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Degenerative Lumbar Spondylolisthesis with Spinal Stenosis

A PROSPECTIVE STUDY COMPARING DECOMPRESSION WITH DECOMPRESSION AND INTERTRANSVERSE PROCESS ARTHRODESIS*†

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ABSTRACT: Fifty patients who had spinal stenosis associated with degenerative lumbar spondylolisthesis were prospectively studied clinically and radiographically to determine if concomitant intertransverse-process arthrodesis provided better results than decompressive laminectomy alone. There were thirty-six women and fourteen men. The mean age of the twenty-five patients who had had an arthrodesis was 63.5 years and that of the twenty-five patients who had not had an arthrodesis, sixty-five years. The level of the operation was between the fourth and fifth lumbar vertebrae in forty-one patients and between the third and fourth lumbar vertebrae in nine patients. The patients were followed for a mean of three years (range, 2.4 to four years). In the patients who had had a concomitant arthrodesis, the results were significantly better with respect to relief of pain in the back and lower limbs.

Degenerative lumbar spondylolisthesis was apparently first described in the German literature, as pseudospondylolisthesis, by Junghanns²³ in 1931, and in the English-language literature by Macnab²⁹ in 1950. The modern concept of degenerative spondylolisthesis was described by Newman³⁴ in 1955; however, the operative management of this disorder when accompanied by spinal stenosis has remained controversial, despite a clearer understanding of its pathogenesis and pathology^{1,6,14-17,24,26,43}.

Some authors have reported satisfactory results with decompressive laminectomy alone^{5,7-9,12,19,44}, while others have advocated that a spinal arthrodesis be done concomitantly with the decompression^{2,4,12,16,24,28,39,49}. It is difficult to compare these series because of differences in the patient populations, operative procedures, surgeons, postoperative management, grading of results, and levels of the spine at which the operation was done. Therefore, the indications for concomitant arthrodesis with decompressive laminectomy in the operative management of patients who have degenerative lumbar spondylolisthesis and spinal stenosis have remained unclear.

To determine these indications, a prospective study was performed to compare the results of decompression alone

with those of concomitant intertransverse-process arthrodesis at the level of the decompression for the management of degenerative spondylolisthesis at a single level associated with lumbar spinal stenosis.

Materials and Methods

Fifty consecutive patients met the criteria for inclusion in the study: a clinical diagnosis of degenerative spondylolisthesis and spinal stenosis, with symptoms that had been

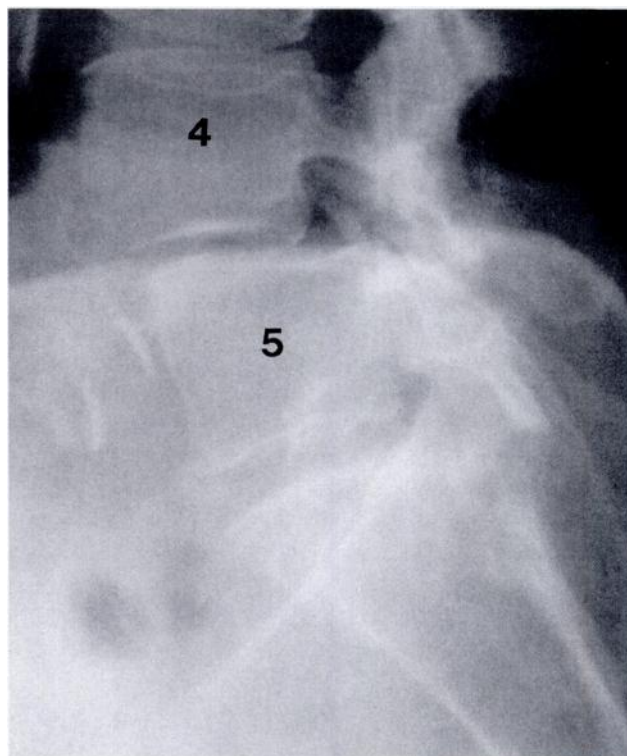


FIG. 1

Lateral radiograph showing the typical appearance of degenerative spondylolisthesis (the fourth on the fifth lumbar vertebra).

unresponsive to an adequate trial of non-operative treatment; a single level of degenerative lumbar spondylolisthesis without a transitional fifth lumbar segment, as seen on plain radiographs (Fig. 1); and imaging studies consisting of a myelogram (Figs. 2-A and 2-B) and either a contrast-medium-enhanced computerized tomography scan or a magnetic resonance scan demonstrating spinal stenosis only at the level of the spondylolisthesis.

Informed consent to inclusion in the study was not

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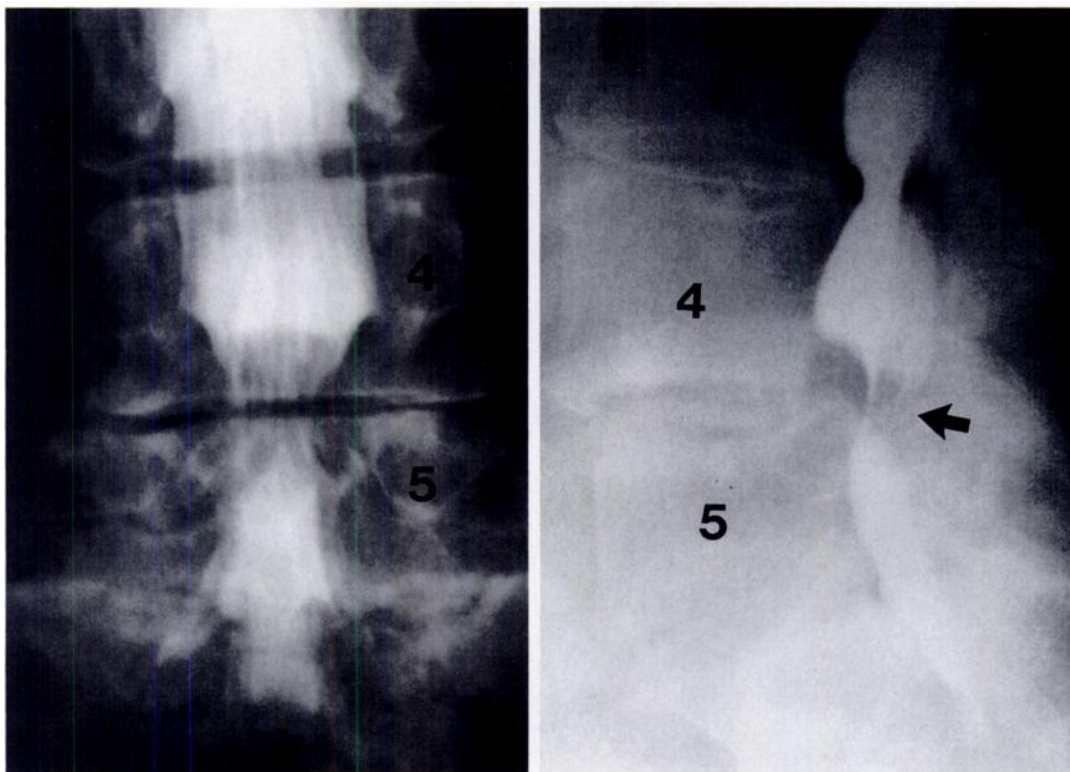


FIG. 2-A

FIG. 2-B

Fig. 2-A: Anteroposterior radiograph of a myelogram showing hourglass-type constriction of the dural sac due to spinal stenosis.
 Fig. 2-B: Lateral radiograph of a myelogram showing constriction of the dural sac (arrow) at the level of the fourth and fifth lumbar vertebrae due to spinal stenosis and degenerative spondylolisthesis.

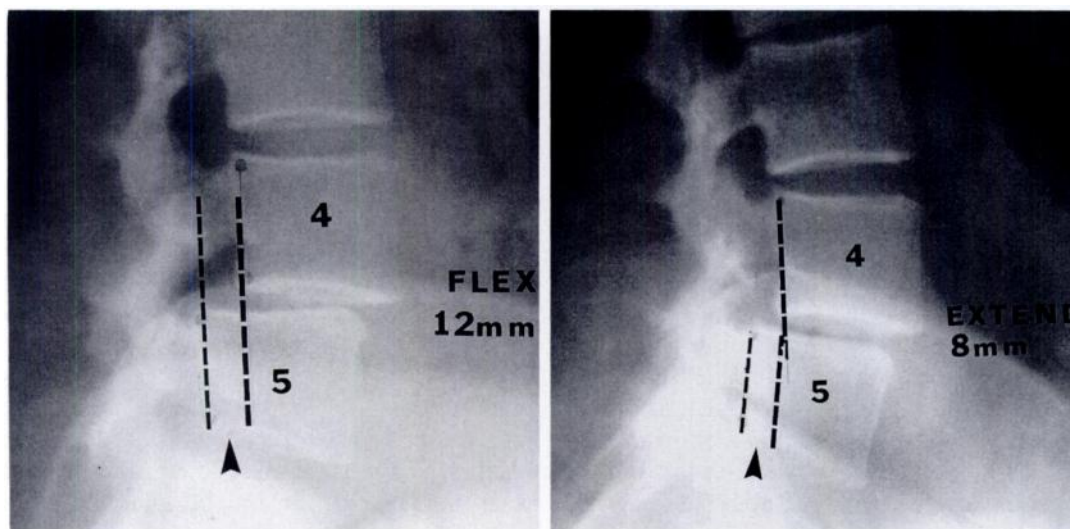


FIG. 3-A

FIG. 3-B

Fig. 3-A: Lateral flexion radiograph showing twelve millimeters of subluxation at the level of the fourth and fifth lumbar vertebrae (arrowhead).
 Fig. 3-B: Lateral extension radiograph showing a reduction in the olisthesis to eight millimeters (arrowhead).

obtained because both treatment options are accepted procedures for treatment of this condition.

The fifty consecutive patients were assigned alternately to one of two treatment groups: decompressive laminectomy (twenty-five patients) or decompressive laminectomy and bilateral lateral intertransverse-process arthrodesis (twenty-five patients). There were thirty-six women and fourteen men. Twenty women and five men had a concomitant ar-

throdesis, and sixteen women and nine men had a decompressive laminectomy only. The ages of the patients who had an arthrodesis ranged from fifty-two to eighty-four years (mean, 63.5 years) and those of the patients who did not have an arthrodesis, from fifty-three to eighty-three years (mean, sixty-five years).

The level of the operation was between the fourth and fifth lumbar vertebrae in forty-one patients and between the

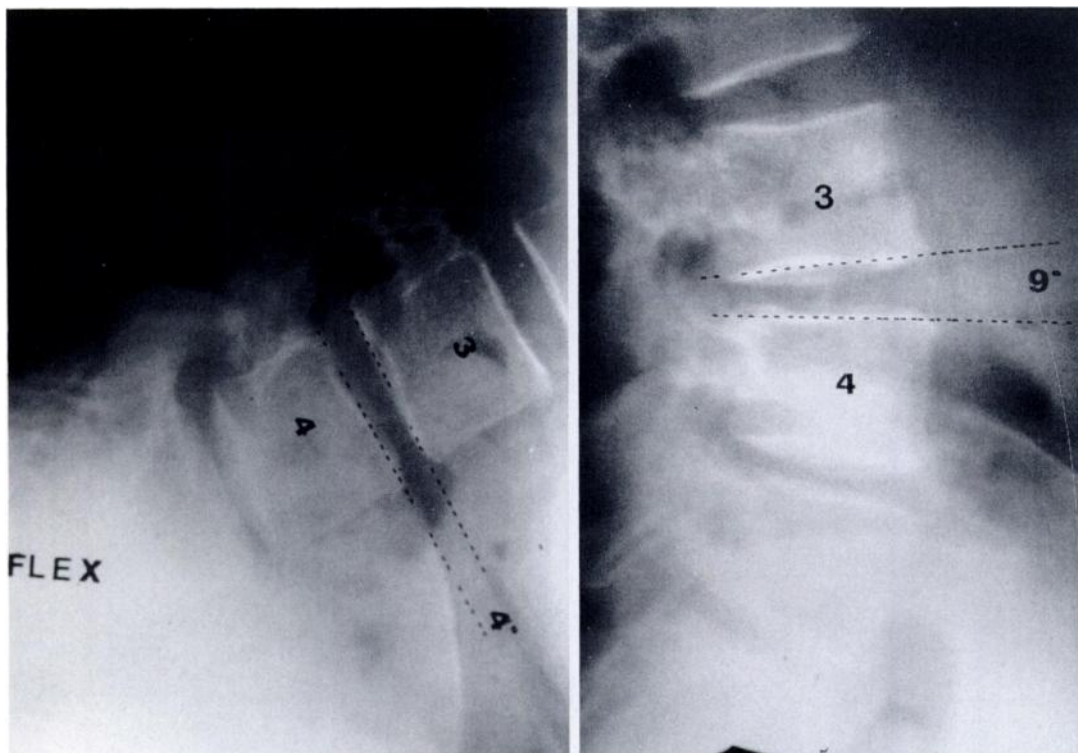


FIG. 4-A

FIG. 4-B

Fig. 4-A: Lateral flexion radiograph showing 4 degrees of angular motion at the disc space between the third and fourth lumbar vertebrae.
 Fig. 4-B: Lateral extension radiograph showing a reversal of the angle of flexion to 9 degrees at the disc space between the third and fourth lumbar vertebrae.

third and fourth lumbar vertebrae in nine patients.

Before the operation, plain radiographs of the lumbosacral spine (including anteroposterior, lateral, left and right oblique, standing lateral [neutral], and standing flexion-extension lateral) were made for all patients. This series of radiographs was repeated at the most recent follow-up evaluation. The preoperative and follow-up radiographs were analyzed with respect to the amount ofolisthesis, in millimeters, on the lateral radiographs; the total amount ofolisthesis, in millimeters, on the flexion-extension lateral radiographs^{8,33,48} (Figs. 3-A and 3-B); the total amount of angular motion, in degrees, between the adjacent vertebral end-plates at the operative level as seen on the lateral flexion-extension radiographs⁸ (Figs. 4-A and 4-B); the development of a pseudarthrosis (defined by a lack of continuity in the fusion mass at any point from the cephalad to the caudad transverse process on one or both sides) on the anteroposterior or oblique radiographs (Fig. 5); and the height of the disc space at the level of the arthrodesis, by the method of Farfan¹¹, on the standing lateral (neutral) radiographs (Fig. 6).

Decompression of the central canal and nerve-roots was achieved by removing one-half of both the cephalad and caudad laminae of the two involved vertebrae, together with bilateral medial caudad and cephalad facetectomy^{3,19,25}. In the patients who also had a concomitant spinal arthrodesis, the technique for distribution of the bone across the transverse process was that described by Macnab and Dall³⁰ and by Wiltse et al.⁵¹ for a single-level bilateral intertransverse-

process arthrodesis. The iliac crest was exposed through the same skin incision that was used for the decompressive laminectomy. Strips of corticocancellous and cancellous bone, four to five centimeters in length, were harvested from the outer and middle tables of the iliac crest and placed across the transverse processes⁵².

Before the operation, all of the patients were asked to rate the pain in the back and lower limbs on a scale ranging from 0 points (no pain) to 5 points (severe pain). The scores for pain in the back and lower limbs were rated separately. This scoring procedure was repeated at the most recent follow-up examination.

The operative results were rated as excellent, good, fair, or poor. The result was excellent when the patient resumed unrestricted activity and essentially had complete relief of pain in the back or lower limbs, or both. A good result meant that there was occasional discomfort in the back or lower limbs necessitating non-narcotic medication, major improvement compared with the preoperative condition, and resumption of unrestricted activity. A fair result was defined as intermittent discomfort in the back or lower limbs, or both; improvement compared with the preoperative condition; restrictions of activity; and an occasional need for non-narcotic medication. Patients who had a poor result had major discomfort in the back or lower limbs, or both, necessitating non-narcotic and occasional narcotic medication; no improvement compared with the preoperative condition; and major restrictions of activity.

The clinical results of the operation and the radio-

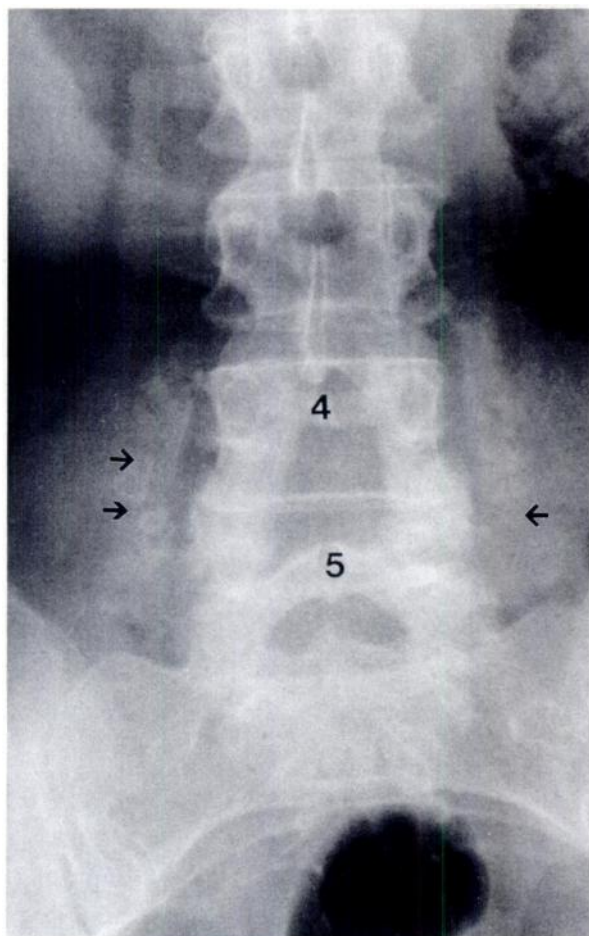


FIG. 5

Anteroposterior radiograph showing a pseudarthrosis bilaterally after an intertransverse process arthrodesis between the fourth and fifth lumbar vertebrae (arrows).

graphic findings were analyzed with use of the Student *t* test, one-way analysis of variance, Mann-Whitney *u* test, chi-square test, and Fisher exact test.

The same postoperative management was used for both groups of patients. Walking was allowed on the first postoperative day. Progressive walking (ten to twenty minutes, twice daily) was permitted during the first four to six weeks postoperatively. Exercises on a stationary bicycle or in water were begun at six to eight weeks, and exercises for gentle flexion of the spine and strengthening of the abdominal muscles were added at eight to twelve weeks. No brace or corset was used postoperatively in either group.

The duration of follow-up ranged from 2.4 to four years (mean, three years).

Results

Over-All Results

There were eleven excellent, thirteen good, one fair, and no poor results in the arthrodesis group; there were two excellent, nine good, twelve fair, and two poor results in the group in which no arthrodesis had been performed. No significant difference in the results between men and women was found with chi-square analysis. The improved results

in the patients who had had an arthrodesis concomitantly with decompression were significant by the Fisher exact test ($p = 0.0001$).

Pain in the Back and Lower Limbs (Table I)

At the most recent follow-up evaluation, significantly more residual pain in the back was reported by the patients who had not had an arthrodesis (mean pain score, 1.3 points for the patients who had had an arthrodesis and 2.5 points for those who had not). Similarly, the scores for pain in the lower limbs revealed significantly more residual pain in the patients who had not had an arthrodesis (mean pain score, 1.0 point for the patients who had had an arthrodesis and 1.7 points for those who had not).

Radiographic Findings

Height of the Disc Space (Table I)

Measurement of the height of the intervertebral disc space at the operative level, preoperatively (6.8 and 7.4 millimeters) and at the most recent follow-up examination (5.7 and 5.8 millimeters), revealed no significant difference between the patients who had had an arthrodesis and those who had not.

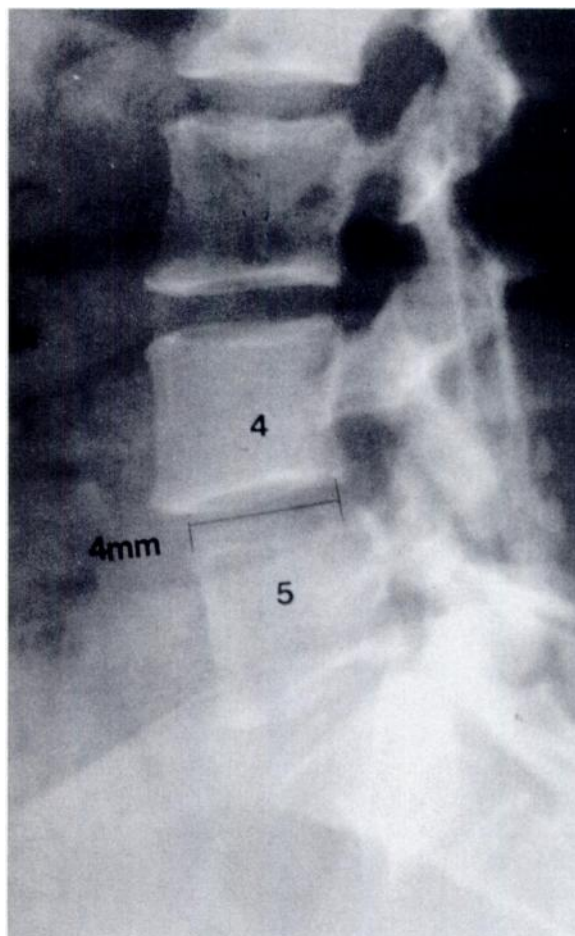


FIG. 6

Lateral radiograph showing the technique for measurement of the height of the disc space.

Olisthesis (Table I)

The patients who had not had an arthrodesis had a significant increase in olisthesis (5.3 to 7.9 millimeters) compared with the preoperative value, including the change occurring on flexion and extension (3.4 to 5.8 millimeters) compared with normal values, as seen on the preoperative and most recent follow-up radiographs. Seven (28 per cent) of the twenty-five patients who had had an arthrodesis and twenty-four (96 per cent) of the twenty-five patients who had not had an arthrodesis had increased olisthesis after the operation.

All seven patients who had had an arthrodesis and had increased olisthesis postoperatively had an excellent or good result, compared with eleven of the twenty-four patients who had not had an arthrodesis and had increased olisthesis. None of the seven patients who had had an arthrodesis and had increased olisthesis had a fair or poor result, compared with thirteen of the twenty-four patients who had not had an arthrodesis.

Vertebral Angulation (Table I)

There was a significant increase in angular motion on lateral bending compared with the preoperative values (9.6 compared with 12.8 degrees) in the patients who had had an arthrodesis ($p = 0.002$). One-way analysis of variance demonstrated that the postoperative radiographic findings of olisthesis that were noted on flexion and extension and of angular motion that were seen on lateral bending were significant contributors to the poorer clinical results in the patients who had not had a concomitant arthrodesis.

Pseudarthrosis

Pseudarthrosis of the fusion mass was observed in nine (36 per cent) of the twenty-five patients who had had an arthrodesis. In two of these patients, the pseudarthrosis was noted on both sides of the fusion mass, and in the other seven, it was confined to one side. However, the clinical result was excellent in five and good in four patients.

Discussion

The literature has been unclear with respect to the role of arthrodesis when a decompressive laminectomy is performed for spinal stenosis associated with degenerative lumbar spondylolisthesis^{2,7,12,20-22,28,41,45,47}. Satisfactory results after decompressive laminectomy alone have been reported in 60 to 96 per cent of patients^{4,7,20-22,28}. Residual or recurrent pain in the back or lower limbs, or both, has been noted, however, in as many as 73 per cent of such patients, with residual low-back pain reported more frequently²⁰. This may be related, to some degree, to residual instability, or it may be related to the development of increased olisthesis postoperatively^{4,7,12,21,22,27,28,43,45,47}. In some series, the olisthesis has been found to increase significantly more often in patients who have a poor result^{7,22}.

In reports on the results of decompressive laminectomy alone, concomitant arthrodesis was recommended for all

TABLE I
DATA ON THE FIFTY PATIENTS

	Arthrodesis (N = 25)		No Arthrodesis (N = 25)	
	Preop.	Postop.	Preop.	Postop.
Result				
Excellent		11 (44%)		2 (8%)
Good		13 (52%)		9 (36%)
Fair		1 (4%)		12 (48%)
Poor		0 (0%)		2 (8%)
Mean scores for pain (points)				
Back	3.3	1.3	2.9*	2.5†
Lower limbs	4.3	1.0	4.0*	1.7
Mean height of disc space (mm)	6.8	5.7	7.4	5.8
Mean olisthesis (mm)	4.8	5.3	5.3	7.9‡
Mean olisthesis on flexion and extension (mm)	2.8	0.1	3.4	5.8
Mean vertebral motion (degrees)	9.3	4.2	9.6	12.8‡

* The patients who had not had an arthrodesis had significantly more pain in the low back and lower limbs at the most recent follow-up evaluation.

† $P < 0.01$ (chi-square test).

‡ $P = 0.002$ (Student t test).

additional patients having the operation who had degenerative spondylolisthesis associated with spinal stenosis, or secondary arthrodesis was recommended when signs of instability or disabling low-back pain developed postoperatively^{4,20-22,28,41,47}.

Retrospective comparisons of patients who had had decompression alone with those who had had decompression and an intertransverse process arthrodesis demonstrated substantially better relief of pain in the back and lower limbs and a decreased prevalence and magnitude of subsequent increased olisthesis in the patients who had had a concomitant arthrodesis^{2,12}.

In the current series, the spondylolisthesis increased postoperatively in twenty-four (96 per cent) of the twenty-five patients who had not had an arthrodesis and in only seven (28 per cent) of the twenty-five patients who had had an arthrodesis. We believe that this contributed directly to the poorer results in the patients who had not had an arthrodesis.

Postoperative progressive olisthesis leads to mechanical instability or recurrent spinal stenosis, or both. This, in turn, results in symptomatic low-back pain or in radicular or neuroclaudicatory symptoms of the lower limbs, or both. By definition, degenerative spondylolisthesis implies that the facet joints of a motion segment and the supporting capsular ligaments are compromised. A decompressive laminectomy with partial excision of the facet joints further destabilizes the weakened segment, leading to progressive olisthesis.

Most authors have thought that if extensive removal of the facet joints is performed at the time of decompression,

an arthrodesis should be added. The criteria of Wiltse et al.⁵⁰ for inclusion of a spinal arthrodesis after decompressive laminectomy in patients who have degenerative spondylolisthesis were an age of less than sixty years for patients who have had total removal of the facet joints and of less than fifty-five years for patients who have had central decompression and in whom the facet joints are intact. Although these criteria have served as guidelines in the past, it must be recognized that the patient's chronological and physiological ages often do not coincide, especially as we enter an era when the elderly are living longer, are healthier, and lead more active lives. Therefore, age restraints on the performance of operative procedures have less validity than in the past. In the current series, age and sex were not significant predictors of the outcome of the operation.

The preoperative and postoperative heights of the disc space were calculated to determine if a normal disc space, without major degenerative narrowing, would predispose to an increase in postoperative olisthesis or affect the outcome, and whether the height of the disc space could be used as a determinant for recommendation of a concomitant spinal arthrodesis. Lombardi et al. noted that disc spaces that were more than six millimeters in height tended to slip the most after decompression²⁸. Although these authors did not specifically state that this was a criterion for performance of an arthrodesis after decompression, that was implied by their findings. Johnsson et al. noted no significant difference in the height of the disc space between patients who had good and poor results after decompressive laminectomy, but they did observe a decrease in the height of the disc space after the operation²². Although the technique of measurement that was used in the current series differed from that of Johnsson et al., our results demonstrated a general tendency for the height of the disc space to decrease in both the patients who had had an arthrodesis and in those who had not, and this measurement was not useful for prediction of the necessity of an arthrodesis.

Despite the fact that a pseudarthrosis occurred in nine (36 per cent) of the twenty-five patients who had had an arthrodesis, the result was excellent in five and good in four patients. It should be noted that seven patients had a pseudarthrosis on only one side of the arthrodesis. Although two patients had a bilateral non-union, attainment of a solid fusion on one side of the arthrodesis or the development of a fibrous union appeared to provide sufficient structural support to prevent progressive olisthesis.

As can be seen from the literature, the criteria for the performance of a spinal arthrodesis after decompression for

spinal stenosis secondary to degenerative lumbar spondylolisthesis have been based on retrospective analysis and anecdotal information^{31-33,35-38}. The preoperative factors that have often been cited as influencing the results are age, sex, the severity of preoperative pain in the back, the amount of preoperative olisthesis, and the amounts of olisthesis and vertebral motion seen on postoperative flexion-extension radiographs^{20-22,28,50}. These factors were evaluated in the present study. The severity of preoperative pain in the back and lower limbs, the age and sex of the patient, and the amount of olisthesis preoperatively and on flexion-extension radiographs postoperatively were not significantly different between the two groups. There was, however, a significant difference postoperatively for all of these parameters except age and sex, and they also were found to be directly related to the outcome.

The indications for an arthrodesis have been linked to excessive removal of the facet joints and disruption of the pars interarticularis during operative decompression^{40,42}. Some surgeons also have recommended the so-called towel-clip maneuver to distract adjacent spinous processes. If excessive movement is noted, an arthrodesis is performed. In the current series, both groups had the same procedure for operative decompression. Despite this limited decompression, there were significantly more postoperative symptoms of pain in the back and lower limbs and vertebral motion in the patients who had had decompression without spinal arthrodesis.

In summary, the determination of which patients should have a spinal arthrodesis concomitant with decompression cannot be based on the preoperative or intraoperative factors that have been discussed. The results of this prospective study clearly demonstrate that decompressive lumbar laminectomy with intertransverse process arthrodesis is the operative procedure of choice for patients who have spinal stenosis associated with degenerative lumbar spondylolisthesis at a single level. The age and sex of the patient and the height of the disc space did not influence the outcome of the operation. A significant postoperative increase in olisthesis, olisthesis on flexion-extension radiographs, and vertebral motion at the operative level occurred more often in the patients who had not had an arthrodesis and was associated with a poorer clinical result. The development of a pseudarthrosis did not preclude a successful result.

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