THE SURGICAL TREATMENT OF CENTRAL LUMBAR STENOSIS

MULTIPLE LAMINOTOMY COMPARED WITH TOTAL LAMINECTOMY

F. POSTACCHINI, G. CINOTTI, D. PERUGIA, S. GUMINA

From the University of Modena and the University of Rome, Italy

We assigned 67 patients with central lumbar stenosis alternately to either multiple laminotomy or total laminectomy. The protocol, however, allowed multiple laminotomy to be changed to total laminectomy if it was thought that the former procedure might not give adequate neural decompression. There were therefore three treatment groups: group I consisting of 26 patients submitted to multiple laminotomy; group II, 9 patients scheduled for laminotomy but submitted to laminectomy; and group III, 32 patients scheduled for, and submitted to, laminectomy. The mean follow-up was 3.7 years.

Bilateral laminotomy at two or three levels required a longer mean operating time than total laminectomy at an equal number of levels. The mean blood loss at surgery and the clinical results did not differ in the three groups. The mean subjective improvement score for low back pain was higher in group I but there was also a higher incidence of neural complications in this group. No patient in group I had postoperative vertebral instability, whereas this occurred in three patients in groups II and III, who had lumbar scoliosis or degenerative spondylolisthesis preoperatively.

Multiple laminotomy is recommended for all patients with developmental stenosis and for those with mild to moderate degenerative stenosis or degenerative spondylolisthesis. Total laminectomy is to be preferred for patients with severe degenerative stenosis or marked degenerative spondylolisthesis.

J Bone Joint Surg [Br] 1993; 75-B:386-92.

Received 11 September 1992; Accepted 22 October 1992

F. Postacchini, Professor of Orthopaedic Surgery
University of Modena, Largo del Pozzo 71, 41100 Modena, Italy.

G. Cinotti, Registrar
D. Perugia, Resident
S. Gumina, Resident
Orthopaedic Clinic, University of Rome, 'La Sapienza' Piazzale Aldo Moro 5, 00185 Rome, Italy.

Correspondence should be sent to Professor F. Postacchini.

©1993 British Editorial Society of Bone and Joint Surgery
0301-620X/93/3572 \$2.00

Until a few years ago, total laminectomy was the standard method of decompression for central lumbar stenosis. In the last decade, CT and MRI have clearly shown that both developmental and degenerative stenosis cause compression of the nervous structures only at the level of the intervertebral space (Schonstrom, Bolender and Spengler 1985; Senegas et al 1988; Postacchini 1989). It has also been shown that total laminectomy may increase or cause vertebral instability unless fusion is performed simultaneously (Shenkin and Hash 1979; Lee 1983; Caffinière 1986; Johnsson, Willner and Johnsson 1986; Hopp and Tsou 1988; Senegas et al 1988; Herkowitz and Kurz 1991).

These observations have led to surgical techniques which preserve part of the posterior osteoligamentous arch. Lin (1982) reported a case in which multiple laminotomy had been used rather than total laminectomy. Young, Veerapen and O'Laoire (1988) described a procedure called multilevel subarticular fenestration, in which laminotomies are performed using an operating microscope. Postacchini (1989) described the use of multiple laminotomy in patients with developmental or degenerative stenosis, including that associated with degenerative spondylolisthesis. Nakai, Ookawa and Yamaura (1991) have described the removal of only the medial part of the inferior facets and the adjoining ligamentum flavum. They do not recommend this procedure for degenerative spondylolisthesis, but they do not specify whether it can be used for any type or degree of central lumbar stenosis in the absence of any degenerative slip.

In recent years, limited opening of the spinal canal has increased in popularity (Nixon 1991). However, we could find no investigation of whether these techniques could replace total laminectomy for all cases of central lumbar stenosis. In this study, we have tried to determine the relative advantages and disadvantages of multiple laminotomy as compared with total laminectomy, and to define the indications for each.

PATIENTS AND METHODS

Our study included 70 consecutive patients with central lumbar stenosis who required surgery. There were 34

men and 36 women, ranging in age from 43 to 79 years (mean 57). All patients had plain and flexion-extension radiographs of the lumbar spine, with one or more of myelography, plain or contrast-enhanced CT, and MRI.

Four types of stenosis were identified: developmental, degenerative, combined (developmental and degenerative) and that associated with degenerative spondylolisthesis. Patients were allocated to one of these four groups, and those in each group were then assigned alternately to either multiple laminotomy or total laminectomy. The protocol was open, however, so that the surgeon could extend multiple laminotomy to total laminectomy in the following circumstances: a) when multiple laminotomy would not allow adequate neural decompression; b) when there was a risk of neural damage because of severe narrowing of the spinal canal; and c) when an inadequate bony bridge remained between laminotomies risking mobility of the residual laminae and spinous process.

Treatment groups. Three treatment groups were obtained: group I, multiple laminotomy; group II, scheduled multiple laminotomy, converted to total laminectomy; and group III, scheduled and had total laminectomy. All the patients were operated on by the senior author (FP). Three were lost to follow-up, and of the remaining 67, 26 were in treatment group I, nine in group II and 32 in group III.

In group I, the stenosis was developmental in six

cases, degenerative or combined in 12, and associated with degenerative spondylolisthesis at one or two levels in eight, with slip ranging from 8% to 26%. Three patients had lumbar scoliosis of 10° to 18°, the stenotic vertebrae being included in the scoliotic curve. Only two patients showed preoperative hypermobility on functional radiographs, both at a single level with mild degenerative spondylolisthesis. Bilateral laminotomy was performed at a single level in 12 patients, at two levels in 11 and at three levels in three (Table I; Fig. 1). Of the patients decompressed at multiple levels, two had bilateral laminotomy at one level and unilateral laminotomy at an adjacent level. Disc excision was performed at a single level in four patients, two of whom had developmental stenosis, while the remaining two had degenerative stenosis and degenerative spondylolisthesis, respectively.

Table I. Surgical procedures in the three groups of patients with central lumbar stenosis

Group*	Number of decompressed levels			Discectomy	Fusion
	1	2	3		
I	12	11	3	4	4
II	4	2	3	1	2
III	15	13	4	3	6

* see text

Developmental lumbar stenosis treated by multiple laminotomy. Figure 1a – Preoperative anteroposterior radiograph. Figure 1b – Preoperative MRI showing posterior compression of the thecal sac from L1-L2 to L4-L5. At the latter level a disc bulge contributes to the interruption of the image of the thecal sac. Figure 1c – Postoperative radiograph showing bilateral laminotomies at L2-L3 to L4-L5. Figure 1d – MRI performed four years after surgery. There is no evidence of bony compression of the thecal sac at the levels operated on, but a mild compression persists at L1-L2.

A unilateral or bilateral intertransverse fusion was performed in four patients with degenerative spondylolisthesis (including the two showing vertebral hypermobility on functional radiographs).

Six of the nine patients in group II, who had an unplanned total laminectomy, had degenerative or combined stenosis and three had degenerative spondylolisthesis with forward slip ranging from 30% to 42%. Decompression was carried out at a single level in four (two with degenerative spondylolisthesis), at two levels in two and at three levels in three (Table I). Two patients had lumbar scoliosis of 13° to 20°, both with stenotic levels within the scoliotic area. No patient showed vertebral hypermobility on functional radiographs. One patient underwent excision of a herniated disc at a stenotic level and two of the three patients with degenerative spondylolisthesis had an intertransverse arthrodesis.

Group III, scheduled for and subsequently submitted to total laminectomy, included five patients with developmental stenosis, 17 with degenerative or combined stenosis and 10 with degenerative spondylolisthesis of from 10% to 38%. Three patients showed vertebral hypermobility of a stenotic vertebra on flexion-extension films; in two there was a degenerative slip and in the other no slip was visible on plain radiographs. Five patients had lumbar scoliosis measuring 11° to 22°. Total laminectomy was performed at a single level in 15 patients, at two levels in 13 and at three levels in four (Table I). A herniated disc was excised in three patients, two with developmental stenosis and one with degenerative stenosis. An intertransverse arthrodesis was performed at one to three levels in five patients with degenerative spondylolisthesis, and in the only patient presenting with vertebral hypermobility in the absence of a degenerative slip on plain radiographs.

In all cases, the operating time and estimated blood loss were recorded, the latter measured from sponge weighing and the amount of blood in the suction

receptacles. In group II patients, scheduled for multiple laminotomy but submitted to total laminectomy, the reasons for the change of protocol were recorded.

Follow-up. The mean follow-up was 3.7 years (2.2 to 5.3). At the latest follow-up, each patient was interviewed and examined by one of the authors (GC), who was unaware of the type of decompression performed. Plain and flexion-extension radiographs of the lumbar spine were obtained for all patients, with MRI in nine (five in group I and four in group II or III).

The clinical results were recorded using a scoring system based on the patient's opinion and the examiner's evaluation. Subjective opinions on the results used a scale of 0 to 100 for each of back pain and radicular symptoms, a low score implying greater disability. The examiner's score related to the range of motion of the lumbar spine (0 to 10); nerve-root tension tests (0 to 10); motor deficit related to preoperative muscle strength (0 to 15); the need for analgesics (0 to 15); the ability to work or to carry out activities of daily living (0 to 25); and walking ability (0 to 25). The mean of the two subjective scores and the examiner's score was recorded as the final score, and rated as excellent, good, fair or poor in the ranges of 81 to 100, 61 to 80, 41 to 60 and 0 to 40, respectively.

We compared the mean operating time and the mean blood loss of patients in group I with those in group III operated on at one or two levels. There were too few patients in group II, or having decompression at three levels, for statistical analysis. The ANOVA test was used for comparison of the results.

RESULTS

Change of procedure in group II. The most frequent reason for extending the procedure to total laminectomy in group II was the insufficient decompression allowed by the laminotomies. This occurred in seven patients: three with degenerative spondylolisthesis of 22% to 42% (Fig. 2), one with marked posterior osteophytosis of the

Fig. 2a

Fig. 2b

Fig. 2c

In a patient with degenerative spondylolisthesis of L4 (a), the preoperative MRI shows marked compression of the thecal sac (b). After performing a bilateral laminotomy at L4-L5, a total laminectomy (c) was done because of persistent compression of the thecal sac between the base of the spinous process of L4 and the posterosuperior border of the body of L5. Bilateral intertransverse arthrodesis was carried out at L4-L5.

Fig. 3a

Fig. 3b

Fig. 3c

Severe degenerative stenosis from L2-L3 to L4-L5. Figures 3a and 3b – Preoperative myelograms show a complete block of the contrast at L3-L4 and L4-L5; the transverse interruption of the contrast at the L5 level in the anteroposterior myelogram indicates severe compression of the neural structures at L4-L5. Figure 3c – A total laminectomy was performed, after the initial laminotomy at the L4-L5 level proved to be extremely difficult and time-consuming, and failed to decompress the nervous structures adequately.

vertebral bodies, and three with very severe multilevel degenerative stenosis, associated in two with lumbar scoliosis (Fig. 3). One of the patients with multilevel stenosis sustained a large dural tear at the first laminotomy and total laminectomy was needed to repair it. One patient with two-level developmental stenosis had the laminal bridge between the laminotomies accidentally removed on both sides.

Operating time and blood loss. The mean operating time for surgery at a single level was slightly, but not significantly, longer in group I than in group III (Table II). By contrast, the mean operating time for decompression at two levels was significantly longer in group I than in group III ($p < 0.05$). In group II, the mean operative time was slightly longer than in comparable subgroups (equal number of decompressed levels) of group I. The mean blood loss was similar in comparable subgroups of the three groups ($p > 0.05$; Table III).

Neural complications. After operation, three patients in group I showed a moderate to complete deficit of a single nerve root, involving L5 in two and L4 in one. Two of these patients had had discectomy at the level at which the root emerged from the thecal sac. Nerve function recovered completely in two, at two and five months, respectively. One patient with an L5 nerve-root palsy failed to recover. There were no neural complications in group II. One patient in group III had a marked increase in a preoperative deficit of the L5 root, but this improved within six months.

Postoperative imaging. In group I, there was a mild increase in slip in four of the eight patients with

Table II. Mean operating time (minutes) in the three groups of patients with central lumbar stenosis

Group*	Number of decompressed levels		
	1	2	3
I	80	125	170
II	85	135	165
III	72	90	125

* see text

Table III. Mean blood loss (ml) in the three groups of patients with central lumbar stenosis

Group*	Number of decompressed levels		
	1	2	3
I	120	200	300
II	140	190	310
III	130	210	340

* see text

degenerative spondylolisthesis; an intertransverse fusion had been performed in three of them. Flexion-extension radiographs showed no evidence of vertebral hypermobility in any of this group.

In groups II and III, other than those with degenerative spondylolisthesis, only two showed vertebral instability postoperatively. Both of these patients had mild lumbar scoliosis, which increased considerably after multilevel decompression with anterior slip of one of the laminectomised vertebrae (Fig. 4). Of the 13 patients in groups II and III with degenerative spondylolisthesis, eight showed a mild to moderate increase in slip; six of the eight had had an intertransverse fusion, which was solid at follow-up.

Of the five patients in group I who had postoperative MRI studies, three showed no significant compression of neural structures at the decompressed levels (Fig. 1), and the other two had mild posterolateral indentations of the

Fig. 4a

Fig. 4b

Fig. 4c

Fig. 4d

Mild lumbar scoliosis in a patient in group III. Figures 4a and 4b – Anteroposterior myelogram and MRI. The myelogram shows mild lumbar scoliosis and an almost complete absence of contrast from L1 to L4. MRI confirms the severity of the stenosis by interruption of the image of the thecal sac from L1-L2 to L4-L5. Figures 4c and 4d – Radiographs taken four years after total laminectomy from L1-L2 to L4-L5. An increase in scoliosis and lateral subluxation of L4 and L1 can be seen on the anteroposterior radiograph. The lateral radiograph shows an anterior slip of L4, a kyphotic deformity at the thoracolumbar level and marked osteophytosis of the vertebral bodies, some of which show a moderate collapse.

Table IV. Clinical results in the three groups of patients with central lumbar stenosis, by number and percentage of each group

Group*	Number	Clinical results			
		Excellent	Good	Fair	Poor
I	26	8 31	13 50	3 11	2 8
II	9	4 45	3 33	0	2 22
III	32	11 34	14 44	4 13	3 9

* see text

Table V. Mean subjective improvement scores for back pain and radicular symptoms in the three groups of patients with central lumbar stenosis

Group*	Back pain	Radicular symptoms
I	63	71
II	40	82
III	42	84

* see text

thecal sac. No residual bony compression was evident in patients in groups II and III.

Clinical results. At the latest follow-up, results were satisfactory (excellent or good) in 81% of patients in group I, 78% of those in group II and 78% of patients in group III (Table IV). Group I had significantly more subjective improvement in low back pain than groups II and III ($p < 0.05$; Table V), but the improvement in

radicular symptoms was greater in groups II and III than in group I, though not to significant levels ($p > 0.05$). There were no significant differences in the mean objective improvement scores for each group.

In group I, two patients had poor results: one failed to recover from a postoperative nerve-root palsy and one, with an L4 degenerative spondylolisthesis with 22% slip, still had leg pain and paraesthesiae after decompression without fusion. In groups II and III, five patients had poor results: three had postoperative vertebral instability, one had a central disc protrusion in the stenotic area not excised at surgery, and one had had decompressive surgery repeated three years after a too-narrow laminectomy at L4-L5.

DISCUSSION

We aimed to randomise the choice of surgical procedure, but had to allow the protocol to be broken when multiple laminotomy appeared to be inadequate to obtain sufficient decompression, or risked damage to neural structures. This might have influenced the result of surgery in the group submitted to multiple laminotomy. However, all the operations were performed by the same surgeon, and any decision to change the procedure was taken only after at least one laminotomy had been done.

We were treating both lateral and central stenosis. Lateral, or nerve-root canal stenosis is caused by the superior articular process and involves the emerging nerve root, either alone or with the lateral portion of the thecal sac (Epstein et al 1972; Crock 1981; Kirkaldy-Willis et al 1982). Central, or spinal canal stenosis involves the whole canal and may include varying degrees

of narrowing of the nerve-root canals (Postacchini 1989). The central constriction is produced by the medial part of the inferior articular processes, the laminae and ligamenta flava, and sometimes the spinous process. Developmental stenosis is usually seen in middle-aged patients, is rarely severe, and is often associated with a disc bulge or herniation. Degenerative and combined forms of stenosis, and that associated with degenerative spondylolisthesis, more often occur in elderly patients.

Laminotomy may allow complete decompression of the nerve in the root canal, but may not give adequate decompression of the dural tube in the central spinal canal when stenosis is caused by the most medial part of the lamina, the ligamentum flavum, and the spinous process. This may occur in very severe central stenosis and in degenerative spondylolisthesis, in which the thecal sac is compressed between the osteoligamentous posterior arch of the slipped vertebra and the posterosuperior border of the underlying vertebral body. These observations may explain why multiple laminotomy was adequate for all patients with developmental stenosis, while conversion to total laminectomy was needed in six patients with severe combined or degenerative stenosis. Similarly, multiple laminotomy was adequate for eight of the 11 patients with degenerative spondylolisthesis. These had mild or moderate slips, while the other three, with more severe slips required total laminectomy.

The greatest advantage of multiple laminotomy is the preservation of vertebral stability (Aryanpur and Ducker 1990; Nakai et al 1991). None of our patients showed vertebral hypermobility, or a significant increase in scoliosis after multiple laminotomy and none developed spondylolisthesis. After total laminectomy, three patients developed marked vertebral instability; two of these had moderate lumbar scoliosis, and one had mild single-level degenerative spondylolisthesis with no hypermobility before operation. However, postoperative instability was never observed after total laminectomy in patients showing no potential or real vertebral instability preoperatively. These findings confirm that the use of multiple laminotomy can preserve vertebral stability, but also indicate that motion segments which are fully stable preoperatively are not made unstable by a total laminectomy, especially when at least the outer quarter of the posterior joints is preserved and no discectomy is performed.

The mean blood loss during multiple laminotomy was similar to that during total laminectomy, and there was little difference in mean operating times for decompression at a single level. By contrast, the mean operating time for bilateral laminotomy at two or three vertebral levels was longer than for total laminectomy at an equal number of levels. The difference is because the approach for total laminectomy, involving opening the spinal canal at the posterior corner, makes the dural tube clearly visible, allowing the easy and rapid removal of the posterior arch. For multiple laminotomy, the spinal

canal is first opened in its lateral part, which is usually narrower than the posterior corner, and this has to be repeated on each side at each level. The increased operating time is an important factor, which may contraindicate this approach for patients who are at poor surgical risk or require decompression at more than two levels.

Aryanpur and Ducker (1990) reported no complications in 32 patients with lateral stenosis undergoing multiple laminotomy, but Young et al (1988) using multiple laminotomy with an operating microscope in 32 patients with lateral or central stenosis, reported a 9% incidence of dural tears. All our patients had central spinal stenosis, and the multiple laminotomy group sustained one dural tear and three instances of deficit of a single nerve root after surgery. Our patients undergoing total laminectomy had a lower incidence of complications, with only one case of increased nerve-root deficit. The higher incidence of neural complications shows that it is necessary to be very cautious in performing multiple laminotomy when the spinal canal is markedly stenotic or disc excision is required, because the nerve root emerging from the dural sac is more easily injured when the spinal canal is approached from the lateral side.

In our series, multiple laminotomy gave similar overall results to total laminectomy, but with less subjective improvement for radicular symptoms, although the difference was not significant. The mean subjective improvement of low back pain, however, was significantly higher after multiple laminotomy. This difference is probably due to the greater postoperative vertebral stability in patients undergoing multiple laminotomy.

Conclusions. Our study shows that multiple laminotomy and total laminectomy both have a role in the treatment of central spinal stenosis. Multiple laminotomy, with its better preservation of vertebral stability, is the treatment of choice for developmental stenosis since the patients are usually middle-aged, the stenosis is rarely severe, and disc excision is often necessary in addition to decompression. Multiple laminotomy is also to be preferred for combined or degenerative stenosis when narrowing of the spinal canal is mild or moderate, particularly if disc excision has been planned. Total laminectomy is usually more effective for severe stenosis, provided that the involved segments are stable preoperatively. When this is not the case, the choice is between multiple laminotomy or total laminectomy with fusion of the decompressed segments. For mild degenerative spondylolisthesis, bilateral laminotomy usually allows sufficient decompression of the neural structures and adequate preservation of vertebral stability. When there is a severe slip (25% or greater), complete decompression can usually be obtained only by total laminectomy.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

- Aryanpur J, Ducker T.** Multilevel lumbar laminotomies: an alternative to laminectomy in the treatment of lumbar stenosis. *Neurosurgery* 1990; 26:429-33.
- Caffinière JY de la.** Évaluation du risque de glissement vertébral après traitement chirurgical d'une sténose lombaire. *Rev Chir Orthop* 1986; 72:73-80.
- Crock HV.** Normal and pathological anatomy of the lumbar spinal nerve root canals. *J Bone Joint Surg [Br]* 1981; 63-B:487-90.
- Epstein JA, Epstein BS, Rosenthal AD, Carras R, Lavine AWF.** Sciatica caused by nerve root entrapment in the lateral recess: the superior facet syndrome. *J Neurosurg* 1972; 36:584-9.
- Herkowitz HN, Kurz LT.** Degenerative lumbar spondylolisthesis with spinal stenosis: a prospective study comparing decompression with decompression and intertransverse process arthrodesis. *J Bone Joint Surg [Am]* 1991; 73-A:802-8.
- Hopp E, Tsou PM.** Postdecompression lumbar instability. *Clin Orthop* 1988; 227:143-51.
- Johnsson K, Willner S, Johnsson K.** Postoperative instability after decompression for lumbar spinal stenosis. *Spine* 1986; 11:107-10.
- Kirkaldy-Willis WH, Wedge JH, Yong-Hing K, et al.** Lumbar spinal nerve lateral entrapment. *Clin Orthop* 1982; 169:171-8.
- Lee CK.** Lumbar spinal instability (olisthesis) after extensive posterior spinal decompression. *Spine* 1983; 8:429-33.
- Lin PM.** Internal decompression for multiple levels of lumbar spinal stenosis: a technical note. *Neurosurgery* 1982; 11:546-9.
- Nakai O, Ookawa A, Yamaura I.** Long-term roentgenographic and functional changes in patients who were treated with wide fenestration for central lumbar stenosis. *J Bone Joint Surg [Am]* 1991; 73-A:1184-91.
- Nixon JE.** Surgical management. In: Nixon JE, ed. *Spinal stenosis*. London, etc: Edward Arnold, 1991:299-341.
- Postacchini F.** *Lumbar spinal stenosis*. Vienna, etc: Springer-Verlag, 1989.
- Schonstrom NS, Bolender NF, Spengler DM.** The pathomorphology of spinal stenosis as seen on CT scans of the lumbar spine. *Spine* 1985; 10:806-11.
- Senegas J, Etchevers JP, Vital JM, Baulny D, Grenier F.** Le recalibrage du canal lombaire, alternative à la laminectomie dans le traitement des sténoses du canal lombaire. *Rev Chir Orthop* 1988; 74:15-22.
- Shenkin HA, Hash CJ.** Spondylolisthesis after multiple bilateral laminectomies and facetectomies for lumbar spondylosis. *J Neurosurg* 1979; 50:45-7.
- Young S, Veerapen R, O'Laoire SA.** Relief of lumbar canal stenosis using multilevel subarticular fenestrations as an alternative to wide laminectomy: preliminary report. *Neurosurgery* 1988; 23: 628-33.