

REVIEW ARTICLE

Effect of Lumbar Flexion on Prone Positioning of Patient for Endoscopic Lumbar Spine Surgery: Narrative Review

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ABSTRACT

Endoscopic spine surgery offers significant advantages over conventional techniques, but its success depends on careful attention to many intraoperative factors, particularly patient positioning. This review highlights the importance of understanding spinal anatomy and common variations, as well as the biomechanical effects of the positioning during surgery. Lumbar flexion increases posterior disc height and intradiscal pressure, enhancing disc bulging and widening the interlaminar window, which facilitates safer and more effective discectomy and decompression. These changes, especially over 20-40 degrees of flexion, also increase foraminal dimensions and surgical access, particularly in lower lumbar levels or cases with foraminal stenosis. Regarding positioning for endoscopic lumbar surgery, preoperative imaging and anatomical assessment are crucial to guide the approach and positioning strategy. Lumbar flexion of approximately 40 degrees is recommended for discectomy and decompression, as it improves access and reduces bone resection in both interlaminar and transforaminal approaches. In certain cases, especially central or foraminal pathology, intraoperative repositioning may be necessary to ensure complete decompression and prevent recurrence. Optimal patient positioning in endoscopic lumbar surgery enhances surgical access, ensures safety, and minimizes tissue trauma.

Keywords: endoscopy, lumbar, minimally invasive, morphology, positioning

INTRODUCTION

Endoscopic spine surgery (ESS) has gained widespread acceptance due to its minimal invasiveness, reduced postoperative pain, and faster recovery time compared to traditional open or microscopic spinal surgery techniques.^{1,2} Despite these advantages, the success of ESS relies on meticulous attention to multiple intraoperative factors, among them is the patient

positioning. There are various techniques and recommendations proposed, but no article dedicated to a comprehensive review on this issue.³ This narrative review aims to describe the surgical-related anatomy, effects of the patient positioning on the procedure based on the surgical approach in ESS, and our recommendations regarding the positioning to facilitate the endoscopic procedure.

CONTENT OF REVIEW

A literature search was conducted using PubMed to identify relevant articles examining the effects of prone patient positioning on anatomical structures associated with endoscopic lumbar spine surgery. The primary search included MeSH terms such as “spine”, “anatomy”, “lumbar”, “prone position”, “dimension”, “morphology”, and “minimally invasive.” Relevant and current literature was subsequently reviewed, and the reference lists of the retrieved articles were screened to identify additional pertinent studies.

Anatomy Relevant to Lumbar Surgery

Generally, lumbar surgery goals depend on the symptoms and pathology, including decompression of the neural elements or providing stability by instrumentation or fusion. Another important consideration is the alignment of the spine, which could greatly impact the surgical outcomes.⁴ To achieve these goals, especially by minimally invasive techniques such as endoscopic surgery, knowing the precise related anatomical structures is very crucial to safely and effectively completing the surgery.⁵ Equally important is awareness of common anatomical variations or anomalies, such as conjoined nerve roots or facet tropism, that can impact surgical strategies.

Bony Landmarks and Joints

The posterior spinal anatomy includes the laminae forming the roof of the spinal canal and the interlaminar space as a natural access corridor, bordered laterally by the facet joint capsule, which provides stability and should be preserved. The facet joints serve as key posterolateral landmarks of the spinal canal, with their orientation shifting from predominantly sagittal in the upper lumbar spine to more coronal at the L5-S1 level.⁶ This orientation of the facet emphasizes the importance of precise preoperative planning, which will influence the choice of surgical approach, as preservation of the facet joint is essential to maintain spinal stability during the procedure.⁷ Partial medial facetectomy exceeding 50-75% has been identified as a threshold beyond which vertebral segment instability significantly increases.^{8,9} Additionally, patients with degenerative spondylolisthesis exhibit more sagittal oriented facet joints and greater facet joint tropism than controls, underscoring the importance of individualized surgical planning.¹⁰

Anatomy Related to Interlaminar Approach

The ligamentum flavum, a paired elastic structure connecting adjacent laminae, forms the posterior boundary of the spinal canal and is encountered during lumbar discectomy. To access the dural sac and nerve roots, the ligament is typically detached from its attachment or incised under protection to expose the epidural space. In spinal stenosis, hypertrophy and infoldings of the ligamentum flavum contribute to neural compression, often requiring flavectomy or laminectomy for adequate decompression.¹¹

The posterior longitudinal ligament (PLL), situated along the back of the vertebral bodies, may be visualized beneath the neural elements. Large disc herniations can breach the PLL, may necessitate partial PLL resection and careful removal of sequestered fragments from beneath the ligament after disc space entry.¹²

In adults, the spinal cord ends at the L1-L2 level, transitioning to the cauda equina, so lumbar discectomy and decompression involve nerve roots rather than the spinal cord.¹³ During interlaminar surgery, the traversing nerve root and dural sac are identified and gently retracted to access the herniated disc or compressing structures, with careful inspection to ensure nerve decompression and avoid injury.

Anatomy Related to Transforaminal Approach

The intervertebral foramen serves as the passage for the exiting spinal nerve root. Consequently, foraminal or far lateral herniations more often involve the exiting nerve root at the corresponding level, whereas paracentral disc herniations typically compress the traversing nerve root. Within the foramen, the nerve root and dorsal root ganglion (DRG) are surrounded by epidural fat and vascular structures.¹⁴ Transforaminal ligaments, when present, are fibrous bands that can occupy up to 28.5% of the foraminal space and may compress the nerve root.¹⁵ Although their contribution to nerve entrapment remains debated, their presence necessitates careful surgical dissection.

In transforaminal endoscopic discectomy, the proximity of the exiting and traversing nerve roots, particularly the DRG, poses a risk of injury. Irritation of the DRG can result in postoperative dysesthesia radicular pain, known as “DRG syndrome”, with reported incidence rates ranging from 10-22%.^{16,17} A well understanding of the location of the DRG helps

the surgeon avoid direct compression during the surgery.

Common Anatomical Variations

A conjoined lumbosacral nerve root is a developmental anomaly where two adjacent roots exit through a single dural sleeve, most often involving L5 and S1, with an incidence of 0.25-1.3% in lumbar disc surgeries.^{18,19} This variant can obscure disc fragments or be mistaken for a single root, increasing the risk of inadequate decompression or nerve injury. Preoperative imaging may suggest the anomaly, but intraoperative recognition and careful foraminal decompression are essential to avoid complications.

Facet joint orientation and morphology vary among individuals and can influence surgical access. Facet tropism, or asymmetry between left and right facet angles at a given level, is common and may contribute to uneven loading and disc herniation.²⁰ Significant asymmetrical anomalies may necessitate adjustments in surgical technique, such as performing a wider laminotomy to access the recess. Furthermore, if the approach angle prevents facet joint preservation, an alternative approach may be required.²¹

Effects of the Patient Positioning

Interlaminar Lumbar Approach

Endoscopic interlaminar approach is one of the most used techniques for lumbar decompression

and discectomy. The approach is done through the space between the upper and lower lamina of the level of pathology. On the lateral margin are the pars interarticularis and the facet joint, while the medial side is the base of the spinous process (Figure 1). These structures are the frame which sometimes limit the access to the compressing pathology such as intervertebral disc or the ligamentum flavum in the lateral recess and central zone.²²

The size of the interlaminar window depends on the position of the patient. Luis et al. conducted a cadaveric study demonstrating that lumbar position, from neutral to flexion, has a great impact on the interlaminar window size.²³ Their study found that in neutral position, the interlaminar distance ranges from 12.21 to 14.88 mm, whereas in flexion ranges from 17.15 to 18.5 mm in young normal cadavers. In upper lumbar segment or severe lumbar spinal stenosis patients, with osteophytes and hypertrophic facets, the interlaminar space can be significantly narrowed, leaving limited access to perform decompression in the spinal canal. Further emphasizes the importance of positioning to aid in the endoscopic procedure.

Lumbar flexion directly affects the intervertebral disc by increasing posterior disc height, which can create additional space to aid in surgical procedures such as discectomy (Figure 2). The flexion position also raises intradiscal pressure, leads to an increase in posterior bulging of the disc,^{24,25} resembling to

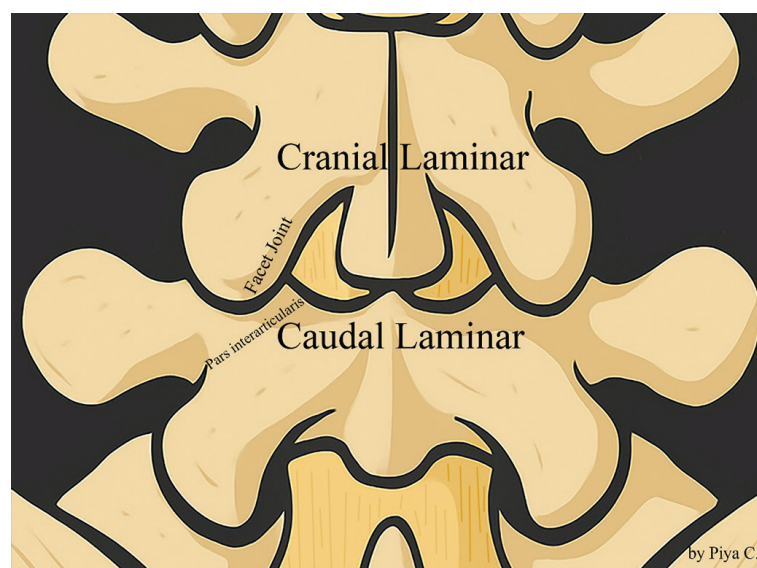


Figure 1 Structures Surrounding the Interlaminar Window in the Lumbar Vertebra

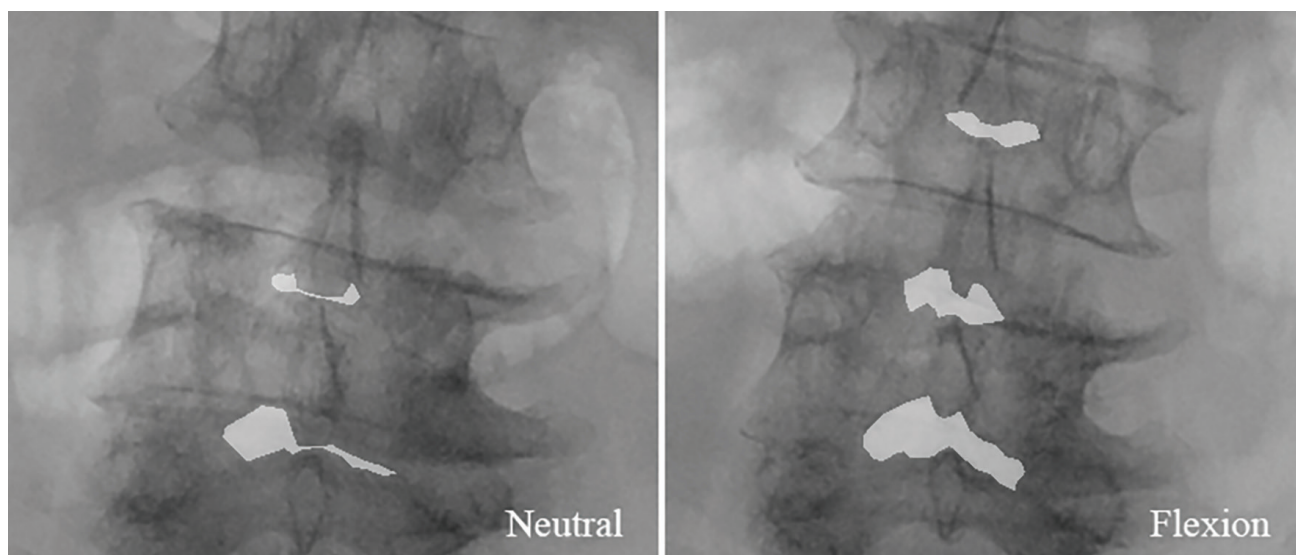


Figure 2 Fluoroscopic Images Comparing the Interlaminar Windows Size in Neutral and Flexion Position

levels observed during upright posture or routine activities, it may also facilitate the extrusion of residual disc fragments, potentially reducing the risk of recurrent disc herniation postoperatively.

Ligamentum flavum is the floor of the interlaminar space guarding the thecal sac and nerve roots. It attaches from the undersurface of the cranial lamina to the upper margin of the caudal lamina. In case of discectomy through this approach, surgeons must go through this layer to reach the herniated disc in the spinal canal. With the lumbar in flexion position, the ligamentum flavum is stretched thinner along the spreading interlaminar window, and with some tension, making it easier to cut or detach from the insertion.²⁶

Transforaminal Approach

In contrast to the interlaminar space, the foraminal height is decreased at the lower lumbar level. The foraminal size generally increased in flexion and decreased in extension, except at L5-S1. The changes were significantly correlated with lumbar angular motion, especially in more than 20 to 40 degrees, particularly affecting foraminal height and area at most levels and foraminal width at L3-4 and L4-5.^{27,28} (Figure 3). With increased posterior disc bulging in flexion position in combined with a wider approach corridor, enhances effective discectomy and safety by reducing the complications related to nerve root injury while approaching, especially in the lower lumbar level or cases with foraminal stenosis.²⁵

Author's Recommendation

Positioning patients for endoscopic lumbar surgery in a prone position, generally based on the goals of the surgery, with consideration to achieve the surgical goals effectively, ensuring the safety, and minimizing unnecessary tissue trauma from the procedure. According to previous literature, authors' recommendations are as follows.

Preoperative Planning

A thorough preoperative assessment, including imaging review and understanding patient-specific anatomical variations and pathology, is essential for determining the surgical approach and the optimal positioning.

Endoscopic Lumbar Discectomy

It is recommended that patients be positioned with approximately 40 degrees of lumbar flexion relative to full extension. This positioning can be accomplished by placing a bolster at the level of the iliac crests combined with surgical table adjustments (Figure 4) or by employing specially designed tables or positioning devices, such as the Wilson frame. This position maximizes the surgical corridor and reduces bone resection for adequate exposure, along with increasing intervertebral disc pressure and posterior bulging to allow effective discectomy. Generally, endoscopic working sleeves range from 7-10 mm in diameter. Therefore, even a few extra millimeters can significantly enhance the surgical procedure. Furthermore, in some patients, especially in central disc discectomy, may

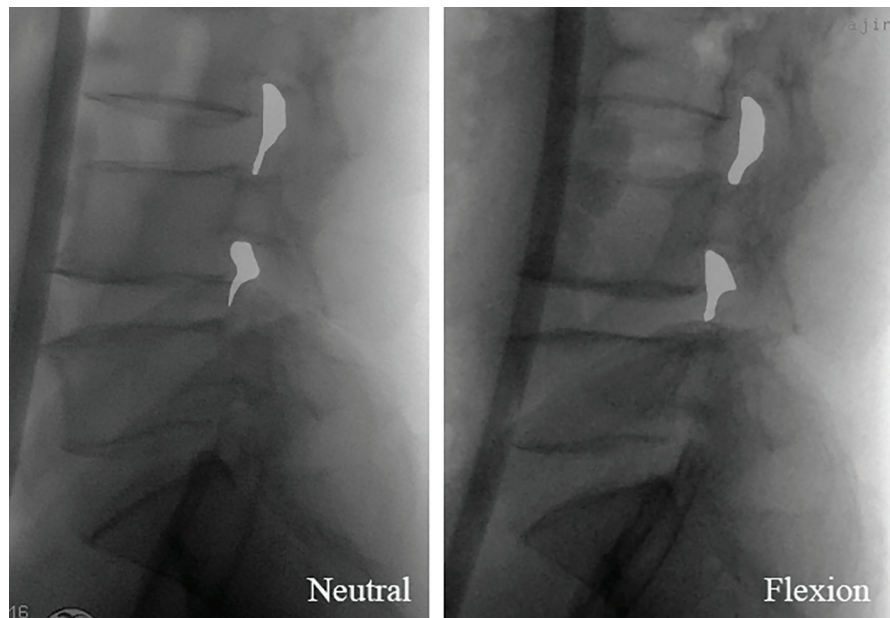


Figure 3 Fluoroscopic Images Comparing Foraminal Size in Neutral and Flexion Position



Figure 4 Lumbar flexion in the prone position can be achieved by placing a bolster under the iliac crests and adjusting the bend of the surgical table.

benefit from intraoperative repositioning by dynamically moving from flexion to neutral or slight extension to ensure no residual disc remains and reduce the risk of early recurrent herniation.

Endoscopic Lumbar Decompression

Most common compression zones are the lateral recess, central canal, and foraminal zone, which

mostly require access to the intracanalicular area and benefit from lumbar flexion positioning to minimize the required bone resection for the approach. However, in the lumbar flexion position, the foraminal zone compressed by the hypertrophic facet joints may be different from the normal physiological state, and the compression may be masked by positioning decompression. Therefore, in foraminal stenosis,

repositioning the patient intraoperatively after the foraminotomy to ensure the decompression is recommended.

However, as part of standard care, it is essential to reassess all pressure points after each adjustment of the patient's position. Particular attention should be given to the eyes, neck, chest, abdomen, and all areas in contact with the support surfaces to prevent complications related to positioning.^{29,30}

Limitation and Future Direction

This study has several limitations. First, it focuses specifically on the uniportal endoscopic decompression technique. However, the underlying principles described may also be applicable to other decompression surgical approaches, such as biportal endoscopic techniques or microscopic surgery. Second, this review focuses on positioning considerations for decompression surgery and does not address fusion or deformity correction procedures, in which spinal alignment plays a more critical role. Finally, the level of evidence supporting optimal positioning to enhance surgical effectiveness remains limited, as current data are largely derived from biomechanical and retrospective studies, with a lack of strong clinical evidence demonstrating clear clinical benefits. Future prospective clinical studies evaluating the impact of surgical positioning may help clarify its role and provide guidance for surgical practice.

CONCLUSION

In our literature review, patient positioning has been shown to influence various morphological structures of the lumbar spine, directly affect the endoscopic lumbar procedures. For most endoscopic lumbar decompression procedures, positioning the patient in approximately 40 degrees of lumbar flexion is recommended. However, tailoring positioning strategies to the specific underlying pathology or anatomical variations may improve surgical visualization, reduce complications, and enhance the overall safety and effectiveness of the procedure.

Conflict of Interests

Ali Guven Yorukoglu serves as a consultant for RIWOspine GmbH, Germany. The other authors have no conflicts of interest to declare.

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During the preparation of this work the author(s) used ChatGPT in order to improve readability and language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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Formal analysis: P.C.

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Methodology: P.C.

Project administration: P.C.

Resources: -

Software: -

Supervision: A.G.

Validation: P.C., A.G.

Visualization: P.C.

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