Recommendations

**Guidelines.** The performance of a lumbar PLF is recommended for patients with lumbar stenosis and associated degenerative spondylolisthesis who require decompression. There is insufficient evidence to recommend a treatment guideline.

**Options.** Pedicle screw fixation as an adjunct to lumbar PLF should be considered as a treatment option in patients with lumbar stenosis and spondylolisthesis in cases in which there is preoperative evidence of spinal instability or kyphosis at the level of the spondylolisthesis or when iatrogenic instability is anticipated.

Rationale

Patients with lumbar stenosis often present with concomitant degenerative spondylolisthesis. Decompression alone in this population may result in deformity progression. Lumbar PLF has been used as a means to prevent postoperative deformity progression and to improve functional outcome after decompressive surgery in this population. The purpose of this review is to examine the literature concerning the role of fusion after decompression surgery in patients with degenerative spondylolisthesis and stenosis.

Search Criteria

A computerized search of the database of the National Library of Medicine from 1966 to August 2003 was conducted using the search terms “fusion and degenerative spondylolisthesis.” The search was restricted to the English language and yielded 217 references. The titles and abstracts of each of these references were reviewed, and papers not concerned with the use of fusion with degenerative spondylolisthesis were discarded. Eighty-five references were identified that provided either direct or supporting evidence relevant to the use of fusion for degenerative lumbar spondylolisthesis. These papers were reviewed, and relevant references from the bibliographies were identified. All papers providing Class III or better medical evidence are summarized in Table 1. Additional
### TABLE I

<table>
<thead>
<tr>
<th>Authors &amp; Year</th>
<th>Class</th>
<th>Description</th>
<th>Comment</th>
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<tr>
<td>Dall &amp; Rowe, 1985</td>
<td>III</td>
<td>17 patients w/ DS had decompressions: 1 group w/ laminect &amp; facetect &amp; the other w/ laminect &amp; foraminot. At 20-mo FU, 5/6 w/ facetect were better &amp; only 4/11 w/ foraminot were better. Overall poor results led authors to recommend extensive decompressions as better than laminect w/ just foraminot.</td>
<td>Fusion-treated patients did better than those receiving decompression alone.</td>
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<tr>
<td>Feffer, et al., 1985</td>
<td>III</td>
<td>19 patients w/ DS underwent decompression w/ &amp; w/o fusion: 8 patients w/ decompression/fusion &amp; 11 w/ decompression alone. Of the 8 w/ fusion, 5 had good results, 3 were fair, &amp; 0 were poor. Of the 11 w/o fusion, 5 had good results, 3 were fair, &amp; 3 were poor. 4 patients w/o fusion suffered gross instability. Good-to-excellent results were 33%, 89%, &amp; 90%, respectively. The addition of a fusion was beneficial.</td>
<td>Large benefit to adding fusion to decompression.</td>
</tr>
<tr>
<td>Lombardi, et al., 1985</td>
<td>III</td>
<td>47 patients w/ DS. Treatment groups of wide decompression w/ facetectomy, decompression, &amp; decompression w/ fusion. Good-to-excellent results were 33%, 89%, &amp; 90%, respectively. The addition of a fusion was beneficial.</td>
<td>Case series—no formal outcomes measures.</td>
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<tr>
<td>Kameda, et al., 1986</td>
<td>III</td>
<td>54 patients w/ unstable DS treated by decompression &amp; fusion. 96% fusion rate w/ excellent clinical results.</td>
<td>Case series—no formal outcomes measures.</td>
</tr>
<tr>
<td>Inoue, et al., 1988</td>
<td>III</td>
<td>36 patients w/ DS treated w/ anterior interbody fusion. All fused &amp; did well clinically.</td>
<td>Case series—no formal outcomes measures.</td>
</tr>
<tr>
<td>Fujii, et al., 1990</td>
<td>III</td>
<td>40 patients w/ unstable DS underwent decompression &amp; fusion. 1 patient suffered a nonunion. At a mean FU of 26 mos, 75% had excellent, 20% good, 5% fair, &amp; 0% poor results.</td>
<td>Small no. of patients &amp; short FU.</td>
</tr>
<tr>
<td>Takahashi, et al., 1990</td>
<td>III</td>
<td>34 patients w/ hyperextension &amp; interbody fusion for DS: 76% w/ satisfactory results at 10-yr FU.</td>
<td>Good results.</td>
</tr>
<tr>
<td>Herron, et al., 1991</td>
<td>I</td>
<td>50 patients w/ DS &amp; stenosis (25 w/ fusion &amp; 25 w/o fusion). In a mean FU of 3 yrs, patients w/ a fusion did better.</td>
<td>Small nos. show trend for better results w/ fusion, but not statistically different.</td>
</tr>
<tr>
<td>Postacchini, et al., 1991</td>
<td>III</td>
<td>32 patients w/ DS treated w/ decompression &amp; some w/ various forms of decompression w/ or w/o fusion. Overall, 17 w/ fusion &amp; 15 w/o. W/ fusion, all 17 had good or excellent results, whereas in those w/o fusion, 10 had good or excellent results &amp; 5 had fair or poor results. Authors stated no statistical difference between fusion &amp; nonfusion &amp; recommended fusion for unstable situations.</td>
<td>Case series—no formal outcomes measures.</td>
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<tr>
<td>Chang, et al., 1993</td>
<td>III</td>
<td>85 patients w/ spondylolisthesis (57 w/ DS) underwent op. Patients w/ instrumentation had better fusion rates &amp; clinical outcomes (60% w/ complete relief of pain).</td>
<td>In subset of 19 patients w/ DS undergoing decompression alone: 3/19 w/ poor results &amp; 16 w/ good results.</td>
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<td>Sanderson &amp; Wood, 1993</td>
<td>III</td>
<td>31 patients w/ decompression w/o fusion (19 w/ DS). Of the poor results, 3 were in patients w/ DS.</td>
<td>In subset of 19 patients w/ DS undergoing decompression alone: 3/19 w/ poor results &amp; 16 w/ good results.</td>
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<tr>
<td>Soini, et al., 1993</td>
<td>III</td>
<td>51 patients (13 w/ DS) having decompression &amp; fusion. Instrumentation resulted in higher fusions, but all did well.</td>
<td>Small series of patients doing well w/ fusion.</td>
</tr>
<tr>
<td>Axelsson, et al., 1994</td>
<td>III</td>
<td>71 patients w/ spinal fusion (subset of 43 w/ DS). 29/43 had good results. In the patients w/ DS, healed fusion correlated w/ a good result, but not so w/ the other diagnoses.</td>
<td>Small series of patients doing well w/ fusion.</td>
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<tr>
<td>Lee, 1994</td>
<td>III</td>
<td>52 patients w/ unstable DS treated w/ reduction &amp; fusion (no formal decompression). 1-yr min FU. 89% had satisfactory outcomes w/ regard to back pain. The remaining w/o satisfactory outcome had PA. For leg pain, 93% satisfactory outcome. Remaining unsatisfactory had good outcomes after formal decompression.</td>
<td>Good results.</td>
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<tr>
<td>Markwalder, et al., 1995</td>
<td>III</td>
<td>Prospective study of 100 patients w/ DS having decompression &amp; fusion. 95 patients w/ good or excellent results.</td>
<td>In subgroup of patients w/ DS, more return to work; more favorable subgroup in overall favorable study.</td>
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<tr>
<td>Gertzbein, et al., 1996</td>
<td>III</td>
<td>Circumferential fusion for various conditions. 67 patients available for 2-yr FU. 15.2% had DS w/ stenosis. 97% successful fusion. 18% returned to either lighter work or job restriction, &amp; 23% were not working. Thus, 77% were performing the same or lighter levels of activity &amp; 23% were not working. In diagnostic categories, the nos. not working were as follows: DDD, 25%; PA, 33%; &amp; SS, 8%. Pain significantly reduced on VAS from 7.1-2.1 (back) &amp; 5.8-1.5 (leg) (p &lt; 0.006 &amp; 0.0001, respectively).</td>
<td>Good results.</td>
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<tr>
<td>Hanley, 1996</td>
<td>III</td>
<td>20 patients w/ DS &amp; stenosis undergoing decompression &amp; fusion. At a min 2-yr FU, satisfactory results were found in 17 (85%).</td>
<td>Good results.</td>
</tr>
<tr>
<td>Fischgrund, et al., 1997</td>
<td>III</td>
<td>76 patients w/ symptomatic stenosis associated w/ lumbar DS were prospectively studied. All underwent posterior decompression &amp; posterolateral intertransverse process arthrodesis. Patients randomized to a segmental transpedicular instrumented or noninstrumented group. 67 were available for a 2-year FU. Clinical outcome was excellent or good in 76% w/ instrumentation &amp; in 85% of those w/o instrumentation (p = 0.45). Successful arthrodesis in 82% of instrumented vs 45% of noninstrumented cases (p = 0.0015). Overall, successful fusion did not influence outcome (p = 0.435). In patients undergoing 1-level PLF for DS &amp; spinal stenosis, PSs may lead to a higher fusion rate, but clinical outcome shows no improvement in back &amp; lower-limb pain. Clinical outcome 78% w/o instrumentation &amp; 85% w/ instrumentation (good or excellent).</td>
<td>Prospective study, lumbar DS, decompression &amp; fusion w/ or w/o fixation. Improvement w/ decompression &amp; fusion.</td>
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<tr>
<td>Katz, et al., 1997</td>
<td>III</td>
<td>Prospective multicenter observational study of 272 patients having up for degenerative lumbar stenosis. 123 identified as having DS or scoliosis. The 1st set of analyses used all patients in the cohort; the 2nd was restricted to patients w/ typical indications for arthrodesis: DS of &lt; 5 mm &amp;/or scoliosis of &lt; 15°. Patients undergoing arthrodesis were significantly younger &amp; mostly female. 97% were Caucasian. The 3 groups had similar levels.</td>
<td>Subgroup had DS or scoliosis &amp; a nonstatistically significant trend of better results in patients w/ noninstrumented fusion. Other outcomes similar between nonfusion, fusion w/ instrumentation, &amp; fusion.</td>
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TABLE 1 Continued

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<td>Katz, et al., continued</td>
<td></td>
<td>of education. Patients who received arthrodesis had significantly fewer levels decompressed &amp; greater frequency of DS. Of the 272 patients, 105 (39%) met entry criteria for the cohort restricted to ≥ 5 mm DS (93 patients), &amp;/or 15° scoliosis (19 patients). 7 patients had both DS ≥ 5 mm &amp; scoliosis &gt; 15°. In this restricted cohort, 52 patients (50%) underwent laminectomy w/o arthrodesis, &amp; 27 (26%) instrumented arthrodesis. On average, those not undergoing fusion were 8 yrs older than those undergoing arthrodesis &amp; had significantly more levels decompressed. Other baseline variables were similar in the 3 groups. Univariate analyses showed that at 6-mo FU, the noninstrumented group had significantly greater improvement in back pain (p = 0.009) &amp; no significant differences in improvement in walking, SIP score, or satisfaction. The 24-mo FU showed greater reduction in back pain among patients receiving noninstrumented fusion, but this trend was not statistically significant (p = 0.20). Other outcomes were similar among the 3 groups. Linear regression models in this restricted cohort showed no significant association between treatment group &amp; improvement in back pain or in walking at 6 &amp; 24 mos. The p values for these tests were all ≥ 0.2.</td>
<td>w/o instrumentation.</td>
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Thomsen, et al., 1997 | II    | Prospective randomized study of fusion & decompression w/ & w/o instrumentation. 130 patients randomly allocated to receive no instrumentation (66) or Cotrel-Dubousset instrumentation (64) in PLF. Variables were registered at the time of op & at 1 & 2 yrs postop. No functional differences bew groups w/ & w/o instrumentation, although fusion rate improved w/ instrumentation (68 vs 85%). Neural compression did better—statistically significant. | Study had subgroup of patients w/ DS & stenosis, but not all. |

Booth, et al., 1999 | III   | 41 patients w/ DS underwent decompression & fusion w/ min 5-yr FU. 36 (88%) returned FU questionnaires, 83% satisfaction w/ op & 86% w/ significantly improved back & leg pain. No nonunions, but worse outcomes w/ adjacent-level problems & > 4 medical comorbidities. | Long-term FU of successful results w/ fusion. |

Mochida, et al., 1999 | III   | 102 patients w/ DS & stenosis had decompression & fusion (Group I: nonrigid instrumentation, 33 patients; Group II: rigid instrumentation, 34 patients; Group III: no instrumentation, 35 patients; Group I, 2 nonunions, 82% success rate; Group II, 1 nonunion, 91% success rate; Group III, 5 nonunions, 71% success rate. | Good improvement, higher fusion rate, higher success rate—rigid instrumentation better. |

Nork, et al., 1999 | III   | 30 patients w/ DS had decompression & fusion w/ SF-36 outcomes data. 93% were satisfied w/ outcomes. Interviewed at FU a mean of 37.1 mos postop (range 24-55 mos). Patients improved significantly in ability to perform heavy & light activities, participate in social activities, sit, & sleep (p < 0.001) & also improved in pain, depression, & medication usage (p < 0.001). SF-36 data showed significantly better overall assessment of health in all categories than that in a published cohort of patients w/ LBP. No difference observed in 7 of 8 categories compared w/ the general population. Fusion rate was 93% at a mean of 128 days. 3 patients required reop: 2 for PA & 1 for a deep infection. A poorer outcome, scored by the SF-36, was associated w/ greater prep stenosis (p < 0.05) or occurrence of a complication (p < 0.05). | Patients treated w/ decompression & fusion for DS had improved functional outcomes when measured by a disease-specific questionnaire & widely used instruments. |

Park, et al., 1999 | III   | Review of 32 patients w/ decompression & fusion; 21 w/ DS & 11 w/ failed-back syndrome. 2 radiographic nonunions, but overall success rate 96% for 1-level & 83% for 2-level. No formal clinical evaluation other than all did well. | Weak clinical outcomes measurements. |

Zhao, et al., 2000 | III   | Retrospective review of 25 patients w/ DS (Group I, 13, single BAK posterior fusion), (Group II, 12, 2 BAK posterior fusion). Group I (11 good or excellent, 2 fair, 0 poor), Group II (9 good or excellent, 1 fair, 2 poor). One patient in each group did not fuse. | Fusion for DS successfully treated problems. Low PA rates w/ low poor outcomes. |

Ido & Unnishilani, 2001 | III   | Retrospective review of 10 patients w/ long-term 5–10-yr FU, DS w/ decompression & fusion. All w/ good clinical results. | Small case series w/ long-term FU. |


Kimoshita, et al., 2001 | III   | 51 patients undergoing microdecompressions for DS & stenosis w/o fusion. 78% good-to-excellent results w/o fusion. | Patients doing reasonably well w/o fusion at 4.7-yr FU. |

Bednar, 2002 | III   | Retrospective review of 54 patients w/ DS & stenosis treated w/ "microdecompression" & instrumented fusion. 2-yr FU. 1 nonunion, 16% lost some reduction. ODI demonstrated 77% had substantial beneficial effect of op. | Good results in majority of patients. |

Kawakami, et al, 2002 | III   | Retrospective review of 47 patients w/ DS & stenosis having decompression & fusion. Sagittal balance measured & slips in mm. 1–3 levels, autogenous bone, some had instrumentation; 2 nonunions. Outcomes dependent on final kordosis & alignment. Overall, ODI score improved from 12.6 to 21.7 w/ a recovery rate of 55.1%. | Fusion-treated patients w/ DS improved. Alignment influenced final outcomes. |

Park, et al., 2002 | III   | Retrospective review of 99 patients w/ single-level DS w/ stenosis or disc herniation. All DS patients healed. 70 (85%) of 1-level had VAS pain scores > 50% for a good or excellent result. | Most patients w/ 1-level DS & stenosis: 100% fusion rate & good clinical outcome. |

* DDD = degenerative disc disease; DS = degenerative spondylolisthesis; facetect = facetectomy; foramint = foramintomy; FUS = follow up; laminect = laminectomy; LBP = low-back pain; ODI = Oswestry Disability Index; PA = pseudarthrosis; PS = pedicle screw; SIP = Sickness Impact Profile; SS = spondylitic spondylolisthesis.
supportive data are provided in references listed in the bibliography.

Scientific Foundation

Several authors have reported the results of studies that demonstrate a beneficial effect when PLF is conducted following decompression in patients with lumbar stenosis associated with degenerative spondylolisthesis. Herkowitz and Kurz presented a series of 50 patients with varying degrees of degenerative spondylolisthesis and stenosis who were treated with decompressive surgery. Patients were alternately assigned to decompression alone (25) or decompression combined with noninstrumented PLF (25). At a mean follow-up interval of 3 years, 96% of the patients treated with a fusion/decompression reported an excellent or good outcome compared with 44% of those treated with decompression alone. Patients who underwent fusion alone also reported statistically significantly less back and leg pain on a VAS (p = 0.01, and p = 0.002, respectively). Poor results were generally associated with progression of spinal deformity in the decompression-alone group. This study is considered to provide Class II medical evidence in support of the use of fusion at the time of decompression to improve functional outcome in patients with lumbar stenosis and spondylolisthesis.

Lombardi, et al., published a retrospective review of 47 patients with lumbar stenosis and degenerative spondylolisthesis who underwent decompression. They divided patients into three treatment groups: decompression with facetectomy, decompression with preservation of the facet joints, and decompression combined with PLF. The decompression/facetectomy group had the worst outcomes; only 33% reported good or excellent results. In the decompression/preserved facet joint group 80% reported good or excellent results. In the decompression/PLF group 90% reported good or excellent results. This paper provides Class III medical evidence suggesting that iatrogenic instability is associated with poor outcomes and that the addition of a PLF improves outcomes after decompression. Several smaller studies have also provided evidence for the beneficial effect of a PLF following decompression for lumbar stenosis and preexisting spondylolisthesis. Feffer, et al., reported their results in a series of 19 patients with stenosis and degenerative spondylolisthesis. Eight patients underwent decompression and fusion and 11 decompression alone. The patients who underwent decompression/fusion reported better results compared with those who underwent decompression alone. Postacchini and colleagues described results obtained in a series of 32 patients with stenosis and degenerative spondylolisthesis. Seventeen patients were treated with decompression and fusion and 15 underwent decompression alone. Again, the decompression/fusion group reported a higher incidence of good or excellent outcomes than the decompression-alone group. These series provide corroborating Class III medical evidence in support of the use of PLF in addition to decompression in patients with stenosis and degenerative spondylolisthesis.

Katz, et al., reported the results of a retrospective multicenter observational trial involving 272 patients with lumbar stenosis. Seventy-one percent of these patients were treated with laminectomy alone and 29% were treated with instrumented or noninstrumented fusion in addition to decompression. At the 6-month follow up, they observed that fusion-treated patients reported better outcomes with respect to back pain scores (p < 0.004) and walking tolerance (p < 0.05). The patients treated with fusion/decompression continued to enjoy improved outcomes at the 24-month follow-up visit (p < 0.01 low-back pain, p < 0.09 walk tolerance). In the subset of patients with stenosis and spondylolisthesis or scoliosis, the statistically significant benefit of fusion was even stronger and remained stable over time (p < 0.0001). In a separate prospective nonrandomized observational trial, Katz, et al., reported a similar benefit of adding fusion in 199 patients with lumbar stenosis and degenerative spondylolisthesis of whom 61 were treated with fusion (31 non-instrumented and 30 instrumented). These observational studies provide Class III medical evidence supporting a beneficial effect of fusion in patients with stenosis and spinal deformity.

Further supporting evidence for the addition of fusion to decompression in patients with stenosis and spondylolisthesis is derived from a number of case series reporting excellent results when using various lumbar fusion techniques. For example, Zhao, et al., studied 25 patients with degenerative spondylolisthesis and stenosis who were treated with decompressive procedures and concomitant fusion involving either one or two interbody fusion cages. The results in both treatment groups were excellent with fusion occurring in greater than 90% of patients in each group, and good or excellent outcomes being reported in greater than 90% of patients in each group. Park, et al., performed an intrafacet fusion supported by pedicle screw instrumentation in 99 patients who suffered from stenosis or recurrent disc herniation and spondylolisthesis. Of the 82 patients with stenosis and degenerative spondylolisthesis, fusion was achieved in all and 85% reported good or excellent results. Bednar reviewed a series of 54 patients with degenerative spondylolisthesis and stenosis who underwent microdecompressive surgery and fusion involving placement of spinal instrumentation. Overall, 77% of patients reported substantial benefit from the surgery. Booth, et al., published a long-term follow-up study of 41 patients who underwent decompression and PLF for degenerative spondylolisthesis and stenosis. Eighty-three percent of patients were satisfied with the results of surgery, and 86% reported significant functional improvement. Nork and colleagues reported a series of 30 patients treated with decompression and fusion for degenerative spondylolisthesis and stenosis. Outcomes were measured using the SF-36 as well as a patient satisfaction score. Ninety-three percent of these patients were satisfied with their outcomes. Patients reported statistically significant improvements in their ability to perform heavy and light activities, participate in social activities, sit, and sleep. Patients treated with decompression/fusion also noted improvements in pain, depression, and medication usage. The SF-36 data showed a significant improvement after surgery compared with baseline and also compared favorably with a matched cohort of conservatively treated patients with low-back pain. These and other series provide corroborating Class III medical evidence in support of the use of fusion following decompression in pa-
Stenosis and spondylolisthesis

Several authors have published their experience in the surgical management of patients with stenosis and spondylolisthesis treated with decompression with or without fusion. The results are variable and all studies involved nonvalidated outcome measures. Kinoshita, et al.,29 reported their results in 51 patients with degenerative spondylolisthesis who underwent decompression without fusion. At a mean follow-up duration of 4.7 years, 78% reported good or excellent results. Herron and Mangeldorf3 reported the results obtained in 24 patients with degenerative spondylolisthesis after decompression without fusion. In 91% of patients who underwent decompression and the fact that patients treated with pedicle screw fixation had a statistically significantly higher fusion rate (83%) than the noninstrumented group (45%). Both groups demonstrated significant score improvements on the VAS for both back and leg pain (p < 0.001), and the majority of patients in both groups reported their outcomes as good or excellent (78% in the instrumented group and 85% in the noninstrumented group). This paper provides Class III medical evidence supporting the use of pedicle screw fixation as an adjunct to decompression for stenosis with degenerative spondylolisthesis, particularly in those patients who require a more extensive decompression. A number of authors have examined the role of pedicle screw fixation as an adjunct to PLF following decompression in this patient population. Bridwell, et al.,4 performed a prospective study of 44 patients with claudication symptoms and stenosis due to degenerative spondylolisthesis. Most patients were randomized into one of three groups: decompression alone (Group I); decompression and noninstrumented fusion (Group II); and decompression and instrumented fusion (Group III). All patients with preoperative instability were automatically placed into Group III. Outcomes were assessed using a satisfaction scale approximately 3 years following surgery. The authors noted improved radiographic and functional outcomes among patients in Group III compared with the other two treatment groups. This paper provides Class III medical evidence supporting the role of instrumented fusion for patients undergoing decompression for stenosis with degenerative spondylolisthesis. Fischgrund and colleagues8 performed a prospective clinical trial of 68 patients with stenosis and degenerative spondylolisthesis who were randomized into one of two groups: decompression and PLF in one group and decompression and PLF supplemented with pedicle screw fixation in the other. Fusion status was assessed using plain and dynamic radiography, and clinical outcomes were assessed using a VAS for pain as well as a patient satisfaction scale. The patients treated with pedicle screw fixation had a statistically significantly higher fusion rate (83%) than the noninstrumented group (45%). Both groups demonstrated significant score improvements on the VAS for both back and leg pain (p < 0.001), and the majority of patients in both groups reported their outcomes as good or excellent (78% in the instrumented group and 85% in the noninstrumented group). This paper provides Class I medical evidence that pedicle screw fixation, as an adjunct to decompression and PLF, improves fusion success, and Class III medical evidence (due to the nonvalidated patient satisfaction score and inadequate sample size) suggesting that pedicle screw fixation does not improve functional outcome following PLF in this patient population. Thomsen, et al.,33 performed a randomized controlled clinical trial of 130 patients with spondylolisthesis who underwent lumbar fusion for low-back pain. Patients were randomized to instrumented (pedicle screw fixation) and noninstrumented PLF groups. Overall, there was no significant difference in functional outcome (measured by the DPQ); however, in the decompression/fusion group, patients who were treated with instrumented PLF scored better than those treated with noninstrumented PLF on the activities of daily living subsection of the DPQ. Although this paper describes a randomized controlled trial with validated outcome measures, the small sample size of patients who underwent decompression and the fact that a significant difference was noted on only one subsection of the DPQ, the medical evidence provided by this report supporting the role for pedicle screw fixation as an adjunct to PLF following decompression in patients is considered Class III. Several other small comparative studies provide Class III medical evidence supporting the use of pedicle screw fixation as an adjunct to fusion; however, these studies are small, retrospective, and use nonvalidated outcome measures.6,5,29

Kimura, et al.,20 reported the results of a retrospective review of 57 patients with degenerative lumbar spondylolisthesis and stenosis treated with decompression and fusion with and without pedicle screw instrumentation. They reported approximately similar intergroup clinical outcomes but noted that patients with “excessive motion” or kyphosis associated with spondylolisthesis did better with pedicle screw fixation. This paper provides Class III medical evidence suggesting that the routine use of pedicle screw instrumentation does not improve functional outcome; however, it also provides Class III evidence supporting the use of pedicle screw fixation in patients with kyphosis or excessive motion at the site of the degenerative spondylolisthesis. Kawakami, et al.,6 also reported an association between preoperative instability, kyphosis, and failure of noninstrumented fusion. They found that patients with preoperative lumbar kyphosis who underwent reduction and pedicle screw instrumentation–augmented fusion did better than patients who were treated with noninstrumented fusion. The authors used the JOA and the VAS scores as outcome measures. Improvements in both scores were reported for the patients treated with instrumentation. Because of the retrospective nature of the study, this paper provides Class III medical evidence supporting the role of pedicle screw fixation as an adjunct to fusion in the presence of preoperative kyphosis. Mochida, et al.,24 also addressed the issue of instability and kyphosis as a selection factor for the use of rigid pedicle screw fixation as an adjunct to lumbar PLF. These authors performed a prospective study (cases alternately assigned) of patients treated with a semirigid instrumentation system compared with those undergoing rigid pedicle screw fixation. They compared the results obtained with both devices with a historical cohort of patients treated with noninstrumented PLF following decompression for stenosis associated with spondylolisthesis. They found that the addition of rigid pedicle screw fixation improved outcomes (as measured using the JOA score) compared with their historical controls. In 91% of patients with screw fixa-

J. Neurosurg.: Spine / Volume 2 / June, 2005
ation the JOA score was greater than 12, compared with 71% of patients treated by noninstrumented fusion; mean scores were 13.2 and 11.2, respectively. The improvement was most significant when patients exhibited greater than 11° of motion on preoperative flexion-extension x-ray films. These three studies all provide Class III medical evidence supporting the use of pedicle screw fixation in patients undergoing decompression and PLF for stenosis associated with spondylolisthesis and either kyphosis or instability.

Summary
The best medical evidence available in the literature confirms the utility of fusion for improving patient outcomes following decompression for stenosis associated with spondylolisthesis. The majority of evidence from other studies comparing outcomes after decompression alone or decompression combined with PLF in patients with stenosis and spondylolisthesis also favors the performance of PLF. The medical evidence regarding the use of pedicle screw fixation in this patient population is rated as Class III and is inconsistent. A consistent benefit associated with the use of pedicle screw fixation has been reported in patients with preoperative instability or kyphosis. Iatrogenic instability following decompression is associated with poor outcomes and may also be treated with PLF involving supplemental instrumentation. The precise definition of instability or kyphosis has varied among researchers and requires further study.

Key Directions for Future Research
A prospective comparison of outcomes using validated outcome measures would add significantly to the evidence supporting or refuting the benefit of fusion following decompression for stenosis associated with spondylolisthesis. A prospective multicenter study exploring the role of pedicle screw fixation for patients with or without preoperative instability or kyphosis and involving standardized definitions would provide Class I or II evidence supporting or refuting the role of pedicle screw fixation in this patient population and would help standardize the definition of instability applied in this patient population.

References
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J. Neurosurg: Spine / Volume 2 / June, 2005
Stenosis and spondylolisthesis

decompression and instrumented posterior spinal fusion for degenerative spondylolisthesis. Spine 24:561–569, 1999

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Address reprint requests to: Daniel K. Resnick, M.D., Department of Neurological Surgery, University of Wisconsin Medical School, K4/834 Clinical Science Center, 600 Highland Avenue, Madison, Wisconsin 53792. email: Resnick@neurosurg.wisc.edu.