OPEN Research Article

Equivalent Patient-Reported Clinical Outcomes Between Single-Level and Multilevel Biportal Endoscopic Decompression at 5-Year Follow-up

Ju Eun Kim, MD
Eugene J. Park, MD
Daniel K. Park, MD

ABSTRACT

Study design: Retrospective.
Objective: To compare long term clinical outcomes of single-level versus multilevel decompression using unilateral biportal endoscopic (UBE) decompression for degenerative lumbar spinal stenosis without instability.
Summary of Background Data: Unilateral biportal endoscopic decompression has been shown to be effective in alleviating spinal stenosis without instability. Long-term data are lacking, and, in particular, a comparison between single-level and multilevel surgery using this minimally invasive technique has not been presented.
Methods: Ninety-eight patients in each group were propensity matched based on demographics. All patients had at least 5-year follow-up. Clinical outcomes, including Oswestry Disability Index, visual analog system (VAS), time to ambulation, surgical time, and length of hospital stay, were investigated.
Result: Oswestry Disability Index improved from 62.98 ± 11.53 before surgery to 18.51 ± 8.63 at the final follow-up in single-level decompression ($P < 0.001$). Multilevel decompression demonstrated improvement from 64.66 ± 13.71 to 19.31 ± 9.42 ($P < 0.001$). Similarly, leg and back VAS decreased from 7.39 ± 0.91 and 6.11 ± 1.21 before surgery to 1.72 ± 0.548 and 1.82 ± 0.67 at the last follow-up ($P < 0.001$) for single-level decompression. In comparison, for the multilevel, leg and back VAS improved from 7.47 ± 1.09 and 6.29 ± 1.28 to 1.86 ± 0.58 and 1.91 ± 0.75 ($P < 0.001$). No difference was observed between the groups at any time point. Complications and revision rates did not differ. Time to ambulation and length stay was markedly longer in multilevel.
Conclusion: Outcomes, complication, and revision rates do not differ between single level and multilevel. UBE decompression can be applied to multiple levels without compromising outcomes if multiple-level decompression is deemed necessary.

From Baroseomyeon Hospital, Busan, Korea (Dr. Kim); Department of Orthopedic Surgery, Kyungpook National University Hospital, Kyungpook National University School of Medicine (Dr. E. J. Park); and Midwest Orthopedics at RUSH Chicago, IL (Dr. D. K. Park).

Correspondence to Dr. Park: danparkmd@gmail.com

JAAOS Glob Res Rev 2025;9: e24.00371

DOI: 10.5435/JAAOSGlobal-D-24-00371

Lumbar spinal stenosis is characterized by pain, numbness, tingling, and weakness that radiates down the buttock and/or legs as a result of compression of the spinal canal. The symptoms are typically relieved by forward flexion and exacerbated by extension. Disease progression reduces the quality of life and causes functional disability due to neurological deficit.[1] Conventional open laminectomy has been widely performed as a surgical treatment option for spinal stenosis if nonsurgical measure fail.[2] However, conventional open laminectomy causes extensive damage to posterior spinal structures, such as ligaments, facets, and paraspinal muscles along with extensive bone resection, which may result in persistent postoperative lower back pain and iatrogenic segmental instability.[3] With multilevel decompression, the collateral damage to these structures can potentially increase the risk for surgical complications and potentially compromise patient-reported outcomes.

To overcome these issues, minimally invasive spinal surgery using a microscope was introduced.[4,5] Microscopic decompression showed good results, but more recently, unilateral biportal endoscopic (UBE) decompression with arthroscopy was introduced and began to emerge as an alternative to microscopic decompression as a surgical option for degenerative spinal stenosis.[6] The purported advantages of UBE over microscopic decompression include less postoperative pain and early rehabilitation, such as time to ambulation and hospital stay.[7]

As the population continues to age, surgery for lumbar stenosis is on the rise. As stenosis is typically the result of degeneration, many patients present with multilevel areas of compression on imaging, whereas some only present with isolated one-level symptomatic compression. A review in 2014 found that 40% of patient with clinically spinal stenosis possess multilevel moderate-to-severe stenosis on diagnostic testing.[8] Often, the decision to decompress only one level versus multilevel is multifaceted. The comorbidities of the patients, presentation, previous surgery, and degree of compression on MRI can all play a role in the number of levels decompressed.

Although outcomes of UBE decompression have been published,[6,7,9] there are limited reports of multilevel decompression. The aim of this study was to compare the surgical outcomes between single-level decompression versus multilevel decompression using the UBE technique at 5-year follow-up.

Material and Method

A retrospective study was conducted after approval by the institutional review board. A single surgeon (J.K.) database was queried between January 2016 and January 2019. Three hundred fifty-eight patients underwent UBE decompression for degenerative spinal stenosis without instability. Sixty-two patients were lost to follow-up. Thirty-eight patients who had acute radiculopathy were excluded because diskectomy was mainly performed. Twenty-four other patients were excluded, as they had previous surgery at the same level. One hundred twenty-seven patients were left who underwent single-level interlaminar decompression, whereas 107 patients had multilevel decompression. A minimum 5-year follow-up was required (Figure 1). Using propensity matching based on demographic data, 98 patients were left in each group.

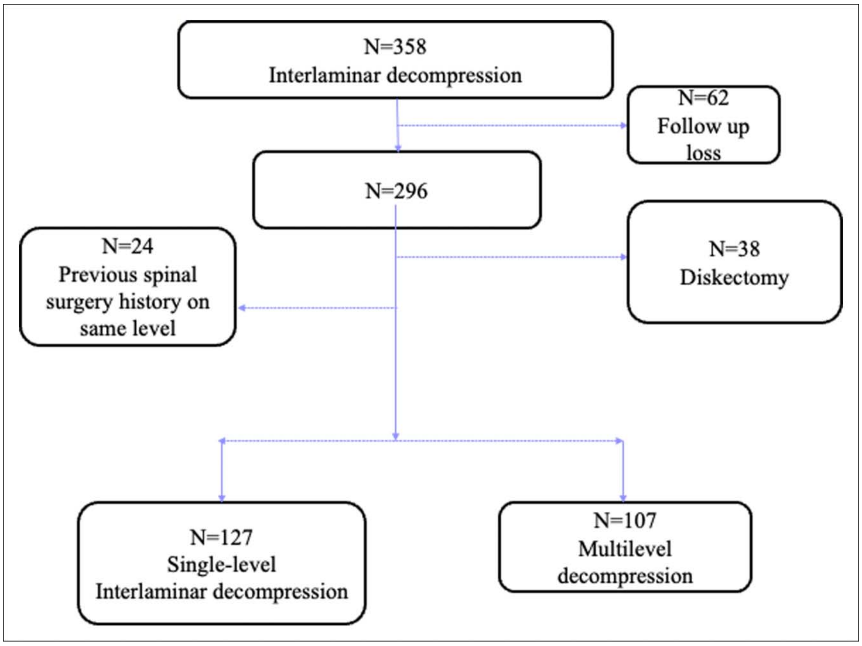
Patients with neurological symptoms consistent with neurogenic claudication that did not improve despite conservative treatment for more than 3 months were included. Patients were excluded if younger than 50 years, which eliminates most true congenital rather than degenerative spinal stenosis. Spondylolisthesis with dynamic instability (more than 4 mm change on flexion/extension), isolated lumbar foraminal stenosis, and degenerative lumbar scoliosis with coronal curvature > 10° measured by Cobb method were also excluded. The decision how many levels of decompression was based on the surgeon, but in general, all levels that demonstrated at least moderate spinal stenosis were decompressed.

All patient data were analyzed through electronic medical records. Demographic data, including age, sex, surgery level, site of stenosis, predominant side of symptoms, and underlying diseases such as body mass index (BMI $kg \cdot m^{-2}$), smoking, hypertension, diabetes, and osteoporosis, were also investigated. Clinical outcomes were investigated using Oswestry Disability Index (ODI) and visualized analog scale (VAS).

Surgical Technique

The surgery was performed under spinal or general anesthesia with the patient in the prone position. The surgical approach side was consistent with the most symptomatic side. The UBE technique has been published before,[6] but in brief, two incisions were made. A 4.0 mm of 0° arthroscopy was used. The portals were made close to the spinous process in the soft spot adjacent to the bony spinous process. Proximally and distally, the incisions were centered around the disk space of interest. The proximal incision was made 1 cm proximal to the midpoint of the disk space, and the distal incision was made 1 cm distal to the midpoint. These incisions approximate the pedicle level of interest.

Figure 1



Flow chart showing table of patients.

For multilevel decompression, typically, the inferior level was done first. Then, the viewing portal of the first level became the working portal of the next proximal level (Figure 2).

Once the incisions were made, a smooth periosteal elevator was used to create a potential space over the bony lamina. Gravity was used for fluid flow, and the working portal was checked to make sure that there was continuous fluid irrigation. Using a burr and Kerrison punch, the ipsilateral lamina and the base of the spinous process were partially removed, exposing the ligamentum flavum proximal insertion. The ipsilateral partial medial facetectomy was then performed releasing the lateral extent of the ligamentum flavum. Contralateral decompression was then performed by removing part of the contralateral sublamina and spinous base. The ligamentum flavum was then removed, and the surgery was completed after freedom of movement of the dural sac and traversing nerve roots were confirmed (Figure 3). A drain tube was inserted into the working portal using pituitary forceps, to minimize the risk of postoperative hematoma.

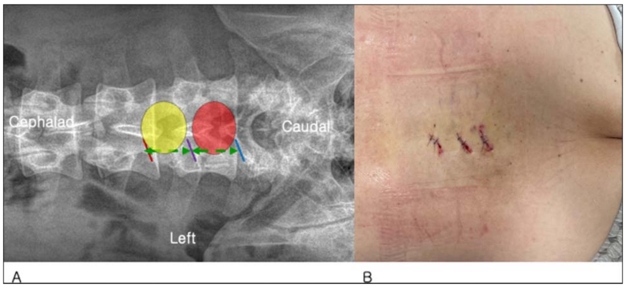
Statistical Analysis

All statistical analyses were done using the Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc, Chicago, IL). Values are presented as means and standard deviations. Patient data were analyzed using the independent *t* test, repeated-measures analysis of variance, and $\chi 2$ test kappa. A $P < 0.05$ was considered statistically significant.

Propensity Score Matching of Patients

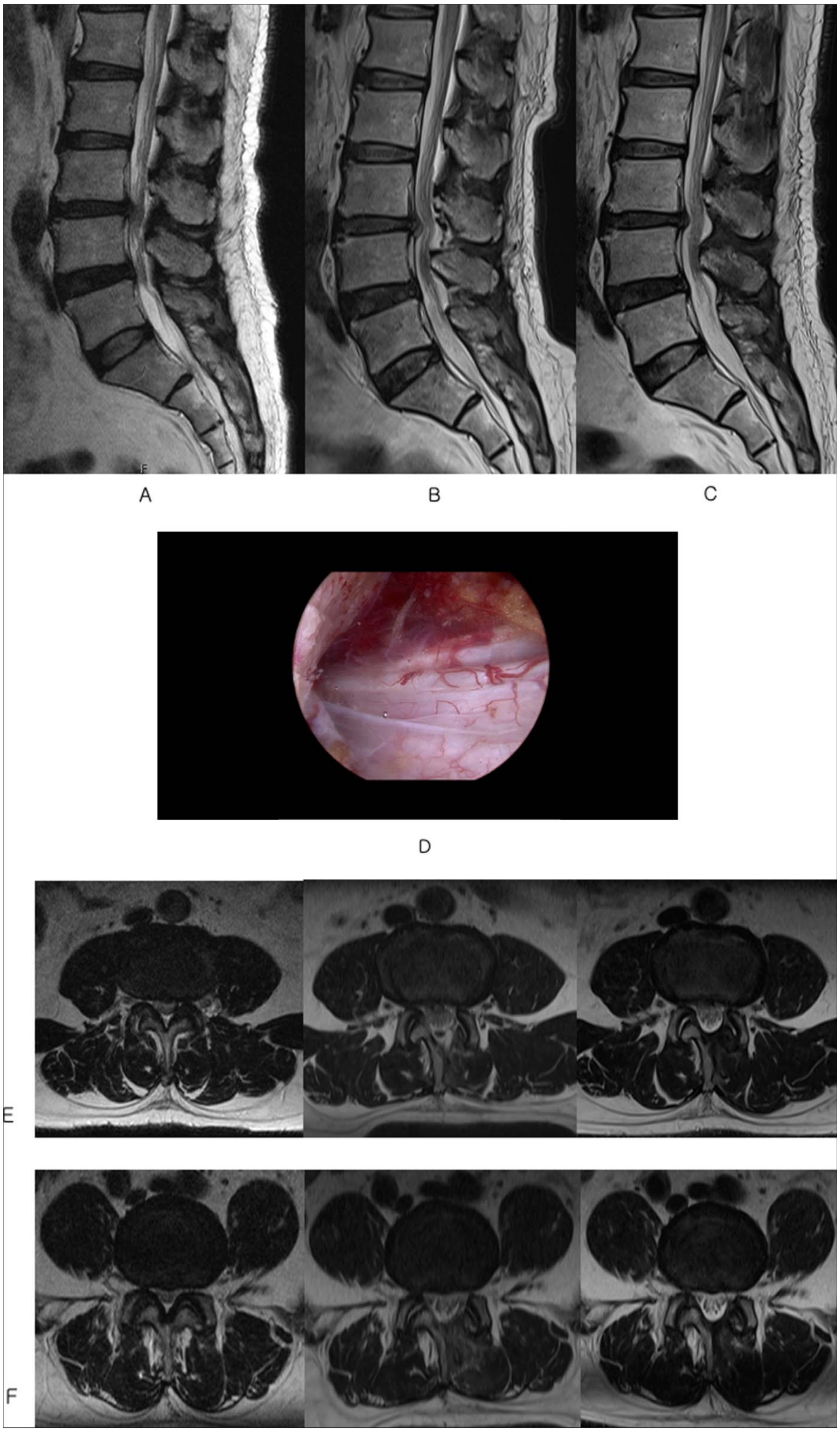
Considering the health-related quality of life of patients who underwent surgery, propensity scores were matched for baseline clinical outcome, age, and sex.

Figure 2



A, Radiographic image showing location of portals for UBE multilevel decompression at L3-4-5. The blue line was the working portal for left L4-5 decompression, and purple was the viewing portal. For L3-4, the purple portal became the working portal, whereas the red line became the viewing portal. The red circle is the interlaminar working zone for the L4-5 decompression, and the yellow circle the working area for the L3-4 decompression. **B,** The incisions were made obliquely in line with the fibers of the multifidus. This is a stylistic option for the senior author (J.K.).

Figure 3



Images explaining case of a 67-year-old woman with spinal stenosis who underwent UBE decompression at L3-4-5. (**A**) Preoperative sagittal MRI, (**B**) postoperative day 3 MRI, and (**C**) 2-year postoperative MRI. **D,** Intraoperative illustration of the L4-5 decompression. **E,** Axial images showing preoperative, postoperative day 3, and 2 years postoperative status of L4-5 and (**F**) L3-4.

These parameters were used in statistics by linear regression analysis. A total of 196 people were matched by propensity score; 98 people in each group. The *P* value of the chi square test of the Hosmer-Lemeshow tests for the propensity score was greater than 0.05, indicating an ideal adaptation model.

Results

Demographic

Two hundred thirty-four patients were enrolled based on exclusion and inclusion criteria. One hundred twenty-seven patients underwent a single-level decompression, whereas 107 patients had multilevel decompression.

After propensity matching, 98 patients remained in each group. The average age of the single-level patient was 64.3 ± 16.1 years and 65.5 ± 17.2 years in the multilevel. A 56.1% preponderance of women was observed in the single level compared with 57.1% female in the multilevel. The average BMI was 25.02 ± 2.71 kg·m^{-2} compared with 25.45 ± 3.02 kg·m^{-2}. Medical comorbidities (hypertension, diabetes, and osteoporosis) occurred less than 25% in both groups, whereas smoking status was 31.63% versus 30.61%. These demographic findings were all not statistically significant.

Predominant sidedness of symptoms did not differ between right and left with left being more common. The average number of levels decompressed in the multiple levels was 2.24 levels. L3-4, L4-5, and L5-S1 accounted for the majority (94.8%) with L4-5 being the most common level (38 cases; 38.7%) in single-level patients. For the multiple levels, the L3-4 to L5-S1 level were the most common levels making up 93.2% of all levels decompressed. For both groups, the L4-5 level was the most common with L5-S1 the second most common, followed by L3-4, then L2-3 (Table 1).

Surgical Results

Surgical time did not differ per level irrespective of single-level or multilevel decompression. The average time for a single-level laminectomy was 50.4 ± 17.8 minutes compared with 48.3 ± 16.2 minutes in the multilevel per level (*P* = 0.259). Surgical time was calculated from the start and completion of each level of decompression. Time to ambulation was markedly longer in the multilevel patients taking 8.1 ± 2.9 hours compared with 6.2 ± 2.6 hours (*P* = 0.027). The postoperative hospital stay was also longer in multilevel surgery staying 4.9 ± 1.6 days compared with 3.3 ± 1.2 days (*P* = 0.012). Surgical complications were similar with four issues in the single level (4.1%) versus three in the multilevel (3.1%) (*P* = 0.801).

Complications in the single level were 4 cases, including 3 cases of incidental dural tears and 1 case of transient palsy. All 4 cases of complications resolved with time. By contrast, three complications were observed in the multilevel group, all of which were small sized dura tears less than 1 cm. For all 6 cases of durotomy, patients recovered without any further sequelae after 48 hours of absolute bed rest and normal saline hydration. Tachosil collagen patch (Baxter, USA) was used to augment the dural repair.

Clinical Result

For single-level decompression, the change in average of VAS leg was 7.39 ± 0.91 preoperatively, 2.79 ± 1.65 at 2 weeks after surgery, 1.85 ± 0.58 at 2 months, and 1.72 ± 0.48 at the last follow-up after 5 years. A notable change was observed after surgery. VAS back markedly improved from 6.11 ± 1.21 preoperatively to 3.87 ± 0.69 at 2 weeks after surgery, 1.98 ± 0.61 at 2 months, and 1.82 ± 0.67 at the last follow-up (Figure 4, Table 2).

In comparison for multilevel, the change in VAS leg was 7.47 ± 1.09 preoperatively, 2.86 ± 1.74 at 2 weeks after surgery, 1.94 ± 0.77 at 2 months, and 1.86 ± 0.58 at the last follow-up after 5 years. Similar to single level, a notable change was observed after surgery. VAS back markedly improved mirroring the improvement in single-level decompression. VAS back was 6.29 ± 1.28 preoperatively to 4.09 ± 0.86 at 2 weeks after surgery, 2.05 ± 0.72 at 2 months, and 1.91 ± 0.75 at the last follow-up. No differences were observed in VAS back and leg between the groups at any time point (Figure 4, Table 2).

With respect to ODI, the mean ODI markedly improved sequentially from 62.98 ± 11.53 preoperatively to 27.02 ± 9.51 at 2 weeks after surgery, 19.34 ± 9.01 at 2 months, and to 18.51 ± 8.63 at the final follow-up in single-level decompression. For multilevel, the mean ODI markedly improved sequentially from 64.6 ± 13.71 preoperatively to 27.37 ± 9.82 at 2 weeks after surgery, 20.42 ± 10.51 at 2 months, and to 19.31 ± 9.42 at the final follow-up. No differences were noticed between the two groups. Improvements were statistically significant from preoperative to final follow-up (Figure 4, Table 2).

Revision Cases

Among the patients who underwent single-level UBE, eight patients underwent revision surgery (8.2%) in

Table 1. Demographic Data

Characteristic	Single Level	Multilevel	*P*
Age (yr)	64.3 ± 16.1	65.5 ± 17.2	0.387
Sex (male:female)	43:45 (43.8%:45.9%)	42:46 (42.8%:46.9%)	0.894
Follow-up (mo)	84.1 ± 21.3	82.6 ± 20.5	0.591
BMI ($kg \cdot m^{-2}$)	25.02 ± 2.71	25.45 ± 3.02	0.816
Smoking currently	31/98 (31.63%)	30/98 (30.61%)	0.925
Hypertension	23/98 (23.46%)	19/98 (19.38%)	0.214
Diabetes	17/98 (17.34%)	18/98 (18.36%)	0.764
Osteoporosis (T score < −2.5)	26/98 (24.29%)	24/98 (24.48%)	0.975
Predominant side			
Left	59/98 (60.20%)	56/98 (57.12%)	0.427
Right	39/98 (39.79%)	42/98 (42.85%)	0.316
No. of levels decompressed total (average)	98 (1.0)	220 (2.24)	
Surgical level	98	220	
L1-2	1	4	
L2-3	4	11	
L3-4	26	57	
L4-5	38	85	
L5-S1	29	63	
Surgical time per level (min)	50.4 ± 17.8	48.3 ± 16.2	0.259
Time to ambulation (hours)	6.2 ± 2.6	8.1 ± 2.9	0.027
Postoperative hospital stay (d)	3.3 ± 1.2	4.9 ± 1.6	0.012
Revision surgery	8	7	0.895
Surgical complication	4	3	0.801

comparison to seven patients who underwent revision surgery in the multilevel decompression (7.1%) (*P* = 0.895). The additional revision was done in on average 34.25 months after the primary surgery, range 7 to 80 months. Six of the surgeries were converted to a fusion mainly for recurrent foraminal stenosis. Only one patient developed progressive spondylolisthesis requiring fusion. One other patient herniated a disk at the same level requiring a diskectomy, whereas the last patient developed recurrent central stenosis at the index level and adjacent level requiring a two-level decompression.

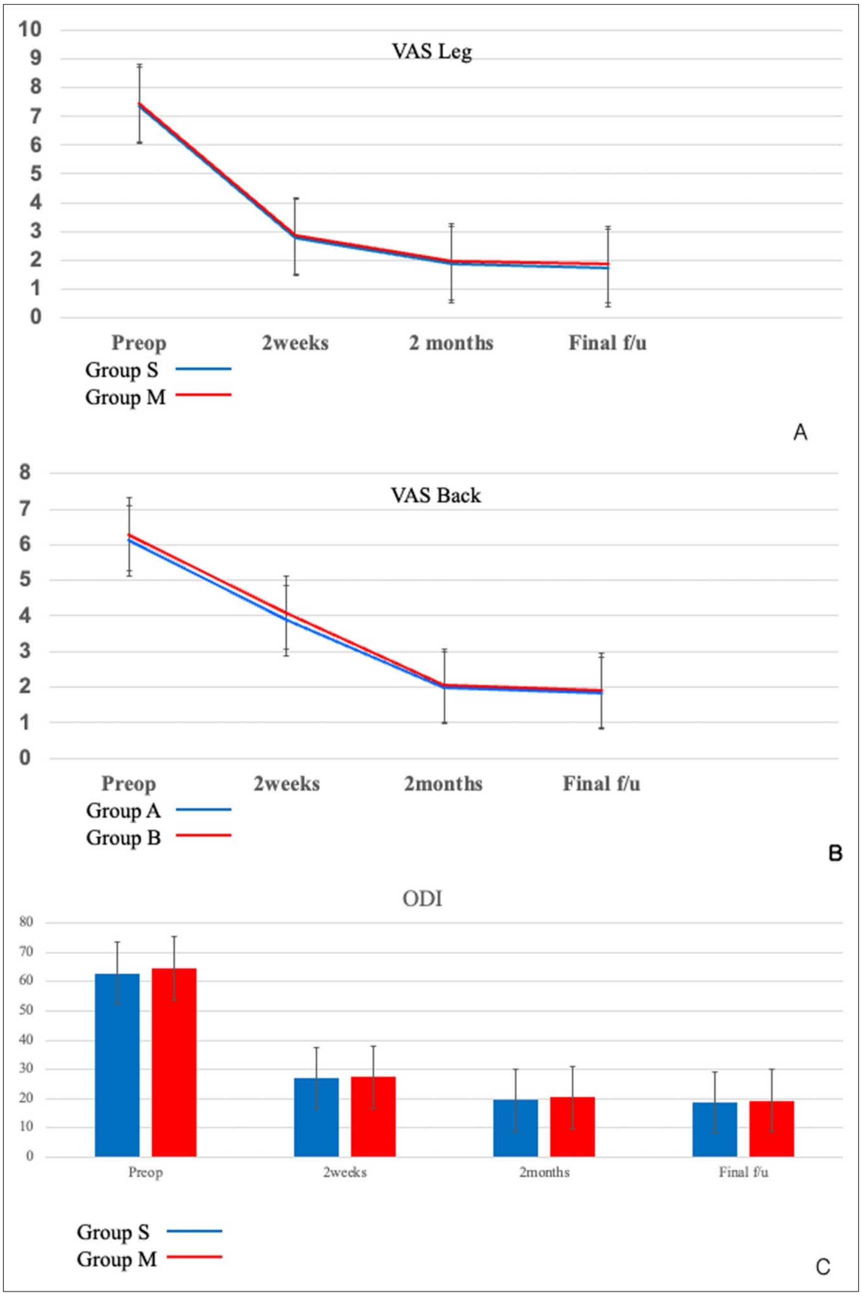
By contrast, the multilevel group had revision on average 36.9 months, range 9 months to 53 months. Four of the seven patients required a fusion. Two patients had progressive spondylolisthesis, whereas two developed recurrent foraminal stenosis. Two patients experienced adjacent level stenosis, and one last patient had an adjacent level disk herniation (Table 3).

Discussion

Lumbar spinal stenosis is a common condition and is the most frequent indication of spinal surgery in patients older than 65 years.[10] The prevalence of stenosis in the United States has been noted to range from 11% to 38% in the older population.[11] Because lumbar stenosis is a result of the degenerative cascade, it is not unusual to assess patients who have multilevel stenosis.[12] Despite involving longer time to ambulation and increased length of stay, the clinical improvement after multilevel laminectomy versus single-level laminectomy using UBE, in this study, did not demonstrate any clinical difference or increased complication or revision rates at minimum 5-year follow-up.

Because symptoms often poorly correlate with radiographic findings,[13] the decision to incorporate multilevel decompression or operate on only the most severe or most clinically relevant level is unclear. Amundsen

Figure 4



A, Chart showing visual analog score (VAS) of leg (Group S blue for single level and Group M red for multilevel), (**B**) VAS back, and (**C**) Oswestry Disability Index score.

et al[14] also found no relationship between degree of stenosis and symptoms. Few studies have analyzed how many levels should be decompressed. Adilay and Guclu[15] retrospectively included 112 consecutive patients. In that study, the authors claimed if the difference in diameter between the second stenotic level and the most stenotic level was greater than 3 mm and second stenotic level diameter was also greater than 9 mm to begin with, the second level was left alone. This decision tree resulted in 48 single-level and 64 multilevel decompressions in a 30-month follow-up study. Single-level decompressed patients had better ODI, VAS, and walking duration. Interestingly, all these cases were done by the standard open technique. In another study, Yoshikane et al found, in multilevel radiographic stenosis patients where only the most severe level was

Table 2. Visual Analog Score (VAS) Back and Leg and Oswestery Disability Index (ODI) Preoperative, 2 Weeks, 2 Months, and at Final Follow-up for Single-Level and Multilevel Decompression

Characteristic	Single Level	Multilevel	*P*
Number	98	98	
Preoperative			
VAS back	6.11 ± 1.21	6.29 ± 1.28	0.725
VAS leg	7.39 ± 0.91	7.47 ± 1.09	0.746
ODI	62.98 ± 11.53	64.66 ± 13.71	0.783
Postoperative 2 weeks			
VAS back	3.87 ± 0.69	4.09 ± 0.86	0.658
VAS leg	2.79 ± 1.65	2.86 ± 1.74	0.834
ODI	27.02 ± 9.51	27.37 ± 9.82	0.658
Postoperative 2 months			
VAS back	1.98 ± 0.61	2.05 ± 0.72	0.725
VAS leg	1.85 ± 0.58	1.94 ± 0.77	0.512
ODI	19.34 ± 9.01	20.42 ± 10.51	0.359
Final			
VAS back	1.82 ± 0.67	1.91 ± 0.75	0.931
VAS leg	1.72 ± 0.48	1.86 ± 0.58	0.457
ODI	18.51 ± 8.63	19.31 ± 9.42	0.534

decompressed, the risk of another level decompression was 12% if symptoms were bilateral. The risk increased to 28% if the other level was also severely stenotic. If the other level was only moderately compressed, the revision rate was 11.8%, whereas if the other level was mild, the rate dropped to 6.2%.[16] In contrast to Adilay and Guclu, these 128 patients were treated with uniportal endoscopic bilateral decompression with 77.9% good or excellent results at 2 years.

Because biomechanically more posterior disruption can lead to potentially more instability, it was hypothesized that multilevel laminectomy portends a worse clinical diagnosis. Cardoso et al[17] found that the spinal column range of motion increases as more posterior structures are disturbed. In another biomechanical model, multilevel decompression induces lumbar spinal instability in flexion.[18] Furthermore, because surgical trauma can lead to paraspinal muscle atrophy, the incidence of spondylolisthesis can increase in patients treated with multilevel laminectomy.[15]

Using only open surgical techniques, in support of Adilay and Guclu, in a prospective multicenter study, Ulrich et al[19] found that in patients with at least three-level stenosis who underwent open multilevel decompression, spinal stenosis symptoms measurement and function scores were less favorable for multilevel decompression compared with primary decompression at 2 years. Iguchi et al also found that multilevel decompression had poorer outcome at 10 years. The authors hypothesized that the difference was due to extension posterior muscle damage.[20]

By contrast, in a large multicenter study, Park et al[21] found that the number of levels did not predict outcomes. The technique chosen was not described, but most likely the decompression was through open techniques based on the time of the SPORT study. Nolte et al[22] also stated that in open standard technique with three or more level decompressed, the clinical outcomes were similar to single-level decompression at 2-year follow-up. Finally, Yukawa et al[23] discovered similar clinical improvement in ODI and VAS between single-level and multilevel decompressed patients.

In support of avoiding extensive surgical trauma to create similar clinical outcomes, Nolte et al[24] found that in multilevel laminectomy that using tubular decompression, a negligible effect was observed on outcome. Yamamoto et al also analyzed 659 patients for minimum 2 years performing lumbar spinous process splitting laminectomy. Clinical scores were similar after propensity score matching between single-level and multilevel decompression.[25] A hidden issue with multilevel surgery that has not been addressed

Table 3. Reason for Revision

Case	Sex	Age	Segment	Main Symptom Before Revision	Diagnosis for Revision	Revision	Time to Revision
Single level							
1	M	56	L4-5	Radiating pain	Herniated disk	Diskectomy	20
2	M	70	L4-5	Claudication	Restenosis and adjacent stenosis	2 level decompression	80
3	F	71	L4-5	Radiating pain	Foraminal stenosis	TLIF	25
4	F	53	L5-S1	Radiating pain	Foraminal stenosis	TLIF	18
5	F	67	L4-5	Claudication	Spondylolisthesis L4-5	TLIF	7
6	F	82	L4-5	Claudication	Foraminal stenosis and adjacent level stenosis	TLIF with L3-4 decompression	52
7	F	73	L4-5	Claudication	Foraminal stenosis	TLIF	56
8	M	70	L5-S1	Radiating pain	Foraminal disk herniation	TLIF	16
Multilevel							
1	M	60	L4-5-S1	Claudication	Spinal stenosis L34	Decompression	26
2	F	74	L3-4-5	Claudication	Spondylolisthesis L4-5	TLIF	51
3	M	63	L4-5-S1	Radiating pain	Foraminal stenosis L5-S1	TLIF	46
4	F	65	L4-5-S1	Radiating pain	Foraminal disk herniation L5-S1	TLIF	53
5	F	59	L3-4-5	Claudication	Spinal stenosis L5-S1	Decompression	48
6	F	66	L3-4-5	Claudication	Spondylolisthesis L4-5	TLIF	9
7	F	72	L3-4-5	Radiating pain	Disk herniation L5-S1	Diskectomy	25

specifically by other studies and this study is the anesthetic risk associated with longer surgeries. It is inherent that multilevel surgery would increase total surgical time. However, surgical complications and clinical outcomes were not different.

One of the newest spinal surgical techniques is biportal endoscopic surgery. Compared with the classic uniportal endoscopic surgery, biportal endoscopic surgery (UBE) allows for the freedom of two hands and the use of faster and more powerful electronic burrs to increase the surgical speed. The authors are not aware of any clinical study analyzing outcomes from multilevel decompressive surgery, albeit at long-term follow-up.

In this article, we found that not only the clinical scores between single and multilevel surgery are similar but also the complication and revision rates did not differ. Yamamoto et al[25] also found similar complication rates between single-level and multilevel surgery. No increased risk was observed for hematomas, infections, and durotomies. The rate of revision surgery was also not statistically significant. One study found that in multilevel decompression, an increase was observed in blood loss, which can lead to increased risk for hematoma.[26] Yamamoto et al[25] also found higher blood loss with multilevel decompression. However, in this study, we did not find that multilevel decompressive surgery resulted in a higher rate of symptomatic hematoma. Because of endoscopic surgery, all patients had drain, and because there was high magnification, we could find the individual bleeders. Furthermore, In the Norwegian population, Tronstad et al[27] found that when comparing single versus multilevel decompression, revision surgeries within 2 year did not differ (4.6% in multilevel versus 7% in single level) and surgical complications were similar at 12% and 10.5%. Ulrich et al also found similar complication rates with durotomy rates between 2.8 to 6.1% and infection rate of approximately 3%.[19]Using tubular techniques in multilevel surgery, Khanna et al found the complication rate to be 17.4% (mostly all durotomy, one epidural hematoma) and 8.6% needed a fusion at 2 years. Most of subsequent fusion patients had preexisting spondylolisthesis.[28] Adilay and Guclu also found that complications were also more common in multilevel patients but were not statistically significant. No cases of instability were observed in the single-level decompression, whereas four multilevel patients required a fusion subsequently.[15] In this study, we did not find high complication rate and instability rate possibly due to the high magnification of endoscopy and the ability to preserve the facet joint integrity better. We had equivalent durotomy rates in both groups of 3%. Durotomy rates are typically quoted less than open or tubular surgeries, as there is high magnification and fluid pressure than can compress the dural tube to create more of a working window to place Kerrison rongeurs and surgical tools more safely. Infection rates are very low in endoscopic spine surgery likely due to the fluid media surgery compared with open and tubular surgery. Our revision rates were 8.2% in the single-level and 7.1% in the multilevel decompression patients, similar to the study of Khanna et al[28] in tubular decompressions. Most of the fusions performed subsequently were for recurrent foraminal stenosis and not instability.

With respective to length of stay, Tronstad et al[27] found that the multilevel laminectomy experienced overall total longer surgical time by 45 minutes and longer length of stay by 1 day. In this study, the multilevel decompression surgeries took longer, but when divided time per level, it did not differ. The length of hospital stay was longer with multilevel decompression.

Finally, this study analyzed longer follow-up than many of the previous articles. Because stenosis is a degenerative problem, long-term data need to be analyzed. Furthermore, Guigui et al[29] found regrowth of bone in 7-11% in 8 years. This study found the sustained benefit of multilevel and single-level UBE decompression at minimum 5 years.

Limitations of this study are that this study was retrospective in nature, and some patients were lost to follow-up, albeit a small number. The retrospective study can limit the ability to control for confounding factors and can have recall bias. Furthermore, only one senior surgeon's database was analyzed for long-term follow-up, which can limit the generalizability in technique and learning curve. The senior surgeon was past the learning curve when this study began, so generalizability to novice endoscopist can be questioned. Finally, the determination of number of levels decompressed were at the sole discretion of the senior surgeon.

Ultimately, using the ultra minimally invasive UBE technique, this study demonstrates that multilevel decompression benefits are sustained. As long as each compressed level is adequately decompressed during surgery, outcomes are good.

References

1. Benoist M: The natural history of lumbar degenerative spinal stenosis. *Joint Bone Spine* 2002;69:450-457.

2. Kim JY, Ryu DS, Paik HK, et al: Paraspinal muscle, facet joint, and disc problems: Risk factors for adjacent segment degeneration after lumbar fusion. *Spine J* 2016;16:867-875.

3. Klemencsics I, Lazary A, Szoverfi Z, Bozsodi A, Eltes P, Varga PP: Risk factors for surgical site infection in elective routine degenerative lumbar surgeries. *Spine J* 2016;16:1377-1383.

4. Ikuta K, Arima J, Tanaka T, et al: Short-term results of microendoscopic posterior decompression for lumbar spinal stenosis. Technical note. *J Neurosurg Spine* 2005;2:624-633.

5. Yagi M, Okada E, Ninomiya K, Kihara M: Postoperative outcome after modified unilateral-approach microendoscopic midline decompression for degenerative spinal stenosis. *J Neurosurg Spine* 2009;10:293-299.

6. Kim JE, Choi DJ: Clinical and radiological outcomes of unilateral biportal endoscopic decompression by 30° arthroscopy in lumbar spinal stenosis: Minimum 2-year follow-up. *Clin Orthop Surg* 2018;10:328-336.

7. Min WK, Kim JE, Choi DJ, Park EJ, Heo J: Clinical and radiological outcomes between biportal endoscopic decompression and microscopic decompression in lumbar spinal stenosis. *J Orthop Sci* 2020;25:371-378.

8. Tomkins-Lane CC, Battie MC, Hu R, Macedo L: Pathoanatomical characteristics of clinical lumbar spinal stenosis. *J Back Musculoskelet Rehabil* 2014;27:223-229.

9. Kim J, Choi D: Clinical and radiological outcomes of unilateral biportal endoscopic decompression by 30° arthroscopy in lumbar spinal stenosis: Minimum 2-year follow-up. *Clin Orthop Surg* 2018;10:328-336.

10. Deyo RA: Treatment of lumbar spinal stenosis: A balancing act. *Spine J* 2010;10:625-627.

11. Jensen RK, Jensen TS, Koes B, Hartvigsen J: Prevalence of lumbar spinal stenosis in general and clinical populations: A systematic review and meta-analysis. *Eur Spine J* 2020;29:2143-2163.

12. Pearson A, Lurie J, Tosteson T, Zhao W, Abdu W, Weinstein JN: Who should have surgery for spinal stenosis? Treatment effect predictors in SPORT. *Spine* 2012;37:1791-1802.

13. Haig AJ, Tong HC, Yamakawa KS, et al.: Spinal stenosis, back pain, or no symptoms at all? A masked study comparing radiologic and diagnoses to the clinical impression. *Arch Phys Med Rehabil* 2006;87:897-903.

14. Amundsen T, Weber H, Nordal HJ, Magnaes B, Abdelnoor M, Lilleâs F: Lumbar spinal stenosis: Conservative or surgical management? A prospective 10-year study. *Spine* 2000;25:1424-1436.

15. Adilay U, Guclu B: Comparison of single-level and multilevel decompressive laminectomy for multilevel lumbar spinal stenosis. *World Neurosurg* 2018;111:e235-e240.

16. Yoshikane K, Kikuchi K, Okazaki K: Clinical outcomes of selective single-level lumbar endoscopic unilateral laminotomy for bilateral decompression of multilevel lumbar spinal stenosis and risk factors of reoperation. *Glob Spine J* 2023;13:1350-1357.

17. Cardoso MJ, Dmitriev AE, Helgeson M, Lehman RA, Kuklo TR, Rosner MK: Does superior-segment facet violation or laminectomy destabilize the adjacent level in lumbar transpedicular fixation? An in vitro human cadaveric assessment. *Spine* 2008;33:2868-2873.

18. Lu WW, Luk KD, Ruan DK, Fei ZQ, Leong JC: Stability of the whole lumbar spine after multilevel fenestration and discectomy. *Spine* 1999;24: 1277-1282.

19. Ulrich NH, Burgstaller JM, Held U, et al.: The influence of single-level versus multilevel decompression on the outcome in multisegmental lumbar

spinal stenosis: An analysis of the lumbar spinal outcome study (LSOS) data. *Clin Spine Surg* 2017;30:E1367-1E1375.

20. Iguchi T, Kurihara A, Nakayama J, Sato K, Kurosaka M, Yamasaki K: Minimum 10 year outcome of decompressive laminectomy for degenerative lumbar spinal stenosis. *Spine* 2000;25:1754-1759.

21. Park DK, An HS, Lurie JD, et al: Does multilevel lumbar stenosis lead to poor outcomes? A subanalysis of the SPORT lumbar stenosis study. *Spine* 2010;35:439-446.

22. Nolte MT, Louie PK, Basques BA, et al: Patients undergoing 3 level or greater decompression only surgery for lumbar spinal stenosis have similar outcomes to those undergoing single-level surgery at 2 years. *Int J Spine Surg* 2021;15:945-952.

23. Yukawa Y, Lenke LG, Tenhula J, Bridwell KH, Riew KD, Blanke K: A comprehensive study of patients with surgically treated lumbar spinal stenosis with neurogenic claudication. *J Bone Joint Surg Am* 2002;84:1954-1959.

24. Nolte MT, Parrish JM, Jenkins NW, et al: The influence of comorbidity on postoperative outcomes following lumbar decompression. *Clin Spine Surg* 2021;34:e390-e396.

25. Yamamoto T, Yagi M, Suzuki S, et al: Multilevel decompression surgery for degenerative lumbar spinal canal stenosis is similarly effective with single-level decompression surgery. *Spine* 2022;47: 1728-1736.

26. Fujita N, Michikawa T, Yagi M, et al: Impact of lumbar hypolordosis on the incidence of symptomatic postoperative spinal epidural hematoma after decompression surgery for lumbar spinal canal stenosis. *Eur Spine J* 2019;28:87-93.

27. Tronstad S, Haug KJ, Myklebust TA, et al: Do patients with lumbar spinal stenosis benefit from decompression of levels with adjacent moderate stenosis? A prospective cohort study from the nordsten study. *Spine J official J North Am Spine Soc* 2024;24:1015-1021.

28. Khanna R, Malone H, Keppetipola KM, et al: Multilevel minimally invasive lumbar decompression: Clinical efficacy and durability to 2 years. *Int J Spine Surg* 2021;15:795-802.

29. Guigui P, Barre E, Benoist M, Deburge A: Radiologic and computed tomography image evaluation of bone regrowth after wide surgical decompression for lumbar stenosis. *Spine* 1999;24:281-289.