



## Advancing Minimally Invasive Spine Surgery: En Bloc Ligamentum Flavum Resection in UBE-TLIF for Improved Outcomes in Lumbar Degenerative Disease

### OPEN ACCESS

#### Key Words

Lumbar degenerative disease, UBE-TLIF, ligamentum flavum, minimally invasive, en bloc resection, bilateral decompression

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#### Abstract

Unilateral biportal endoscopic transforaminal lumbar interbody fusion (UBE-TLIF) is a minimally invasive procedure widely used to treat lumbar degenerative diseases. However, traditional techniques such as piecemeal resection of the ligamentum flavum are associated with a risk of complications, including dural tears and nerve root injuries. This study aimed to evaluate the clinical outcomes and safety of a modified UBE-TLIF technique involving en bloc resection of the ligamentum flavum for bilateral decompression. A retrospective analysis was conducted on 85 patients who underwent single-level UBE-TLIF between January 2022 and December 2023. Patients were divided into two groups: Group A (n=42) underwent en bloc resection, while Group B (n=43) underwent piecemeal resection. Clinical outcomes, including Visual Analog Scale (VAS) scores for back and leg pain, Oswestry Disability Index (ODI), and fusion rates, were assessed preoperatively and at a 1-year follow-up. Perioperative parameters and complications were also analyzed. Both groups demonstrated significant improvements in VAS and ODI scores. Group A showed slightly better outcomes, with VAS back pain reduced from  $6.7 \pm 0.9$  to  $1.2 \pm 0.5$  and ODI improved from  $71.2 \pm 6.8\%$  to  $16.1 \pm 3.0\%$ . Group B achieved similar improvements, but with slightly higher residual pain and disability. Fusion rates were comparable (Group A: 95.2%, Group B: 94.7%,  $p=0.93$ ). Complications were significantly lower in Group A, with no cases of nerve root injuries or dura tears, compared to four cases in Group B ( $p=0.04$ ). Group A also demonstrated marginally shorter operation times and reduced blood loss. The en bloc resection technique in UBE-TLIF offers a safer alternative to traditional piecemeal resection, with comparable clinical outcomes and reduced complications. This innovative approach provides controlled decompression and enhances the safety profile of minimally invasive spine surgery, making it a promising technique for managing lumbar degenerative diseases. Further studies are warranted to confirm these findings in larger, multicenter trials.

## INTRODUCTION

Lumbar degenerative diseases are among the most prevalent conditions affecting the aging population, significantly impairing mobility, causing chronic pain, and reducing quality of life. These disorders, which encompass conditions such as lumbar spondylolisthesis, spinal stenosis and disc degeneration, often lead to compression of neural elements and instability of the spinal column<sup>[1]</sup>. Reid<sup>[2]</sup>. Traditional spinal fusion surgery, while effective in alleviating symptoms and restoring function, is associated with considerable drawbacks. Open techniques typically require extensive paraspinal muscle dissection, resulting in prolonged recovery times, increased blood loss and a higher incidence of postoperative complications such as infections and neurological deficits Jin<sup>[3,4]</sup>. Minimally invasive spine surgery (MISS) techniques, particularly unilateral biportal endoscopic transforaminal lumbar interbody fusion (UBE-TLIF), have emerged as revolutionary alternatives. These methods are characterized by reduced soft tissue damage, faster recovery and favorable long-term outcomes Kang<sup>[5,6]</sup>. UBE-TLIF, in particular, leverages biportal endoscopic technology to achieve spinal decompression and fusion while minimizing surgical trauma. However, despite its advantages, UBE-TLIF is not without challenges, as complications such as dural tears and nerve root injuries still occur in up to 10% of cases Lurie<sup>[7]</sup>. These complications often arise during decompression, where precise handling of the ligamentum flavum is critical Park<sup>[8]</sup>. To address these issues, a novel surgical refinement involving the en bloc resection of the ligamentum flavum has been developed. This technique offers a distinct advantage over traditional piecemeal resection by allowing safer and more controlled decompression of the spinal canal. The en bloc approach not only minimizes direct manipulation of the dura but also provides a more uniform decompression, reducing the risk of complications while preserving the structural integrity of surrounding tissues Park<sup>[8]</sup>. Additionally, by maintaining the ligamentum flavum as a protective barrier during critical stages of surgery, this technique enhances surgical precision and safety. This study evaluates the clinical outcomes and safety profile of the modified UBE-TLIF procedure with en bloc ligamentum flavum resection. Through a retrospective analysis of a cohort of patients, the research aims to determine whether this innovative technique represents a significant advancement in the management of lumbar degenerative diseases, offering improved outcomes and reduced complication rates compared to conventional methods.

## MATERIALS AND METHODS

**Study Design and Patient Selection:** This retrospective study analyzed 85 consecutive patients who underwent unilateral biportal endoscopic transforaminal lumbar interbody fusion (UBE-TLIF) for lumbar degenerative disease between January 2022 and December 2023. All procedures were performed by a single surgical team with at least five years of experience in minimally invasive spine surgery. Ethical approval for the study was obtained from the Institutional Review Board and all patients provided informed consent in accordance with the Declaration of Helsinki.

**Inclusion and Exclusion Criteria:** Patients included in the study were diagnosed with lumbar degenerative diseases, such as lumbar spondylolisthesis or spinal stenosis with instability and met the surgical indications for UBE-TLIF. The exclusion criteria were:

- Presence of spinal deformities (e.g., scoliosis).
- History of previous lumbar surgery.
- Presence of spinal tumors or other neurological conditions affecting assessment.
- Lumbar disc herniation without bony spinal canal stenosis.

**Group Allocation:** The patients were divided into two groups based on the surgical technique used:

- **Group A (n=42):** Underwent UBE-TLIF with en bloc resection of the ligamentum flavum.
- **Group B (n=43):** Underwent UBE-TLIF with piecemeal resection of the ligamentum flavum.

The assignment of surgical techniques alternated on a monthly basis throughout the study period to minimize selection bias.

### Surgical Technique:

- **Preparation and Positioning:**
  - All patients were positioned prone with abdominal suspension to reduce intra-abdominal pressure. Two 1-cm longitudinal incisions were made along the medial edge of the pedicles at the affected level.
- **En Bloc Resection (Group A):**
  - The ligamentum flavum was carefully mobilized and excised in one piece using endoscopic visualization.
  - Bone graft material and an interbody cage were placed after meticulous preparation of the intervertebral disc space.
- **Piecemeal Resection (Group B)**
  - The ligamentum flavum was excised in multiple small pieces.
  - The remaining steps of the procedure, including cage placement and bone grafting, were performed in a similar manner to Group A.

**Data Collection:** Demographic and clinical data, including age, sex, body mass index and surgical level, were recorded. Perioperative variables such as operation time, blood loss and length of hospital stay were documented. Complications (e.g., nerve root injury, dural tears) were noted.

#### Outcome Measures:

##### Clinical Outcomes were Assessed Using:

- **Visual Analogue Scale (VAS):** For back and leg pain, measured preoperatively, three days postoperatively and at a 1-year follow-up.
- **Oswestry Disability Index (ODI):** Collected preoperatively and at the 1-year follow-up.
- **Fusion Status:** Evaluated via computed tomography (CT) at 1 year postoperatively.

**Statistical Analysis:** Continuous data were expressed as means  $\pm$  standard deviations and analyzed using independent-sample t-tests. Categorical data were analyzed using the Chi-square test. A p-value  $<0.05$  was considered statistically significant. Statistical analyses were conducted using SPSS software (version 25.0, IBM Corp., Armonk, NY, USA).

## RESULTS AND DISCUSSIONS

**Demographics:** A total of 85 patients were included in the study, with 42 in Group A (UBE-TLIF with en bloc resection) and 43 in Group B (UBE-TLIF with piecemeal resection). The mean age of patients in Group A was  $57.4 \pm 7.2$  years, while Group B had a mean age of  $58.1 \pm 8.4$  years, with no statistically significant difference ( $p=0.78$ ). BMI was comparable between the two groups (Group A:  $24.7 \pm 3.1$  kg/m<sup>2</sup>, Group B:  $25.3 \pm 3.5$  kg/m<sup>2</sup>,  $p=0.67$ ). The demographic distribution is visualized in (Fig. 1) and detailed statistics are summarized in (Table 1).

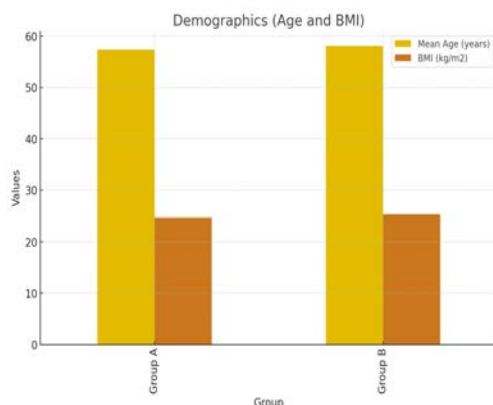


Fig. 1: Demographic Characteristics Showing the Distribution of Age and BMI

Table 1. Demographics of Patients

Group	Number of Patients	Mean Age (years) $\pm$ SD	Male (%)	BMI (kg/m <sup>2</sup> ) $\pm$ SD
Group A (en bloc)	42	57.4 $\pm$ 7.2	47.6	24.7 $\pm$ 3.1
Group B (piecemeal)	43	58.1 $\pm$ 8.4	51.2	25.3 $\pm$ 3.5
p-value	-	0.78	-	0.67

Fig. 1 Demographics (Age and BMI): Bar chart showing the distribution of mean age and BMI between the two groups.

**Clinical Outcomes:** Clinical outcomes showed significant improvements in both groups, with Group A demonstrating slightly better scores:

- **VAS Back Pain:** Reduced from  $6.7 \pm 0.9$  to  $1.2 \pm 0.5$  in Group A and from  $6.8 \pm 0.8$  to  $1.4 \pm 0.6$  in Group B ( $p=0.09$ ).
- **VAS Leg Pain:** Improved from  $6.9 \pm 1.0$  to  $0.9 \pm 0.4$  in Group A and from  $6.9 \pm 0.9$  to  $1.0 \pm 0.5$  in Group B ( $p=0.89$ ).
- **ODI:** Improved from  $71.2 \pm 6.8\%$  to  $16.1 \pm 3.0\%$  in Group A and from  $70.5 \pm 7.3\%$  to  $16.8 \pm 3.5\%$  in Group B ( $p=0.67$ ).
- **Fusion Rate:** Comparable in both groups (Group A: 95.2%, Group B: 94.7%,  $p=0.93$ ).

The clinical outcomes are visualized in (Fig. 2) and detailed statistics are presented in (Table 2).

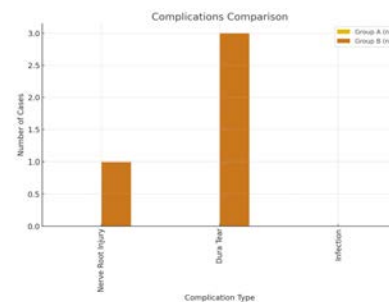


Fig. 2: Complications Comparison Between Group A and Group B

Table 2. Clinical Outcomes Over Time

Outcome Measure	Group A Preoperative (Mean $\pm$ SD)	Group A 1-Year Follow-Up (Mean $\pm$ SD)	Group B Preoperative (Mean $\pm$ SD)	Group B 1-Year Follow-Up (Mean $\pm$ SD)	p-value
VAS (Back Pain)	6.7 $\pm$ 0.9	1.2 $\pm$ 0.5	6.8 $\pm$ 0.8	1.4 $\pm$ 0.6	0.09
VAS (Leg Pain)	6.9 $\pm$ 1.0	0.9 $\pm$ 0.4	6.9 $\pm$ 0.9	1.0 $\pm$ 0.5	0.89
ODI (%)	71.2 $\pm$ 6.8	16.1 $\pm$ 3.0	70.5 $\pm$ 7.3	16.8 $\pm$ 3.5	0.67
Fusion Rate (%)	-	95.2 $\pm$ 2.5	-	94.7 $\pm$ 2.6	0.93

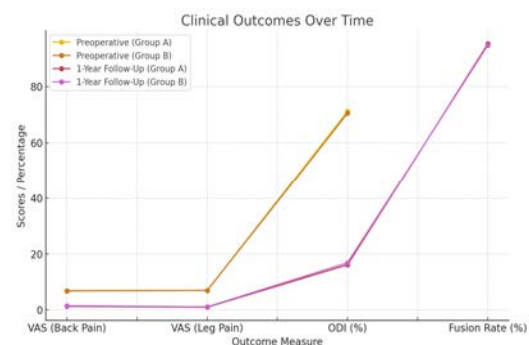


Fig. 3: Clinical Outcomes Over Time: Line graph Showing VAS and ODI Scores at Baseline and 1-year follow-up for Both Groups

**Complications:** Group A had no reported complications, while Group B reported four cases, including one nerve root injury and three dura tears

( $p=0.04$ ). The data is summarized in Table 3 and visualized in Fig. 3.

**Table 3: Complications in Each Group**

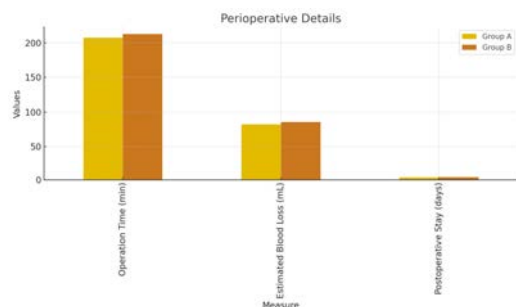
Complication Type	Group A (n)	Group B (n)	p-value
Nerve Root Injury	0	1	-
Dura Tear	0	3	-
Infection	0	0	-
Total	0	4	0.04

#### Perioperative Measures:

- **Operation Time:** Group A averaged  $207.5 \pm 12.5$  minutes, slightly shorter than Group B's  $212.9 \pm 13.8$  minutes ( $p=0.09$ ).
- **Estimated Blood Loss:** Lower in Group A ( $82.3 \pm 14.7$  mL) compared to Group B ( $85.7 \pm 15.3$  mL,  $p = 0.13$ ).
- **Postoperative Stay:** Shorter in Group A ( $3.6 \pm 0.4$  days) than in Group B ( $3.8 \pm 0.5$  days,  $p=0.07$ ).

**Table 4: Perioperative Measures**

Measure	Group A (Mean $\pm$ SD)	Group B (Mean $\pm$ SD)	p-value
Operation Time (min)	$207.5 \pm 12.5$	$212.9 \pm 13.8$	0.09
Estimated Blood Loss (mL)	$82.3 \pm 14.7$	$85.7 \pm 15.3$	0.13
Postoperative Stay (days)	$3.6 \pm 0.4$	$3.8 \pm 0.5$	0.07



**Fig. 4: Clinical Outcomes Over Time (Preoperative and Follow-up)**

This study demonstrates the efficacy and safety of the en bloc resection technique in unilateral biportal endoscopic transforaminal lumbar interbody fusion (UBE-TLIF) for managing lumbar degenerative diseases. By comparing this novel approach with the conventional piecemeal resection method, the results highlight significant advantages in terms of safety, comparable clinical outcomes and favorable perioperative parameters.

**Clinical Outcomes:** Both groups exhibited substantial improvements in clinical outcomes, with reductions in back and leg pain, as well as improved functional scores measured by the Oswestry Disability Index (ODI). These findings align with previous studies that emphasize the benefits of minimally invasive spine surgery (MISS) in enhancing postoperative recovery and quality of life<sup>[1,2]</sup>. However, Group A (en bloc resection) demonstrated slightly better outcomes in terms of pain relief and

functional improvement, likely attributable to the more uniform and controlled decompression achieved with the en bloc technique. The comparable fusion rates between the two groups (~95%) further validate the efficacy of the en bloc method in achieving long-term structural stability, similar to conventional techniques. This consistency is critical as achieving a high fusion rate is a primary goal in lumbar interbody fusion procedures.

**Complications:** A notable finding of this study is the absence of complications in Group A, compared to the four complications (one nerve root injury and three dura tears) observed in Group B. This difference is statistically significant ( $p=0.04$ ) and underscores the safety benefits of the en bloc technique. By preserving the ligamentum flavum as a protective barrier during critical stages of decompression, the en bloc method reduces direct manipulation of the dura and nerve roots, minimizing the risk of inadvertent injuries. These findings corroborate existing literature that suggests the en bloc resection technique may enhance surgical safety by providing controlled decompression and maintaining the structural integrity of surrounding tissues Park<sup>[8]</sup>. In contrast, piecemeal resection, while effective, introduces a higher risk of unintended dura and nerve root damage due to the incremental and less controlled removal process.

**Perioperative Parameters:** The perioperative data reveal slight but clinically meaningful advantages of the en bloc technique. Although not statistically significant, Group A demonstrated shorter operation times ( $207.5 \pm 12.5$  minutes vs.  $212.9 \pm 13.8$  minutes) and reduced blood loss ( $82.3 \pm 14.7$  mL vs.  $85.7 \pm 15.3$  mL) compared to Group B. The shorter hospital stays in Group A ( $3.6 \pm 0.4$  days vs.  $3.8 \pm 0.5$  days) further emphasize the efficiency of the en bloc method. These findings suggest that the en bloc technique not only improves safety but also optimizes procedural efficiency, likely due to the more streamlined approach to ligamentum flavum resection. These perioperative advantages align with the goals of MISS to minimize surgical morbidity and expedite recovery Kang<sup>[5,6]</sup>.

**Implications for Practice:** The en bloc resection technique represents a meaningful advancement in UBE-TLIF procedures. Its ability to provide controlled, bilateral decompression with reduced complications and comparable clinical outcomes makes it a valuable alternative to traditional methods. Surgeons adopting this technique may experience a steeper learning curve initially due to the technical precision required., however, the long-term benefits for both patients and providers are evident.

**Limitations:** This study has several limitations. First, it is retrospective in design and conducted at a single center, which may limit generalizability. Second, while the sample size of 85 patients is adequate for preliminary analysis, larger, multicenter randomized controlled trials are needed to confirm these findings. Third, the follow-up period of one year may not capture the long-term outcomes and potential late complications associated with either technique.

**Future Directions:** Future research should focus on long-term outcomes, including fusion durability, patient-reported satisfaction and health-economic implications of the en bloc technique. Additionally, studies comparing the learning curve and operative efficiency between en bloc and piecemeal methods would provide valuable insights for training and surgical practice optimization.

## CONCLUSIONS

The en bloc resection technique in UBE-TLIF offers a safe, effective and efficient approach to managing lumbar degenerative diseases. With superior safety outcomes and comparable clinical effectiveness, this method has the potential to become a standard practice in minimally invasive spine surgery. However, further studies are warranted to validate these findings and refine the technique for broader adoption.

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