BONE REGROWTH AFTER SURGICAL DECOMPRESSION FOR LUMBAR SPINAL STENOSIS

FRANCO POSTACCHINI, GIANLUCA CINOTTI

From the Universities of Modena and Rome

We reviewed 40 patients treated surgically for lumbar stenosis at an average time of 8.6 years after operation. In 32, total laminectomy had been performed and in eight bilateral laminotomy, both at one or more levels. Of the 16 patients with degenerative spondylolisthesis, ten had had a concomitant spinal fusion. Patients were assigned to one of four groups according to the amount of bone regrowth: group 0 had no regrowth and groups I, II, and III, had mild, moderate or marked regrowth, respectively.

Only 12% of the patients showed no bone regrowth; 48% were assigned to group I, 28% to group II and 12% to group III. Imaging studies showed varying degrees of recurrent stenosis in patients with moderate or marked bone regrowth. All patients with degenerative spondylolisthesis showed bone regrowth, which was more severe in those who had not had a fusion. The clinical results were satisfactory in most of the patients with mild or no bone regrowth and significantly less good in those with moderate or marked regrowth. In the group with degenerative spondylolisthesis, the proportion of satisfactory results was significantly higher in patients who had had spinal fusion.

The long-term results of surgery for lumbar stenosis depend both upon the amount of bone regrowth and the degree of postoperative vertebral stability.

The results of surgical decompression in lumbar spinal stenosis have been reported by several authors (Epstein, Epstein and Lavine 1962; Kirkaldy-Willis et al 1974; Cauchoix, Benoist and Chassaing 1976; Paine 1976; Tile et al 1976; Getty 1980; Dall and Rowe 1985; Lassale, Deburge and Benoist 1985; Lombardi et al 1985; Kaneda et al 1986; Nasca 1987) but very little is known about the regrowth of the resected portion of the posterior arch. We have found only three reports in which this was briefly mentioned. In a series of 231 patients with postoperative spinal stenosis, Brodsky (1976) described " several cases presenting a sheet of spontaneous new bone formation across the laminae after previous simple laminectomy", and Verbiest (1977) reported one case in which radiographs taken 30 years after total laminectomy showed complete regrowth of the laminae. Sano et al (1990), reporting on patients with instability of the lumbar spine after laminectomy described two patients who, at surgery, showed considerable formation of new bone.

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

G. Cinotti, Resident
Orthopaedic Clinic, University of Rome, 'La Sapienza' Piazzale Aldo Moro 5, 00185 Rome, Italy.

Correspondence should be sent to Professor F. Postacchini.

0301-620X/92/6453 $2.00
J Bone Joint Surg [Br] 1992; 74-B:862-9.

We have studied the clinical and radiographic status of patients treated surgically for lumbar stenosis to determine the incidence and clinical significance of regrowth of the posterior vertebral arch.

PATIENTS AND METHODS

Between 1972 and 1985, 88 patients had surgery for stenosis of the lumbar spinal canal at the Orthopaedic Clinic of La Sapienza University of Rome; 27 could not be traced or had died from unrelated causes and 21 had had no immediate postoperative radiographs. The remaining 40 were reviewed after five to 19 years (mean 8.6). There were 24 men and 16 women and their ages at operation ranged from 38 to 71 years (mean 54). Two patients had had a second operation for recurrent stenotic syndrome, at three and five years after the initial procedure. One was reviewed at five years, and the other at six years after the second operation. Pre-operatively, the stenosis had been classified as developmental, degenerative (with or without spondylolisthesis) or combined (Postacchini et al 1980; Postacchini 1989). Of the 16 patients with degenerative spondylolisthesis 13 had listhesis at one level and three at two contiguous levels.

Total laminectomy had been performed in 32 patients and bilateral laminotomy in eight, in both groups at one to four vertebral levels. In seven patients, partial or complete foraminectomy had been performed delib-

erately or inadvertently at one to three levels, on one or both sides (11 foraminectomies). Six patients with degenerative spondylolisthesis treated by laminectomy and four treated by laminotomy had also had an intertransverse fusion.

Radiographs of the lumbar spine were obtained in all cases at one to six weeks after surgery. In 13 (excluding the two reoperated cases), radiographs had also been taken at two to 12 years after surgery because of persistence or recurrence of low back pain or radicular symptoms. CT scans had also been performed in three of these patients. In the two patients reoperated on, myelography was done before the second operation; MRI had been carried out on one of them and CT scanning on the other.

At follow-up, patients were interviewed and examined, and new radiographs of the lumbar spine were obtained. CT scans were taken in six patients, three of whom had already undergone this investigation 1.5 to five years after surgery. MRI scans were performed in two other patients.

The clinical results were evaluated by a scoring system. For subjective evaluation, the patients gave their opinion of the result, using a 50-point scale for each of back pain and leg symptoms. The two scores were then added to provide an overall score from 0 to 100. A low score implied greater disability and a high score less disability. For objective assessment, the examiner assigned a score of 0 to 100 based on six measurements: range of motion of the lumbar spine; nerve root tension tests; improvement in muscle strength; need for medication; ability to work or, in retired patients, to carry out the activities of daily living; and ability to walk. The highest score that could be assigned was 15 points for each of the first three parameters, ten for the fourth, and 20 and 25 respectively for the last two. The mean of the subjective and objective scores was taken as the final score. The result was rated excellent when the score was 81 to 100 points, good between 61 and 80, fair between 41 and 60, and poor when 40 or less was scored.

To detect regrowth of the posterior arch, the early

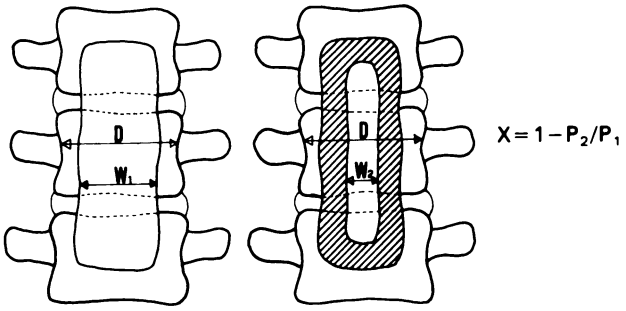

Fig. 1

Diagram to show the calculation of regrowth of the posterior arch as a percentage of the original defect. The widths of the laminectomy defect on the immediate postoperative film (W1) and on the follow-up film (W2) were expressed as a percentage of the width of the vertebral body (D) to obtain two values, P_1 and P_2; P_2 was then expressed as a percentage of P_1. The resulting value (Y) represented the percentage of the residual laminectomy defect remaining at follow-up; 100 − Y is therefore the percentage of the resected portion of the arch which had been reformed. This percentage can be obtained using the equation: $X = 1 - P_2/P_1$.

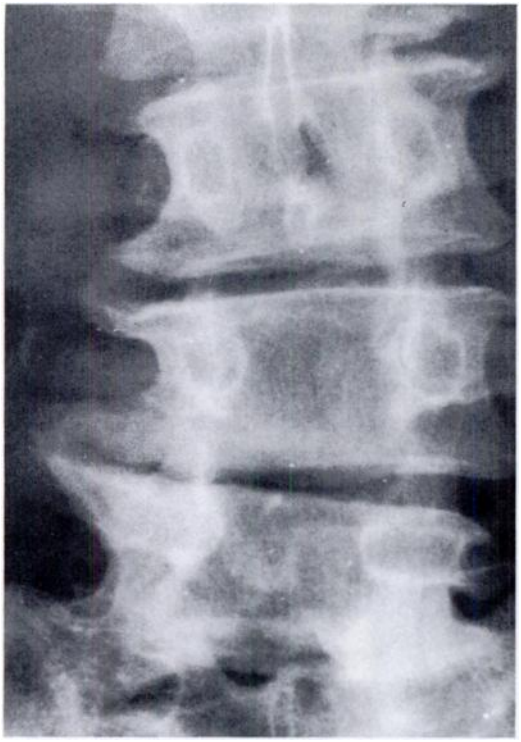

Fig. 2a

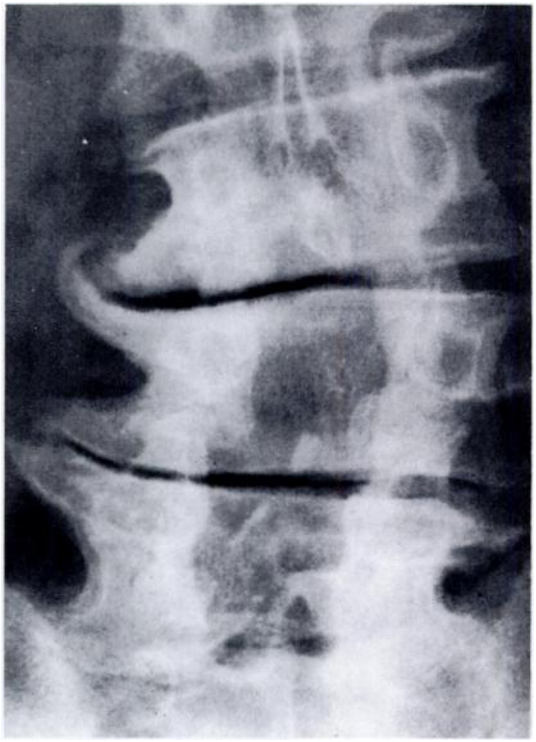

Fig. 2b

Mild regrowth of the posterior arch after total laminectomy at L3 to L5 (group I). Figure 2a – Early postoperative radiograph. Figure 2b – Radiograph nine years after surgery.

postoperative radiographs were compared with those obtained over the following years (when available) and those taken at follow-up. Regrowth in the transverse direction, between the articular processes, was measured as the percentage by which the surgical defect had decreased in width. In patients who had had a total laminectomy, this was the shortest distance between the medial borders of the residual articular processes (Fig. 1). The width of a laminotomy defect was measured, on each side, as the shortest distance between the articular processes and a vertical line traced through the centre of the spinous processes. In a few patients, the early postoperative radiographs and the later radiographs had been taken using different focal distances, and the apparent width of the laminectomy or laminotomy defect was therefore expressed as a percentage of the apparent width of the vertebral body at each measurement. The percentage of bone regrowth was calculated as shown in Figure 1.

Four degrees of bone regrowth were distinguished:

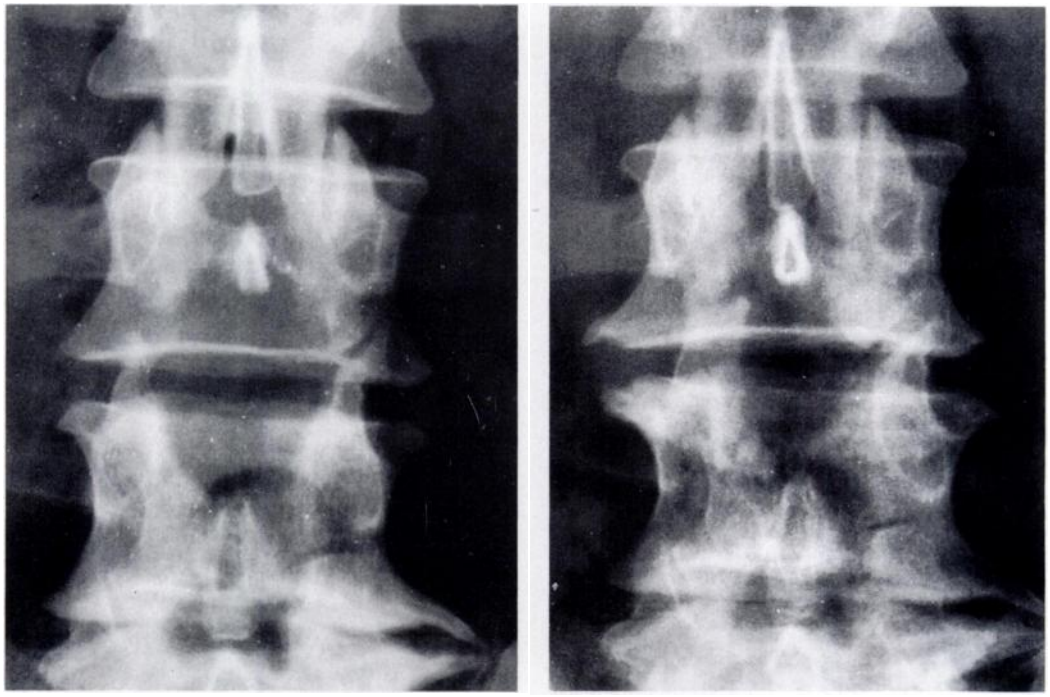

Fig. 3a Fig. 3b

Moderate regrowth of the posterior arch (group II). Figure 3a – Early postoperative radiograph showing extensive total laminectomy at L3-L4 level. Figure 3b – The anteroposterior radiograph six years after surgery shows moderate regrowth of the articular processes almost completely resected at surgery.

Marked regrowth of the posterior vertebral arch (group III). Figure 4a – Early postoperative radiograph showing total laminectomy at L4-L5 level. Figure 4b – Radiograph eight years after surgery showing almost complete regrowth of the posterior arch.

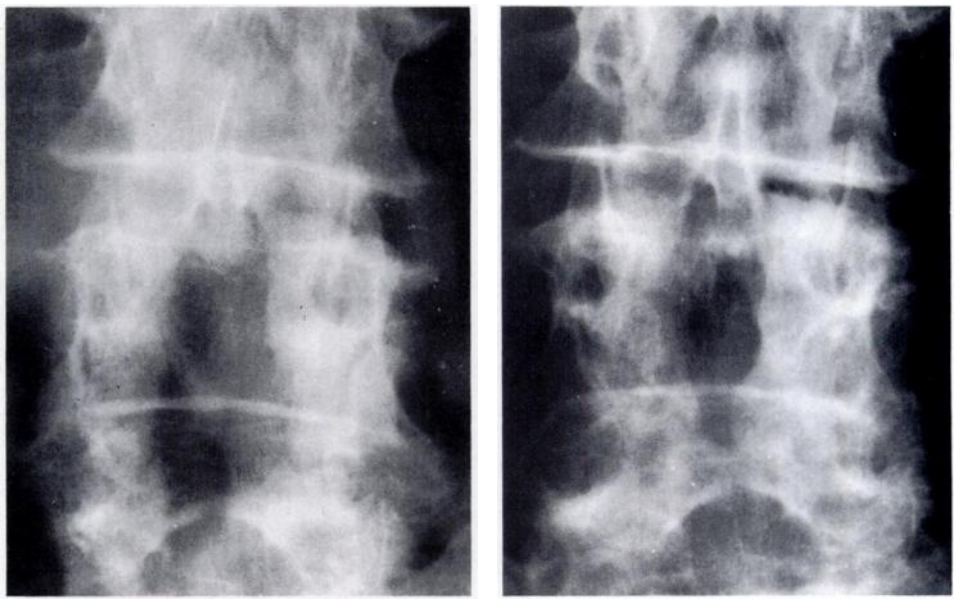

Fig. 4a Fig. 4b

no significant regrowth (group 0, 10% or less), and mild, moderate or marked regrowth (group I, 11% to 40%; group II, 41% to 70%, and group III, 71% to 100% respectively). Examples are shown in Figures 2 to 4. In patients decompressed at several levels, that with the most regrowth was used to assign the patient to a group. In patients with bilateral laminotomy, there was usually little difference in the regrowth on the two sides (Fig. 5), but if there was one the side with most regrowth was used to group the patient.

Two degrees of decompression, narrow and wide, were distinguished. Decompression was considered to be narrow when less than half of the posterior joint facets had been removed, and wide when resection of the articular processes had been more extensive.

The chi-squared test was used for the statistical analysis of data.

RESULTS

Extent of bone regrowth. In five patients, the margins of the defect had undergone a remodelling process, but no significant bone regrowth had occurred. Of the patients showing bone regrowth, 19 were assigned to group I, 11 to group II and five to group III. Of the 74 decompressed vertebral levels, 15 showed no bone regrowth, 36 were allocated to group I, 18 to group II and five to group III. The vertebral levels showing the highest (56%) and the lowest (8%) rates of moderate or marked bone regrowth were L4-L5 and L2-L3, respectively.

In patients who had undergone one or more foraminectomies, the articular processes showed no regrowth at the four sites where they had been completely or almost completely resected. The posterior joint had reformed, however, in seven cases of incomplete foraminectomy; in these, at least the basal one-third of the two opposing articular processes had been preserved at surgery.

Progression of bone regrowth. Of the 13 patients with radiographs taken after surgery, four showed no significant differences from the radiographs taken at follow-up. In the remaining nine patients, a progressive increase in new bone was observed with the increasing time interval (Fig. 6). Five of the nine had moderate and four had marked bone regrowth.

Effects on the spinal canal and the nerves. Three of the patients on whom CT scans had been performed at follow-up had already had a CT study during the years after total laminectomy at several levels. One of these had only mild bone regrowth and no significant stenosis was observed at the site of the laminectomy in either of the CT studies. In the other two, bone regrowth was moderate at the time of the first study and marked at follow-up. In addition, the CT scans showed marked narrowing of the lumbar spinal canal over the entire laminectomy area and, to a greater extent, at one of the levels operated on (L4-L5 in one patient and L3-L4 in the other). Stenosis, as a result of bone regrowth, had increased considerably with time (Fig. 7).

The CT scans through the intervertebral spaces showed that the reformed portion of the posterior arch consisted of abnormally large articular processes, which invaded the laminectomy defect and compressed the neural structures. CT scans through the vertebral bodies showed that the articular processes were often in continuity with sheets of newly formed bone representing a sort of lamina. These sheets rarely caused compression of the neural structures. In the fibrous lamina bridging the laminectomy defect, calcified areas or bone islets were sometimes visible, either isolated or in continuity

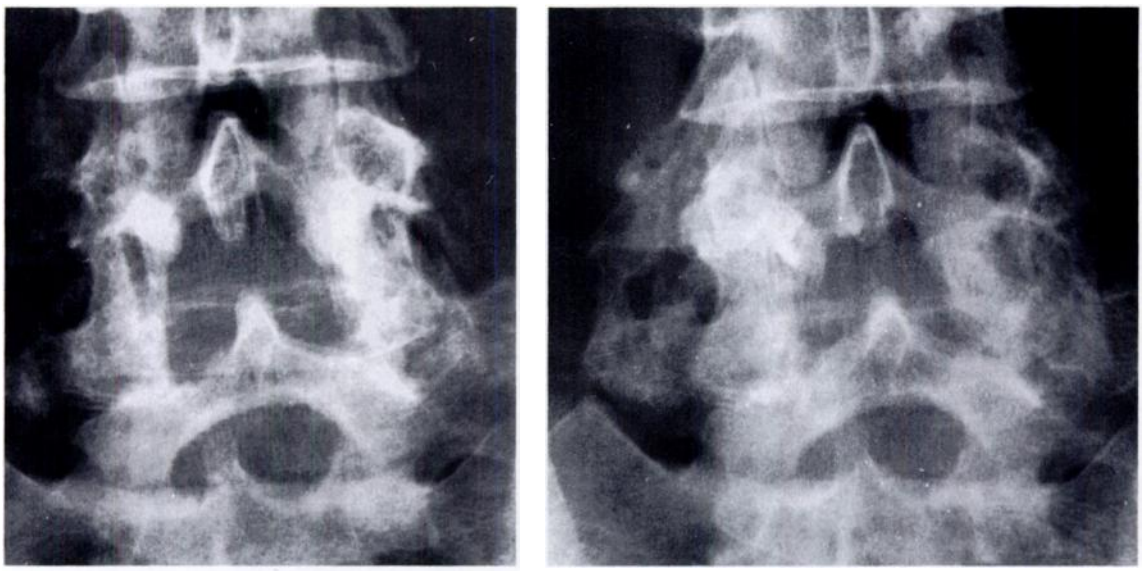

Fig. 5a Fig. 5b

Figure 5a Early postoperative radiograph after bilateral laminotomy and intertransverse fusion for degenerative spondylolisthesis of L4 and spinal stenosis. Figure 5b – Radiograph taken five years after surgery showing moderate narrowing of the laminotomy defects and a solid intertransverse fusion. The bony regrowth is similar on both sides.

with the articular processes or the newly formed laminal bone. Similar findings were observed in the three patients (one with marked and two with moderate bone regrowth) in whom CT scans had been performed at follow-up.

Moderate bone regrowth had occurred in the two patients who had undergone MRI studies. There was posterolateral compression of the thecal sac at the site of the previous laminectomy in one but no significant compression in the other.

Vertebral stability and the width of the defect. Bone regrowth was not related to the patient's sex, age at operation, type of stenosis or type of decompression. The degree of vertebral stability and the width of the decompression did, however, appear to be significant. Of the six patients with degenerative spondylolisthesis who did not have an arthrodesis, two had mild, one had moderate, and three had marked bone regrowth, while of the ten patients who had fusions, four had mild and six had moderate regrowth. Two patients, who had undergone total laminectomy at one level only, developed mild spondylolisthesis after surgery. In these two cases, in which flexion-extension radiographs showed hypermobility of the listhetic vertebra, moderate bone regrowth had occurred. In the two groups of patients with spondylolisthesis, bone regrowth was significantly greater than in patients with no vertebral slipping ($p = 0.01$, Table I).

In six patients, eight of the 12 segments decompressed were less mobile than normal on the pre-operative radiographs due to the presence of large osteophytes between the vertebral bodies. Three of these stiff segments showed no bone regrowth and five had mild regrowth. Of the remaining four segments, two had mild and two moderate bone regrowth. Patients with a narrow surgical defect showed a greater tendency to bone regrowth

Table I. Bone regrowth in patients with spondylolisthesis (degenerative or postoperative), and without spondylolisthesis, with the significance of the difference

		Degree of bone regrowth				
Type	**Number**	**0**	**I**	**II**	**III**	
Spondylolisthesis	18	0	6	9	3	$p=0.01$
No spondylolisthesis	22	5	13	2	2	

Table II. Bone regrowth in patients who had had a wide or a narrow laminectomy or laminotomy, with the significance of the difference

		Degree of bone regrowth				
Laminectomy or laminotomy	**Number**	**0**	**I**	**II**	**III**	
Wide	26	4	16	5	1	$p=0.02$
Narrow	14	1	3	6	4	

Table III. Clinical results in four groups of patients with different degrees of bone regrowth*

		Degree of bone regrowth			
Clinical results	**Number**	**0**	**I**	**II**	**III**
Excellent	7	2	5	0	0
Good	21	2	11	6	2
Fair	7	1	2	3	1
Poor	5	0	1	2	2

*no significant difference was found between the groups ($p > 0.05$)

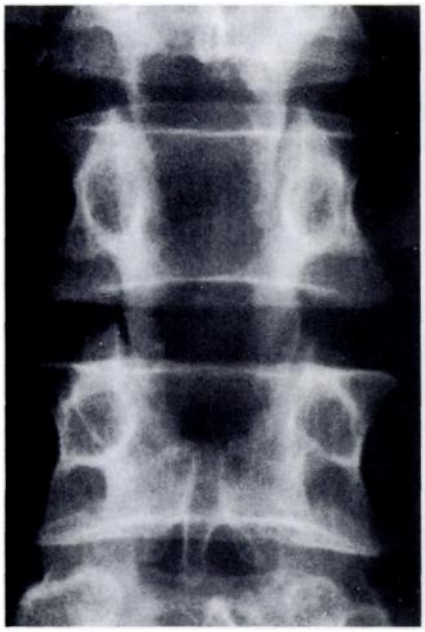

Fig. 6a

Fig. 6b

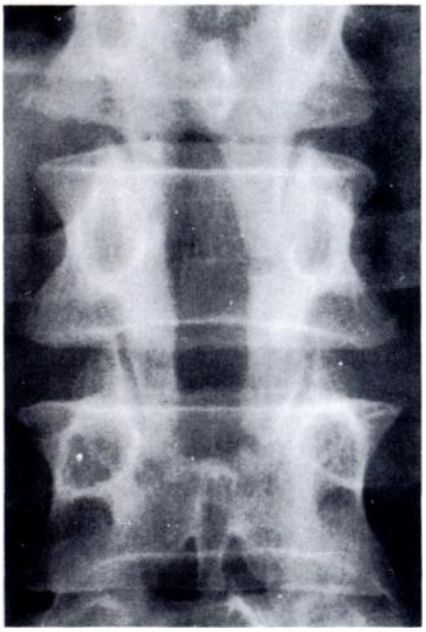

Fig. 6c

Progressive regrowth of the posterior arch over the years after surgery. Figure 6a – Early postoperative radiographs showing total laminectomy from L2 to L4. Figure 6b – Radiograph taken four years after surgery showing moderate regrowth of the resected articular processes. Figure 6c – Seven years after surgery, the laminectomy defect has further narrowed particularly in the transverse plane.

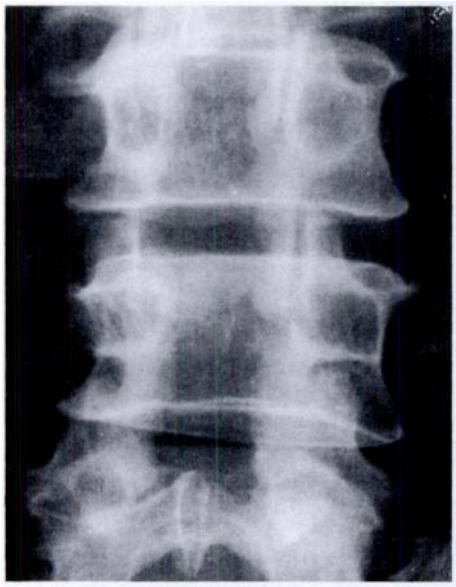

Fig. 7a

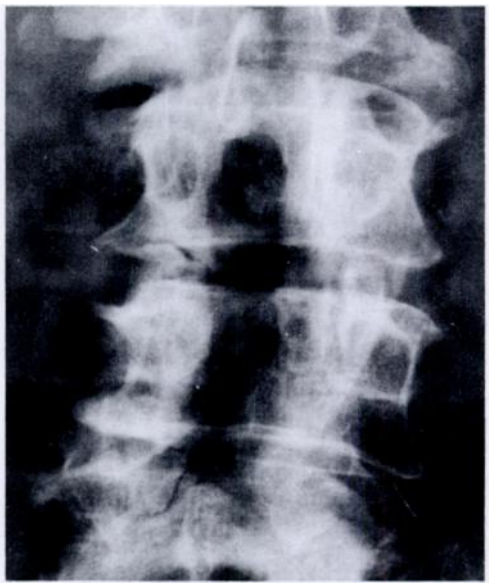

Fig. 7b

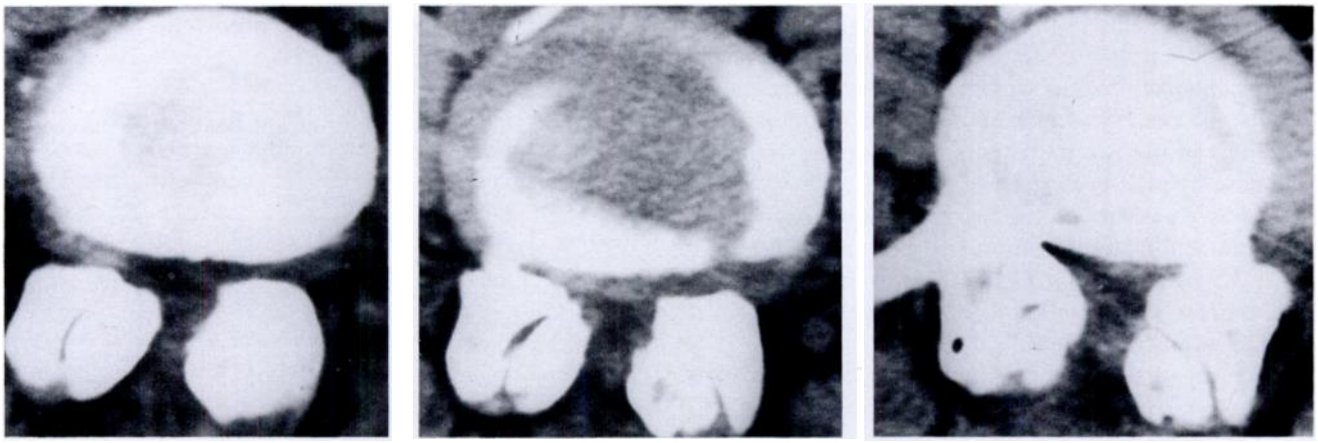

Fig. 7c

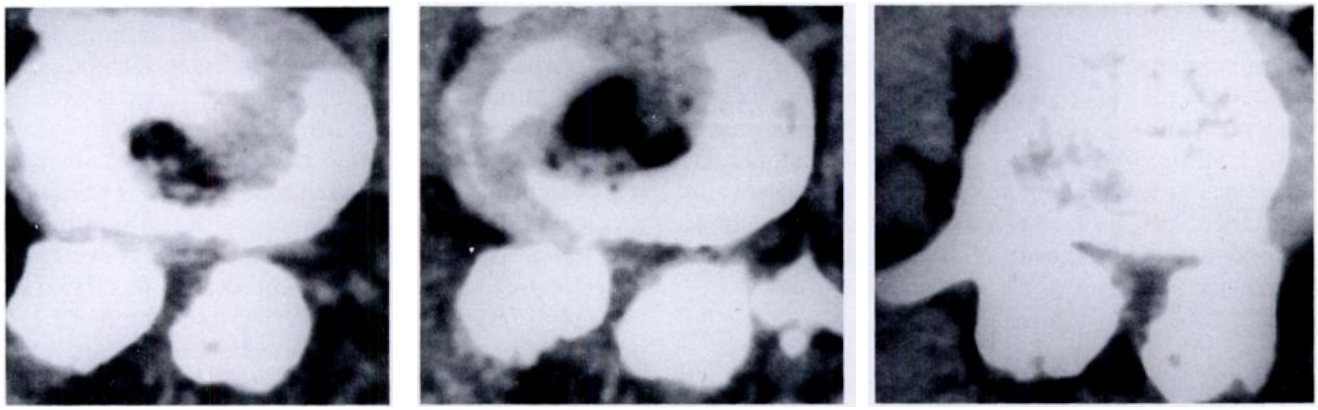

Fig. 7d

Progressive increase in spinal canal stenosis in a patient with marked posterior arch regrowth. Radiographs taken postoperatively (a) and 12 years after surgery (b) show marked bone regrowth, particularly at L4-L5. CT scans obtained five years after surgery (c) show a narrow laminectomy defect and moderate spinal canal stenosis at L4-L5. CT scans at 12 years after surgery (d) show a marked increase in spinal canal stenosis at L4-L5 level.

than those who had had a wide laminectomy ($p = 0.02$, Table II).

Clinical results. The clinical results were excellent or good in 80% of the patients with no significant bone regrowth and in 84% of those with mild regrowth of the posterior arch. In patients with moderate or marked bone regrowth, the proportion of satisfactory results was 55% and 40%, respectively (Table III). Of the patients with fair results, two had no significant symptoms in the lower limbs and five complained of leg symptoms of varying degree at rest or during walking. All five patients with poor results complained of leg symptoms and three of them (two with marked and one with moderate bone regrowth) could only walk 200 m or less. These three patients, and the only patient showing marked bone regrowth among those with fair results, reported that their leg symptoms had gradually recurred or worsened after an initial period of relief.

The clinical outcome did not appear to be related to the type of decompression. In the patients with degenerative spondylolisthesis, a significant difference was found between those who had had a fusion and those who had not (Table IV). In the fused group the proportion of satisfactory results (80%) was much higher than in the unfused group (33%). In these patients, however, no significant relationship was found between the clinical results and the extent of bone regrowth. Clinical results were fair in the two patients in whom spondylolisthesis had developed after surgery.

Reoperated patients. In the two patients who had second operations, total laminectomy had been performed from L3 to L5 in one and at L4-L5 level in the other. There was narrow decompression at the level of the fourth lumbar interspace in both.

In the first patient, intermittent claudication recurred three years after surgery. Myelograms and CT scans showed severe compression of the neural structures at L4-L5 level due to marked bone regrowth. Five years after the second decompression, the clinical result was good and radiographs showed only mild bone regrowth.

The second patient had recurrence of radicular symptoms five years after the first operation. Myelograms and MRI scans showed recurrence of compression due to moderate bone regrowth and posterior bulging of the disc at L4-L5 level. Wide laminectomy and discectomy led to complete relief of the radicular symptoms. At follow-up, the patient had no leg symptoms and the radiographs showed only mild regrowth of the articular processes at L4-L5 level.

DISCUSSION

This study shows that in most patients with lumbar spinal stenosis treated surgically, there is regrowth of the excised portion of the posterior arch; this may be mild and cease within a few years or it may continue until the entire posterior arch has reformed at one or more levels. The reasons for the different response of individual patients remain to be identified. Some observations arising from this study may contribute, however, to a better understanding of the aetiology of bone regrowth. All patients who, either pre- or postoperatively, showed evidence of vertebral instability had bone regrowth, which was on average greater than in those with no instability. Spinal segments which were less mobile than normal, due to large vertebral body osteophytes, had less bone regrowth than segments with normal mobility. The highest rate of bone regrowth was at L4 to L5, which is known to be the most mobile of the lumbar intervertebral levels (Pearcy 1985). These findings seem to indicate that regrowth of the posterior arch is stimulated by abnormal vertebral motion and represents an attempt to increase vertebral stability.

All our patients with degenerative spondylolisthesis who had had fusion showed some bone regrowth, although it was on average less than in patients whose spines had not been fused. Bone regrowth in these patients suggests that more than one aetiological factor is involved in the process of posterior arch regrowth. It is possible, however, that in these cases the bone regrowth occurred before solid fusion had been achieved (Sano et al 1990).

Table IV. Clinical results in patients with degenerative spondylolisthesis with or without fusion, with the significance of the difference

		Clinical results				
Treatment	**Number**	**Excellent**	**Good**	**Fair**	**Poor**	
Fusion	10	3	5	2	0	$p < 0.05$
No fusion	6	0	2	1	3	

Two types of bone regrowth were identified: gradual regrowth of the laminae and the articular processes partially resected at surgery; and enlargement and coalescence of islets of bone tissue within the fibrous sheet filling the laminectomy or laminotomy defect. The first process is the one mainly responsible for narrowing of the surgical defect in the transverse plane. The second process, probably occurring after the first, seems to contribute significantly to the regrowth of the laminae at the ends of the surgical defect and to be responsible for regrowth of the vertebral arch medially to the posterior joints. Two findings are consistent with this interpretation. First, complete resection at one level of the inferior articular process or both articular processes was found to hinder or prevent regrowth of the posterior arch. This is probably because complete resection of an articular process prevents the first type of bone regrowth taking place and, in this instance, the second type cannot occur or is deficient. Secondly, patients with wide surgical defects on the early postoperative radiographs showed less tendency to bone regrowth than patients with a narrow defect. A possible explanation of this finding is

that coalescence of bony islets is more likely to occur where they are close to each other.

We could not determine the time at which bone regrowth occurred but our study suggests that in most cases it begins or the process begins within a few months of operation. In patients who have progressive bone regrowth, it may take five to 15 years for the posterior arch to reform completely.

Regrowth of the posterior arch, while increasing vertebral stability, may cause narrowing of the nerve root canals or of the central portion of the spinal canal. Narrowing of the vertebral canal is caused mainly by the posterior facet joints, whose regrowth may reproduce pathological conditions identical to those before surgery. On the other hand, regrowth of the laminal arch does not usually cause significant compression except in degenerative spondylolisthesis. In this condition, regrowth of the laminal arch may contribute to compression of the neural structures at the level of the intervertebral space, as did the original laminae before the operation.

In our series, the proportion of satisfactory clinical results progressively decreased from the group with mild bone regrowth to the group with marked regrowth. Vertebral instability also prejudiced the clinical outcome. It is likely that fusion eliminates, while instability increases, the dynamic changes in the size of the vertebral canal, which are known to affect both the degree of compression and the blood supply to the spinal nervous structures (Breig and Marions 1963; Parke and Watanabe 1985).

In many studies (Getty 1980; Surin, Hedelin and Smith 1982; Dall and Rowe 1985; Hall et al 1985; Lassale et al 1985; Herron and Trippi 1989; Herkowitz and Kurz 1991; Katz et al 1991), the results of operative treatment for lumbar stenosis were analysed, on average, several years after surgery, but in only one (Verbiest 1977) were they assessed at very long term. Only one previous study (Katz et al 1991) reported significant deterioration in the quality of the results with increasing time from surgery, and ours is the first long-term radiographic survey of patients treated for lumbar stenosis by decompression. We have shown that the results of operative treatment may deteriorate with time due to gradual regrowth of the resected portion of the posterior arch. This is more likely to occur after a narrow laminectomy and if the operated vertebral level is unstable. We strongly believe that decompression, while preserving vertebral stability, should be as wide as possible. The medial two-thirds or even three-quarters of the articular processes should be excised and the decompression should extend as far as half of the height of the vertebra above and below the stenotic area. When stenotic vertebral levels are unstable or potentially unstable, fusion should be considered.

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

Breig A, Marions O. Biomechanics of the lumbosacral nerve roots. *Acta Radiol* 1963; 1:1141-60.

Brodsky AE. Post-laminectomy and post-fusion stenosis of the lumbar spine. *Clin Orthop* 1976; 115:130-9.

Cauchoix J, Benoist M, Chassaing V. Degenerative spondylolisthesis. *Clin Orthop* 1976; 115:122-9.

Dall BE, Rowe DE. Degenerative spondylolisthesis: its surgical management. *Spine* 1985; 10:668-72.

Epstein JA, Epstein BS, Lavine L. Nerve root compression associated with narrowing of the lumbar spine canal. *J Neurol Neurosurg Psychiat* 1962; 25:165-76.

Getty CJM. Lumbar spinal stenosis: the clinical spectrum and the results of operation. *J Bone Joint Surg [Br]* 1980; 62-B:481-5.

Hall S, Bartleson JD, Onofrio BM, et al. Lumbar spinal stenosis: clinical features, diagnostic procedures, and results of surgical treatment in 68 patients. *Ann Intern Med* 1985; 103:271-5.

Herkowitz HN, Kurz LT. Degenerative lumbar spondylolisthesis with spinal stenosis. *J Bone Joint Surg [Am]* 1991; 73-A:802-8.

Herron LD, Trippi AC. L4-5 degenerative spondylolisthesis: the results of treatment by decompressive laminectomy without fusion. *Spine* 1989; 14:534-8.

Kaneda K, Kazama H, Satoh S, Masanori F. Follow-up study of medial facetectomies and posterolateral fusion with instrumentation in unstable degenerative spondylolisthesis. *Clin Orthop* 1986; 203: 159-67.

Katz JN, Lipson SJ, Larson MG, et al. The outcome of decompressive laminectomy for degenerative lumbar stenosis. *J Bone Joint Surg [Am]* 1991; 73-A:809-16.

Kirkaldy-Willis WH, Paine KWE, Cauchoix J, McIvor G. Lumbar spinal stenosis. *Clin Orthop* 1974; 99:30-50.

Lassale B, Deburge A, Benoist M. Résultats á long terme du traitement chirurgical des sténoses lombaires opérées. *Rev Rhum Mal Osteoartic* 1985; 52:27-33.

Lombardi JS, Wiltse LL, Reynolds J, Widell EH, Spencer C, III. Treatment of degenerative spondylolisthesis. *Spine* 1985; 10: 821-7.

Nasca RJ. Surgical management of lumbar spinal stenosis. *Spine* 1987; 12:809-16.

Paine KWE. Results of decompression for lumbar spinal stenosis. *Clin Orthop* 1976; 115:96-100.

Parke WW, Watanabe R. The intrinsic vasculature of the lumbosacral spinal nerve roots. *Spine* 1985; 10:508-15.

Pearcy MJ. Stereo radiography of lumbar spine motion. *Acta Orthop Scand* 1985; 56:suppl.212.

Postacchini F. *Lumbar spinal stenosis.* Vienna, etc: Springer-Verlag 1989.

Postacchini F, Pezzeri G, Montanaro A, Natali G. Computerised tomography in lumbar stenosis: a preliminary report. *J Bone Joint Surg [Br]* 1980; 62-B:78-82.

Sano S, Yokokura S, Nagata Y, Young SZ. Unstable lumbar spine without hypermobility in postlaminectomy cases: mechanism of symptoms and effect of spinal fusion with and without spinal instrumentation. *Spine* 1990; 11:1190-7.

Surin V, Hedelin E, Smith L. Degenerative lumbar spinal stenosis: results of operative treatment. *Acta Orthop Scand* 1982; 53:79-85.

Tile M, McNeil SR, Zarins RK, Pennal GF, Garside SH. Spinal stenosis: results of treatment. *Clin Orthop* 1976; 115:104-8.

Verbiest H. 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]* 1977; 59-B:181-8.