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Clinical Article

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Minimally Invasive Lumbar Spinal Decompression : A Comparative Study Between Bilateral Laminotomy and Unilateral Laminotomy for Bilateral Decompression

Objective : Bilateral laminotomy and unilateral laminotomy for bilateral decompression are becoming the minimally invasive procedures for lumbar spinal stenosis (LSS). With the aim of less invasiveness and better preservation of spinal stability, these techniques have been developed. But there are no large randomized studies to show the surgical results between these two techniques. The objective of this study was to examine the safety and efficacy of these two minimally invasive techniques.

Methods : A total of 80 patients were included in this study (Group I : bilateral laminotomy, Group II : Unilateral laminotomy for bilateral decompression). Perioperative parameters and complications were analyzed. Symptoms and scores such as visual analog scale (VAS) scores, Oswestry Disability Index (ODI) scores, and SF-36 scores of prospectively accrued patients were assessed preoperatively and at 1 month and 12 months after surgery. Paired-t test, two-sample student-t tests, and nonparametric tests were used to determine cross-sectional differences between two groups.

Results : No major complications such as spinal instability or deaths occurred during follow-up periods. VAS, ODI scores and SF-36 body pain and physical function scores showed statistically significant improvements in both groups ($p<0.001$). The significant widening of the spinal canal diameter was also noted in both groups. But, in Group II, there were minor postoperative complications such as dural tear (2 cases 5.0%), fracture of ipsilateral inferior facet (1 case 2.5%), and 5 cases of transient leg symptoms of contralateral side.

Conclusion : Both bilateral laminotomy and unilateral laminotomy for bilateral decompression allow achievement of adequate and long-lasting operative results in patients with LSS. But postoperative complications are more frequent in Group II (unilateral laminotomy and bilateral decompression). These results indicate that bilateral laminotomy is the preferred minimally invasive technique to treat symptomatic LSS.

KEY WORDS : Lumbar stenosis · Laminotomy · Results · Minimally invasive surgery.

INTRODUCTION

Lumbar spinal stenosis (LSS) is being diagnosed increasingly in elderly as advanced imaging studies. For symptomatic patients, the goal of surgery is to relieve pain and to improve function. There are various surgical procedures used in the decompression of LSS including laminectomy, laminoplasty, or wide decompression with or without fusion. But so far, LSS has usually been treated by a wide laminectomy with spinal fusion. With the development of minimally invasive surgical techniques, bilateral laminotomy and unilateral laminotomy for bilateral decompression (ULBD) have recently been performed as one of the treatment options for spinal stenosis[1,9,11,13]. It was hypothesized that these techniques yield better clinical outcome by preserving the structural integrity of the posterior spine. But, there is little empiric evidence to support the surgical outcome. The purpose of this study was to examine the safety and efficacy of minimally invasive techniques for LSS, namely, bilateral laminotomy and ULBD.

MATERIALS AND METHODS

Patients population

A prospective clinical follow-up review was performed for 80 consecutive patients who underwent microsurgical decompression of one level symptomatic LSS refractory to conservative

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Table 1. Summary of the baseline characteristics of patients

	Group I (bilateral laminotomy)	Group II (Unilateral laminotomy and bilateral decompression)
Patients (No.)	40	40
Male:Female	17:23	19:21
Mean age (years)	67.2	62.9
Mean body mass index	27	25.2
Mean dural sac of most stenotic cross-sectional area (mm^2)	60.25±18.50	62.39±20.00
Affected level		
L3-L4	10	8
L4-L5	28	30
L5-S1	2	2
Symptom (No. of case)		
*LBP	37	33
Leg pain	35	37
†NIC	39	38
Numbness	39	36

*LBP : low back pain, †NIC : neurogenic intermittent claudication

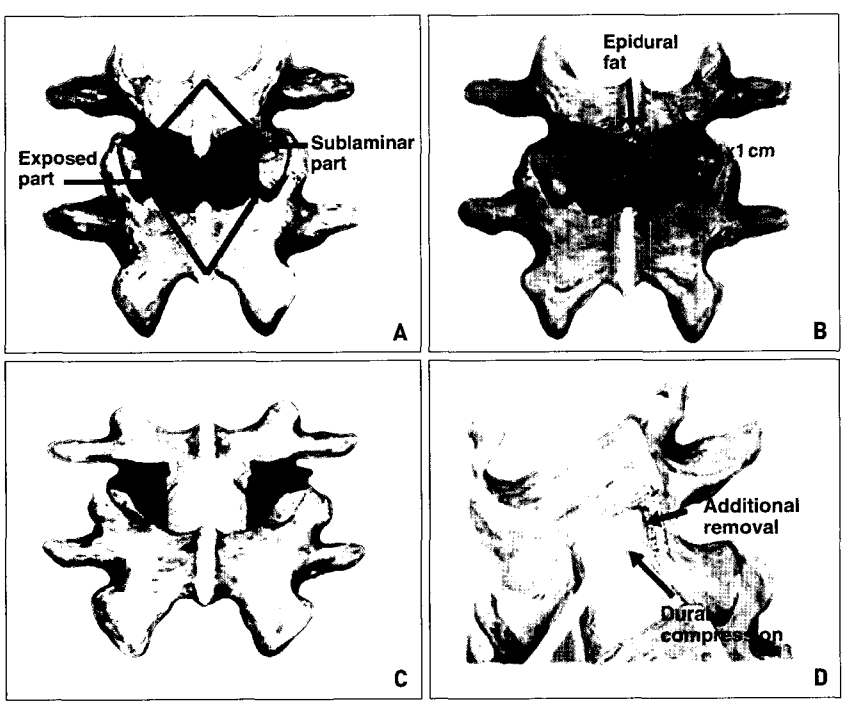

Fig. 1. Surgical procedure of bilateral laminotomy. A : Midline is incised on the supraspinous and infraspinous ligaments and spinous processes and lamina are elevated subperiostealy and paraspinal muscles are retracted bilaterally. B : Removal of lower 1/3 of upper spinous process to the base and then expose yellow ligament underneath. C : Detachment of sublaminar part with curved sharp-tipped freer and removal of exposed part of the yellow ligament. D : After tilting of patient to opposite side from the operator the lateral sublaminar part of ligament is detached and removed and mesial facetectomy can be done if needed.

treatment between 2003 and 2004 (Table 1).

Group I (n=40) consisted of patients who underwent bilateral laminotomy and decompression (Fig. 1) and Group II (n=40) was of ULBD (Fig. 2).

All patients fulfilled the following inclusion criteria : 1) narrowing of the central portion of the spinal canal with an area of the dural sac measuring less than $80mm^2$ at one intervertebral level, 2) neurogenic claudication as defined by leg pain limiting standing, ambulation, or both, 3) age more than 50 years, and 4) preoperative and postoperative MR evaluation. The exclusion criteria were : 1) previous back surgery, 2) age less than 50 years 3) decompression for malignancy and decompression with instrumented fusion, and 4) the presence of instability, spondylolisthesis or combined disc herniation. We conducted an analysis of prospectively maintained patient databases. The databases contain patient's demographic, surgical, and complication data as well as pre- and postoperative outcome scores. The pain was measured separately for low back and leg pain using self-assessment 10-point VAS. Disability, physical or health status was assessed using ODI and SF-36 health survey[15]. The primary study endpoints were changes in VAS, ODI, and SF-36 scores, length of hospitalization, and perioperative complications. All operations were performed by one author and an operating microscope (Carl Zeiss Co., Germany) was used in all cases. Standardized self-assessment questionnaires were used at preoperative, 1 month and 12 months after surgery. All values are expressed as the means ±SDs. Pre-and postoperative VAS pain score, ODI, and SF-36 quality of life indices as well preoperative clinical and demographic characteristics were compared by using paired t tests, chi-square test and Fisher exact test. A p-value less than 0.05 was considered statistically significant.

RESULTS

Between 2003 and 2004, 80 patients were at least 50 years of age among those underwent minimally invasive lumbar spine decompression for spinal stenosis (Group I : bilateral

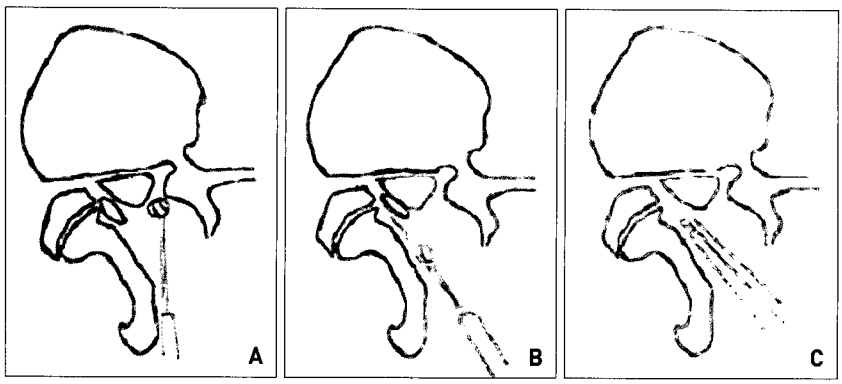

Fig. 2. Schematic drawing of unilateral laminotomy and bilateral decompression. A : Removal of the ipsilateral lamina and ipsilateral ligamentum flavum. B : The base of the spinous process is undermined under the microscope. C : Undercutting the medial part of the facet with rongeur or punch and performing contralateral decompression under direct vision.

Table 2. Self-reported postoperative results of Group I (Bilateral laminotomy)

	Preoperative	Postoperative (1 month)	Postoperative (12 months)	*p*-value
VAS				
Back	5.5±1.2	2.2±0.8	2.5±1.0	<0.001
Legs	5.7±1.2	2.1±1.2	2.2±1.1	<0.001
ODI	47±10.7	22±9.8	22±11.1	<0.001
SF 36				
Physical function	25±11.0	46±12.3	46±12.1	<0.001
Body pain	27±15.0	50±14.3	48±14.3	<0.001
General health	60±15.3	65±9.0	66±9.0	0.52

Table 3. Self-reported postoperative results of Group II (Unilateral laminotomy and bilateral decompression)

	Preoperative	Postoperative (1 month)	Postoperative (12 months)	*p*-value
VAS				
Back	5.6±1.2	2.4±0.9	2.5±1.1	<0.001
Legs	5.6±1.4	2.8±1.3	2.2±1.2	<0.001
ODI	46±12.2	24±8.7	22±10.2	<0.001
SF 36				
Physical function	22±12.1	37±14.3	38±12.5	<0.001
Body pain	23±17.2	42±13.9	42±12.6	<0.001
General health	60±19.7	68±15.4	66±24.8	0.60

Table 4. Complications of lumbar decompression surgery

Complication	Group I	Group II
Spinal instability	0	0
Unintentional dural tear	0	2
Inferior facet fracture	0	1
Transient dysesthesia	0	5

laminotomy and decompression, Group II : ULBD). All patients were evaluated for at least one year period. There were no intergroup significant differences in the preoperative characteristics (Table 1). The median length of hospitalization was 5.9 days (Group I) and 6.2 days (Group II) respectively. There was no significant difference in the length of hospitalization between the Group A and Group B.

The VAS, ODI and Short-Form 36 body pain and physical function scores showed statistically significant improvements after surgery in both groups ($p<0.001$). The SF-36 General health score alone did not show significant improvement in both groups (Table 2, 3). The preoperative dural sac cross-sectional area at the level of most stenosis was $60.25\pm18.5mm^2$, whereas on postoperative scans it was $98.15\pm22.10mm^2$ in Group I ($p<0.05$). In Group II, there was also significant canal widening from preoperative 62.39 ± 20.00 to postoperative 97.00 ± 21.95 ($p<0.05$). No major complications or perioperative deaths occurred and no vertebral instability was detected in both groups. But, in group II, there were minor postoperative complications such as dural tear (2 cases 5.0%), fracture of ipsilateral inferior facet (1 case 2.5%), and 5 cases (12.5%) of transient leg symptoms of contralateral side (Table 4).

DISCUSSION

Spinal stenosis is the most common surgical indication for the geriatric patients[5]. These elderly patients frequently have comorbid medical conditions such as cardiovascular disease, low respiratory reserve, exercise intolerance, and profound osteoporosis[6].

Traditional total laminectomy with or without fusion remains the standard operative technique for LSS. However, traditional bilateral laminectomy is burdened by postoperative complications, such as vertebral instability, severe atrophy of paraspinal muscles, and posterior scarring, which can lead to poor results[4,12,14]. Especially, spinal instability has been implicated as a cause of surgical failures, because wide posterior decompression significantly alters spinal anatomy and biomechanics, thus prompting many neurosurgeons to perform fusion procedures to treat lumbar stenosis[7]. But spine fusions in the elderly population are associated with many complications and high morbidities such as

pseudoarthrosis rates[2]. Instead of combining fusion with decompression and thus maximizing surgical and associated perioperative risks, operative options that are less invasive, such as the modified bilateral laminotomy involving spinous process osteotomies and, in particular, the unilateral laminotomy for bilateral decompression (ULBD), have been introduced during the past years[8,13]. It was hypothesized that these approaches have the theoretical advantages of minimizing tissue injury, thereby reducing the likelihood of an adverse surgical stress response, while maintaining the spine's structural integrity and stability. But, only limited follow-up data exist to confirm this hypothesis. The results of this study demonstrate that minimally invasive surgeries such as bilateral laminotomy or ULBD can be an effective treatment for LSS.

VAS, ODI, and SF-36 Bodily Pain scores demonstrate significant improvements after surgery and the SF-36 Physical Function score was improved in most of the patients of both groups. However, surgery-related complications were more common in the group of ULBD even though they were minor and acceptable ones. Unilateral laminotomy and bilateral decompression is a minimally invasive surgical technique which can be used to treat lumbar spinal stenosis. Because decompression of the contralateral side can be performed simultaneously via unilateral approach, and the midline and contralateral posterior spinal structures can be preserved during ULBD. Therefore, it is expected that the number of patients who need spinal fusion after having ULBD is much less than that of patients who need spinal fusion after having conventional posterior decompression procedures[11]. The clinical outcomes of ULBD have been reported to be comparable to those of standard laminectomy[3,13]. Recently, several authors have modified the surgical techniques of ULBD with using a tubular retractor or a microendoscopic system, which resulted in smaller skin incisions and less injury to the paraspinal muscles[8]. However, several perioperative complications have been reported with this approach. According to the report of Ikuta et al. who analyzed the short-term results of performing ULBD for spinal stenosis with using the microendoscopic system, the postoperative complication rate was 31.9%; there were some dural tears, fractures of the inferior facet joint, one postoperative epidural hematoma and seven transient leg symptoms on the contralateral side[3,10]. They thought that the transient leg symptoms on the contralateral side might be due to nerve root compression that occurred during surgery or to the postoperative epidural hematoma. When performing ULBD, ligamentum flavum on the contralateral side is removed while the contralateral lamina is preserved. Therefore, there is always potential dead space between the contralateral lamina and the dural sac. Furthermore, bleeding control of the cephalad or caudal end on the contralateral side via the ipsilateral laminectomy site may be troublesome.

In this study, the surgical procedure carried out in Group I is bilateral laminotomy following removal of the posterior 1/3 of spinous process. This procedure achieves complete decompression of nerve root through removal of ligamentum flavum occupying lateral recess and the medial partial resection of facet joint if necessary. It allows more effective decompression under the direct vision with minimizing nerve root irritation. It is considered that bilateral laminotomy for degenerative LSS is effective for symptom relief and prevention of spinal instability caused by weakness of facet joint. It also brings little complications compared to ULBD.

CONCLUSION

Both bilateral laminotomy and ULBD lead to good surgical outcome to the patients with LSS. These two surgical procedures result in substantial widening of the spinal canal and increased cross-sectional area of the dural sac. These procedures can make good results without the risk of postoperative segmental instability and can yield highly significant improvement in symptoms. However, perioperative minor complications are less common in the patients having bilateral laminotomy compared to ULBD.

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COMMENTARY

Traditional treatment of lumbar spinal stenosis has been wide laminectomy involving undercutting of the medial facet and foraminotomy. A variety of less extensive resections have been proposed in an attempt to preserve normal spinal anatomy. The goal of limited resection is to lessen the risk of postoperative spondylolisthesis, but it is important not to compromise neural decompression in an effort to perform minimally invasive surgery. The primary goal of the procedure is to achieve adequate decomprssion of the neural elements. Minimally invasive procedures have had increasing application in spinal surgery. More limited decompressive procedures including bilateral foraminotomies and unilateral approaches for bilateral decompression have been shown to be effective.

The authors compared the results of surgical decompression between bilateral and unilateral laminotomies for bilateral decompression of aquired lumbar spinal stenosis, and they suggested that both procedures could make good surgical results without the risk of postoperative segmental instability and could yield highly significant improvement in symptoms. Perioperative minor complications were less common in the patients having bilateral laminotomy compared to unilateral laminotomy. The authors seemed to be in favor of the bilateral laminotomies for adequate decompression of aquired lumbar spinal stenosis.

As the results had shown unilateral laminotomy is associated with more frequent minor complications compared to bilateral laminotomies especially in patient with severe lumbar stenosis in which the dural sac appears as the letter "1" on preoperative T2-weighted axial MR images. It is recommended to perform bilateral laminotomies for adequate decompression in such a severe stenotic cases without sticking to unilateral laminotomy. When the operator makes a decision that unilateral laminotomy is not adequate for bilateral decompression, changing the decompression method to bilateral laminotomies during operation is not to be blamed as it dosen't give any additional damage to the patient.

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