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Efficacy of Unilateral Laminectomy for Bilateral Decompression in Lumbar Spinal Stenosis

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ABSTRACT

OBJECTIVE: We have conducted a prospective study to evaluate the results and effectiveness of bilateral decompression via a unilateral laminectomy in 50 patients with 98 levels of degenerative lumbar spinal stenosis without instability.

METHODS: Clinical outcomes were assessed using the Visual Analog Scale, Oswestry Disability Index, Short Form–36, and subjective Satisfaction Measurement.

RESULTS: Adequate decompression was achieved in all patients. The mean follow-up time was 22.8 months (range 19 - 47 months). Surgical decompression resulted in a dramatic reduction of overall pain in all patients (late postoperative VAS score was 2.16 ± 0.81). The ODI scores decreased significantly in early and late follow-up evaluations and the SF-36 scores demonstrated significant improvement in late follow-up results in our series. Patient satisfaction rate was 94%, and its improvement rate was 96%.

CONCLUSION: For degenerative lumbar spinal stenosis with or without mild degenerative spondylolisthesis, the unilateral approach allowed sufficient and safe decompression of the neural structures and adequate preservation of vertebral stability, resulted in a highly significant reduction of symptoms and disability, and improved health-related quality of life.

KEY WORDS: Degenerative spine, Lumbar spinal stenosis, Unilateral approach, Vertebral stability

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INTRODUCTION

The only treatment option available to patients who fail to respond to nonoperative therapies that may include epidural steroid injections, oral steroids, nonsteroidal anti-inflammatory medication, analgesics and physical therapy is decompressive surgery. Several surgical techniques for lumbar spine decompression have been described over last few decades. The surgical aim of treatment for symptomatic lumbar canal stenosis is relief of symptoms by adequate neural decompression while preserving much of the anatomy and the biomechanical function of the lumbar spine. Traditional treatment of spinal stenosis has involved wide laminectomy and undercutting of the medial facet with foraminotomy. The frequent surgical failures have been attributed to local tissue trauma [4, 53] and to postoperative spinal instability [12, 23, 27, 36, 51, 53] that have led to a dramatic increase in lumbar fusion surgery [9, 30]. Turner's meta-analysis of 74 published studies of surgery for lumbar spinal stenosis found good to excellent results ranging from 26 to 100% (mean 64%) [52].

Increasing knowledge of the pathoanatomy, coupled with the development of magnetic resonance imaging, has allowed a more precise delineation of soft tissue and bony stenosing lesions [49, 53, 57]. The unilateral approach preserves the facet joints and neural arch of the contralateral side, limits postoperative destabilization and protects the nervous structure against posterior scarring [32]. Initially described by Young et al in 1988 [57] and subsequently modified by McCulloch [34], a microscopic technique characterized by unilateral multifidus retraction, ipsilateral microdecompression, and contralateral microdecompression performed under the midline posterior structures has been used with some modification at the current authors' center since 1995. The purpose of our prospective study was to evaluate the safety and the clinical outcome after unilateral laminectomy for bilateral decompression in patients with lumbar spinal stenosis.

MATERIAL AND METHOD

This prospective observational study was undertaken for analysis of 50 patients with degenerative lumbar spinal stenosis refractory to adequate conservative treatment who underwent 1- or adjacent multilevel bilateral decompression via a unilateral approach between January 2000 and January 2002. All patients who met one or more of the following criteria were included in this study: (1) symptoms of neurogenic claudication referable to the lumbar spine, (2) radiological/neuroimaging evidence of degenerative lumbar stenosis, (3) Failure of conservative measures; minimum 3 months, (4) the absence of associated pathology such as instability, inflammation or malignancy, and (5) no history of surgery for lumbar stenosis or lumbar fusion. Patients presenting with stable spondylolisthesis were not excluded. We also were not excluded from outcome analysis seven patients who required discectomies, which had been identified on preoperative imaging studies.

The assessment of neurologic status of patients was evaluated by physical examination, and preoperative radiological investigations were performed with plain roentgenograms, magnetic resonance (MRI) and computed tomographic (CT) images for all patients. Postoperative CT scans were acquired in all patients before discharge to evaluate the adequacy of the decompression. All patients were followed-up regularly at intervals of 1, 3, 6, 12, and 24 months, and routine radiological investigations, including neutral, flexion/extension lateral radiographs, at these time intervals were taken routinely.

The features studied on these imaging data included (1) extent of lumbar spinal decompression at each stenotic level, (2) the presence of abnormal motion and/or progression of spondylolisthesis at dynamic roentgenograms (spinal instability was defined as sagittal-plane translation of 5 mm or more documented on flexion–extension radiography [11, 54]), (3) relationship between the radiological investigations and neurologic status and life quality status of the patients.

The outcomes of surgery in the long-term follow-up were measured for all patients according to the criteria used by the VAS, ODI, SF-36, and subjective Satisfaction Measurement. Follow-up data were obtained from the questionnaires forwarded directly to the patients at pre-operative term and postoperative 3rd and 24th months. Pain was measured according to a self-assessment 10-point VAS. Disability was assessed using the ODI, and physical and mental health status was measured using the SF-36 health survey that has been validated and reported on for Turkish-language speakers [39, 55]. The success rate was judged using self-assessment questionnaires.

Surgical Procedure: The proper level is verified by a C-arm scope pre- and peroperatively. The incision is midline and extends over, but is limited to, the underlying region of stenosis as documented on magnetic resonance imaging. A 2-6 cm skin incision is made for 1-4 levels stenosis. A linear median fascial incision then is made on the patient's most symptomatic side. The paraspinal muscles are removed from their bony attacments on the spinous process and lamina to expose the bony detail. A modified mini Taylor retractor then is used. A full view of the ipsilateral interlaminar space is now obtained, and the microscope is brought into place. Using Kerrison rongeurs or a high-speed burr, ipsilateral cephalad and then caudal hemilamina are totally resected. The microscope then is angulated into the ipsilateral subarticular zone and, moving cephalad to caudal, the soft tissue and bony stenosing pathology is excised using Kerrison rongeurs. This is done sequentially until cephalad and caudal nerve roots at the operative level are seen exiting freely into the foramen. This should be performed by maximally preserving the pars interarticularis and facet joint. After complete ipsilateral microdecompression, the contralateral side is addressed. The microscope is angulated medially and, quite often, the patient tilted contralaterally, to afford visualization across the midline beneath the deepest portion of the interspinous ligament. A dissector is used to confirm that the anterior surface of the ligamentum flavum is free from adhesion to the dura, and the ligamentum is then resected sequentially from cephalad to caudal and medial to lateral. This affords, by nature of the scope angulation, a trumpeted decompression, which is extended lengthwise and laterally in a fashion similar to that described for the ipsilateral microdecompression. Both the ipsilateral and contralateral nerve roots are well visualized after the bilateral decompression. Then same procedure is used for each proper level. When decompression is confirmed with direct inspection under surgical microscope, the operation is completed. To reduce postoperative granulation, the decompressed nerve roots are protected with small blocks of fat resected from subfascial tissue. All affected levels can be successfully decompressed through this unilateral approach. Suction drains are not routinely placed (Figure 1).

The patient is allowed out of bed without a lumbosacral corset the day after surgery and is discharged within 24 hours. An exercise program is started after three weeks to strengthen the paravertebral muscles and patients can return to their daily activities after two weeks.

Statistical analysis: Statistical calculations were performed with GraphPad Prisma V.3 program for Windows. Besides standard descriptive statistical calculations (mean and standard deviation), one way ANOVA was used in the comparison of groups, post Hoc Newman Keuls multiple comparison test was utilized in the comparison of subgroups, unpaired t-test was used for two treatment values, and the Chi square test was performed during the evaluation of qualitative data. Statistical significance level was established at $p < 0.05$.

RESULTS

Of these 50 patients, 29 were female (58%) and 21 male (42%) with a mean age of 69,81 ± SD 15,15 SD (range 43 – 82 years). The duration of symptoms ranged from 9 to 58 months. Preoperative clinical symptoms and signs were low back pain (92%), leg pain (90%), neurogenic claudication (98%), sensory change (78%), motor weakness (22%), incontinence (4%). In total, 101 stenotic/spondylolisthetic levels were decompressed and seven patients underwent concomitant discectomies at the index level. The operated levels were as follows: L1-2 (in four patients), L2-3 (in eight patients), L3-4 (in 34 patients), L4-5 (in 48 patients), L5-S1 (in seven patients), (Table I).

Figure 1: Preoperative and postoperative T2-weighted MR images obtained in a patient undergoing four levels decompression. Preoperative (a) and postoperative (b) sagittal images, and pre- (c) and postoperative (d) axial images.

The mean follow-up time was 22.8 months, ranging from 19 to 47 months. The routine radiological investigations at these time intervals were taken and follow-up data were obtained from the VAS, ODI, SF-36 questionnaires, and subjective Satisfaction Measurement in 48 of 50 patients. One of the remaining 2 patients refused to have control radiological investigations after 18 months, and another patient died of unrelated causes after 20 months.

Clinical Analysis:

There were no perioperative deaths. Accidental duratomy occurred in 3 of all the surgically treated levels (3.06%). All dural tears occurred in the ipsilateral side and primary repair was not performed but the lesions were covered with fibrin

Table I: Clinical and demographic data of patients

Parameters	
no. of cases	50
mean age (years)	69.81 ± 15.15
male / female	21 / 29
stenotic level of the lesion	
L1-2	4
L2-3	8
L3-4	34
L4-5	48
L5-S1	7
number of stenotic levels	
Single	14
Two	25
Three	7
Four	4
initial chief complaint	
leg pain	45
low back pain	46
claudication	49
numbness/tingling	39
weakness	11
incontinence	2

glue. These three patients were admitted to the hospital for 48 hours of bed rest and duratomies and were not noticeably associated with postoperative morbidity, and no subsequent postoperative CSF fistula was observed. No neural injury or other complication was observed during the surgery. No patient required re-exploration because of complications (for instance, epidural hematoma) in the early postoperative period. There were no infections.

Pain Assessment: Surgical decompression resulted in a dramatic reduction of overall pain in all patients. The VAS scores decreased significantly in both early and late follow-up evaluations (Newman-Keuls multiple comparison test, $p < 0.001$), from a mean preoperative score of 6.92 ± 1.04 (Mean ± SD), to 2.40 ± 0.79 at 3rd months and 2.16 ± 0.81 at 18th – 24th months (Figure 2).

Disability Assessment: The ODI scores decreased significantly in both early and late follow-up evaluations (Newman-Keuls multiple comparison test, $p < 0.0001$), from a mean preoperative score of 31.14 ± 9.27, to 14.22 ± 9.88 at 3rd months and 14.02 ± 9.27 at 18th – 24th months. Most of the changes occurred between preoperative and early follow-up

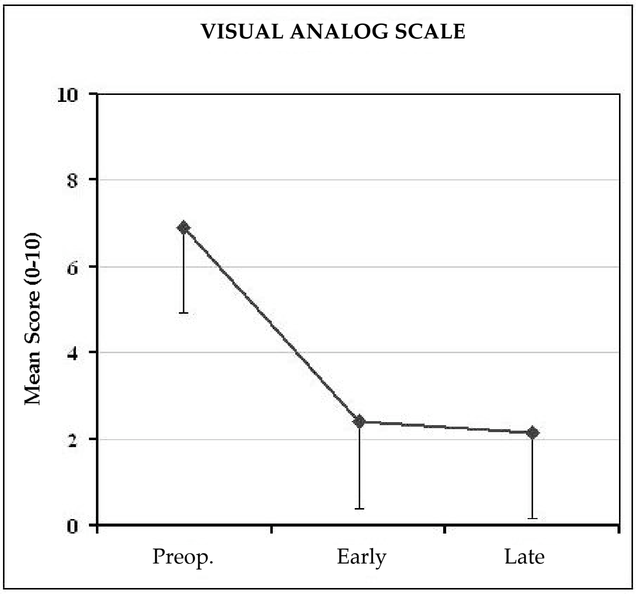

Figure 2: Bar graph showing the mean VAS scores preoperatively and at 3rd, 18th – 24th months postoperatively.

assessments with little changes between early and late follow-up reviews (Newman-Keuls multiple comparison test, $p > 0.05$), (Table 2).

Quality of life: Comparison of preoperative, early and late postoperative SF-36 scores demonstrated a marked and significant improvement, except in the area of emotional role. No significant differences in preoperative, early postoperative, and late postoperative scores of emotional role were identified (Newman-Keuls multiple comparison test, plate = 0.604 compared with admission). Most of the changes occurred between preoperative and early follow-up assessments with little changes between early and late follow-up reviews, except in the area of bodily pain. Significant difference was found between early and late follow-up assessments, only in the area of bodily pain (Newman-Keuls multiple comparison test, $p < 0.05$), (Figure 3).

Patient Satisfaction: In general, patients were satisfied with the reduced pain levels and

Table II: Mean ODI scores preoperatively and at 3rd, 18th – 24th months postoperatively

	Preoperative	**Early**	**Late**
Mean	31.14	14.22	14.02[1]
SD	9.27	9.88	9.27
	F = 127	p = 0.0001	

[1]p > 0.05 compared with early follow-up

improvement in everyday activities. Overall 6% (three of 50; [4% (two of 50) were fairly satisfied, 2% (one of 50) were not very satisfied] of patients were unsatisfied after 18 – 24 months (Figure 4).

Radiographic Analysis:

Postoperative CT scanning demonstrated adequate decompression in all patients, and in no patient was reoperation required for residual or recurrent spinal stenosis at the same segment(s) within 18 to 24 months. Adjacent level stenosis requiring decompression did not occur. Degenerative spondylolisthesis (Grade I) was observed at seven different levels in the seven patients preoperatively. Abnormal motion in the sagittal plane was not observed on the preoperative x-ray films. No radiograph revealed an increase in the degree of spondylolisthesis in the late postoperative period. In no patient postoperative instability developed requiring instrumentation assisted secondary fusion.

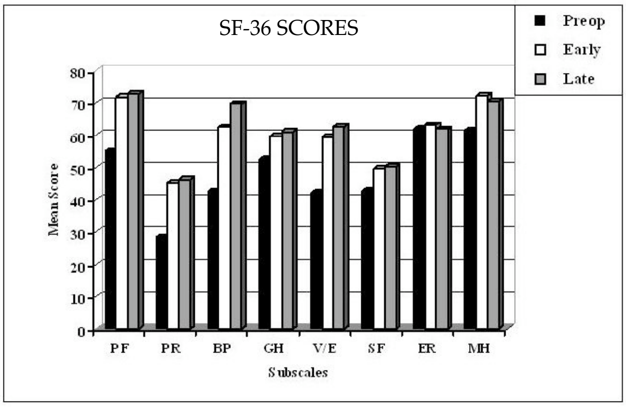

Figure 3: Bar graph showing the mean SF-36 scores in eight categories; PF: physical function, PR: physical role, BP: body pain, GH: general health, V/E: vitality/energy, SF: social function, ER: emotional role, MH: mental health.

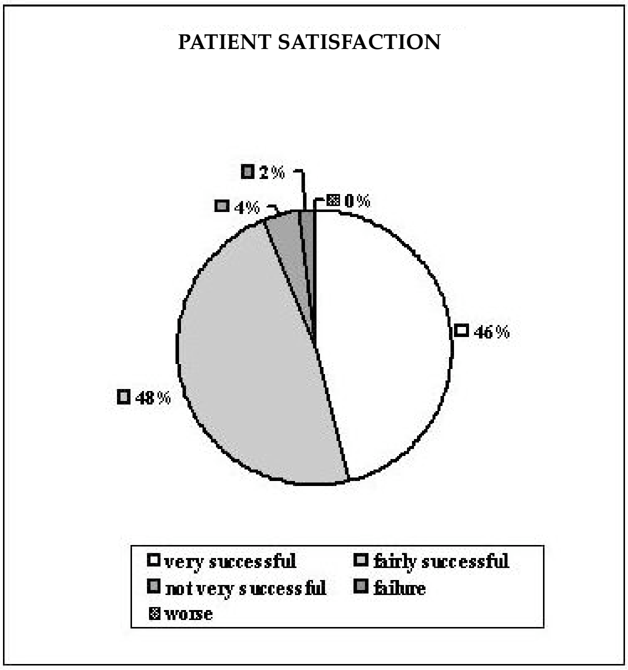

Figure 4: Success rate as judged using self-assessment questionnaires at 18th – 24th months postoperatively.

DISCUSSION

We have presented the results of the prospective study to evaluate the safety and outcome of unilateral laminectomy for bilateral decompression in 50 patients with lumbar degenerative spinal canal stenosis. This procedure yielded highly significant improvement in symptoms and scores.

Many authors have challenged the traditional treatment of spinal stenosis in which wide laminectomy and partial or complete facetectomy was performed. Older techniques of laminectomy or unroofing of the spinal canal, while affording wide decompression, often resulted in destruction or insufficiency of the pars interarticularis or facet joints with resultant iatrogenic instability. From an extensive review of the literature, Turner et al [52] attempted a meta-analysis and concluded that approximately 64% of surgically treated patients had a good outcome over a midterm follow-up period (3–6 years). In particular, spinal instability has been implicated as a cause of surgical failures [12, 23, 35, 51], because wide posterior decompression significantly alters spinal anatomy and biomechanics [8, 42, 58], thus prompting many spine surgeons to perform fusion procedures to treat lumbar stenosis [26, 28]. The frequency of fusion surgery, however, has been steadily increasing in the treatment of degenerative lumbar disease despite numerous concerns. They bring up a very important issue: Is the tendency towards more extensive fusions and more and more metal of value to patients?

We must also be aware that the surgical decompression is only a symptomatic procedure, and a single decompression may not eliminate the pathomechanism of an ongoing spinal stenosis. The surgical management of lumbar spinal stenosis with decompression and additional instrumentation will treat the local instability as a cause of progressive stenosis, but the rigid fixation of the affected levels provokes an overloading and acceleration of the degenerative spondylosis in the adjacent motion segments [16]. In fact, only a few patients really required additional lumbar instrumentation after surgical decompression because of progressive instability [15, 38, 48, 53]. Most elderly patients, especially women, have osteoporosis and the prevalence increases with age. The laminectomy with fusion for an osteoporotic patient carries the risk of operation-related problems as screw loosening, which may lead to the loss of correction and nonunion. Its rate ranged from 0.6 to 11% of the cases [37]. Considering that lumbar spinal stenosis often is a multi-segmental disease, stabilization procedures seemed to be also only a symptomatic and temporary treatment modality.

In the other hand extensive open decompression is associated with significant pain, prolonged hospitalization and recovery period, morbidity, and an increased incidence of medical complications. The most important event leading to the stress response is tissue trauma. Indeed, the greater the trauma, the greater the response [21]. Extensive surgical tissue trauma can also result in delayed functional sequelae as well.

Commonly used techniques of exposure for lumbar decompression that include elevation of the multifidus bilaterally with subsequent wide retraction have potentially serious consequences. Mayer et al [33] demonstrated a decrease in paraspinal muscle strength with concomitant atrophy on postoperative computed tomography scans. See and Kraft [43] echoed these concerns in their observation of chronic denervation and electromyographic abnormalities of the paraspinal muscles 4 years after open surgery. Sihvonen et al [44] noted similar computed tomography and electromyographic abnormalities and correlated these with the postoperative failed back syndrome. The described technique of microdecompression limits ipsilateral retraction to the level of the medial facet border. Contralaterally, no elevation or retraction of the paraspinal musculature is undertaken, thereby minimizing the risk of iatrogenic muscular trauma and therefore prove to be an important tool in decreasing the risk of these undesirable sequelae.

Most surgical approaches to decompression involve excision of the interspinous or supraspinous ligament complexes, altering an already pathologic biomechanical milieu. Loss of the midline supraspinous/interspinous ligament complex can lead to a loss of flexion stability, thereby increasing the risk of delayed spinal instability [49, 50]. Goel et al [13] found that, under normal conditions, the supraspinous ligament experienced the greatest force when exposed to an external flexion moment across an anatomic segment. Hindle et al [19] also demonstrated load with flexion in the supra- and interspinous ligaments. Prestar [40] observed similar findings and believed that, in regions lacking this ligamentous support, the paraspinal musculature must come to the aid of stability. The biomechanics of the normal spine have been extensively studied. The supra- and interspinous ligaments resist 19% of flexion forces, with the facet capsular ligaments resisting 39% and the disc resisting 29% [2, 3]. The supra/intraspinous ligamentous complex has the greatest mechanical advantage because it is farthest from the axis of rotation. It is also the first to fail in flexion [3].

Postsurgical dead space has serious potential consequences. Increased volume to be filled results in increased blood loss and provides an ideal bacterial culture medium with potential for increasing the infection rate. Dead space and its consequent risks are significantly decreased using the described technique [53].

Besides, complete decompression may not be necessary to achieve symptomatic relief as previously suggested by Aryanpur and Ducker [6]. Thomas, et al. [47], reported a statistically significant increase in dural sac size after laminotomy or laminectomy but found no statistical relationship between the extent of decompression and clinical outcome. It may only be necessary to bring the patient below a symptomatic threshold. Indeed, in one of the only studies correlating the degree of radiographic with clinical outcome, it was observed that the satisfaction of patients with the results of surgery (e.g., Oswestry score and walking capacity) was more important in surgical outcome than the degree of decompression as seen on a postoperative CT scan [17]. Herno et al [17] have shown that the clinical results were similar in patients whether they had undergone complete decompression of all stenotic levels, complete decompression in one level but no decompression in adjacent stenotic level, or incomplete decompression of all stenotic levels. It seems that the decompression of LSS should be adequate but it does not need to be complete.

Instead of combining fusion with decompression and thus maximizing surgery and associated perioperative risks, other investigators have attempted to decrease the operative failure rate by minimizing the invasiveness of the decompressive procedure. Fenestration with minimal soft tissue dissection and limited bone removal instead of extensive laminectomy to prevent subsequent lumbar instability has become widely accepted for the treatment of spinal stenosis [15, 31, 38, 48, 53]. A unilateral approach for bilateral decompression has been modified and performed successfully by many surgeons [1, 10, 38]. We therefore undertook a prospective study of this technique.

Discectomy was performed in seven patients with concomitant disc herniations. There has been concern that disruption of the annulus fibrosus might increase the risk of iatrogenic spondylolisthesis. Hopp and Tsou [20] performed disc excision in half of their 344 patients and found no relationship between this surgery and postoperative vertebral instability. In our seven patients no postoperative subluxation occurred.

As mentioned previously, total laminectomy is associated with improvement in 64% of patients at 3 to 6 years after surgery according to a metaanalysis [52]. Postacchini, et al., [41] demonstrated good results in 78% (25 of 32 patients) at 4 years. The authors of a study that used standardized patient-derived measures of symptom relief 4 years after decompression reported a success rate of just 57% [25]. In a large retrospective study, Airaksinen, et al., [5] found good outcomes after 4 years in 62% of their 438 patients, whereas others have described satisfactory results in approximately 70% [22, 45]. In a literature review Herron and Mangelsdorf [18] reported rates of good outcome ranging from 50 to 86% and stressed that results deteriorated over time. Recently, success rates of 68% (in 27 of 40 patients) [48] have been reported.

Following the description of the bilateral laminotomy technique [29], the authors of clinical case series reported good results in 90% (29 of 32 patients) [6] , and 80% (in 32 of 40) [48] at 1 year; 87% (13 of 15) [14], 78% (21 of 27) [56], and 68% (34 of 50) [49] at 2 years; 85% (27 of 32) [57] at 3 years. Nevertheless, Postacchini, et al. [41] prospectively and, Thomas, et al. [47], and Kalbarczyk, et al. [24] retrospectively compared bilateral laminotomy and laminectomy and found no difference in outcome.

The authors who performed unilateral laminotomy for bilateral decompression, demonstrated good results in 87% (26 of 30 patients) [53] at 9 months; 82% (18 of 22) [32] at 1 year; 88% (22 of 25) [46], and 70% (in 28 of 40) [48] at 18 months; and 67,6% (in 23 of 34) [7] at 2 years; and 68% (in 15 of 22) [32] at 4 years in their studies.

In the present randomized study, patient satisfaction rate was 94%, and its improvement rate was 96% during the 18 to 24-months follow-up period. These results are in accordance with other outcome parameters, such as VAS and SF-36. None of our patients showed vertebral hypermobility, or a significant increase in spondylolisthesis after surgical procedures. For degenerative lumbar spinal stenosis with or without mild degenerative spondylolisthesis, unilateral approach usually allows sufficient decompression of the neural structures and adequate preservation of vertebral stability. Certainly, long-term follow-up is needed to confirm these results because every decompressive procedure bears the risk of secondary instability, which may require further stabilization.

CONCLUSION

We think that the goal of the unilateral approach to treat lumbar spinal stenosis is to achieve adequate decompression of the neural elements. An additional benefit of a minimally invasive approach may be the potential to decrease a patient's postoperative pain and disability as well as to decrease hospital lengths of stay and thereby treatment costs.

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