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Expansive lumbar laminoplasty for degenerative spinal stenosis in patients below 70 years of age

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Abstract We reviewed the clinical and radiological results of patients with lumbar degenerative spinal stenosis who underwent expansive laminoplasty with a mean follow-up term of 5.6 years. Twenty-seven patients underwent open-door-type expansive lumbar laminoplasty, which has both decompression and stabilization effects. Clinical results were assessed based on the score system devised by the Japanese Orthopaedic Association (JOA score). The number and causes of repeat surgery were also evaluated. Radiological changes, such as degenerative scoliosis and spondylolisthesis, were evaluated at the operated levels and at levels L1–L5. There was marked recovery of clinical symptoms assessed by pre- and postoperative JOA score. Nearly 80% of patients obtained good or excellent results. Only one patient (4%) required additional surgery, which involved discectomy at the caudal level of the laminoplasty. Radiographic evaluation revealed that postoperative changes of spondylolisthesis and scoliosis were slight both in the expanded area and the L1–L5 levels. Range of motion of the disc space angle in the expanded area showed a significant decrease postoperatively. However, pre- and postoperative radiological changes showed no significant correlation with JOA score changes and repeat surgery. In conclusion, lumbar fusion after posterior decompression in active patients with spinal stenosis offers satisfactory clinical results concomitantly with a relatively small risk of repeat surgery.

Key words Spinal stenosis · Lumbar spine · Expansive laminoplasty

Introduction

To accomplish relief of leg pain and neural claudication in degenerative lumbar spinal stenosis, all symptomatic neural elements must be decompressed. However, the significance of lumbar fusion following posterior decompression is still controversial [1, 14]. Although decompressive wide laminectomy is one of the most commonly performed operations for this disease, postoperative instability is, to some degree, unavoidable in degenerative and/or spondylolisthetic spinal stenosis [5, 8]. Some authors have reported a satisfactory outcome with laminectomy alone [2, 4], whereas others have reported better results with laminectomy in conjunction with spinal fusion [3, 12]. To preserve the facet joints, we performed trumpet laminectomy, in which the minimal width of the lamina is removed, and the posterior wall of the lateral recess is chiseled out obliquely in degenerative lumbar stenosis [9, 17]. However, repeat surgery and progression of radiological degenerative changes cannot be avoided even using trumpet laminectomy [9]. From 1983, for active patients with this disease, we utilized expansive laminoplasty to obtain both neural decompression and spinal stability [13, 17, 18]. The purpose of the present study was to review the clinical and radiological outcome of posterior decompression surgery with fusion for degenerative lumbar stenosis in patients below 70 years of age at the time of operation.

Materials and methods

Forty-six patients with degenerative lumbar stenosis were surgically treated by expansive laminoplasty at the University Hospital between 1984 and 1995. Patients whose age at operation was 70 years and over and those with a minimum follow-up term of less than 2 years were excluded. There were 27 patients who underwent expansive laminoplasty between 1984 and 1993, consisting of 20 men and 7 women, with a mean age of 53.3 years (range: 37–69 years). The average number of laminae that received expansive laminoplasty was 3.2 (range: 2–6 laminae). The average follow-up term was 5.6 years. The clinical diagnosis was made by physical examination, plain radiography, CT, and myelography. All patients had lumbar spinal stenosis at more than one level and presented intermittent claudication. Namely, they presented symptoms from central canal stenosis with or without lateral stenosis. Regarding lesions associated with degenerative spinal stenosis, degenerative spondylolisthesis was found in five patients, disc herniation in seven, and ossification of the intraspinal ligament in eight. Informed consent for this study was obtained from all patients.

Surgical method

The surgical method of expansion of laminae is similar to open-door laminoplasty for cervical spinal stenosis [6]. After making grooves just medial to each facet joint using an air drill, the laminae are turned up to an angle of about 45° at the open side. Bone grafts, which are harvested from the spinous process, are placed in the open side gap and tied with a steel wire, which is passed through the laminae, the bone graft, and the articular process. The laminae and facet joint are decorticated with an air drill, and corticocancellous sliver bone graft and cancellous bone chips from the posterior ilium are placed in the decorticated bone surfaces (Fig. 1) [17, 18].

Postoperative course

Standing and walking were allowed 1 week after surgery. A body cast was applied for 1 month and then a soft brace was applied for approximately 2–3 months.

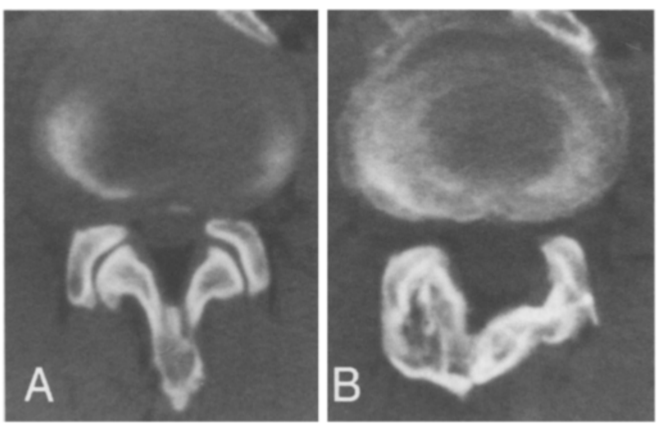

Fig. 1A, B CT appearance in a patient who underwent expansive laminoplasty. **A** Preoperative CT: degenerative spinal stenosis at the central and lateral canal is demonstrated. **B** Postoperative CT: spinal canal is enlarged into a rectangular shape; bilateral facet joints are completely fused

Table 1 The evaluation system for the treatment of low back pain disorders devised by the Japanese Orthopaedic Association [7]. (MMT = manual muscle testing)

	Score
Subjective symptoms	
Low back pain	
None	3
Occasional mild pain	2
Frequent mild or occasional severe pain	1
Frequent severe pain	0
Leg pain and/or numbness	
None	3
Occasional mild leg pain and/or numbness	2
Frequent mild or occasional severe leg pain and/or numbness	1
Frequent severe leg pain and/or numbness	0
Walking capacity	
Normal	3
Able to walk > 500 m with leg pain and/or numbness	2
Able to walk for 100–500 m	1
Able to walk for <100 m	0
Clinical signs	
Straight leg raising test	
Normal	2
30°–70°	1
< 30°	0
Motor function	
Normal	2
Slight weakness (MMT: good)	1
Severe weakness (MMT: less than good)	0
Sensory function	
Normal	2
Minimal sensory disturbance	1
Apparent sensory disturbance	0
Bladder function	
Normal	0
Mild dysuria	–3
Severe dysuria	–6

	Impossible	Difficult	Easy
Restriction of activities of daily living			
Tossing about in bed	0	1	2
Standing up	0	1	2
Washing face	0	1	2
Half-sitting posture	0	1	2
Sitting	0	1	2
Lifting	0	1	2
Running	0	1	2
Total for normal			29

Clinical evaluation

Operation time and blood loss during surgery were evaluated. Pre- and postoperative neurology and symptom evaluation were assessed on the scale devised by the Japanese Orthopaedic Association (JOA score, Table 1) [7], which is composed of scores for evaluation of subjective symptoms, clinical signs (straight leg raising test, motor and sensory function, and urinary dysfunction), and restriction of activities of daily living; the normal scale has a maximum of 29 points. The average preoperative JOA score was 11.0 out of 29 points. The rate of recovery, which indicates the degree of normalization after surgery, was calculated by the following formula:

$$\frac{\text{postop. score} - \text{preop. score}}{\text{29 (full score)} - \text{preop. score}} \times 100$$

A recovery rate of more than 75% was graded as excellent, from 50 to 75% good, from 25 to 50% fair, and 25% and less was considered as poor.

Radiological evaluation

Anteroposterior and neutral lateral lumbar spine radiographs were obtained pre- and postoperatively for each patient, and the increase of spondylolisthesis at the operated and unoperated levels and degenerative scoliosis at the L1–L5 and operated levels were measured (Fig. 2A, B). In nine patients who underwent laminoplasty between L3 and L5, flexion and extension radiographs were also taken to measure the pre- and postoperative disc space angle from L1–L2 to L5–S1 and the range of motion at each level was compared (Fig. 2C). Bony fusion in the expanded laminae was determined by consolidation of the grafted sliver bone in neutral lateral radiographs taken every 2 or 3 weeks after surgery.

Results

Clinical evaluation

The average operation time and blood loss per one lamina were 63.2 min (range: 37–94 min) and 246.2 g (range: 62–625 g), respectively. The incidence of blood transfusion was 9/27 (33.3%). In the recent cases, autologous blood transfusion was introduced and allogenic transfusion was avoided. There were no general or neurological complications intra- or postoperatively.

The average JOA score improved from 11.0 points (range: 4–20) preoperatively to 19.3 points (range: 11–25) at 2 months postoperatively on average. The recovery reached a plateau at 3 years of follow-up on average (average JOA score: 23.2, range: 16–28), which was still maintained at the average follow-up of 5 years (average JOA score: 23.8, range: 16–28; Fig. 3). The overall recovery rate as well as each item considered in the postoperative JOA score showed good restoration. The postoperative score for low back pain (2.5 ± 0.6) at the average follow-up of 5 years showed marked recovery compared with the preoperative score (1.4 ± 0.5). Ten patients were graded as excellent, 12 as good, 4 as fair, and 1 as poor. Thus, 22 (81%) of the 27 patients obtained good or excellent results (Table 2).

At a follow-up examination, a patient who had undergone L4–L5 laminoplasty complained of right leg pain 4 years postoperatively. The patient had an extraforaminal

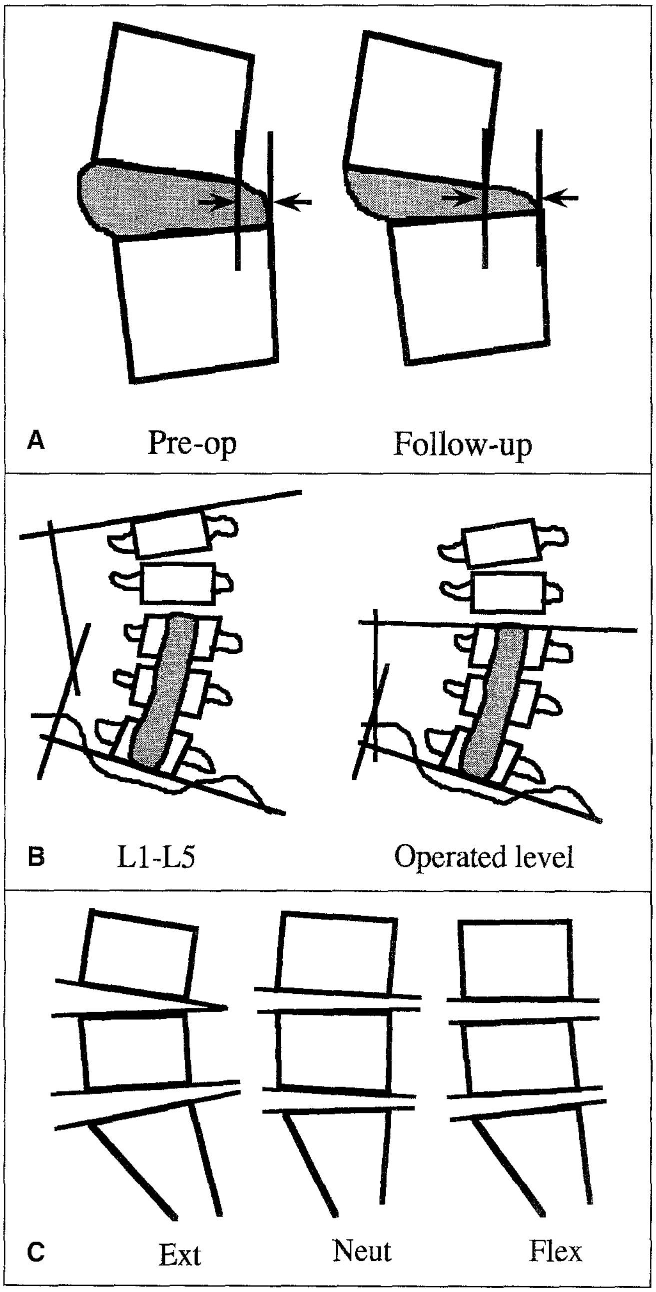

Fig. 2 A–C Schemas illustrating methods for measuring radiological changes. **A** Measurement of degenerative spondylolisthesis. An increase in degenerative spondylolisthesis of more than 3 mm was considered significant. **B** Measurement of degenerative scoliosis. An increase in degenerative scoliosis of more than 5° was considered significant. Degenerative scoliosis was measured at L1–L5 and at operated levels. **C** Measurement of the disc space angle in functional radiographs. Disc space angles in extension, neutral, and flexion positions were measured on radiograph in nine cases

L5–S1 disc herniation that caused right L5 nerve root compression symptoms. The disc herniation was located at the hinge side and caudal end of the laminoplasty. Through the lateral fenestration, the disc herniation was

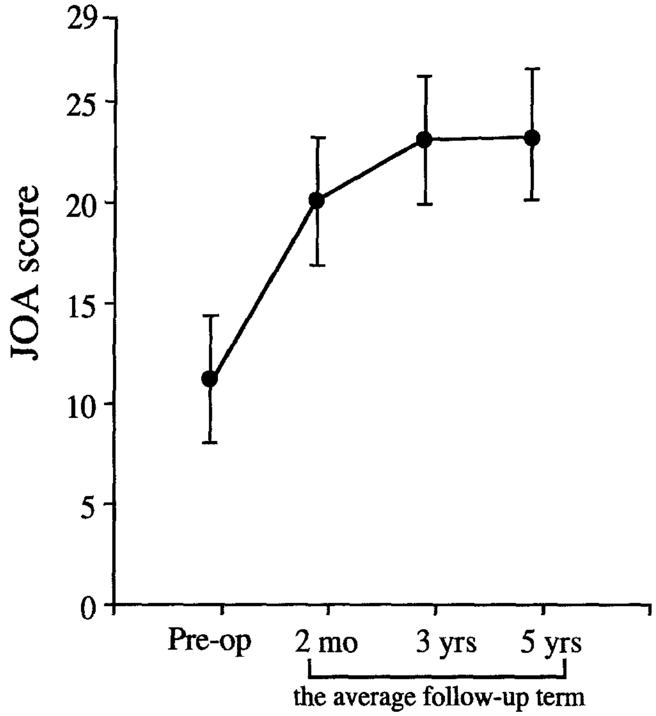

Fig. 3 Clinical results according to serial changes of JOA score. Recovery of preoperative symptoms and signs assessed by JOA score reached a plateau at 3 years' follow-up, which was still maintained 5 years after surgery on average

Table 2 Summary of clinical and radiological results in patients who underwent expansive laminoplasty

Clinical results		
Blood loss (g/level)		246.2 ± 189.0
Operation time (min/level)		63.2 ± 17.9
No. patients requiring blood transfusion		9
Bony fusion (months)		3.8 ± 1.2
Neurological and subjective changes		
Preop JOA score[a]		11.0 ± 3.9
Postop JOA score		23.8 ± 3.0
Rate of recovery (%)		80.1 ± 15.5
Overall result (*n*)		
Excellent		10 (37%)
Good		12 (44%)
Fair		4 (15%)
Poor		1 (4%)
No. of repeat operations		1 (3.7%)
Radiological results	**Preop**	**Postop**
Mean disc angle motion at the operated level ($n = 9$)	7.2°	3.4°[b]
Spondylolisthesis (> 3 mm)		
Operated level		0/27
Unoperated level		1/27
Degenerative scoliosis (> 5°)		
Operated level		1/27
L1–L5		1/27

[a] The evaluation system for the treatment of low-back pain disorders devised by the Japanese Orthopaedic Association (Table 1)
[b] There is a significant decrease in disc angle motion compared with the preoperative value

resected. The patient showed marked symptom recovery and returned to work.

Radiological evaluation

The time taken to achieve bony fusion in the region of laminoplasty was 3.8 months on average. In the nine patients who underwent L3–L5 laminoplasty, the average range of motion of disc space angle in the expanded area in the flexion-extension radiographs significantly decreased from 7.2° preoperatively to 3.4° per one intervertebral level postoperatively (Fig. 4).

Progression of degenerative spondylolisthesis (> 3 mm) was observed in one patient, who showed a 4-mm progression of anterior slip at the cranial edge of laminoplasty. There was no progression of spondylolisthesis in the operated levels of laminoplasty. Regarding degenerative scoliosis, one patient showed progression of degenerative scoliosis (> 5°) both in L1–L5 and in the expanded area (Table 2). However, these radiological changes were not directly correlated with the causes of repeat surgery.

Discussion

Bone union of expansive laminoplasty usually occurs 3–4 months after surgery; the range of flexion/extension in L1–L5 is reduced with slight segmental mobility remaining [13, 18]. In the present study, the postoperative disc space angle on functional radiographs after laminoplasty revealed a stabilizing effect in the expanded area. The range of motion of expanded segments showed a decrease to half the preoperative value. This decrease of angular motion is similar to the results of spinal arthrodesis with bone grafting across the transverse process reported by Herkowitz and Kurz [3]. Senegas et al. reported another type of lumbar laminoplasty in 1988 [16]. They also preserved the posterior arches using dacron in addition to fusion with internal fixation. The effectiveness both regarding nerve tissue decompression and preservation of postoperative spinal stability is considered to be common among various types of laminoplasty. However, surgical trauma in lumbar laminoplasty is not small compared with laminectomy, as shown in the present study. We think that indications for lumbar laminoplasty should be limited to relatively young and active patients with degenerative spinal stenosis.

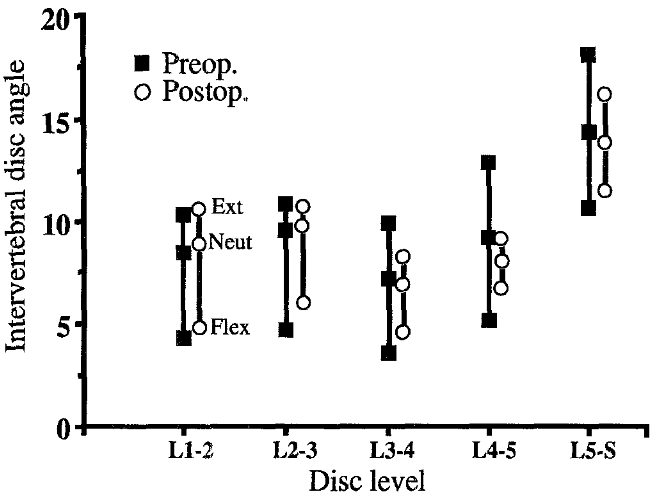

Fig. 4 Intervertebral disc angle motion before and after L3–L5 expansive laminoplasty. Each point indicates an average intervertebral disc angle on lateral radiographs in the extension, neutral, and flexion positions ($n = 9$). The motion of the postoperative intervertebral disc angle shows a decrease to half the preoperative value at the L3–L4 and L4–L5 levels

In patients with multisegmental spinal stenosis, laminectomy is one of the most commonly performed surgical treatments. However, postoperative aggravation of the degenerative changes such as degenerative spondylolisthesis or scoliosis can occur [5, 8, 9]. Tuite et al. [19] reported in a radiological study of laminectomized patients that the operated level shows a greater change in radiographic measurements such as spondylolisthesis or disc space angle after surgery compared to the unoperated levels. Herkowitz and Kurz [3] observed a significant increase in spondylolisthesis and vertebral angular motion in nonarthrodesis patients with degenerative spinal stenosis. The results of the present study on laminoplasty may indicate that the advantage of fusion following posterior decompression lies in its preventive effect for degenerative changes in the operated area. However, problems in the level adjacent to the laminoplasty area, such as in the reoperated case, may be inevitable in a long-term follow-up; an increased load may be placed on the disc adjacent to the fusion [15]. Therefore, regular examinations are necessary.

There are not many studies on long-term follow-up results after lumbar laminectomy. The incidence rate of repeat surgery after laminectomy is reported to be 18–23% [9–11]. Pathogenesis of repeat surgery has been attributed to recurrence of stenosis or occurrence of instability only in a few reports [9–11]. In the present study, the incidence of repeat surgery was only 4% and its cause was a disc herniation at the level adjacent to the laminoplasty. Minimization of the postoperative increase of degenerative changes by spinal arthrodesis may be a contributing factor for prevention of repeat surgery.

Expansive laminoplasty is most suitable for so-called central canal stenosis. However, lateral recess decompression can be performed at the open side with results as good as those achieved by trumpet laminectomy [9, 17]. When decompression of the lateral recess at the hinge side is required, decompressive fenestration should be performed before lifting up the laminae. For decompression of the nerve root tunnel, unroofing of the tunnel can be performed in the same manner. If intraspinal intervention, such as discectomy or removal of ossification of the ligamentum flavum, is necessary, access to the lesion is easy through the laminal opening after rotatory elevation of the laminae [13, 17, 18].

The advantages of laminoplasty are considered to be as follows: no recurrence of spinal stenosis due to osteophyte formation at the facet joint and reproduced lamina at the operated area, and a low risk of reoperation. However, in the long-term follow-up of more than 4 years, disc herniation at the level adjacent to the laminoplasty area was observed in one case. This may be a disadvantage of spinal fusion in laminoplasty. Surgical trauma in terms of the amount of bleeding and operation time in laminoplasty is more severe than that in laminectomy. However, autologous blood transfusion has recently been introduced and allogenic transfusion is hardly ever performed now. Although the low incidence of reoperation in laminoplasty was not decisive and further follow-up study is necessary, lumbar fusion following posterior decompression in active and relatively young patients with degenerative spinal stenosis offers good clinical results and it may decrease the risk of repeat surgery.

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