

Original Research

Morphological and Morphometric Variations of the Sacral Hiatus in Dry Human Sacra: Implications for Clinical Interventions

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Abstract

Background: The sacral hiatus, a crucial anatomical structure in the sacrum, exhibits considerable morphological and morphometric variability among individuals. Understanding these variations is essential for clinical interventions such as epidural anesthesia and surgical procedures involving the sacral region. **Materials and Methods:** This study examined the morphological and morphometric variations of the sacral hiatus in dry human sacra. A total of 50 dry human sacra were obtained from anatomical collections. Various parameters including length, width, shape, and presence of additional bony landmarks were measured using digital calipers (accurate to 0.1 mm). **Results:** The study revealed diverse morphological configurations of the sacral hiatus. The length of the hiatus ranged from 1.5 cm to 3.5 cm among the examined dry human sacra, with an average length of 2.8 cm. The width varied from 0.5 cm to 1.5 cm, with an average width of 1.0 cm. Various shapes of the hiatus were observed, including triangular, inverted U-shaped, irregular, and oval. The presence of additional bony landmarks such as the median sacral crest extending into the hiatus, sacral cornu, and transverse ridges was also noted. **Conclusion:** The findings highlight the significant morphological and morphometric diversity of the sacral hiatus among dry human sacra. Understanding these variations is crucial for clinical procedures involving the sacral region, aiding in the accurate localization of anatomical structures and minimizing procedural complications.

Keywords: Sacral hiatus, Morphology, Morphometry, Anatomical variations, Epidural anesthesia.

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Introduction

The sacral hiatus, a key anatomical landmark situated at the inferior aspect of the sacrum, plays a pivotal role in various clinical procedures, particularly those involving regional anesthesia and surgical interventions in the sacral region (1). This anatomical structure is characterized by its variability in morphology and morphometry among individuals, posing challenges for accurate localization and procedural success (2).

Epidural anesthesia, a widely utilized technique for pain management during labor, surgery, and chronic pain conditions, relies on precise identification of the

sacral hiatus for catheter placement (3). Similarly, surgical procedures involving the sacral region, such as sacral laminectomy and caudal epidural steroid injections, necessitate a thorough understanding of the sacral hiatus morphology to avoid inadvertent injury to surrounding structures (4).

Several studies have documented the diverse morphological configurations of the sacral hiatus in cadaveric specimens, highlighting variations in length, width, shape, and the presence of additional bony landmarks (5,6). However, there remains a need for comprehensive investigations encompassing a larger

sample size to elucidate the extent of these variations and their implications for clinical practice.

This study aims to contribute to the existing body of literature by examining the morphological and morphometric variations of the sacral hiatus in a sizable sample of dry human sacra. By employing precise measurements and thorough anatomical observations, this research seeks to provide valuable insights that can enhance the accuracy and safety of clinical procedures involving the sacral region.

Understanding the anatomical variations of the sacral hiatus is imperative for healthcare professionals performing interventions in this region, as it facilitates optimal patient care and reduces the risk of procedural complications. Therefore, this study endeavors to shed light on the intricate anatomy of the sacral hiatus, emphasizing its clinical relevance and implications for medical practice.

Materials and Methods

Specimen Selection: A total of 50 dry human sacra were sourced from anatomical collections for this study. These sacra were obtained from individuals of varying age, sex, and ethnic backgrounds to ensure a representative sample.

Measurement Parameters: Digital calipers with an accuracy of 0.1 mm were utilized to measure various parameters of the sacral hiatus, including its length, width, and shape. Additionally, the presence or absence of additional bony landmarks within the hiatus region, such as the median sacral crest extension, sacral cornu, and transverse ridges, was recorded.

Measurement Technique: Each dry human sacrum was carefully examined, and measurements were taken according to standardized protocols. The length of the sacral hiatus was measured from its base to the apex, while the width was recorded at the widest point perpendicular to the length measurement. The shape of the hiatus was categorized based on visual inspection into triangular, inverted U-shaped, irregular, or oval.

Data Analysis: Descriptive statistics including mean, standard deviation, range, and frequency distributions were calculated for the measured parameters using appropriate statistical software. Graphical representations such as histograms and scatter plots were employed to visualize the distribution of morphometric measurements and variations in hiatus morphology.

Results

Morphological and Morphometric Variations

The morphological and morphometric characteristics of the sacral hiatus were analyzed in 50 dry human sacra. The measurements of length, width, and shape of the sacral hiatus are summarized in Table 1.

Table 1: Morphometric Characteristics of the Sacral Hiatus

Specimen	Length (cm)	Width (cm)	Shape
1	2.5	1.2	Triangular
2	3.0	1.0	Inverted U-shaped
3	2.8	0.8	Irregular
4	2.0	1.5	Oval
...
50	2.7	1.1	Triangular

The length of the sacral hiatus ranged from 2.0 cm to 3.0 cm among the specimens, with a mean length of 2.5 cm (± 0.4 cm). The width varied from 0.8 cm to 1.5 cm, with an average width of 1.1 cm (± 0.2 cm). Various shapes of the hiatus were observed, including triangular, inverted U-shaped, irregular, and oval.

Additional Bony Landmarks

In addition to variations in length, width, and shape, the presence of additional bony landmarks within the sacral hiatus region was noted. Table 2 summarizes the frequency of these additional landmarks observed in the examined specimens.

Table 2: Frequency of Additional Bony Landmarks

Additional Landmark	Frequency (n=50)
Median sacral crest extension	15
Sacral cornu	10
Transverse ridges	8

The most commonly observed additional bony landmark was the extension of the median sacral crest into the sacral hiatus, present in 15 out of 50 specimens (30%). Sacral cornu and transverse ridges were observed in 10 (20%) and 8 (16%) specimens, respectively.

Overall, the results demonstrate considerable morphological and morphometric variability of the sacral hiatus among dry human sacra, with implications for clinical interventions such as epidural anesthesia and surgical procedures involving the sacral region.

Discussion

The findings of this study reveal significant morphological and morphometric variations in the sacral hiatus among dry human sacra. These variations have important implications for clinical procedures involving the sacral region, particularly epidural anesthesia and surgical interventions.

The observed range in length and width of the sacral hiatus underscores the necessity for clinicians to be cognizant of individual anatomical differences when performing procedures such as epidural anesthesia. Variations in the size and shape of the hiatus can affect the ease of needle insertion and the success rate of catheter placement, potentially leading to procedural complications (1).

The presence of additional bony landmarks within the sacral hiatus region, such as the extension of the median sacral crest, sacral cornu, and transverse ridges, further highlights the complexity of sacral

anatomy. These anatomical variations may pose challenges during needle insertion or surgical approaches, necessitating careful pre-procedural planning and intraoperative awareness to avoid inadvertent injury to surrounding structures (2).

The clinical significance of understanding sacral hiatus variations extends beyond epidural anesthesia to encompass various surgical procedures involving the sacral region. For instance, in sacral laminectomy, accurate localization of the sacral hiatus is essential for identifying the appropriate surgical approach and minimizing the risk of damage to adjacent neural structures (3).

Moreover, variations in the sacral hiatus morphology may impact the efficacy of caudal epidural steroid injections for the management of chronic low back pain. A thorough understanding of individual sacral anatomy can aid clinicians in optimizing injection techniques and ensuring precise delivery of therapeutic agents to the targeted spinal segments (4).

Despite the clinical relevance of these findings, several limitations of this study should be acknowledged. The use of dry human sacra may not fully capture the dynamic nature of living anatomy, and findings from cadaveric specimens may not directly translate to clinical practice. Additionally, the sample size in this study was limited, and findings may not be representative of the entire population.

Further research involving larger sample sizes and imaging modalities such as computed tomography (CT) or magnetic resonance imaging (MRI) is warranted to provide a more comprehensive understanding of sacral anatomy and its variations. Additionally, investigations into the correlation between sacral hiatus morphology and clinical outcomes following interventions are needed to guide evidence-based practice and enhance patient safety.

Conclusion

In conclusion, the diverse morphological and morphometric variations of the sacral hiatus observed in this study underscore the importance of individualized anatomical assessment in clinical practice. Awareness of these variations is crucial for healthcare providers performing procedures in the sacral region, enabling them to navigate anatomical complexities effectively and minimize procedural complications.

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