION

The sacrum is a triangular bone formed by the fusion of five sacral vertebrae, constitutes a crucial element of the human skeletal system.[1] Situated in the posterior superior aspect of the pelvis, it forms essential articulations with the hip bones at the sacroiliac joint. Its upper portion, characterized by robustness, plays a pivotal role in supporting and transmitting body weight to the hip bones. Structurally, the sacrum exhibits distinct surfaces: the pelvic surface, smooth and concave, and the dorsal surface, rough, irregular, and convex, projecting upwards and backwards.[2]

Within the median plane of the sacrum lies the median sacral crest, marked by 3 to 4 spinous tubercles, indicative of the fusion of the upper four sacral vertebrae. Below the fourth tubercle, a significant anatomical feature, the sacral hiatus, emerges. This hiatus appears as an inverted U-shaped opening in the posterior wall of the sacral canal, caused by the partial fusion of the laminae of the S5 vertebra.[3]

The sacral hiatus serves as a conduit for several important anatomical structures, including the fifth sacral nerve, coccygeal nerves, and the filum terminale. Understanding the morphology and morphometrics of the sacral hiatus is crucial due to its clinical implications, particularly in the context of caudal anesthesia. Hence, a comprehensive analysis of the sacral hiatus can provide valuable insights into its anatomical variations and clinical relevance.[4]

Caudal epidural block stands as a cornerstone in various medical domains, including pediatrics, obstetrics, and peri/post-operative analgesia. A fundamental prerequisite for proficiently performing this technique is a precise understanding of the sacral hiatus. However, in certain demographics, such as adults and individuals with obesity, locating the exact position of the sacral hiatus can pose a challenge. This challenge highlights the essential need to understand the anatomical variations of the sacral hiatus, as these variations can significantly affect the effectiveness and reliability of caudal epidural blocks.[5] A caudal epidural block has a failure rate of 25%, often attributed to anatomical variations at the apex of the sacral hiatus, which can make palpation

ISSN (O): 2687-5365; ISSN (P): 2753-6556

challenging in certain patients. Even experienced clinicians may struggle to consistently identify the caudal epidural space, with anatomical differences potentially complicating the procedure.[6]

The primary objective of our study was to carefully investigate the morphological and morphometric characteristics of the sacral hiatus in human sacra. By undertaking this investigation, our aim was to facilitate the accurate and uncomplicated administration of caudal epidural blocks (CEB). Through a thorough analysis of the sacral hiatus, we sought to enhance the precision of locating this anatomical landmark, thereby improving the success rates and safety profiles of caudal epidural procedures across diverse patient populations. Ultimately, our research endeavors to contribute valuable insights that may optimize clinical practices and enhance patient care in the realm of regional anesthesia.[7,8]

MATERIALS AND METHODS

The study employed a cross-sectional design utilizing human dry sacra. In this study, we utilized all 48 human sacra bones available at the institute for our morphological and morphometric analysis, as this was the complete sample accessible for examination and these sacra were selected irrespective of sex or age due to the focus on morphological and morphometric analysis.

The methodology involved a comprehensive examination of each sacrum to assess its morphological characteristics, including the presence and dimensions of the sacral hiatus. Morphometric measurements were conducted to quantify specific anatomical parameters relevant to the sacral hiatus.

Utilizing appropriate instruments like vernier calliper and standardized protocols, data collection proceeded systematically to ensure consistency and accuracy across all specimens.

Morphological parameters:

1. The shape of the sacral hiatus exhibits variability in posterior surface, encompassing inverted U shaped [Figure 1], V-shaped [Figure 2], Dumbbell-shaped [Figure 3], Irregular-shaped [Figure 4], and Bifid-shaped [Figure 5] configurations.
2. The opening of the apex of the sacral hiatus may occur at the level of S3, S4, or S5 vertebrae.
3. The opening of the base of the sacral hiatus typically occurs at the level of the S4, S5 vertebra and extends towards the coccyx.[9]

Morphometrical parameters:

1. Length of the sacral hiatus: Measured from the apex to the midpoint of the base of the sacrum. [Figure 6-A]
2. Width of the sacral hiatus: Defined as the distance between the two sacral cornua, also known as the inter cornual distance. [Figure 6-B]
3. Depth of the sacral hiatus: Determined at the level of the apex, providing insight into the spatial dimensions of this anatomical feature.[8] [Figure 6-C]

These morphological and morphometric parameters serve as essential metrics for characterizing the sacral hiatus, enabling a comprehensive understanding of its anatomical variations and clinical significance in procedures such as caudal epidural blocks.

Ethical consideration: As this study does not involve any human participants or any other living organism, study was granted exemption from requiring ethical approval from the Institute.

RESULTS

A) Morphological Analysis

Variability in Sacral Hiatus Shape: The analysis revealed a variety of shapes exhibited by the sacral hiatus among the specimens studied which is shown in [Table 1]. Inverted U shape was most common.

Location of Apex Opening: As shown in [Table 2] the opening of the apex of the hiatus was most frequently seen at S4 vertebra (50%).

Location of Base Opening: Total 23 specimens (47.92%) of sacra showed the opening of the base of the sacral hiatus was at the level of fifth sacral vertebra. While in other 17 specimens (35.41%) it was observed at S4 level & remaining 16.67% were at coccyx level.

B) Morphometric Parameters

Length: The length of the sacral hiatus was varying between 7-50 mm, with a mean value of 24.70 mm and a standard deviation of 7.88 mm. The distribution of lengths within specified ranges are shown in [Table 3].

Width: The width of the hiatus ranged from 0 to 40 mm, with a mean value of 12.521 mm and a standard deviation of 3.90 mm. The distribution of widths within specified ranges are shown in [Table 4].

Depth: The depth of the hiatus ranged from 0 to 15 mm, with a mean value of 8.1 mm and a standard deviation of 2.72 mm. The various depth of sacral hiatus is shown in [Table 5].

Figure 1: Inverted U shape of Sacral hiatus

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Figure 2: Inverted V shape of Sacral hiatus

Figure 3: Dumbbell shape of Sacral hiatus

Figure 4: Irregular shape of Sacral hiatus

Figure 5: Bifid shape of Sacral hiatus

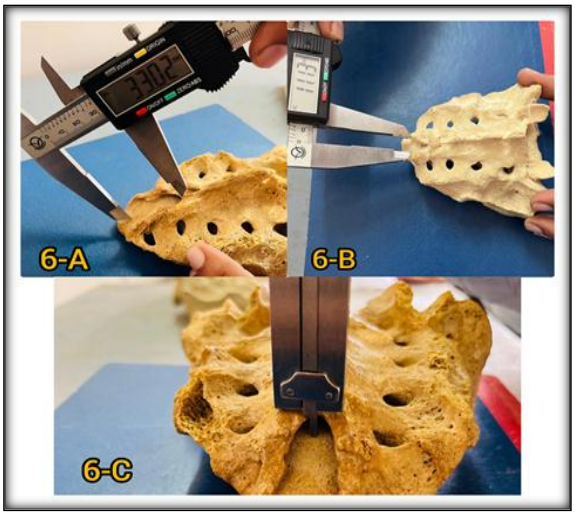

Figure 6: Measurement of Length (6-A), Width (6-B), Depth (6-C) of Sacral Hiatus

Table 1: Shapes of Sacral Hiatus (N=48).

Shape	Frequency	Percentage
Inverted U	22	45.83%
Inverted V	12	25.00%
Dumbbell	7	14.58%
Irregular	2	4.17%
Bifid	5	10.42%
Total	48	100%

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 2: Levels of Apex opening of Sacral Hiatus (N=48)

Level of Apex Opening	Frequency	Percentage
S1 vertebrae	1	2.08%
S2 vertebrae	5	10.42%
S3 vertebrae	12	25.00%
S4 vertebrae	24	50.00%
S5 vertebrae	6	12.50%
Coccyx	0	0%
Total	48	100%

Table 3: Length distribution of Sacral Hiatus (N=48)

Length Range (mm)	Frequency	Percentage
< 10	2	4.16%
10.1 - 20	14	29.16%
20.1 - 30	18	37.50%
30.1 - 40	12	25.00%
40.1 - 50	2	4.16%
Total	48	100%

Table 4: Width distribution of Sacral Hiatus (N=48)

Width Range (mm)	Frequency	Percentage
0 - 10	11	22.91%
10.1 - 20	35	72.91%
30.1 - 40	2	4.16%
Total	48	100%

Table 5: Depth of Sacral Hiatus (N=48)

Depth Range (mm)	Frequency	Percentage
0 - 3	2	4.16%
3.1 - 6	10	20.83%
6.1 - 9	18	37.50%
9.1 - 12	17	35.41%
12.1 - 15	1	2.08%
Total	48	100%

DISCUSSION

Performing caudal anaesthesia and administering analgesic drugs necessitates a comprehensive understanding of anatomical variations in the sacral hiatus. Our study focused on elucidating these variations, particularly in shapes, apex, base location, and morphometric parameters, and their relevance to clinical practice, notably in caudal epidural block procedures for obstetric and perianal analgesia.[10-13]

Morphologic Parameters: The sacral hiatus exhibits diverse shapes, including inverted U, inverted V, bifid, irregular, and dumbbell configurations. In Our findings proportion of inverted U shape of sacral hiatus was 45.83%, followed by inverted V (25%), dumbbell (14.58%), Bifid (10.41%) and irregular (4.16%) shapes. A study by Saha D. and et al showed that inverted U shape of sacral hiatus was most common (70.09%) followed by inverted V (14.53%), irregular (12.82%), bifid (1.71%) and dumbbell (0.85%) shapes.[5] Similar findings were observed in study reported by Bagoji IB et al, where inverted U shape (42.02%) was most common shape of hiatus.[3] In other study it was found that inverted U-shaped being the most commonly observed (34.83%) followed by inverted V (26.45%) and irregular (19.99%).[8] Inverted V shape (35.85%) was most commonly observed in a study conducted in Chennai by Anupriya A.et al.[9] Similar findings were also observed in a study where Inverted V shape (59.3%) of sacral hiatus was prominent. A study done by David SJ showed that elongated shape of hiatus was most common (33.3%).[14] A radiographic analysis of sacral hiatus by Khokhar SK et al suggested that in cases inverted U and controls inverted V was most commonly observed shape of sacral hiatus.[15,16] Comparing our results with previous studies, the most common shape of Sacral hiatus was inverted U shape, but still significant variability is evident across different populations, suggesting the need for individualized approaches in clinical settings.

The apex of the sacral hiatus is essential as a landmark for performing successful caudal epidural blocks. Our study documented variations in apex and base location, with the majority of apex located at S4 (50%) and base at S5 (47.92%) vertebrae level. Similar finding was observed by Singh A et al in their study where majority apex was located at S4 (50%) and base at S5 (82%).[7] In a study conducted by Saha D. et al., it was found that the most commonly observed positions of the apex and base of the sacral hiatus were the fourth sacral vertebra (74.36%) and the fifth sacral vertebra (95.73%).[5] Apex of the hiatus was found most commonly at S4 level in 60.04% sacra and the base of hiatus was found at S5 level in 77.03% sacra in the study conducted by Bharambe V et al.[6] This kind of findings was also

ISSN (O): 2687-5365; ISSN (P): 2753-6556

seen in study conducted at Solapur of Aurangabad, where 66% of apex opening found at S4 and 82% of base openings found at S5 vertebrae.[10] Study by Vasuki et al also suggested the same findings in which 4th sacral vertebra was most common opening for apex (48%) and 5th sacral vertebra common for base opening (64%).[11] 4th sacral vertebra was most common opening for apex (55.9%) and 5th sacral vertebra was most frequent opening for base opening in a study conducted by Nagar S.[13] These findings provide valuable guidance for needle insertion techniques and minimize procedural complications. In these studies, opening of apex at S2 level was seen in lesser number. Notably, apex locations at S2 and S3 pose increased risks of dural sac puncture during procedures, underscoring the importance of precise localization.

Morphometric Parameters: Analysis of sacral hiatus dimensions revealed mean values for length (24.70 ± 7.88 mm), width (12.521 ± 3.90 mm), and depth (8.1 ± 2.72 mm). The length of sacral hiatus was found between 7 to 50 mm and in 37.50% of sacra length of the sacral hiatus was ranged between 20.1 to 30mm. A morphometric study of sacral hiatus in human sacra by Ishwar B et al revealed mean length (26.80 ± 2.14), width (17.70 ± 2.14) and depth (6.80 ±2.81) respectively.[3] Another study conducted in Greece by E. Nastoulis E et al documented mean values for length (19.05 ± 8.65), width (12.4 ± 3.16) and depth (5.39± 1.84) respectively for sacral hiatus.[8] The mean length of sacral hiatus 22.69 mm was observed in study by Seema et al.[12] The Study by Nadeem G. revealed length of hiatus between 11 to 30 mm in 57% of sacra and width more than 16mm in 52% of sacra.[15] Similar findings were observed in study by Punja R et al,[17] where mean length of hiatus was 24.5mm and mean depth was 5.5mm and study by Abera Z et al,[19] where average length of the hiatus was 22.67 ± 11.84 mm, the mean width and mean depth of sacral hiatus was 13.14 mm ± 2.85 mm and 5.57 mm ± 1.53 mm. Depth of hiatus less than 3 mm produces difficulties in needle insertion and increases chances of failure of CEB.[20]

Morphologic and morphometric parameters of sacra serve as crucial reference points for procedural planning and optimizing anaesthesia delivery. Comparisons with previous studies showed some minor variations in measurements across populations. Additionally, the identification of variations in the shape and size of the sacral hiatus enhances our understanding of its clinical implications, facilitating informed decision-making during medical procedures.

CONCLUSION

In conclusion, our morphological and morphometric analysis of 48 sacra revealed that the inverted U shape (45.83%) is the most common configuration of the sacral hiatus, with its apex and base located predominantly at S4 and S5. The mean length of sacral hiatus was found to be 24.707 ± 7.88 mm, with an average AP diameter at the apex of 12.521 ± 3.90 mm and a depth of 8.1 ± 2.72 mm. These findings are crucial for the precise administration of caudal epidural anaesthesia, as anatomical variations in the sacral hiatus can affect the success rate of the procedure. These significant variations in its size and shape of human sacra can complicate this process, and can lead to a higher chance of failure of anaesthesia.

Thus, the insights gained from this study contribute to the body of knowledge surrounding sacral anatomy and its relevance in clinical practice.

Acknowledgements: The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such research can potentially increase mankind's overall knowledge which can then improve patient care. Therefore, these donors and their families deserve our highest gratitude.[21]

REFERENCES

1. Bothsa V, Thaduri N. Morphological and Morphometrical study of sacral hiatus in male and female sacrum of central Indian population. ISSN. 2022;62.
2. Chaurasia's Human Anatomy: lower limb and abdomen. 2022.
3. 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 (Buchar) 2020;15(4):468–76. Available from: http://dx.doi.org/10.26574/maedica.2020.15.4.468
4. Singh V. Textbook of anatomy abdomen and lower limb; Volume II. 3rd ed. New Delhi, India: Elsevier; 2018.
5. Saha D, Bhattacharya S, Uzzaman A, Mazumdar S, Mazumda A. Morphometric study of variations of sacral hiatus among West Bengal population and clinical implications. IJAE. 2016;121:165–71.
6. Bharambe V, Shinde A, Manvikar P. Morphometric study of sacral hiatus and its significance in caudal epidural anesthesia. Sahel Med J. 2015;18(3):134. Available from: http://dx.doi.org/10.4103/1118-8561.169281
7. Singh A, Gupta R, Singh A. Morphological and Morphometrical Study of Sacral Hiatus of Human Sacrum.ResearchGate 2018 at https://www.researchgate.net/publication/330654787
8. Nastoulis E, Tsiptsios D, Chloropoulou P, Karapepera V, Thomaidis V, Pavlidis P. Fiska Morphological and morphometric features of sacral hiatus and its clinical significance in caudal epidural anaesthesia Folia Morphol.2023 Via Medica. 82:603–14. Available from: http://dx.doi.org/10.5603/FM.2022.0078
9. Anupriya A, Sophia MM. Anatomical study of sacral hiatus in South Indian population and its clinical significance in caudal epidural anaesthesia. National Journal of Clinical Anatomy. 2014;03(03):128–36. Available from: http://dx.doi.org/10.1055/s-0039-3401751
10. Shewale S, Laeeque M, Kulkarni P, Diwan C. Morphological and morphometrical study of sacral hiatus. International Journal of Recent trends in Science and Technology. 2013;06(01); 48-52.
11. Vasuki AKM, Sundaram KK, NirmaladevI M, Jamuna M, Hebzibah DJ, Fenn TKA. Anatomical Study of Sacrum and its Clinical Significance. Ann. Int. Med. Den. Res. 2016;2(3):123-27.
12. Seema; Singh M; Mahajan A. An anatomical study of variations of sacral hiatus in sacra of North Indian origin and

ISSN (O): 2687-5365; ISSN (P): 2753-6556

its clinical significance. Int J Morphol. 2013 Mar;31(1):110-114.
13. Nagar S. A study of sacral hiatus in dry human sacra. J Anatomical Soc India. 2004 Dec;53(1):18-21.
14. David SJ. Morphometric measurements of sacral hiatus in South Indian dry human sacra for safe caudal epidural block. Int J Anat Res. 2019 Sep;7(3.3):6911-6917. Available from: http://dx.doi.org/10.16965/ijar.2019.254
15. Nadeem G. Importance of knowing the level of sacral hiatus for caudal epidural anesthesia. J Morphol Sci. 2014;31(01):009–13. Available from: http://dx.doi.org/10.4322/jms.ao053913
16. Khokhar SK, Surti A, Qamar A, Khaliq S. Radiographic assessment of sacral hiatus anatomy with backache. Pak J Med Sci. 2023;39(6):1757-1762. doi: https://doi.org/10.12669/pjms.39.6.7112
17. Punja R, Sumalatha S, Afrah F, Hosapatna M. Clinically Relevant Morphometry of Sacral Hiatus and Morphology of Sacrum. Turk Neurosurg. 2021 33(3):373-378. doi: 10.5137/1019-5149. JTN.35322-21C.4
18. Saluja S, Agarwal S, Paul S, Tuli A, Raheja S, Tigga SR. Morphometric analysis of the sacral hiatus in Indians: its clinical importance. Int J Anat Res. 2019;7(1.1):6064-6070. doi: 10.16965/ijar.2018.406
19. Abera Z, Girma A, Bekele A, Oumer M. Assessment of Morphological and Morphometrical Variations of Sacral Hiatus in Dry Human Sacrum in Ethiopia. Local Reg Anesth. 2021 Feb 24;14:25-32. doi: 10.2147/LRA.S277556. PMID: 33658843; PMCID: PMC7917331.
20. Chhabra N. An anatomical study of size and position of sacral hiatus; its importance in caudal epidural block. Int J Health Sci Res. 2014;4(12):189-196.
21. Iwanaga J, Singh V, Ohtsuka A, Hwang Y, Kim HJ, Morys J, et al. Acknowledging the use of human cadaveric tissues in research papers: Recommendations from anatomical journal editors. Clin Anat 2021;34:2-4.