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Unilateral Laminotomy for Bilateral Decompression of Lumbar Spinal Stenosis

Part II: Clinical Experiences

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Summary

The surgical aim in the treatment of symptomatic lumbar spinal stenosis is the relief of the patient's complaints by an adequate neural decompression. Unilateral laminotomy and bilateral spinal canal decompression represents such a safe, effective and minimally invasive surgical method. This technique has been successfully used in the operative treatment of 29 patients with symptomatic mono- or multisegmental lumbar stenosis. There was no surgically induced neurological deterioration. In one patient, an inadvertent dural tear occurred, and due to unchanged symptoms another patient with a multisegmental stenosis had to be re-operated on at an additional level. Postoperatively, 25 of the 27 patients with neurogenic claudication (93%) demonstrated a marked improvement of the walking distance. The follow-up of 25 patients (mean follow-up time was 18 months) demonstrated an excellent result without pain in 7 patients (28%); a good outcome with mild residual pain, but a normal working capacity in 15 patients (60%); and a fair outcome with unchanged postoperative low-back pain but markedly improved working capacity and walking distance in 3 patients (12%). Postoperative morphometric evaluation as well as the clinical improvement of the patient's symptoms clearly demonstrated that bilateral ligamentectomy and recess decompression were adequately and successfully achieved via unilateral approach.

Keywords: Spinal stenosis; lumbar spine; neurogenic claudication; spinal instability; surgical treatment; low back pain.

Introduction

The classification of lumbar spinal stenosis is non-uniform. Spinal stenosis is defined as any type of narrowing of the vertebral canal and/or the lateral recesses and/or the foramina [1, 23, 34, 35]. For classification either a functional definition is used, related to the patient's symptoms and signs, or a morphometrical definition, with diameter or cross-sectional area measurements of the spinal canal. Accordingly, absolute and relative spinal stenosis is a frequently used differentiation, based on the measurement of the antero-posterior diameter (APD) [18, 26, 34, 35]. Nevertheless, people with radiologically proven absolute spinal stenosis may be asymptomatic [4, 6, 9], and the antero-posterior diameter is not an adequate measurement, especially in patients with severe hypertrophy of the facet joints. For this reason we used in the present study a functional classification based on the clinical presentation of the patient's symptoms in relation to the neuro-radiological images with standardized measurements of the spinal canal.

The aim of surgical treatment should be an adequate decompression of the dural sac and the affected nerve roots combined with preservation of spinal stability. The basic idea of the present unilateral surgical approach is to overcome the disadvantage of surgically induced instability by reducing the impairment of the spinal integrity.

Patients and Methods

Clinical Data

Encouraged by our experimental experiences which had proved the surgical feasibility of unilateral laminotomy for the bilateral decompression procedure, we applied this new method in the surgical treatment of patients with symptomatic lumbar spinal stenosis. Between October 1993 and September 1995, twenty-nine patients (14 men, 15 women) with symptomatic lumbar spinal stenosis were operated on by a unilateral laminotomy and bilateral decompression. The mean age was 62 years (range, 34 to 83 years). All 29 patients were symptomatic, and the mean duration of symptoms was 3.5 years (range, 3 months to 15 years). The pre-operative clinical findings are demonstrated in Table 1. If there was a pre-dominant side for the bilateral symptoms, the unilateral laminotomy was performed on the mainly affected side.

In total, 37 laminotomies were performed in 29 patients (27 left-sided and 10 right-sided approaches). In 22 patients, a monosegmental decompression was performed (Figs. 1 and 2). Two lev-

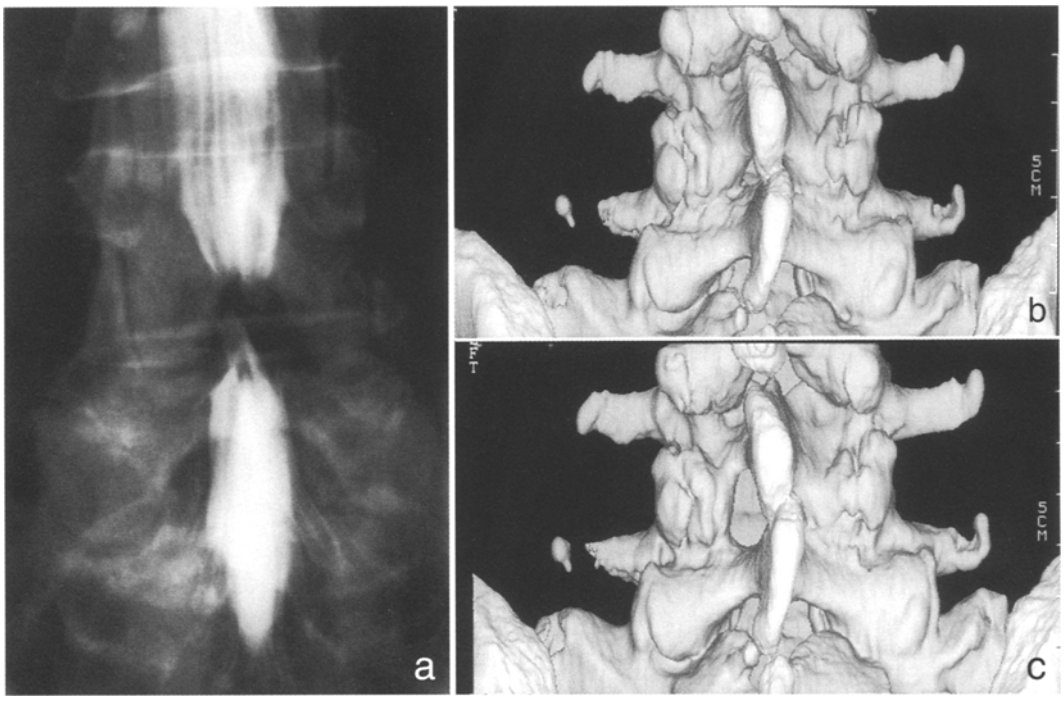

Fig. 1. Images of a 56 years old woman with symptomatic spinal stenosis L4-L5. (a) Pre-operative myelogram (antero-posterior view) showing a monosegmental hourglass stenosis with subtotal obstruction of the spinal canal due to bilateral hypertrophy of the facets and the ligamentum flavum. (b) Pre-operative 3-D CT-scan. (c) Postoperative 3-D CT-scan demonstrating the bony resection of the unilateral surgical approach

Table 1. *Pre-operative Clinical Findings of the 29 Patients with Lumbar Spinal Stenosis Undergoing Unilateral Laminotomy for Bilateral Decompression*

Clinical findings	No. of patients
Neurogenic claudication	27
Low back pain	26
Sensory disturbances	15
Pseudoradicular symptoms	11
Radiculopathy	10
Paresis	6
Genito-urinary disturbances	2

Table 2. *Localization of the Lumbar Spinal Stenotic Level (N = 37) Treated by Unilateral Approach and Bilateral Decompression in 29 Patients*

Localization	No.
L1-L2	1
L2-L3	6
L3-L4	11
L4-L5	17
L5-L6	1
L5-S1	1

els were decompressed in 6 patients, and three levels in 1 patient. The distribution of the treated segments is shown in Table 2. In terms of pre-operative radiological examinations, all patients had conventional x-rays, 93% CT-scans, 79% myelograms (Fig. 1a), and 52% MRI studies. According to the classification of Meyerding [21], 6 patients (21%) demonstrated pre-operatively a spondylolisthesis Grade I at the stenotic level. In 2 patients (7%), a herniated disc was found intra-operatively, which was not visible on pre-operative neuroradiological images. In addition to the decompression procedure, a discectomy was performed in both cases. Otherwise, the discs were left untouched, even if there was a protrusion. Pre-operatively, all 29 patients have been treated with physiotherapy, analgesics and muscle relaxants.

Routinely the patients were mobilized on the first postoperative day. For further postoperative evaluation in all 29 patients plain radiographs of the lumbar spine and in 5 patients (17%) lumbar CT-scans and 3-D CT-scans were obtained (Fig. 1b and c). All patients underwent physical and neurological examination at the time of discharge as well as 8 to 10 weeks after surgery. For final evaluation, 25 out of 29 patients (86%) were contacted by telephone. If they complained of residual symptoms, a re-examination was performed. In one patient a re-operation was necessary due to persistent symptoms. The mean follow-up period was 18 months (range, 6 to 26 months). For evaluation of the surgical results (Table 3 a), the following criteria were used: *Excellent:* no residual pain, normal working capacity or premorbid activity level and complete relief of neurogenic claudication or neurological deficit; *Good:* mild residual pain but normal working capacity or pre-morbid activity level and complete relief of neurogenic claudication or

Table 3. *Postoperative Outcome in 25 Patients with Symptomatic Lumbar Spinal Stenosis Treated with Unilateral Laminotomy and Bilateral Decompression After a Mean Follow-up Period of 18 Months*

(a) Assessment of the Overall Postoperative Outcome

Outcome	No. of patients	%
Excellent	7	28
Good	15	60
Fair	3	12
Poor	0	0

(b) Assessment of the Postoperative Low Back Pain

Residual pain	No. of patients	%
No low back pain	7	28
Improved low back pain	13	52
Unchanged low back pain	5	20

neurological deficit; *Fair:* pre-operative pain slightly improved or persistent, reduced but improved working capacity or reduced pre-morbid activity level, but improved neurogenic claudication and improved initial neurological defict; *Poor:* unchanged or worsened pain, incapable to work or unchanged pre-morbid activity level, and unchanged claudication and neurological deficit.

Morphometrical Procedures

In 5 patients a morphometrical evaluation of pre- and postoperative CT-scans was performed (Fig. 3). The interfacet diameter (IFD), the antero-posterior diameter (APD) were measured, also computerized planimetric measurements of the cross-sectional area of the dural sac (CSAD) and of the cross-sectional area of the bony spinal canal (CSAC) were performed. Direct comparison of these measurements within the spinal canal, permitted the evaluation of the degree of surgical decompression achieved by our surgical procedure.

Results

Clinical Findings

Bilateral decompression via unilateral laminotomy was performed at 37 levels in 29 patients with symptomatic lumbar spinal canal stenosis (Fig. 2). The mean time of surgery was 114 minutes (range 81–192 minutes), and the mean blood loss was 160 ml (range 50–550 ml). The average length of hospitalization was 8.5 days (range 5 to 21 days). No additional instrumentation was necessary, even in those 6 patients with a pre-operative spondylolisthesis, since no increase of the olisthesis and no surgical induced instability occurred. Long-term follow-up (range 6–26 months) demonstrated an improvement of the neurogenic claudication in all patients. In total, 22 patients (88%) reported an excellent or good outcome

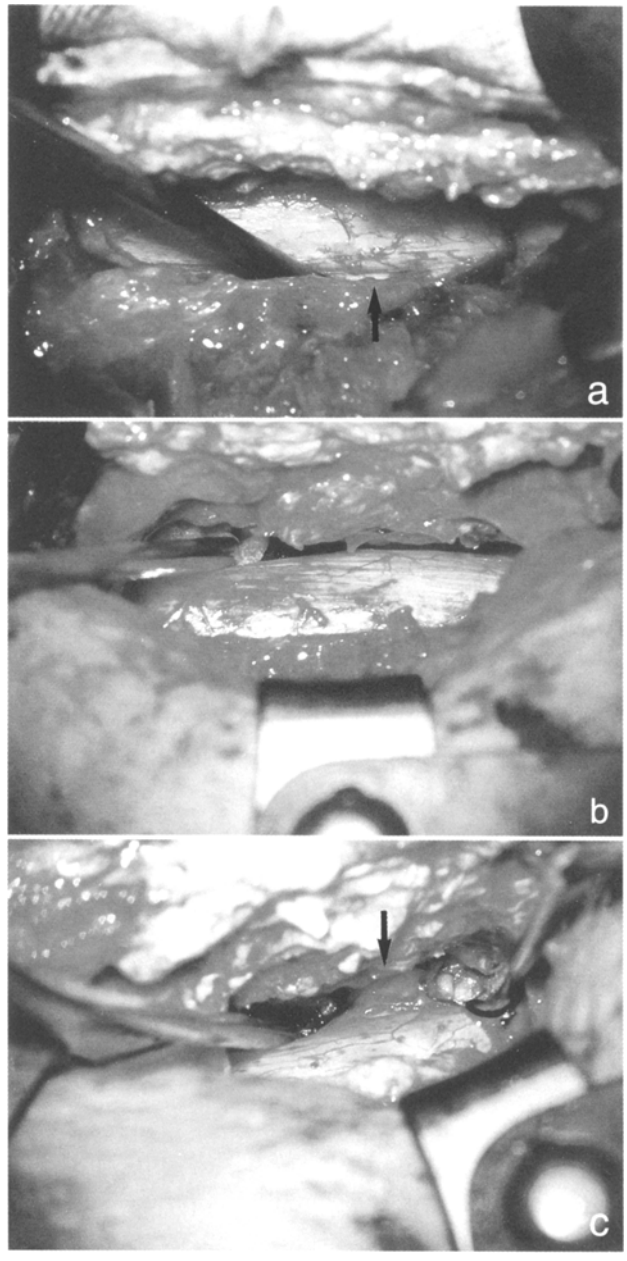

Fig. 2. Intra-operative photographs demonstrating a left-sided unilateral approach. (a) Typical, orthograde view of the dural sac with a dissector beneath the ipsilateral L5 root (arrow). (b) Medial angulation of the microscope after bilateral flavectomy and undercutting of the spinal process showing the contralateral dural sac. (c) After bilateral microsurgical decompression via the unilateral approach the contralateral L5 root is visible (arrow). The microscope is further angulated medially and the decompressed dural sac is only slightly retracted with a dissecto

and no patient a poor overall outcome (Table 3a). However, low back pain was the major residual postoperative complaint (Table 3 b). Seven patients (28%) described complete relief of their low back pain, 13 patients (52%) a marked improvement as compared to

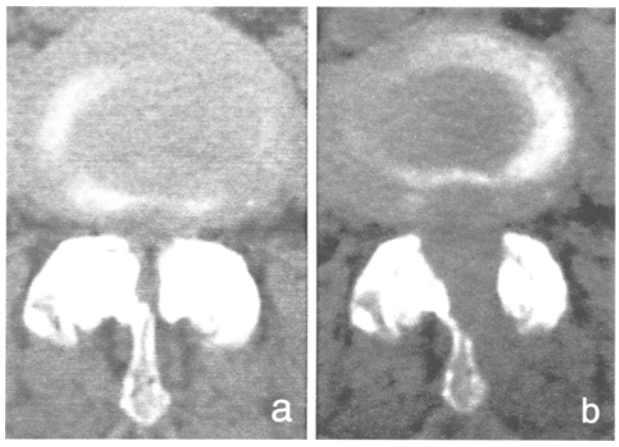

Fig. 3. CT-scans showing the level of maximal spinal stenosis. (a) Pre-operative image of a patient with severe neurogenic claudication – walking distance 50 m – and sensory disturbances. (b) Postoperative image 6 days after surgery at discharge demonstrating the left-sided laminotomy and bilateral decompression. The walking distance was markedly improved – over 1000 m – and the sensory disturbances were nearly completely resolved

the pre-operative condition, and 5 patients (20%) had unchanged low back pain postoperatively. However, in 2 out of these 5 patients the initially existing severe entrapment syndrome – like sensorimotor and genitourinary disturbances as well as the neurogenic claudication – were completely resolved postoperatively.

During surgery a dural tear at the contralateral side occurred in one patient. The dura was reconstructed, without additional neurological deficit. Other surgical complications were wound dehiscence without deep infection in one individual and one femoral thrombosis in another. One patient with a multisegmental stenosis had to be re-operated on in another level after 3 months because of unchanged sensory disturbances and recurrence of the initially improved walking capacity. Repeated lumbar myelography revealed a sufficient decompression of the initially treated level L4-L5, but confirmed the stenosis at L2-L3 and more pronounced at L3-L4. Re-operation with unilateral laminotomy and bilateral decompression at the level L3-L4 resulted in a good final outcome.

Radiological and Morphometrical Findings

IFD and APD measurements of the spinal canal in 23 pre-operative CT-scans demonstrated the degree of the lumbar stenosis. The IFD ranged from 11 to 22 mm (normal 15–20 mm) [25, 37]. The APD ranged from 8 to 16 mm (normal 15–27 mm) [25, 32, 37].The severity of neural compression was mostly represented by the reduced cross-sectional area of the dural sac (CSAD) which ranged from 36 to 110 mm^2 (normal 130–230 mm^2) [25]. The dimensions of the bony canal (normal 180–350 mm^2) [25, 32] were also markedly reduced in our patients, the CSAC ranged from 94 to 269 (Tables 4 and 5).

Table 4. *Measurements of the Maximal Level of the Lumbar Stenosis in CT-Scans of 23 Pre-operative Patients*

Measurement	Mean	Range
IFD	14.4 mm	11–22 mm
APD	11.6 mm	8–16 mm
CSAD	60.1 mm^2	36–110 mm^2
CSAC	138.5 mm^2	94–269 mm^2

mm millimeter; *IFD* interfacet diameter; *APD* antero-posterior diameter; *CSAD* cross-sectional area of the dural sac; *CSAC* cross-sectional area of the bony spinal canal.

Table 5. *Comparison of the Measurements in Pre- and Postoperative CT-Scans (Level of Maximal Stenosis) of 5 Patients with Symptomatic Lumbar Spinal Stenosis Treated by Microsurgical Unilateral Laminotomy and Bilateral Decompression*

Patient	IFD (mm) preop/postop	APD (mm) preop/postop	CSAD (mm^2) preop/postop	CSAC (mm^2) preop/postop
E.S.	12/17	12/13	81/159	212/266
K.R.	14/19	11/12	65/ 91	99/136
H.G.	14/24	15/18	108/257	181/342
H.S.	12/17	14/15	38/114	105/159
I.O.	13/19	16/16	56/107	112/153

mm millimeter; *IFD* interfacet diameter; *APD* antero-posterior diameter; *CSAD* cross-sectional area of the dural sac; *CSAC* cross-sectional area of the bony spinal canal.

Bilateral resection of the thickened ligamentum flavum caused an increase of the CSA of the dural sac, with generally unchanged measurements of the bony canal (Table 5). The degree of the surgical removal of the medial part of the hyperthrophic facets is shown in the increase of the postoperative IFD, which additionally increased the CSA of the bony spinal canal (Table 5). Due to our unilateral approach, the posterior arch was left untouched, resulting in a nearly unchanged postoperative APD (Table 5).

Discussion

Lumbar spinal stenosis is a slowly progressive disease in which developmental and acquired factors contribute to chronic pain and neurological deficits. Spondylosis affects predominantly the motion segment of L4-L5, and progressive degeneration of the facet joints as well as hypertrophy of the ligamentum

flavum commonly cause chronic low back pain, neurogenic claudication and entrapment radiculopathy [3, 7, 9, 18, 20, 23, 35–38].

Surgical Considerations

Postoperatively, no secondary stabilization procedure was necessary in all our patients, and even in those 6 patients with an initial spondylisthesis no further deterioration occurred. Undoubtedly, long-term follow-up has to confirm these preliminary results, because every decompressive procedure bears the risk of secondary instability which may require further stabilization [13–15, 19, 23]. Long-term follow-up studies are also mandatory to estimate the relapse rate. 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 the progressive stenosis, but the rigid fixation of the affected levels provokes an overloading and acceleration of the degenerative spondylosis in the adjacent motion segments [8]. In fact, only a few patients really required additional lumbar instrumentation after surgical decompression because of progressive instability [23]. Considering that lumbar spinal stenosis often is a multisegmental disease, stabilization procedures seemed to be also only a symptomatic and temporary treatment modality. However, the single decompressive surgery with short operation time and generally only a small amount of blood loss is a less invasive procedure as compared to spinal instrumentation [3, 16, 20, 23, 24, 28]. This method may easily be repeated in additional motion segments, if necessary, without permanent immobilization. Only long-term evaluation and randomized trials of different surgical procedures in the treatment of symptomatic spinal stenosis will clarify these problems.

Our intra- and postoperative rate of complications was comparable to other surgical procedures [20, 23, 24, 35], and refutes the initial fear that dural sac and nerve roots were injured by using this unilateral approach. A single inadvertent dural tear occurred in the beginning of the series, and was caused by too early resection of the ligamentum flavum, before an adequate undermining of the spinous process had been achieved. The mean follow-up after 18 months demonstrated that all initial symptoms caused by direct compression or entrapment of neural structures, such as paresis, sensory disturbances or neurogenic claudication, were treated successfully. Similar to other experiences, low back pain – a major complaint in patients with spinal stenosis – was hard to influence [5, 9, 10, 12, 24]. Actually, the majority of patients had clearly pain relief, but only 28% were completely free of pain. The presence of postoperative low back pain is not unusual, since chronic low back pain is a multicausal and multiform syndrome. It is therefore unlikely that a single decompression procedure can be the global solution for this complex problem [2, 5, 9, 22, 36].

Patients with radiologically proven spinal stenosis combined with intractable low back pain, but without neurological deficit and without neurogenic claudication form a common selected subgroup. However, such patients were ruled out in this prospective study, and were treated conservatively. In consideration of these arguments, we emphasize that a clear indication for the operative treatment in lumbar spinal stenosis is mandatory.

Morphometric Considerations

The postoperative cross-sectional area measurements revealed that this small unilateral approach is definitely sufficient for the microsurgical decompression of lumbar spinal stenosis. The comparison of the pre- and postoperative CT-scans of 5 patients with lumbar stenosis demonstrated that bilateral flavectomy and bilateral partial medial facetectomy were the essential surgical procedures for an adequate operative decompression. The technique of our unilateral approach – with undercutting of the spinous process – allows the surgeon to leave the posterior arch untouched, and therefore, the APD remained postoperatively nearly unchanged (Table 5). A laminectomy or bilateral facetectomy, however, superimposed on such a postoperative CT-scan (Fig. 3b) would not show a greater expansion of the dural sac. Moreover, from the morphometric view, a single laminectomy is inappropriate, because a dorsal decompression alone neglects the bilateral compression of the dural sac due to the hypertroplic facets. A bilateral facetectomy may achieve sufficient decompression, but at the price of almost certainly affecting spinal stability [8, 16, 27, 30, 31]. Our morphometric evaluation revealed that the unilateral approach yields an excellent decompression and minimal impairment of the essential spinal supporting structures.

Conclusion

Unilateral laminotomy with bilateral microsurgical decompression offers significant advantages, as compared to the traditional wide decompressive procedures: less invasiveness, low postoperative complication rate, preservation of spinal stability with a similar degree of decompression, and at least equally good postoperative results.

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References

1. Arnoldi CC (1976) Lumbar spinal stenosis and nerve root entrapment syndroms. Definition and classification. Clin Orthop Rel Res 115: 4–5
2. Caputy AJ, Luessenhop AJ (1992) Long-term evaluation of decompressive surgery for degenerative lumbar stenosis. J Neurosurg 77: 669–676
3. Conley FK, Cady CT, Lieberson RE (1990) Decompression of lumbar spinal stenosis and stabilization with knodt rods in the elderly patient. Neurosurgery 26: 758–763
4. Esses SI, Huler RH (1992) Indications for lumbar spine fusion in the adult. Clin Orthop 279: 87–100
5. Ganz JC (1990) Lumbar spinal stenosis: postoperative results in terms of preoperative posture-related pain. J Neurosurg 72: 71–74
6. Getty CJM (1980) Lumbar spinal stenosis. The clinical spectrum and the results of operation. J Bone Joint Surg (Br) 62: 481–485
7. Grabias S (1980) The treatment of spinal stenosis. J Bone Joint Surg (Br) 62: 308–313
8. Haher TR, O'Brien M, Dryer JW, Nucci R, Zipnick R, Leone DJ (1994) The role of the lumbar facet joints in spinal stability. Identification of alternative paths of loading. Spine 19: 2667–2671
9. Hall S, Bartleson JD, Onofrio BM *et al* (1985) Lumbar spinal stenosis. Clinical features, diagnostic procedures, and results of surgical treatment in 68 patients. Ann Intern Med 103: 271–275
10. Herno A, Airaksinen O, Saari T (1993) Long-term results of surgical treatment of lumbar stenosis. Spine 18: 1471–1474
11. Herron LD, Trippi AC (1989) L4-5 degenerative spondylolisthesis. The results of treatment by decompressive laminectomy without fusion. Spine 14: 534–538
12. Herron LD, Mangelsdorf C (1991) Lumbar spinal stenosis: results of surgical treatment. J Spinal Disord 4: 26–33
13. Hopp E, Tsou PM (1988) Postdecompression lumbar instability. Clin Orthop 227: 143–151
14. Johnsson KE, Willner S, Johnsson K (1986) Postoperative instability after decompression for lumbar spinal stenosis. Spine 11: 107–110
15. Johnsson KE, Redlund-Johnell I, Uden A, Willner S (1989) Preoperative and postoperative instability in lumbar spinal stenosis. Spine 14: 591–593
16. Kaneda K, Kazama H, Satoh S, Fuija M (1986) Follow-up study of medial facetectomies and posterolateral fusions with instrumentation in unstable degenerative spondylolisthesis. Clin Orthop Relat Res 203: 159–167
17. Katz JN, Lipson SJ, Larson MG *et al* (1991) The outcome of decompressive laminectomy for degenerative lumbar stenosis. J Bone Joint Surg (Am) 73: 809–816
18. Lange M, Hamburger C, Waidhauser E, Beck O (1993) Surgical treatment and results in patients suffering from lumbar spinal stenosis. Neurosurg Rev 16: 27–33
19. Lee CK (1983) Lumbar spinal instability (olisthesis) after extensive posterior spinal decompression. Spine 8: 429–433
20. Markwalder TM (1993) Surgical management of neurogenic claudication in 100 patients with lumbar spinal stenosis due to degenerative spondylolisthesis. Acta Neurochir (Wien) 120: 136–142
21. Meyerding HW (1932) Spondylolisthesis: surgical treatment and results. Surg Gynecol Obstet 54: 371–377
22. Nachemson AL (1991) Instability of the lumbar spine. Pathology, treatment, and clinical evaluation. Neurosurg Clin N Am 2(4): 785–790
23. Pappas CTE, Sonntag VKH (1994) Lumbar stenosis in the elderly. Neurosurg Quart 4: 102–112
24. diPiero CG, Helm GA, Shaffrey CI, Chadduck JB, Henson SL, Malik JM, Szabo TA, Simmons NE, Jane JA (1996) Treatment of lumbar spinal stenosis by extensive unilateral decompression and contralateral autologous bone fusion: operative technique and results. J Neurosurg 84: 166–173
25. Poletti CE (1995) Central lumbar stenosis caused by ligamentum flavum: unilateral laminotomy for bilateral ligamentectomy: preliminary report of two cases. Neurosurgery 37: 343–347
26. Postacchini F, Pezzeri G (1981) CT scanning versus myelography in the diagnosis of lumbar stenosis. Intern Orthop 5: 209–215
27. Shenkin HA, Hash CJ (1979) Spondylolisthesis after multiple bilateral laminectomies and facetectomies for lumbar spondylosis. Follow-up review. J Neurosurg 50: 45–47
28. Silvers HR, Lewis PJ, Asch HL (1993) Decompressive lumbar laminectomy for spinal stenosis. J Neurosurg 78: 695–701
29. Spanu G, Messina AL, Assetti R *et al* (1988) Lumbar canal stenosis: results in 40 patients surgically treated. Acta Neurochir (Wien) 94: 144–149
30. Stromqvist B (1993) Postlaminectomy problems with reference to spinal fusion. Acta Orthop Scand [Suppl] 251: 87–89
31. Suzuki K, Ishida Y, Ohmori K (1993) Spondylolysis after posterior decompression of the lumbar spine. 35 patients followed for 3–9 years. Acta Orthop Scand 64(1): 17–20
32. Ullrich CG, Binet EF, Sanecki MG, Kieffer SA (1980) Quantitative assessment of the spinal canal by computed tomography. Radiology 134: 137–143
33. Turner JA, Ersek M, Herron L *et al* (1992) Surgery for lumbar spinal stenosis. Attempted meta-analysis of the literature. Spine 17: 1–8
34. Verbiest H (1954) A radicular syndrome from developmental narrowing of the lumbar vertebral canal. J Bone Joint Surg (Br) 36: 230–237
35. Verbiest H (1977) Results of surgical treatment of idiopathic developmental stenosis of the lumbar vertebral canal. A review

of twenty-seven years' experience. J Bone Joint Surg (Br) 59: 181–188
36. Verbiest H (1990) Lumbar spine stenosis. In: Youmans JR (eds) Neurological surgery. Saunders, Philadelphia, pp 2805–2855
37. Weinstein PR, Ciricillo SF (1994) Lumbar spinal stenosis and lateral recess syndrome. In: Rengachary SS, Wilkins RH (eds) Principles of neurosurgery. Wolfe, London, pp 46.1–46.18
38. Weisz GM, Lee P (1983) Spinal canal stenosis. Clin Orthop 179: 134–140

Comments

The first part is an anatomical study describing a surgical technique on a normal cadaver. It is, in my opinion, a microscopic variation of the amplified flavectomy but here extended by the removal of the corresponding plate, half of the spinal apophysis and a part of the inter-spinal ligament.

This technique is not new. Its application in neurosurgical routine will be determined by the surgery time, its results and advantages over other techniques which also do not alter the stability of the spinal column and which are routinely carried out.

In Part II the authors carry out a study of 29 patients with excellent results and a morphometric pre- and post-operative study which shows the effectiveness of this technique described in Part I.

The excellent iconography completes the clinical data.

The bibliography is up-to-date.

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