Analysis of the interlaminar window of lumbar vertebrae using morphometry

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Abstract

Introduction: The present study was conducted to precisely observe the morphometric dimensions of interlaminar space or window of the lumbar spine. The anatomy of interlaminar space holds paramount importance as it provides a passage or acts as a gateway to underlying vital structures such as spinal nerves, intervertebral disc, and spinal cord ensheathed by meningeal covering.

Materials & Methods: The present study was carried out on 20 vertebral columns (100 lumbar vertebrae). We measured the interlaminar space at three locations: near the spinous process, the middle of the lamina, and the articular process. We also measured the horizontal distance from the tip of the spine to the widest space of the interlaminar window.

Results: The widest interlaminar window was observed at the middle of the lamina. Neurosurgeons could utilize this window for undertaking different types of spinal surgeries. Horizontal distance was measured from the tip of the spine to the middle of the lamina, which could help determine the area of access for spinal surgeries.

Conclusions: In patients with complex spinal anatomy where patient positioning becomes difficult, the interlaminar space at the middle of the lamina could be used by anesthesiologists to give central neuraxial block as the midline approach in these conditions is very difficult. Since this area has the maximum space in the interlaminar window, the morbidity, mortality, pain, and complications related to multiple punctures could significantly be reduced, resulting in better patient care.

Keywords

Lumbar vertebrae, Interlaminar space, Spinous process, Middle of the lamina, Articular process

Introduction

The lumbar vertebrae, the largest vertebrae in the vertebral column, bear the maximum body weight and provide crucial support for the overall load. [1] The laminae of lumbar vertebrae are bilateral bony structures located at the posterior aspect of the vertebrae, which provide a protective covering for the spinal cord. Additionally, the laminae and the superior and inferior facets may play a critical role in stabilizing the spine. Any damage or pathology affecting the laminae or facet joints can have significant implications for spinal stability and may contribute to a range of clinical conditions, including degenerative disc disease, spinal stenosis, and herniated discs. Therefore, a comprehensive understanding of the anatomy and function of the laminae is essential for clinicians when evaluating and treating patients with spinal pathologies. [2] The interlaminar window is the most crucial corridor during interlaminar approaches to intervertebral discs. [3] Precise knowledge of the interlaminar space is critical for a variety of spinal procedures, including laminectomy, interlaminar screw fixation, laminar hook placement, percutaneous endoscopic discectomy, epidural and subarachnoid block in complex spinal anatomy. These techniques require accurate identification of the interlaminar space, which is the area between adjacent laminae of vertebrae. Therefore, a thorough understanding of the interlaminar space anatomy is paramount for successful and safe spinal surgery and specific anaesthetic techniques. [4] The present study aims to measure the interlaminar distance of the lumbar vertebrae from L1-L5 near the spinous process, at the middle of the lamina and near the articular process. The study also aimed to measure the horizontal distance from the tip of the spine to the widest space of the interlaminar window.

Materials and Methods

The study was conducted in the Department of Anatomy, Hamdard Institute of Medical Sciences and Research (HIMSR), Jamia Hamdard, New Delhi after taking permission from Institute Ethics Committee (HIMSR/IEC/00173/2023). Present study was carried out on 20 vertebral columns (100 lumbar vertebrae). The duration of the study was one year. Dry, normal and unbroken lumbar vertebrae were utilized for the purpose of study. Deformed, fused and developmentally anomalous vertebrae were excluded from the study.

Equipment required

Digital vernier calliper was used to obtain precise and accurate measurements.

Digital vernier calliper

When the jaws are closed, the movable scale lines up with the fixed scale, and the zero of the vernier scale lines up with a division of the main scale. The gap between the zero on the vernier scale and the nearest main scale division is measured as the jaws are opened and the movable scale is moved away from the fixed scale. Linear encoders are at the heart of the digital

vernier calliper, translating jaw motion into an electric signal that is subsequently shown on the screen.

The interlaminar distance (Figure 1) was measured by using a digital vernier calliper at three distinct locations between adjacent lumbar vertebrae (L1-L5) on both right and left sides.

(1) Near the spinous process: It was measured near the spinous process from lower border of lamina of upper lumbar vertebra to the upper border of lamina of lower lumbar vertebra.

(2) At the middle of the lamina: It was measured from the midpoint of lower border of the lamina of upper lumbar vertebra to the midpoint of upper border of lamina of lower lumbar vertebra.

(3) Near the articular process: It was measured near the articular process from the lower border of lamina of upper lumbar vertebra to the upper border of lamina of lower lumbar vertebra.

From the tip of the spine, we also measured horizontal distance to the widest space of the interlaminar window using a vernier calliper.

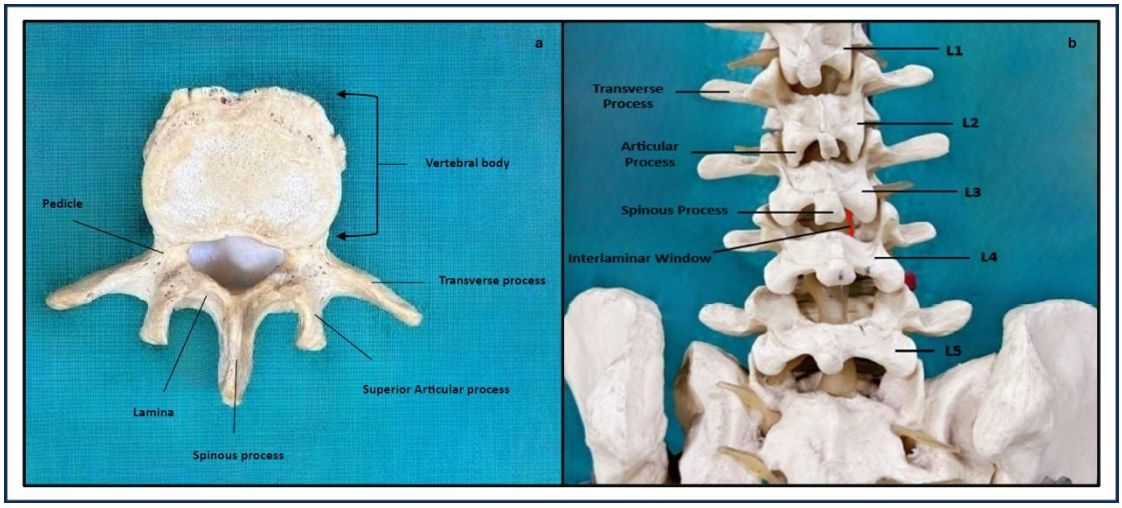

Figure 1. a. Superior view of Lumbar vertebra; b. Posterior view of lumbar spine

Statistical analysis

Data was analysed by Graph Pad Prism. Data presented as mean ± SD. One-way ANOVA was used for the comparisons; $*p \leq 0.05$ was considered statistically significant.

Results

The present study was conducted on 20 vertebral columns (100 dried lumbar vertebrae) to determine the different parameters of the lumbar vertebrae.

Measurements of interlaminar distance near the spinous process: We measured the interlaminar window near the spinous process. The maximum distance near the spinous process was found to be 13.15±1.95 mm on the right side and 13.09± 1.95 mm on the left side. (Figure 2)

Measurements of interlaminar distance at the middle of the lamina: The maximum distance at the middle of the lamina was found to be 14.45±2.03 mm on the right side and 14.36± 2.02 mm on the left side. (Figure 2)

Measurements of interlaminar distance near the articular process: The maximum distance near the articular process was found to be 10.11±1.75 mm on the right side and 10.05± 1.72 mm on the left side. (Figure 2)

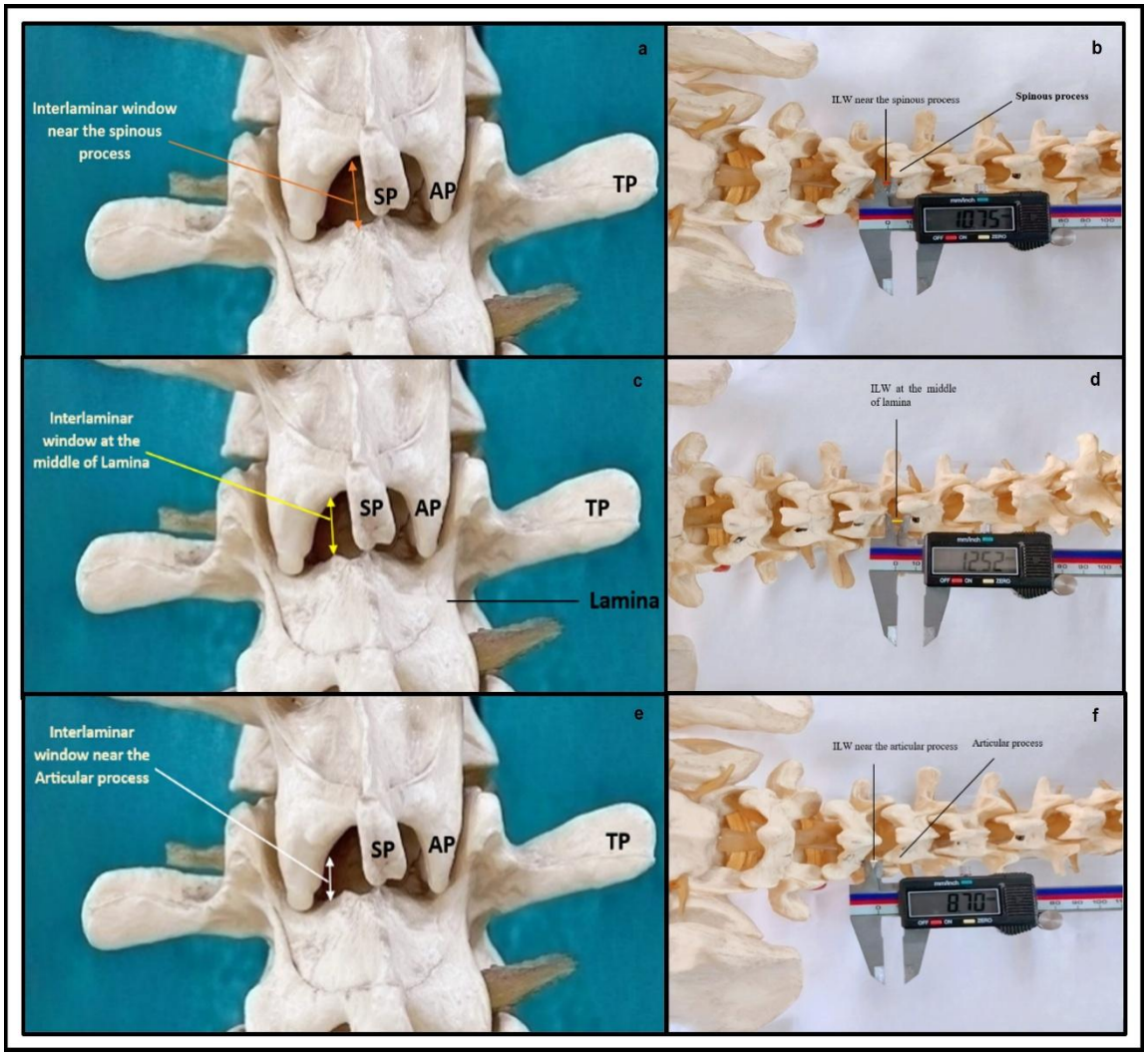

Figure 2. a. Interlaminar window near the spinous process; b. Measurement of Interlaminar window near the spinous process; c. Interlaminar window at the middle of lamina; d. Measurement of Interlaminar window at the middle of the lamina; e. Interlaminar window near the articular process; f. Measurement of Interlaminar window near the articular process
ILW: Interlaminar window
SP: Spinous Process
AP: Articular Process
TP: Transverse Process

Comparison of interlaminar distance (Right side): We compared all the interlaminar distances of right side. The comparisons were made between

spinous process vs at the middle, spinous process vs articular process, and at the middle of the laminae vs articular process. Statistical analysis was done using One-Way ANOVA and we found highly significant results, with a p-value of ≤0.0001 for all the comparisons (Figure 3).

Comparison of interlaminar distance (Left side): We compared all the interlaminar distances of left side. The comparison was done between spinous process vs at the middle, spinous process vs articular process, and at the middle vs articular process. Statistical analysis was done using One-Way ANOVA and we found highly significant results, with a p value of ≤0.0001 for all the comparisons (Figure 3).

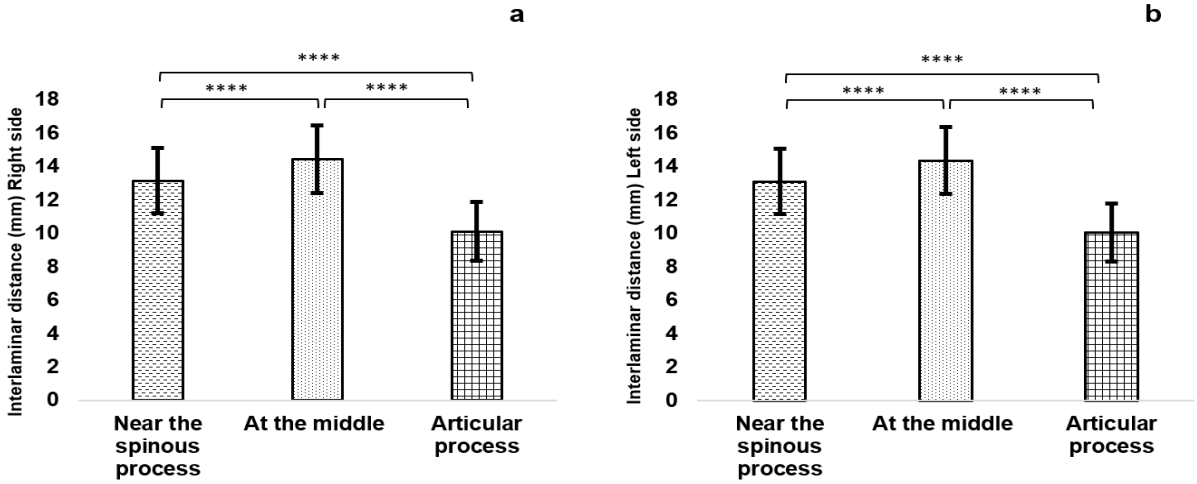

Figure 3. Comparison of interlaminar distance [Right side (a), Left side (b)]. Data presented as mean± SD. One-way ANOVA was used for the comparison, *p≤0.05 was considered statistically significant; *p≤0.05, **p≤0.01, ***p≤0.001, ****p≤0.0001

Linear distance measured in horizontal plane from the tip of the spinous process to the middle of the lamina: The horizontal distance represented as mean± SD from the tip of spinous process to the middle of the lamina was found to be 10.10±0.43 mm on the right side and 10.10± 0.41 mm on the left side (Table 1).

Table 1. Horizontal distance from the tip of the spinous process to the middle of the lamina

Parameters	Right side Mean ± SD (mm)	Left side Mean ± SD (mm)	p value (Paired t-test)
Horizontal distance from the tip of spinous process to the middle of the lamina	10.10±0.43	10.10±0.41	0.47

Discussion

Understanding the measurements and shapes of the lumbar spine is crucial. It helps us not only in understanding how the lower back works but also in improving procedures to stabilize it and fix any problem. Precise details

about the structure and positioning of lumbar vertebrae are essential for creating and using devices and tools for the spine. Many conditions can affect this area of our spine, including lower back pain, arthritis, degenerative bone and disk disease, and stenosis. The lumbar interlaminar window is crucial for epidural injections, where medication is delivered into the epidural space around the spinal cord and nerve roots. The interlaminar approach is advantageous in patients with multi-level spinal pathology, as it permits treatment across multiple levels simultaneously. [5] Conditions such as spinal stenosis, disc herniation, or degenerative disc disease affecting multiple lumbar levels can benefit from this approach. Minimally invasive procedures through the lumbar interlaminar window can reduce the risk of complications and promote faster recovery compared to more invasive surgical approaches. These techniques require accurate identification of the interlaminar space, which is the area between adjacent laminae of the vertebrae.

In the present study, the interlaminar window was measured at three different points (spinous process, middle of the lamina, articular process). The widest interlaminar window was found to be in the middle of the lamina. The measurements of interlaminar distance at three distinct locations are of paramount importance for a variety of spinal procedures, including laminectomy, interlaminar screw fixation, laminar hook placement, percutaneous endoscopic discectomy, epidural and subarachnoid block in difficult spinal anatomy. Also, the data obtained from the present study can be useful in successful and safe spinal surgeries and certain anaesthetic techniques. Spinal stenosis, a prevalent condition in the spinal region, stems from a series of degenerative processes initiated by the breakdown of the posterior annulus, progressing through disc herniation, dehydration, and culminating in the loss of disc height. This cascade may lead to the overriding of facets and/or the infolding of the ligamentum flavum, ultimately resulting in stenosis. Age-related spinal degeneration, particularly in the interlaminar space and ligamentum flavum, is a primary contributor to this condition. Typical symptoms include radicular pain and neurogenic claudication, with surgical intervention often being the primary treatment approach. [6, 7, 8] To perform this operation successfully, precise anatomical parameters of the interlaminar space are essential. Moreover, when dealing with the extraction of schwannomas from the spinal canal, proper access through the interlaminar space is essential. [9, 10]

We observed that the interlaminar window height increased as we descend down from L1-L5. A previous study by Leng et al. reported similar results. They studied the height and width of the interlaminar space and observed that there was a gradual increase from L1 to L5 in both parameters [11]; however, Sakci et al., in their study, using CT images, reported that the interlaminar window height decreased from L2-L5 levels [3]

We also observed the mean horizontal distance from the tip of the spine of the lumbar vertebra to the middle of the lamina (widest space) of the

interlaminar window. In our previous study on 50 patients, using ultrasonography by paramedian approach, for various lower limb orthopaedic surgeries, we could determine the approximate point of entry for instrumentation for neuraxial blocks, reducing multiple puncture attempts, which ultimately lowers pain and complications associated with it, thereby resulting in better patient care and compliance. [12]. This study provides a fundamental investigation of healthy and dry lumbar vertebrae. While diagnosing and treating lumbar spine issues like lumbar stenosis, spondylolisthesis, sciatica, disk herniation, requires an understanding of the normal anatomy of the lumbar vertebrae, complicated clinical concerns may not be adequately addressed by the present study alone. Despite the significance of our results, they need to be clinically extrapolated, which is what our prospective research will accomplish.

Conclusion

The present study was conducted to precisely study the morphometric dimensions of interlaminar space or window of lumbar spine. The anatomy of interlaminar space holds paramount importance as it provides a passage or acts as a gateway to underlying vital structures such as spinal nerves, intervertebral disc, spinal cord ensheathed by meningeal covering. In this study, we measured the interlaminar space at three different locations, near the spinous process, at the middle of the lamina and near the articular process. The widest window was observed at the middle of the lamina. This window could be utilized by Neurosurgeons for undertaking different types of spinal surgeries. In patients of difficult spinal anatomy like fused vertebrae as in Ankylosing spondylitis, abnormal curvature of spine, deformed vertebrae, old age calcified spine and in patients with fractures of neck of femur where positioning of patient becomes a difficult task, this interlaminar space could be used by Anesthesiologist to give central neuraxial block as midline approach in these conditions is very difficult. We also measured the approximate horizontal distance from the tip of the spine to the widest space of interlaminar window i.e. middle of the lamina.

This study may help to optimize surgical outcomes and certain anaesthetic techniques in case of difficult spinal anatomy, reduce the risk of complications, and improve the overall safety and effectiveness of spinal surgeries and anaesthetic blocks involving the interlaminar space.

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Competing interests

The author(s) declare that they have no competing interests.

Authors' contributions

Conceptualization: MAK, PA. Data acquisition: RS, MAK, PA. Data analysis and interpretation: PA, MAK, RD. Drafting of the manuscript: MAK, PA, RS, SK. Critical revision of the manuscript: PA, MAK, SK, RD. Approval of the final version of the manuscript: all authors.

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