Bilateral Operation of Lumbar Degenerative Central Spinal Stenosis in Full-endoscopic Interlaminar Technique With Unilateral Approach

Prospective 2-year Results of 74 Patients

Martin Komp, MD,* Patrick Hahn, MD,* Harry Merk, MD,† Georgios Godolias, MD,‡
and Sebastian Ruetten, MD*

Study Design: Prospective study of the patients with degenerative spinal central stenosis, operated bilateral in a full-endoscopic unilateral technique.

Objective: The objective of this prospective study was to examine the technical possibilities of full-endoscopic interlaminar bilateral technique with unilateral approach in degenerative lumbar central spinal stenosis and predominant leg symptoms using new designed endoscopes and instruments.

Summary of Background Data: Extensive decompression with laminectomy where appropriate, is often still described as the method of choice in the operation of degenerative lumbar spinal stenosis. Nonetheless, tissue-sparing procedures are becoming more common. Endoscopic techniques have become the standard in many areas because of the advantages they offer in surgical technique and in rehabilitation. At the spine, 1 essential point was the developing of the instruments for sufficient bone resection under continuous visual control. This enabled the use in the operation of spinal canal stenoses.

Methods: A total of 72 patients with lumbar central spinal stenosis full-endoscopic unilateral decompression were followed for 2 years. In addition to general and specific parameters, these measuring instruments were used: VAS, German version North American Spine Society Instrument, Oswestry Low-back Pain Disability Questionnaire.

Results: The results show that 70.8% no longer have leg pain or it was nearly completely reduced and 22.2% have occasional pain. The decompression results were equal to those of conventional procedures. The complication rate was low. The full-endoscopic techniques brought advantages in these areas: operation, complications, traumatization, and rehabilitation.

Conclusions: The recorded results show that the full-endoscopic interlaminar bilateral decompression with unilateral approach is a sufficient and safe supplement and alternative to conventional procedures when the indication criteria are fulfilled. At the same time, it offers the advantages of a minimally invasive intervention.

Key Words: spinal stenosis, central stenosis, neurogenic claudication, spinal decompression, endoscopic spinal decompression, minimally invasive spine surgery

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Degenerative lumbar stenosis is owing to bony, discal, capsular, or ligamentary structures. The compression may lead to the classical, clinical symptoms of neurogenic claudication with radicular signs. Back pains are more likely attributable to the degenerative secondary phenomena, such as segment instabilities or deformities. There are various hypotheses to explain the onset of pain associated with spinal stenosis and they include mechanical neural and vascular, inflammatory, and biomechanical components.[1–4] There is no unequivocal correlation between the extent of stenosis observed in imaging procedures and the clinical symptoms.[1,5]

Therapeutically, the surgical intervention can be considered in the cases of decompensation or intolerable persistence. In this respect, decompression, fusion, or combination of the 2 procedures are to be considered owing to the possible leg and back symptoms. Numerous surgical procedures have been described, some of which are still a matter of controversial discussion.[1,6–15] Overall, there seems to be a trend over the past years away from more aggressive to more selective techniques. The tendency at present in predominant leg symptoms, without signs of segment instability and deformity and the use of stability-preserving decompression techniques is to dispense with fusion. But there are no clear-cut

definitions of these criteria. These days it seems, according to EBM-criteria, that decompression can improve neurogenic claudication and neurologic deficits. The required extent of decompression and the circumstances in which additional fusion is necessary remain unclear.

One operative consequence of surgery is scarring of the epidural space,[16–19] which may become clinically symptomatic in 10% or more of cases[17–19] and makes revision surgery more difficult. An analysis of study results in decompression showed the occurrence of operation-induced destabilization owing to the necessary resection of spinal canal structures.[20–26] The point of access influences the stabilization and coordination system in the innervation area of the dorsal nerve roots of the spinal nerves.[27–29] The use of microsurgical techniques has reduced tissue damage and its consequences.[30–32]

The goal of new procedures must be to achieve results and commensurate with current results of standard techniques while minimizing traumatization and its negative long-term consequences. A focal point of technical developments in spinal surgery has been and remains optimization of the intraoperative vision and light conditions. Referring to this, endoscopic operations have become standard in various areas, such as arthroscopy or laparoscopy. These days, herniated discs and stenoses of the lumbar and cervical spine can also be operated full-endoscopically using various accesses and techniques.[33–39]

The goal of this prospective study was to examine the technical possibilities of full-endoscopic bilateral interlaminar decompression with unilateral approach in the treatment of degenerative lumbar central spinal stenosis using new designed endoscopes and instruments. The focus was on the question of sufficient decompression, possible effects of reduced traumatization, possible specific complications, and the technical performance of the access depending on the pathologic and anatomic correlates.

PATIENTS OR MATERIALS AND METHODS

Patients Characteristics and Study Group

Ninety patients (49 f, 41 m) who were operated in 2005/2006 in full-endoscopic bilateral interlaminar technique with unilateral approach for degenerative lumbar central spinal stenosis were included in the prospective study. The age ranged from 43 to 81 years (mean 61 y). The duration of symptoms ranged from 5 months to more than 5 years (mean 15). All the patients had received a mean of 13 months conservative treatment. The walking time possible averaged less than 20 minutes. Five operations were done at the L5-S1 level, 48 at L4 to 5, 31 at L3 to 4, and 6 at L2 to 3. The indication for surgery was defined according to present-day standards based on radicular pain symptoms or neurogenic claudication and existing neurologic deficits.[40,41] All the operations were carried out by 2 surgeons, who have many years of experience in both the techniques.

Inclusion Criteria

These inclusion criteria applied: predominant leg symptomatic; neurogenic claudication with or without paresis; back pain max. 20/100 on the VAS; conservative therapy exhausted or no longer indicated owing to the symptoms; monosegmental central stenosis. Exclusion criteria were: predominant back pain; foraminal stenosis in the lower level; disc herniation; degenerative spondylolisthesis more than Meyerding Grade I; multidirectional rotation slide; Scoliosis more than 20 degrees; prior surgery in the same segment; cauda equina syndrome. In summary, an attempt was made to define inclusion criteria that do not represent a clear indication for additional fusion, also taking clinical symptoms into account.

Full-endoscopic Instruments

The working sheaths, which are inserted bluntly using a dilatator, have an outer diameter of 10 mm and a beveled opening, which enable creation of visual and working fields in an area without clear anatomically preformed cavity. The optic has an outer diameter of 9.5 mm and is inserted through the working sheath. The optic contains an intraendoscopic, excentric working canal with a diameter of 5.7 mm, the light conductor system, a canal for continuous irrigation and the rod lens system. The angle of vision is 20 degrees. Various instruments including drills up to 5.5 mm in diameter can be used (Fig. 1). All of the operating instruments and optics were products supplied by WOLF (Richard Wolf GmbH, Knittlingen, Germany).

Operative Technique

The full-endoscopic interlaminar operation was carried out bilateral through a unilateral access in the sense of an "undercutting technique." After making a ca. 9-mm long paramedian skin incision, blunt insertion of a dilatator toward the interlaminar window. Insertion of

FIGURE 1. Optic for the full-endoscopic interlaminar decompression with dilator and working sheath, and optic with inserted drill.

the operation sheath through the dilatator with the beveled opening toward medial in the direction of the ligamentum flavum. Thereafter, the procedure is carried out under visual control and constant irrigation. Depending on the pathology, first performance of ipsilateral decompression by means of cranial and caudal laminotomy, partial facettectomy, and flavum resection. Then entry to the contralateral side dorsal to the Dura. The ligamentum flavum is initially left in as far as possible as protection for the Dura and bony decompression is carried out again by means of cranial and caudal laminotomy and partial facettectomy. Subsequently, the ligamentum flavum is completely resected. The decompression is concluded when the Dura and spinal nerves are visibly clearly decompressed on both sides (Fig. 2).

The operation was carried out under general anesthesia and radiographic control with the patient supine. No drainage is required. There was no opening of the anulus for performance of intradiscal nucleotomy. All the patients are given a lumbar brace for 8 weeks.

Follow-up

Follow-up examinations were conducted at Day 1 (90 patients) and at months 3 (86 patients), 6 (83 patients), 12 (81 patients), and 24 (74 patients) after surgery. All patients received the appropriate questionnaire by mail 4 working days in advance. They came personally to the clinic for follow-up examination. The examinations were done by 2 doctors in the clinic, who were not involved in the operations. In addition to general parameters, other information was obtained using these instruments: a VAS for back and leg pain, the German version of the North American Spine Society Instrument (NASS),[42,43] and the Oswestry Low-Back Pain Disability Questionnaire (ODI).[44] All the patients underwent functional x-rays after the end of the follow-up period.

FIGURE 2. Postoperative CT-scan after full-endoscopic bilateral decompression.

Statistical Analysis

The Wilcoxon rank-sum test and the Mann-Whitney U test were applied for the comparison of preoperative and postoperative global results and comparison of results in the MI versus the FI group at various times. The McNemar Test was used to compare the characteristics of the groups.

The descriptive assessments and analytical statistics were carried out depending on the group characteristics with the program package SPSS. A positive significance level was assumed at probability of less than 0.05.

RESULTS

Baseline Characteristics

A total of 74 (82.2%) patients were included in follow-up after 2 years. The remaining cases were lost for these reasons: 1 operation-unrelated deaths (14 months postoperative), 2 patients moved away and left no forwarding address, 13 patients did not respond to letters or telephone calls. Overall, there were no differences in results in dependence on the individual surgeons.

Operative Technique

The mean operating time was 44 minutes (35 to 61). There was no measurable blood loss. There was no hindrance owing to intraoperative bleeding thanks to continuous lavage and the possibility of radiofrequent, bipolar preparation, and coagulation. No drainage was required. Measurement of the lavage fluid inflow and outflow showed maximal 15 ml remaining intracorporal. The operation was technically feasible in all patients. An intraoperative switch to a conventional procedure was not made in any case. The patients were mobilized directly postoperative, depending on the effects of anesthesia.

Perioperative Complications and Revisions

These complications occurred: 5 times transient postoperative dysesthesia; 2 times transient urinary retention; 2 times Dura injuries; 1 time increase in preoperatively-existing foot dorsiflexion paresis. There were no other complications such as hematoma, delayed wound healing, soft-tissue infection, spondylodiscitis, Cauda-equina syndrome, or thrombosis. Apart from transient dysesthesia and transient urinary retention, the complication rate was 3.3%.

Two patients (2.7%) required revision surgery with additional fusion owing to persistent leg pain and/or progradiant back pain. All revision operations were carried out during the follow-up observation period, the earliest after 7 months.

Radiologic Findings

All patients were examined at the end of the follow-up period using functional x-rays (72 patients without fusion). Nine patients (12.5%) showed progradience of disc degeneration in the operated level that had existed preoperative. Three patients (4.2%) presented with an increase in the kyphosis angle in the operated segment.

The height of the intervertebral space decreased in 8 patients (11.1%). There was 1 case of increased spondylolisthesis from grade I to grade II after surgery. Apart from these patients, there was no increased instability in the functional examinations.There was no significant dependence between kyphosis, height of intervertebral space, radiologic instability, and the clinical outcome.

Clinical Outcome

Excluding the patients revised by fusion, 72 patients remained after 2 years. Figure 3 shows the course of leg and back pain, rated using the VAS scale. There is a significant reduction of radicular pain symptoms. A similar result was obtained in evaluating the ODI score (Fig. 3). Figure 4 shows the values of the NASS score, which also illustrates equal pain reduction. Overall, the measuring instruments show constant and significant ($P < 0.001$) improvement in leg pain and daily activities. Figure 5 shows the complete depiction of the leg pain status after 2 years. Fifty-one patients (70.8%) no longer had leg pain or it was nearly complete reduced, 16 (22.2%) had pain occasionally or the pain was greatly reduced and 5 (6.9%) experienced no essential improvement. Walking time proved from on average less than 15 minutes to more than 45 minutes. In general, there was slight deterioration in the follow-up period between the first and second years, but it was not significant. One patient suffered progradient back pain.

Overall, 2 patients (2.7%) underwent revision with decompression and additional fusion. Overall, 7 patients (9.5%) had a poor result in terms of no leg pain reduction or had to undergo conventional revision surgery later for persistent pain. Sixty-four patients (86.5%) reported subjective satisfaction and would undergo the operation again. Neurologic deficits were significantly ($P < 0.001$) reduced when the patient's history of weakness was less than 8 weeks. Overall, the clinical results were significantly better ($P < 0.01$) if the general anamnesis time was less than 1.3 years.
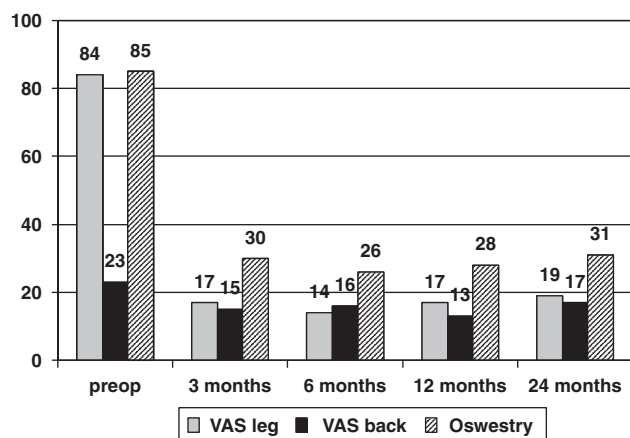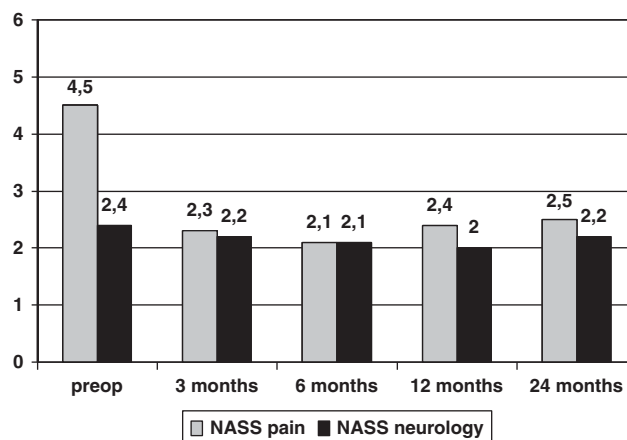

FIGURE 4. Mean values of North American Spine Society Instrument (NASS) pain and neurology.

No operation-related pain medication was required. Mobilization was made immediately depending on the narcosis. Rehabilitative measures were not necessary except in existing pareses. All results were independent of general parameters, such as sex, age, height, weight, occupation, or secondary illnesses. The maximum time in hospital was 8 days in the MI group and 3 days in the FI group.

DISCUSSION

Conventional decompression of degenerative lumbar stenosis with laminectomy or extensive resection has been and is still frequently described as the technique of choice.[6,7,11,14,45] Scarring of the epidural space can be problematical,[16–19,28,46] which may become clinically symptomatic,[17–19] make revisions more difficult, and may lead to "tethering" of the Cauda equina owing to the postoperative connection between the epidural space and paravertebral musculature.[14,47–49] The resection of stability-preserving structures may promote operation-induced segmental instability.[20–26] The route of access in the innervation area of the dorsal branch of the spinal
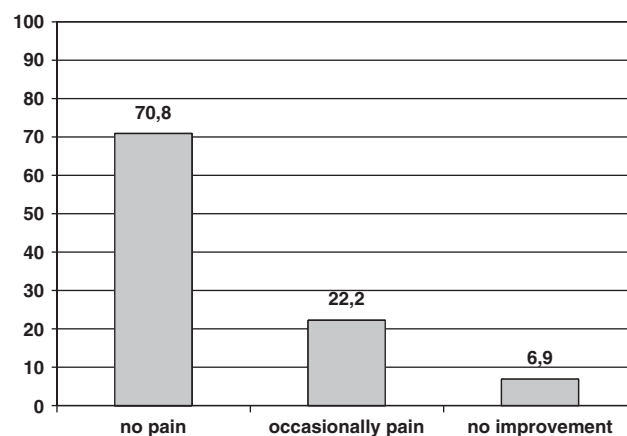

FIGURE 3. Mean values of VAS leg and back and Oswestry Low-back Pain Disability Questionnaire (ODI).

FIGURE 5. Clinical results in percent after 2 years.

nerves may have a negative influence on the stabilization and coordination system.[27–29] Resection of joint and soft tissue structures in the lateral and ventral area is also especially often required for decompression of degenerative stenosis. This is possible with more tissue-sparing techniques that are finding increasing use[8,12,14,15,50–53] and are also used in other indications.

Technical advances have been made in the operation of disc herniations in the cervical and lumbar spine which these days enable a full-endoscopic procedure under continuous irrigation which can provide the advantages of a truly minimally-invasive procedure.[33,35–39] One essential point was the possibility of sufficient bone resection under continuous visual control.[33–38] This also enabled use in the operation of spinal canal stenoses.[34]

The clinical results of decompressions without fusion described in the literature could be achieved in our study by means of the full-endoscopic technique.[6–8,12,14,15,45,48,50–56] This has been taken as the minimum prerequisite for new techniques. A significant improvement was achieved after 2 years without significant differences. A slow deterioration in surgical results over time has been described.[55,57–60] When resection of spinal canal structures is avoided or the extent reduced, a minimally traumatic procedure seems capable of reducing operation-induced consequences.[19,25,45,61–66] The results of these parameters in a literature comparison also favor the full-endoscopic technique.[67–71] The rate of complications, operating time, and necessity of resection stabilizing structures was reduced.[6–8,12,14,15,45,48,51–53,55,72,73] The reduction in operation time, traumatization, and operation-related sequelae using a full-endoscopic technique is also found in comparison with the literature in discectomies.[34–37,69,71,74] The full-endoscopic procedure was technically feasible in all cases in a short operation time. Surgery under continuous fluid flow is known to reduce intraoperative bleeding and enables very good vision in combination with the 25 degrees-optics. No blood loss was observed in the FI-group, no drainage was required.

To date, it remains difficult to define generally applicable, clear parameters according to EBM-criteria that require fusion in addition to decompression. The tendency at present in predominant leg symptoms, without signs of segment instability and deformity, and the use of stability-preserving decompression techniques is to dispense with fusion. In the study conducted, no significant parameter with reference to operation-induced instability had occurred after 2 years. Overall, there was no significant dependence between kyphosis, height of intervertebral space, radiologic instability, and the clinical outcome. In the indication monosegmental central stenosis with predominant leg pain on which this study was based, it seems that additional fusion can be dispensed with a stability-preserving surgical technique as long as there are no clear-cut signs of instability or axis deviations preoperatively.

The goal of surgical treatment of lumbar stenosis is sufficient decompression with minimization of operation-induced traumatization and its consecutive sequelae. This prospective study shows that predictable sufficient decompression can be achieved by full-endoscopic bilateral interlaminar decompression with unilateral approach under continuous visualization in a short operation time taking the described inclusion criteria into account. The clinical results of the standard procedure are achieved; whereas the advantages of a minimally invasive procedure are given. The instruments enable the technical performance of the operation.

The full-endoscopic bilateral operation with unilateral approach of lumbar degenerative central stenosis is a sufficient and safe supplementation and alternative. This is a minimally invasive surgical technique for spinal decompression, which has long been a validated and established standard procedure. In our opinion, these advantages are offered: facilitation for the operator owing to excellent visualization, good illumination, and expanded field of vision with 25 degrees optics; cost-effective procedure because of short operating time, rapid rehabilitation, and low-postoperative costs of care; reduced anatomic trauma; monitor image as training basis for assistants. These must be considered disadvantages: limited possibility of extending the approach in the event of unforeseen hindrances; and difficult learning curve.

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