Microscopic decompression for lumbar spinal canal stenosis

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Study design
A retrospective review and prospective follow-up were performed of 106 patients who had undergone microscopic decompressive surgery without fusion in the year 2006 at Munich Spine Center, Germany.

Objective
This study aimed to determine the 4–5-year outcome of microscopic unilateral laminotomy for bilateral decompression in degenerative lumbar spinal stenosis and to detect the possible predictors of the surgical outcome.

Summary of background data
There is limited information on the impact of surgery for lumbar spinal stenosis on symptoms, functional status, and satisfaction, as well as reoperation.

Patients and methods
Patients were considered eligible for the study if they had clinical and radiographic evidence of degenerative lumbar spinal stenosis, including patients with degenerative spondylolisthesis type 1 according to Myerding and patients with degenerative scoliosis. All patients underwent microscopic decompressive surgery without fusion in the year 2006 at the Munich Spine Center, Germany. One hundred and six patients were available for follow-up during the year 2010.

Results
At 4–5 years after the operation, 76 (71.7%) patients were satisfied with the surgical outcome. The overall complication rate was 12.2%. 23 (21%) patients required a second operative procedure, whereas three (2.8%) patients required a third operative procedure after the index operation. Two of the 23 patients who had second operations had presumed instability and underwent fusion.

Conclusion
Unilateral laminotomy for bilateral decompression is an adequate microsurgical technique for decompression of lumbar spinal stenosis that minimizes operative invasiveness and tissue trauma while maximizing preservation of the spinal integrity and stability. Secondary postoperative instability is avoided and excellent long-term clinical outcome could be expected.

Keywords:
decompression, lumbar, microscopic, stenosis

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Introduction

The surgical management of lumbar degenerative spinal canal stenosis has become progressively less invasive. 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 [1]. A multitude of other surgical methods for decompression of lumbar spinal stenosis (LSS) has been developed.

Operative options that are less invasive, such as the bilateral laminotomy and, in particular, the unilateral laminotomy for bilateral decompression (ULBD), have been introduced over the past few years. It was hypothesized that these techniques yield better clinical outcome by minimizing tissue trauma and preserving the spinal architecture; however, limited follow-up data exist to confirm this hypothesis [2]. Therefore, the authors carried out the present study to evaluate the effectiveness and mid-term results of ULBD.

Patients and methods

Patient population

We performed a retrospective clinical follow-up review of 106 consecutive patients who underwent microscopic decompressive surgery using the ULBD technique (over the top decompression) without fusion in the year 2006 at the Munich Spine Center, Germany. All patients had clinical and radiographic evidence of degenerative

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lumbar spinal stenosis. All patients had limitation of functional activities because of back or lower extremity pain. The original preoperative plain radiographs were reviewed to ascertain the presence and extent of spondylolisthesis and scoliosis.

Computed tomography or MRI documented central or centrolateral compression of the cauda equina by degenerative lesions of the disc, facet joint, or ligamentum flavum in each patient. Patients were investigated at discharge and within 4–5 years postoperatively. Follow-up data were obtained from a questionnaire that was filled out during clinical follow-up visits, telephone interviews, or by mail. The questionnaire included the Oswestery Disability Index (ODI), current intensity of back and leg pain using the Visual Analogue Scale (VAS), repeat spinal surgery, self-reported general health status (excellent, good, fair, or poor), current comorbities, and satisfaction with the results of surgery.

Surgical technique [3]

Patients were operated upon by different surgeons at the Munich Spine Center. A surgical microscope (The OPMI Vario/NC 33 system; Carl Zeiss at Carl-Zeiss-Strasse 22, 73447 Oberkochen, Germany) was used. All patients were operated under general anesthesia.

The spinal canal is approached through a modified microsurgical interlaminar route, usually from the most symptomatic side. In cases with associated degenerative lumbar scoliosis, the approach from the convex side is preferred.

Positioning of the patient [3]

The patient is placed on a special operating table in the knee-chest position. The posterior part of the operating table can be tilted selectively to reduce or completely compensate lumbar lordosis. This not only leads to an enlargement of the spinal canal volume but also 'opens' the interlaminar space.

Localization [3]

A line for the skin incision is marked after localization of the disc space to be approached. After disinfection of the skin, a needle is placed parallel to the spinous process at the presumed level of the disc space. The needle is inserted on the contralateral side to avoid subcutaneous or intramuscular hematoma on the approach side. Lateral fluoroscopy verifies the correct placement of the needle at the level of the disc space.

Superficial exposure [4]

The operation is started with the microscope from the skin level. The fascia is opened in a semicircular manner, leaving the medial parts attached to the supraspinous ligament and the lamina. The paravertebral muscles are retracted after subperiosteal elevation. Retraction does not extend beyond the lateral border of the facet joint to avoid disruption of segmental innervation. The laminae of the adjacent vertebrae are exposed and the interlaminar window is cleaned of soft tissue. Usually, the window is very small and the yellow ligament is bulging. A self-retaining microdiscectomy retractor is then used.

Interlaminar exposure [4]

Using Kerrison rongeurs or a highspeed burr, an ipsilateral laminotomy of the cephalad hemilamina is performed. It is extended cephalad until the insertion of the ligamentum flavum is reached. A similar but less extensive laminotomy is then performed on the ipsilateral caudal lamina, which enables removal of the intervening ligamentum flavum and provides a midline hemidecompression.

The microscope is then angulated into the ipsilateral subarticular zone and, moving cephalad to caudal, soft tissue and bony stenosing pathology is excised using Kerrison rongeurs. This is done sequentially and throughout the interlaminar window until the cephalad and caudal nerve roots at the operative level are seen exiting freely into the foramen.

After complete ipsilateral microdecompression, the contralateral side is addressed. The microscope is angulated medially and, quite often, the patient tilted contralaterally, to provide visualization across the midline beneath the deepest portion of the interspinous ligament. This deepest portion is excised to allow the posterior surface of the contralateral ligamentum flavum to be seen. A probe is used to confirm that the anterior surface of the ligamentum is free from adhesion to the dura and the ligamentum is then resected sequentially from cephalad to caudal and medial to lateral.

Besides the previously described microscopic decompression, an additional discectomy at the index level was required in 17 patients of this series.

Discectomy was usually indicated for extruded soft disc material or a free fragment as violation of degenerated well-contained discs may lead to unnecessary destabilization of the anterior column.

In another seven patients, an interspinous spacer was inserted after microscopic decompression. The Coflex interspinous spacer (Paradigm Spine LLC; GmbH Eisenbahnstrasse 84 D-78573 Wurmlingen, Germany) was used. The main indications for use of the interspinous spacer were moderate to severe degenerative stenosis, with concomitant low back pain. None of these patients had degenerative spondylolisthesis; however, two of these patients had concomitant degenerative scoliosis.

Closure [4]

At the end of the procedure, there should be dural pulsations and four free nerves (two traversing and two exiting nerves). Hemostatic agents such as FloSeal (Baxter Healthcare, Fremont, California, USA) or Arista (Medafor, Bad Wiessee, Germany) can be used. If possible, the insertion of a drain is avoided. If there is a significant amount of epidural fat tissue left, the spinal nerves can be covered after gentle mobilization of the fat. The surgical field is irrigated with saline solution, and the fascia and the skin are closed with resorbable sutures.

Postoperative care [4]

The patients are allowed to mobilize within 6 h. In patients with more than two-level decompression, a short brace was recommended for 4–6 weeks postoperatively.

Results

Demographic data

The mean age of the patients at the time of surgery was 69.3 years (range, 45–90 years). Sixty one (57%) patients were men and 45 (43%) patients were women. Thirteen (12.3%) patients had degenerative spondylolisthesis type 1 according to Myerding. In these patients, lateral radiography in flexion and extension excluded instability of the segment of the spondylolisthesis.

Although 19 (17.9%) patients had degenerative scoliosis, these were mostly minor curves with a predominant complaint of neurogenic claudication.

The average duration of symptoms was more than 2 years (27 months).

Neurogenic claudication was evident in 84 (79.2%) patients, which reflects a central stenosis, whereas 22 (20.8%) patients complained of sciatica alone, which reflects lateral recess stenosis. Neurological motor examination was normal in 83 (78.3%) patients. Deficits in motor power were present in 23 (21.7%) patients. In 105 (99%) patients, the decompressive surgery was elective, whereas in one patient, there was a cauda equina syndrome with bladder and bowel dysfunction and the surgery was performed emergently. The average preoperative walking distance was 450 m.

The questionnaire included an item on how the patients rate their current general health. Five patients rated their general health as excellent, 50 patients as good, 35 patients as fair, and 16 patients as poor.

Overall, a total of 202 laminotomies were performed in the 106 patients; 39 (36.8%) patients were decompressed at one level, 42 (36.8%) patients at two levels, 21 (19.8%) patients at three levels, and four (3.8%) patients at four levels. In 17 patients, an associated disc herniation was removed (16%). The most affected level was L4–L5 (82.1%). The distribution of symptomatic spinal stenotic levels decompressed is shown in Table 1.

Comorbidity was high. The coexisting medical diseases are shown in Table 2.

The mean operating time was 63 min per segment and the average blood loss was 57 ml/segment.

Outcome after surgery

The leg pain intensity on the VAS decreased from 7.8 preoperatively to 2.3 at 4–5 years of follow-up, whereas the back pain decreased from 7.2 to 3.2. The results were analyzed statistically using the paired *t*-test and the *P* values for both leg pain (P=0.000) and back pain (P=0.000) were highly significant.

Table 1 Distribution of spinal levels of symptomatic lumbar spinal stenosis and surgical intervention

Level decompressed	Patients [*n* (%)]
L1/L2	5 (4.7)
L2/L3	28 (26.4)
L3/L4	68 (64.2)
L4/L5	87 (82.1)
L5/S1	14 (13.2)

Table 2 Comorbidites and their distribution in the patient cohort

	Patients [*n* (%)]
Hip arthrosis	23 (21.7)
Knee arthrosis	34 (32.1)
Neurologic disease	9 (8.5)
LL vascular	8 (7.5)
Rheumatoid	10 (9.4)
DM	14 (13.2)
Circulatory	31 (29.2)
Lung	6 (5.7)
Depression	10 (9.4)
Others	11 (10.4)

DM, diabetes mellitus; LL, lower limb.

At 4–5 years after the operation, the results of the ODI were as follows: excellent in 51 (48.1%) patients, very good in 29 (27.4%) patients, good in 17 (16%) patients, fair in six (5.7%) patients, and poor in three (2.8%) patients. The average ODI decreased from 80% preoperatively to 37% postoperatively and the results were analyzed statistically using the paired t-test; the P value (0.000) was highly significant.

At 4–5 years after the operation, 76 (71.7%) patients were satisfied with the operation and 30 (28.3%) patients were unsatisfied.

Complications

The overall complication rate was 12.2% and the complications were as follows: three (2.8%) patients had intraoperative dural leaks, which were repaired using 6/0 prolene sutures, artificial dural substitutes (Tachoseal), and fibrin glue, three (2.8%) patients had postoperative epidural hematomas that needed early revision, four (3.8%) patients had evidence of postoperative infection and were treated by surgical debridement and antibiotics according to the results of culture and sensitivity, and three (2.8%) patients had a residual stenosis and required early redecompression. The incidence of complications and their distribution are shown in Table 3.

Table 3 Incidence of complications and their distribution

	n (%)
Dura injury	3 (2.8)
Hematoma	3 (2.8)
Infection	4 (3.8)
Residual stenosis	3 (2.8)

Reoperations

During the follow-up period, 23 (21%) patients required a second operative procedure, whereas three (2.8%) patients required a third operative procedure after the index operation.

Two of the 23 patients who underwent second operations had presumed instability and underwent fusion. Of the remaining 21 patients, seven patients underwent discectomy at the same level, three patients required redecompression at the same level, three patients required evacuation of a postoperative hematoma evacuation, two patients had postoperative wound infection that required debridement, one patient had decompression at an adjacent level, one patient underwent discectomy at an adjacent level, one patient received an interspinous spacer, one patient underwent vertebroplasty at an adjacent level, and one patient required a dural repair for a dural leak that was diagnosed postoperatively. In one patient, the details of the reoperation could not be ascertained. In the three patients who required a third operation, the operative procedure was a residual discectomy at the same level (Table 4).

Table 4 Details of the reoperation(s) performed

Index operation	Reoperation 1	Reoperation 2
Decompression L4–L5	Discectomy L4–L5	
Decompression L2–L3	Wound debridement	
Decompression L1–L4	Vertebroplasty L5	
Decompression L4–L5	Dural repair	
Decompression L3–L4	Hematoma evacuation	Residual discectomy L3–L4
Decompression L2–L5	Discectomy L2–L3	
Decompression L3–L5	Redecompression and fusion L4–L5	
Decompression L1–L4	Interspinous Spacer (elsewhere)	
Decompression L4–S1	Redompression L4–S1	
Decompression L2–L5	Fusion	
Decompression L3–S1	Discectomy L4–L5	
Decompression L3–L5	Hematoma evacuation	
Decompression L1–L3	Redecompression (elsewhere)	
Decompression L2–L5	Wound debridement	
Decompression L4–L5	Discectomy	
Decompression L3–L5	Hematoma evacuation	
Decompression L3–L5	Discectomy L3–L4	Rediscectomy L3–L4
Decompression L3–L5	Discectomy L4–L5	
Decompression L3–L5	Decompression L1–L3	
Decompression L2–L5	Discectomy L3–L4	Rediscectomy L3–L4
Decompression L3–L5	Discectomy L2–L3 extraforaminal	
Decompression L2–L5	Redecompression L3–L4	
Decompression L2–L5	Reoperation	

Correlates of clinical outcomes

Patient satisfaction was correlated to some of the baseline variables to determine possible predictors of the surgical outcome. Statistical analysis was carried out using the paired t-test and the χ^2, and the results are shown in Table 5.

The results indicate that older age, associated scoliosis, poor self-rated general health status, and higher number of comorbidities predicted poorer subjective outcome.

Discussion

Unilateral and bilateral laminotomy for decompression of LSS as a less invasive surgical option in LSS was introduced by Getty *et al.* [5].

Tsai *et al.* [6] reported retrospectively the clinical results after laminotomy. After a mean follow-up period of 2.25 years, 84% of 50 patients showed good postoperative results. In a prospective study of 21 patients, Nyström *et al.* [7] observed good outcome in 66% of patients at a mean duration of 2.25 years after surgery. Comparable results with 59–91% improvement rates after laminotomy were described by other authors during mean follow-up periods of up to 5.5 years [8–10].

Only a few series have directly compared laminotomy with laminectomy [11–13]. With 50 and 58% good results, Thomas *et al.* [11]. retrospectively found no significant difference in clinical outcome and postoperative instability between these different techniques. However, with 14 and 12 patients in each group and a mean follow-up period of 3.1 years, the patient population was small and the follow-up period was short. Postacchini *et al.* [12] compared the clinical results and postoperative stability of 41 patients treated by laminectomy with those of 26 patients undergoing bilateral laminotomy after a mean follow-up period of 3.7 years. Spinal instability was more frequent after laminectomy than after laminotomy, whereas the clinical results were comparable (78 vs. 81% good outcome). Rompe *et al.* [13] evaluated the results of 117 patients treated either by laminotomy, laminectomy alone, or laminectomy plus instrumented fusion (mean follow-up interval, 8 years). Laminotomy yielded the most favorable results, followed by laminectomy alone. These findings seem to indicate that, compared with laminectomy, laminotomy can adequately decompress LSS and that laminectomy represents a procedure that is too aggressive for adequate preservation of spinal stability.

Table 5 Correlates of clinical outcome

Variables	*P* value
Age of the patient	*0.020*
Number of operations	0.173
Number of levels decompressed	0.378
Associated scoliosis	*0.042*
Associated spondylolishesis	0.270
Interspinous spacer	0.987
Occurrence of complications	0.883
Duration of symptoms	0.063
General health status	*0.000*
Number of comorbidities	*0.017*

Less invasive surgery using microsurgical and endoscopic procedures has been used more commonly for the treatment of lumbar spinal stenosis over the last decade. The target of these procedures is maximal preservation of structural components such as midline structures, facet joints, and paravertebral muscle to prevent postoperative instability [14]. Microsurgical bilateral decompression by a unilateral approach was first described by Poletti [14]. The procedure was modified by McCulloch and Young [15] and described in detail. In this technique, the dural sac and bilateral nerve roots can be decompressed with preservation of the supraspinous or interspinous ligament complex as well as the contralateral paraspinal muscles and facet joints. Moreover, the 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.* [16] reported a decrease in paraspinal muscle strength with concomitant atrophy on postoperative computed tomography scans.

Furthermore, 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 the potential for increasing the infection rate. The region is inevitably replaced with scar tissue, thereby complicating or necessitating secondary surgical interventions. Resection of portions or all of the spinous processes, interspinous ligaments, and supraspinous ligaments, and iatrogenic damage to the paraspinal musculature result in a large volume of dead space. Dead space and its consequent risks are significantly decreased using the described technique of microsurgical bilateral decompression by a unilateral approach [1].

Weiner *et al.* [1] prospectively analyzed the results of 30 patients undergoing bilateral microdecompression by a unilateral approach, with good outcomes in 87% of the patients (follow-up period, 0.75 year). Similar results were reported by other authors (mean follow-up period, 0.25–3.5 years) [17]. In our study, the ODI and VAS scores for both leg and back pain decreased significantly and the mid-term results reported in this study seem to confirm that ULBD is more beneficial than more invasive operative procedures in terms of patient outcome. This finding was supported by the meta-analysis of Niggemeyer *et al.* [18], who found that the least invasive surgical procedure and decompression without any fusion could yield the most favorable results in patients with LSS.

The surgery-related complications encountered in our series (12.2%) were minor and acceptable and similar to, or even less frequently encountered than, those reported by others [17,19]. It was believed that, with the unilateral approach in particular, access to the opposite lateral spinal canal might require significant dural sac retraction, with a possibly higher risk of tears of the spinal dura mater. However, the rate of incidental durotomies in our series was only 2.8%, which is similar to the average documented previously for ULBD (0–18%) [1,17]. This is even lower than that reported in most series in decompressive surgery for LSS by laminectomy, with a published overall incidence of dural tears approaching 14% [20]. Despite the high preoperative comorbidity, we did not experience complications related to these coexisting medical diseases, which could be interpreted as a surrogate parameter of the low invasiveness of ULBD.

In the present series, the 19.8% incidence of surgery-related reoperation for remaining or restenosis at operated levels, disc herniations, secondary spinal instability, and complications, as well as the 23.8% overall resurgery rate, are close to or lower than the average of values reported in the literature [21,22].

The outcome after surgical decompression, even in patients with initial good short-term results, is considered to deteriorate in the long-term interval, resulting in a fairly high percentage of reoperation. This may be related, in part, to the progressive nature of degenerative lumbar disease, with recurrent stenosis caused by gradual laminar bone regrowth, and mechanical disruption of the lumbar spine integrity and postoperative instability [23]. Bone regrowth in a surgical defect after posterior decompression in LSS is reported to occur in 44–94% of patients. Some authors believe that bone regrowth is a sign of spinal instability [23]. In our series, the reoperation rate for recurrent stenosis was 2%, which is lower than most rates reported for laminectomy and bilateral laminotomy [22]. One possible explanation could be a better preservation of the spinal integrity with the ULBD technique, with minimal bone regrowth postoperatively.

Postoperative instability

In 2% of the patients in the present series, resurgery for spinal fusion became necessary. In contrast, the postoperative incidence of spinal instability and associated reoperation rate in laminectomy and bilateral laminotomy series are markedly higher [24,25]. Moreover, in our study, there were no significant differences in the measurements of satisfaction between patients with lumbar degenerative spondylolisthesis with stenosis and patients with degenerative stenosis (P=0.27). Out of 13 patients with degenerative spondylolisthesis in our study, 11 patients were satisfied with the result of surgery whereas two were not satisfied. Therefore, for the authors, spondylolisthesis in itself is not an indication for fusion.

Conclusion

In experienced hands, ULBD is an adequate microsurgical technique for decompression of LSS that minimizes operative invasiveness and tissue trauma while maximizing preservation of the spinal integrity and stability. Secondary postoperative instability is avoided and excellent long-term clinical outcome could be expected.

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Conflicts of interest

There are no conflicts of interest.

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