

A review: Reduced reoperation rate for multilevel lumbar laminectomies with noninstrumented versus instrumented fusions

Nancy Ellen Epstein

Department of Neurosurgery, Winthrop Neuroscience, Winthrop University Hospital, Mineola, New York, USA

E-mail: *Nancy Ellen Epstein - nancy.epsteinmd@gmail.com

*Corresponding author

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Abstract

Background: The reoperation rate, including for adjacent segment disease (ASD), is lower following multilevel lumbar laminectomy with noninstrumented versus instrumented fusions.

Methods: This study reviews selected literature focusing on the reoperation rate, including for ASD, following multilevel laminectomies with noninstrumented versus instrumented fusions. Several prior studies document a 1.3–5.6% reoperation rate following multilevel laminectomy with/without noninstrumented fusions.

Results: The reoperation rates for instrumented fusions, including for ASD, are substantially higher. One study cited a 12.2–18.5% frequency for reoperation following instrumented transforaminal lumbar and posterior lumbar interbody fusions (TLIF and PLIFs) at an average of 164 postoperative months. Another study cited a 9.9% reoperation rate for ASD 1 year following PLIF; this increased to 80% at 5 postoperative years. A further study compared 380 patients variously undergoing laminectomies/noninstrumented posterolateral fusions, laminectomies with instrumented fusions (PLFs), and laminectomies with instrumented PLF plus an interbody fusions; this study documented no significant differences in outcomes for any of these operations at 4 postoperative years. Furthermore, other series showed fusion rates for 1–2 level procedures which were often similar with or without instrumentation, while instrumentation increased reoperation rates and morbidity.

Conclusions: Many studies document no benefit for adding instrumentation to laminectomies performed for degenerative disease, including spondylolisthesis. Reoperation rates for laminectomy alone/laminectomy with noninstrumented fusions vary from 1.3% to 5.6% whereas reoperation rates for ASD after instrumented PLIF was 80% at 5 postoperative years. This review should prompt spinal surgeons to reexamine when, why, and whether instrumentation is really necessary, particularly for treating degenerative lumbar disease.

Key Words: Adjacent segment disease, instrumented fusion, low reoperation rate, lumbar surgery, multilevel laminectomy, noninstrumented fusion, spondylolisthesis

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INTRODUCTION

In this review, we document that the reoperation rate, including for adjacent segment disease (ASD), is lower following multilevel lumbar laminectomy with noninstrumented versus instrumented fusions. We utilized literature focused on the reoperation rate, including for ASD, after multilevel laminectomies with noninstrumented versus instrumented fusions. In a previous study from 2008, only 1 (1.3%) of 75 predominantly geriatric patients undergoing multilevel laminectomy with noninstrumented fusion required a reoperation.^[8] In the recent 2015 study, only 9 (2.7%) of 336 patients undergoing multilevel laminectomies with noninstrumented fusions required reoperations at an average of 6.3 years later.^[9] Another study showed a nearly comparable 5.2–5.6% reoperation rate for ASD following laminectomy with/without noninstrumented fusion and contrasted these findings with a 12.2–18.5% reoperation rate for ASD following multilevel decompressions with transforaminal lumbar interbody fusion (TLIF)/posterior lumbar interbody fusion (PLIF) fusions.^[17] A further study compared 380 procedures, including laminectomy/noninstrumented fusions, posterolateral instrumented fusions (PLF), and PLF with interbody fusion; there were no differences in outcomes between these procedures at 4 postoperative years.^[1] In addition, some found that 1–2 level fusions rates were often similar with or without instrumentation, while others documented that instrumentation correlated with a higher reoperation rate and greater morbidity.^[2,14] Costs, furthermore, were higher with instrumentation, but had no clear “value added.”^[12] In short, many studies document no added benefit for instrumentation utilized in elective lumbar surgery performed for degenerative disease. Following multilevel laminectomies with noninstrumented fusions, the reoperation rates vary from 2.7% to 5.2–5.6%, whereas the reoperation rates with instrumentation are reported at 9.9% at 1 postoperative year and up to 80% at 5 postoperative years. This review should prompt spinal surgeons to reexamine when, why, and whether instrumentation is really necessary.

Primary internal fixation in spondylolisthesis

In 1993, McGuire and Amundson in their prospective randomized 2-year study evaluated the efficacy of primary fusions for two groups of patients with spondylolisthesis undergoing L5 laminectomy (Gill procedure)/L5 nerve root decompressions [Table 1].^[14] Ten (72%) of 14 patients undergoing *in situ* posterolateral arthrodesis versus 11 (78%) of 13 having internal stabilization (Steffee plate/screws) fused; notably, there were no statistically significant differences between the two fusion rates utilizing different modalities.

Comments: Although the number of patients in this study’s two groups undergoing decompressions with

noninstrumented versus instrumented fusions was extremely small, the comparable frequencies of fusion for 1 and 2 level procedures, respectively, 10 (72%) of 14 and 11 (78%) of 13 were of interest.^[14] Although subsequent larger studies in this review often documented higher fusion rates with the addition of instrumentation, they did not demonstrate a clear-cut correlation with better outcomes.

About 71 posterolateral lumbar fusions; outcomes at 4 years

In 1994, Axelsson *et al.* reported on the outcomes of 71 consecutive posterolateral lumbar fusions performed without spinal instrumentation at 4 postoperative years [Table 1].^[3] Surgery addressed: “spondylolysis-olisthesis, degenerative disc disease/facet joint arthrosis, or pain after prior laminectomy.” Solid fusion was documented in 54 (76%) patients (e.g., radiographic osseous trabecular bridging at all intended levels) and no complications were reported. One-level fusions healed at higher rates than two-level fusions. For patients with spondylolysis-olisthesis, fusion positively correlated with good outcomes, but no such findings were noted in the other groups. The authors concluded; “noninstrumented posterolateral lumbar fusion is a valid method for treating low-grade spondylolysis-olisthesis, especially when the aim is to fuse a single level.”

Comments: This study documented a 76% fusion rate (54 of 71 patients) among a rather varied patient population undergoing laminectomy with noninstrumented fusion.^[3] Of interest, they found that for patients with spondylolysis-olisthesis, noninstrumented fusion positively correlated with good outcomes; this finding was not substantiated for other subgroups. Notably, higher rates of arthrodesis were documented for 1 versus 2 level fusions.

Lumbar laminectomy alone or with instrumented or noninstrumented arthrodesis in degenerative lumbar spinal stenosis

Katz *et al.* in 1997 evaluated the results of laminectomy alone, laminectomy/noninstrumented fusions, and laminectomy/instrumented fusions for lumbar stenosis over a 6–24-month postoperative period [Table 1].^[11] They analyzed 272 patients undergoing surgery for degenerative lumbar stenosis performed by eight surgeons at four centers; 37 patients had additional noninstrumented and 41 had instrumented fusions. The major predictor for performing the fusion was the individual surgeon’s decision (not different clinical variables, e.g., spondylolisthesis). Notably, noninstrumented fusion correlated with better relief of low back pain at 6 and 24 postoperative months (borderline significance), but otherwise, there were no significant differences for any of the other variables among the different treatment groups. Interestingly, the average hospital cost of a laminectomy

Table 1: Literature of reoperations, including adjacent segment disease (ASD) following lumbar laminectomies with/without noninstrumented (*in situ*) versus instrumented fusions 1993-2004

Author (reference) Date	Number of patients Follow-up duration	Outcomes including Adjacent Segment Disease (ASD)	ASD Outcomes Frequency Other	Conclusions ASD with/ without <i>in situ</i> versus instrumented fusions
McGuire and Amundson ^[14] 1993	27 patients 2 years study	14 <i>in situ</i> fusions 13 Steffee plate fusions	Same fusion rates 72% <i>in situ</i> 78% instrumented fusions	Same fusion rates with/ without instrumentation
Axelsson <i>et al.</i> ^[3] 1994	71 posterolateral lumbar <i>in situ</i> fusions 4 years	Spondylolysis Spondylolisthesis Degenerative disc Facet arthrosis Prior laminectomy	Solid fusion 54/71 (76%) No complications	One-level <i>in situ</i> fusions higher fusion rates 76%
Katz <i>et al.</i> ^[11] 1997	194 laminectomy alone 37 <i>in situ</i> fusion 41 instrumented fusions 6-24 months	Degenerative lumbar stenosis Indication for fusion: Surgeon preference	<i>In situ</i> fusion Better relief of low back pain	Costs Laminectomy \$12,615 <i>In situ</i> fusion \$18,495 Instrumented fusion \$25,914
Kuntz <i>et al.</i> ^[12] 2000	Cost-effectiveness of fusion with/without instrumentation	Indications: Spinal stenosis DS	QALY \$56,500 laminectomy <i>in situ</i> fusion \$82,400 instrumented fusion	QALY \$56,500 <i>in situ</i> fusion \$82,400 instrumented fusion
Jäger <i>et al.</i> ^[10] 2003	16 single-level noninstrumented 17 instrumented PLFs	Indications: Degenerative lumbar instability	All elderly patients improved 86.6%	No added benefit of instrumentation in elective lumbar fusions
Park <i>et al.</i> ^[17] 2004	TLIF/PLIF Risk factors ASD	Risk factors Malalignment Facet injury Age/prior disease	ASD <i>in situ</i> 44.8 months; 5.2-5/6% 164 months instrumented 12.2-18.5%	ASD with instrumentation 12.2-18.5% at 164 months No fusion/ <i>in situ</i> fusion 5.2-5.6% at 44.8 months

DS: Degenerative spondylolisthesis, ASD: Adjacent segment disease, TLIF: Transforaminal lumbar interbody fusion, PLIF: Posterior lumbar interbody fusion, QALY: Quality-adjusted year of life, PLF: Posterolateral fusion

alone (\$12,615), laminectomy/noninstrumented fusion (\$18,495), and instrumented arthrodesis (\$25,914) were also assessed. The authors concluded: “these results highlight the need for randomized controlled trials and cost-effectiveness analyses of lumbar arthrodesis and instrumentation in patients with degenerative lumbar spinal stenosis.”

Comments: There are several factors that are of interest in this study.^[11] First and foremost, there appeared to be no clear indications for surgeons to perform fusions other than “surgeon preference” (eight surgeons at four centers); this meant that 37 patients had noninstrumented and 41 had instrumented fusions without selection criteria necessitating these procedures. It was also of interest that patients undergoing noninstrumented fusions exhibited better relief of low back pain at 6 and 24 postoperative months when compared with fused counterparts; although this finding was of “borderline significance,” there were no other significant differences between outcomes for the three treatment groups. Of added interest, the differences in the cost of \$12,615 for a laminectomy,

\$18,495 for a laminectomy/noninstrumented fusion, and \$25,914 for a laminectomy instrumented arthrodesis are considerable given there is no clear-cut “value added” for the instrumentation.

Cost-effectiveness of fusion with/without instrumentation for spinal stenosis and degenerative spondylolisthesis

Kuntz *et al.* in 2000 looked at the cost-effectiveness and benefits of laminectomy alone and laminectomy with lumbar fusion (noninstrumented vs. instrumented) for patients with degenerative lumbar spondylolisthesis and spinal stenosis [Table 1].^[12] Short-term risks included perioperative complications, pseudarthrosis rates, and short-/long-term symptomatic relief. Laminectomy with noninstrumented fusion cost an average of \$56,500 per quality-adjusted year of life (QALY) versus instrumented fusion where the QALY was \$82,400.

Comments: This study documented utilizing QALY data that instrumentation costs more without a clear-cut “value added.”^[12]

Clinical outcome in single-level noninstrumented versus instrumented fusion for degenerative lumbar instability

In 2003, Jäger *et al.* evaluated the outcome of 16 single-level noninstrumented versus 17 instrumented posterolateral fusions in elderly patients with degenerative lumbar instability [Table 1].^[10] Overall improvement was noted in 86.6% of all patients. Of interest, patient-reported clinical and radiographical outcomes for the two groups were similar, leading the authors to conclude; “The results do not indicate a benefit in outcome from added instrumentation in elective lumbar fusions.”

Comments: This article cites an extraordinarily small number of patients in each sample; 16 single-level noninstrumented versus 17 instrumented posterolateral fusions for older patients with degenerative lumbar instability.^[10] Nevertheless, one has to appreciate their conclusion, likely not popular at the time; “The results do not indicate a benefit in outcome from added instrumentation in elective lumbar fusions.”

Adjacent segment disease after lumbar or lumbosacral fusion: Review of the literature

Park *et al.* in 2004 assessed the risk factors contributing to ASD in their review article of TLIF and PLIF [Table 1].^[17] Risk factors included malalignment, facet injury, older age, and prior disease. ASD occurred in 5.2–5.6% of patients undergoing laminectomy with no fusion/laminectomy with noninstrumented fusions at an average of 44.8 postoperative months. In contrast, a much higher ASD was observed for instrumented fusions, ranging from 12.2% to 18.5% at 164 average postoperative months. Clearly, there was a substantially higher frequency of ASD following instrumented versus noninstrumented lumbar fusions.

Comments: This is an extraordinary study that was well ahead of its time. It nicely documented the much lower reoperation rate for ASD following laminectomy alone or with noninstrumented fusion (5.2–5.6%) compared with a much higher 12.2–18.5% reoperation rate with instrumented fusions.^[17] This study signaled a problem that was, nevertheless, largely ignored, perhaps until now.

Fusion rates and short form-36 outcomes after multilevel laminectomy and noninstrumented lumbar fusions in a predominantly geriatric population

In 2008, Epstein prospectively analyzed posterolateral fusion rates and short form-36 (SF-36) outcomes for 75 patients, averaging 69 years of age, underwent average 4.9 level lumbar laminectomies and average 2.0 level noninstrumented fusions using lamina autograft and demineralized bone matrix [Table 2].^[9] Outcomes were assessed using the SF-36 questionnaire up to 24 months

postoperatively. Patients were followed an average of 3.3 years (minimum 2 years). Thirteen (17.3%) patients demonstrated pseudarthrosis on both dynamic X-ray and two-dimensional computed tomography studies on an average of 5.6 months postoperatively. Nevertheless, only one patient (a 55-year-old vasculopathy requiring immediate reintroduction of full-dose aspirin) was sufficiently symptomatic to require a secondary fusion; this yielded a very low, 1.3% (1 of 75 patients), frequency of reoperation.

Comments: This study involved 75 multilevel laminectomies with noninstrumented fusions performed in largely geriatric patients (e.g., average age 69).^[9] Although there was a 17.3% pseudarthrosis rate, only 1 (1.3%) patient was sufficiently symptomatic to require a reoperation following a laminectomy/noninstrumented fusion.

Surgical versus nonoperative treatment for lumbar degenerative spondylolisthesis; 4-year results in the Spine Patient Outcomes Research Trial (SPORT)

Weinstein *et al.* in the 2009 Spine Patient Outcomes Research Trial (SPORT) trial (13 centers/11 states) evaluated 4-year postoperative results of surgical versus nonoperative treatment of degenerative spondylolisthesis (DS) [Table 2].^[19] Patients were symptomatic for at least 12 weeks' duration, had studies documenting DS with spinal stenosis (randomized cohort or observational cohort), and were treated with decompressive laminectomies (with or without fusion) versus nonoperative care. Outcomes were assessed utilizing the short form-36 (SF-36) and Oswestry Disability Index (ODI) scales starting at 6 weeks and extending up to 4 postoperative years. The authors concluded; “compared with patients who are treated nonoperatively, patients in whom DS and associated spinal stenosis are treated surgically maintain substantially greater pain relief and improvement in function for 4 years.”

Comments: In this large SPORT study, patients with DS and spinal stenosis were treated with decompressive laminectomy (with or without fusion) versus nonoperative care.^[19] Four years later, they found that those managed surgically had better outcomes. Large SPORT trial databases better enable us to answer basic questions like this one; does surgery help patients with stenosis/spondylolisthesis versus nonoperative treatment? The answer was “yes”, and this was accomplished with substantially greater validity.

Degenerative spondylolisthesis: Does the fusion method influence outcome?

Abdu *et al.* in 2009 compared the outcomes of different fusion methods for treating DS [Table 2].^[1] Data were obtained from 13 centers in 11 states (SPORT). The

Table 2: Literature of reoperations, including adjacent segment disease following lumbar laminectomies with/without noninstrumented (*in situ*) versus instrumented fusions 2008-2014

Author (reference) Date	Number of patients Follow-up duration	Outcomes including Adjacent Segment Disease (ASD)	Adjacent Segment Disease (ASD) Outcomes Frequency Other	Conclusions Adjacent Segment Disease (ASD) with/without <i>in situ</i> versus instrumented fusions
Epstein ^[8] 2008	75 multilevel laminectomy <i>In situ</i> fusions Followed 3.3 years	Average 69 years old 4.9 laminectomies 2 level <i>in situ</i> PLFs	13 (17.3%) 2D-CT failed to fuse at 5.6 months	17.3% pseudarthrosis Noninstrumented fusion 1/75 (1.3%) reoperation rate low with <i>in situ</i> fusion
Weinstein <i>et al.</i> ^[19] 2009	SPORT trial DS and stenosis	Surgery versus nonoperative treatment	Laminectomy versus conservative care	Surgery: Greater pain relief and improvement in function at 4 years
Abdu <i>et al.</i> ^[11] 2009	380 patients 3 operations Spondylolisthesis Outcomes 4 years	21% laminectomy/ posterolateral <i>in situ</i> fusion (PL) 56% PLF instrumented fusion 17% instrumented PLF fusion with interbody device	At 2 years: 360 fusion better outcomes	No differences between operations (with/without instrumentation) at 4 postoperative years
Andersen <i>et al.</i> ^[2] 2009	94 instrumented lumbar fusions Followed 2-7 years	Average age 70 51 noninstrumented posterolateral fusions (PLF) 43 instrumented PLF fusions	Fusion 81% instrumented versus 68% noninstrumented Fusion correlated with better outcomes	15 patients ASD 6 (11.8%) noninstrumented 9 (20.9%) instrumented More ASD/secondary surgery lesser improvement
Mehta <i>et al.</i> ^[15] 2011	119 patients 37% TLIF procedures 63% PLIF procedures 5 years	Degenerative disease Spondylolisthesis Root injury PLIF 7.8% root TLIF 2% root Durotomy 17% PLIF 9% TLIF	Pseudarthrosis 2.6% PLIF 4.6% TLIF	Conclusion Only consider TLIF and PLIF when goals of surgery cannot be met with decompression and traditional PLF
Ye <i>et al.</i> ^[20] 2014	Meta-analysis DS (instrumented)	PLIF versus PLF equal Pain relief Quality of life Fusion, infection	Visual analog Oswestry disability scores; same	5 studies showed higher fusion rates with PLIF
Santiago-Dieppa <i>et al.</i> ^[18] 2014	376 <i>in situ</i> PLF Followed 92 months Average age 61.1	Stenosis - 56.1% (211) Back pain - 91.5% (344) Radiculopathy - 80.9% (304)	ASD 18.35% (69 patients)	Reoperation 30.59% (115 patients) Concluded needed to perform more primary fusions (no documentation)

DS: Degenerative spondylolisthesis, PLF: Posterolateral instrumented fusion, TLIF: Transforaminal lumbar interbody fusion, PLIF: Posterior lumbar interbody fusion, SPORT: Spine patient outcomes research trial, ASD: Adjacent segment disease, 2D-CT: Two-dimensional computed tomography

380 patients selected were symptomatic for at least 12 weeks and underwent the following surgical procedures; decompressive laminectomy with posterolateral *in situ* fusion (21%: PLF: 80 patients), posterolateral instrumented fusion with pedicle screws (PPS; 56%: 213 patients), PPS plus interbody fusion (17%: 63 patients: 360°), or laminectomies alone (6%). Outcomes were assessed at 1.5, 3, 6 months, and yearly up to 4 postoperative years utilizing the SF-36 and the modified ODI. At 2 years, 360 fusions showed better outcomes, but no consistent differences in clinical outcomes were seen among fusion groups over 4 years. In short, noninstrumented and instrumented fusions yielded comparable results.

Comments: This large SPORT database study evaluated 380 patients who were variously treated with decompressive

laminectomy with posterolateral *in situ* fusion, PPS, PPS plus interbody fusion, or laminectomies alone.^[11] Outcomes were assessed at 4 postoperative years using major validated questionnaires (SF-36, ODI); they concluded that patients in all groups (e.g., with/without instrumented fusions) demonstrated comparable outcomes.

Impact of 94 noninstrumented versus instrumented lumbar fusions in elderly patients followed for 2–7 years

In 2009, Andersen *et al.* looked at the impact of performing 94 lumbar spinal fusions with/without instrumentation utilizing fresh frozen allograft versus autograft to avoid donor-site pain in older patients (e.g., average age 70; range 60–88) [Table 2].^[2] Patients who had posterolateral

noninstrumented (51 patients) or instrumented (43 patients) fusions were assessed over a 2–7-year duration. Fusion occurred at a higher rate (81%) in the instrumented versus noninstrumented group (68%), and successful fusion correlated with better outcomes. However, 15 patients, consisting of a lower 6 patients (11.8%) in the noninstrumented group versus a higher 9 patients (20.9%) in the instrumented group, underwent repeated lumbar surgery for ASD; thus, more instrumented patients demonstrated poorer functional outcomes. The authors concluded instrumentation did result in a “larger number of additional surgeries, which resulted in a lesser degree of improvement.”

Comments: This study is a unique example wherein higher fusion rates were for instrumented (81%) versus noninstrumented fusions correlated with better outcomes.^[2] However, the reoperation rate was higher (20.9%) for the instrumented versus noninstrumented fusion patients (11.8%), and these patients exhibited poorer outcomes correlating with the need for secondary surgery.

Surgical morbidity of transforaminal lumbar interbody fusion versus posterior lumbar interbody fusion

Over a 5-year period, Mehta *et al.* in 2011 retrospectively compared the relative risk of durotomy, nerve root injury, and other complications utilizing TLIF (37% of patients with its unilateral exposure) versus PLIF (63% of patient with its bilateral exposure) for 119 patients’ with degenerative spinal disease or spondylolisthesis [Table 2].^[15] Notably, 92% of patients had surgery for mechanical back pain, 80% for radicular pain, while only 8% exhibited accompanying motor deficits. Of interest, PLIF correlated with higher rates of postoperative iatrogenic nerve root dysfunction (7.8%) versus TLIF (2%) and higher durotomy rates; PLIF 17% versus TLIF 9%. Other operative variables/complication rates were similar for both procedures; these included similar estimated blood loss, nearly comparable pseudarthrosis rates at 12 months (e.g., PLIF 2.6% vs. TLIF 4.6%), similar improvement in radiculopathy (88% vs. 79%), and low back pain (74% vs. 80%). Despite the reduction of major complications with TLIF versus PLIF, the authors interestingly still concluded: “TLIF and PLIF should only be considered when the goals of surgery cannot be addressed with decompression and traditional posterolateral fusion.”

Comments: What first stands out in this instrumented TLIF/PLIF study were the rather poor indications for surgery; for example, 92% of 119 patients had surgery for mechanical back pain, 80% for radicular pain, while only 8% had motor deficits.^[15] It would, therefore, appear that only 11 patients really warranted surgery. Interestingly, while attempting to document the reduced morbidity

of TLIF versus PLIF, they ended up showing significant major morbidities for both procedures (e.g. nerve root injuries of 2% for TLIF to 7.8% for PLIF, and with durotomy rates varying from 9% to 17%). Finally, they are to be congratulated for having come to the right conclusion: “TLIF and PLIF should only be considered when the goals of surgery cannot be addressed with decompression and traditional posterolateral fusion.”

The comparison of instrumented and noninstrumented fusion in the treatment of lumbar degenerative spondylolisthesis: A meta-analysis

Ye *et al.* in 2014 performed a meta-analysis to determine whether lumbar noninstrumented versus instrumented fusions differently impacted patient-centered outcomes [Table 2].^[20] Utilizing MEDLINE, Cochrane, EMBASE, and Google Scholar databases, they looked for randomized control trials evaluating patients with severe chronic lower back pain due to localized lumbar/lumbosacral instability attributed to isthmic spondylolisthesis or DS. No significant differences were encountered in pain resolution and satisfaction levels for patients undergoing instrumented versus noninstrumented fusions; this was noted despite significantly higher fusion rates with instrumentation. The authors concluded; “...the inclusion of fusion surgery with instrumentation provided no benefit as evaluated by patient-reported outcomes in patients with lumbar spondylolisthesis.”

Comments: This meta-analysis evaluated patients with low back pain due to isthmic spondylolisthesis or DS undergoing instrumented versus noninstrumented fusions; interestingly, clinical outcomes were comparable for both groups.^[20] The authors correctly came to the conclusion: “...the inclusion of fusion surgery with instrumentation provided no benefit as evaluated by patient-reported outcomes in patients with lumbar spondylolisthesis.” Why do not more of us pay attention to such major findings and also stop operating on patients for pain alone?

Noninstrumented lumbar fusions address different types of spinal degenerative lumbar diseases

Santiago-Dieppa *et al.* in 2014 noted that noninstrumented lumbar fusions address different types of spinal degenerative diseases [Table 2].^[18] In a retrospective review over a 20-year period, they analyzed long-term outcomes of *in situ* fusions, the incidence of ASD, and requirements for reoperations. The 376 patients in the series averaged 61.1 years of age. Patients exhibited back pain (344 [91.5%] patients) and radiculopathy (304 [80.9%] patients) and were symptomatic from multilevel spinal stenosis/neurogenic claudication (211 [56.1%] patients). They were followed

for an average of 92 (range 24–154) postoperative months. Although the rate of ASD was 18.35% (69 patients), the rate of re-operation due to failure to improve/worsening was 30.59% (115 patients). They attributed this high reoperation rate to instability and the need to perform more primary instrumented fusions.

Comments: This study retrospectively evaluated 376 patients who underwent lumbar multilevel laminectomy with noninstrumented fusions for relatively minimal indications: 91.5% had back pain and 80.9% had radiculopathy.^[18] Perhaps that explains why 18.35% had ASD 18.35% and 30.59% had reoperations due to failure to improve. Notably, there was no basis for their conclusion that primary fusions would have limited the reoperation rate. Rather, fewer initial operations for insufficient indications would likely have led to better results.

Risk of infection following 817 consecutive posterior instrumented lumbar fusions for degenerative spine disease

Chaichana *et al.* in 2014 evaluated the incidence and risk factors contributing to infections for lumbar spinal fusions performed to address degenerative lumbar disease [Table 3].^[7] Data for 817 consecutive patients were retrospectively reviewed from 1993 to 2010; 37 patients (4.5%) developed postoperative spine infections at an average of 0.6 months (interquartile range 0.3–0.9) postoperatively. Risks factors contributing to infections included advanced age, diabetes, obesity, previous spine surgery, and longer length of hospital stay. For the 37 patients with infection, 21 (57%) required reoperations, but only 3 (8%) necessitated the removal of instrumentation.

Table 3: Literature of reoperations, including adjacent segment disease following lumbar laminectomies with/without noninstrumented (*in situ*) versus instrumented fusions 2014-2015

Author (reference) Date	Number of patients Follow-up duration	Outcomes including Adjacent Segment Disease (ASD)	Adjacent Segment Disease (ASD) Outcomes Frequency Other	Conclusions Adjacent Segment Disease (ASD) with/ without <i>in situ</i> versus instrumented fusions
Chaichana <i>et al.</i> ^[7] 2014	Infection risk 817 patients Infection 0.6 months	Advanced age, DM Obesity Prior surgery Longer stay	37 (4.5%) infections	21 (57%) reoperation for infections 8% removal old instrumentation
Macki <i>et al.</i> ^[13] 2015	103 patients DS	56.31% PLF/TLIF (instrumented PLF) 34.69% PLF only (instrumented PLF)	PLF alone > outcome > reoperations > fusion failed	PLF/TLIF (interbody) << outcomes < reoperation rates < pseudarthrosis rates
Bydon <i>et al.</i> ^[6] 2015	39 reoperations laminectomy No fusion Degenerative disease Followed 4 years	Reoperations more cephalad; L2-L3 (31%) L3-L4 (26%) L4-L5 (15%) L5-S1 (31%)	Secondary surgery Laminectomy (95%) Discectomy (26%) Fusion (49%)	9-10% ASD reoperation Laminectomy without fusion Half required secondary fusions
Bydon <i>et al.</i> ^[4] 2015	1395 patients 30 days complications Instrumented PLF	Four age cohorts <65, 65-75, 75-85, and ≥85	Complication rate 11.47% 9.04% <65 14.05% >65	Patients >65 significantly higher complication rates after lumbar fusions versus younger patients
Bydon <i>et al.</i> ^[5] 2015	500 patients 1-3 level laminectomies Degenerative disease Followed 46.8 months	Durotomy 10% 1.6% postoperative CSF leaks	5.6% one complication 8% overall reoperation risk requiring fusion after lumbar laminectomy	72 (14.4%) reoperations for ASD; average 3.4 years 55.56% secondary decompression alone 44.44% decompressions/PLF (instrumented PLF)
Nakashima <i>et al.</i> ^[16] 2015	101 PLIF	9.9% (10) reoperations for ASD at 1 year 80% reoperation for ASD at 5 years	Cranial ASD 10 years MR 62 disc 25 stenosis	Caudal ASD 10 years MR 68 disc 12 stenosis
Epstein ^[9] 2015	336 lumbar laminectomies <i>In situ</i> fusions	9 (2.7%) reoperations Average 6.3 years Between cases	Average 2.9 original laminectomy Second 4.8 level laminectomy	Original fusion 1.0 level Second fusion 1.1 level 2.7% reoperations

MR: Magnetic resonance imaging, PLIF: Posterior lumbar interbody fusion, PLF: Posterolateral fusion, TLIF: Transforaminal lumbar interbody fusion, ASD: Adjacent segment disease, DM: Diabetes mellitus, DS: Degenerative spondylolisthesis

Comments: In this study, 37 (4.5%) of 817 consecutive lumbar instrumented fusions became infected and 21 (57%) required reoperations.^[7] Notably, the infection rate would likely have been substantially reduced without the initial unnecessary use of instrumentation and would have avoided the need for reoperations and instrumentation removal.

Lower reoperation rate for posterolateral fusion/interbody device versus posterolateral fusion alone for lumbar spondylolisthesis

Macki *et al.* in 2015 evaluated whether better outcomes could be achieved in 103 patients with DS utilizing either instrumented posterolateral fusion (PLF) with an interbody fusion device (PLF + PLIF/TLIF: 56.31%) versus instrumented posterolateral fusion (PLF: 43.69%) alone [Table 3].^[13] Patients undergoing PLF alone exhibited greater clinical improvement when compared with those receiving the interbody device. Nevertheless, patients undergoing fusions with the interbody device (PLF + PLIF/TLIF) demonstrated greater radiographic improvement in spondylolisthesis (average of 13.06% after vs. 5.67% after PLF), lower reoperation, pseudarthrosis, and instrumentation failure rates.

Comments: Here, we have 103 patients with DS undergoing PLF or PLF + PLIF/TLIF; most likely many of these patients could have been adequately managed with laminectomy alone or with laminectomy/noninstrumented fusions.^[13] Of interest, those undergoing the less extensive PLF procedures (e.g., without manipulation of the cauda equina/nerve roots to place an interbody device) demonstrated better clinical outcomes, despite higher reoperation/pseudarthrosis rates and lesser correction of olisthesis.

Incidence of adjacent segment disease requiring reoperation after lumbar laminectomy without fusion: A study of 398 patients

Bydon *et al.* in 2015 determined a 9–10% incidence of ASD requiring reoperations following 1 (10%)–2 (9%) level laminectomy without fusion, respectively, in patients with degenerative spinal disease [Table 3].^[6] Patients were followed at an average of 4 years. More common cephalad versus caudad ASD disease was observed in 39 patients involving the L2–L3 (31%), L3–L4 (26%), L4–L5 (15%), and L5–S1 (31%) levels. Of interest, secondary surgery required laminectomy (95%), discectomy (26%), and nearly half (49%) required fusions. Notably, the time to reoperation for ASD was equivalent for those in the 1- and 2-level laminectomy cohorts.

Comments: At 4 postoperative years, this study nicely documents that the risk of ASD following 1–2 level laminectomy was 10% for 1 level and 9% for 2 level procedures.^[6] Almost all required secondary laminectomy (95%), but there was an accompanying disc in 26% of

patients with an added 49% with instability warranting a fusion.

Impact of age on short-term outcomes after lumbar fusion

Bydon *et al.* in 2015 studied the safety and efficacy (e.g., 30-day complication rate) for older patients undergoing instrumented posterolateral lumbar fusions between 2005 and 2011 [Table 3].^[4] Using The American College of Surgeons National Surgical Quality Improvement Program (NSQIP), they studied four patients in the following four age groups: <65, 65–75, 75–85, and ≥85. Of the 1395 patients, the overall 30-day complication rate was 11.47%; 9.04% for those under 65; and 14.05% for patients older than 65. Although there was no statistically significant difference between the <65 and ≥65 age cohorts, they concluded that patients over 65 had significantly higher complication rates after lumbar fusions versus younger patients.

Comments: This study documents, utilizing NSQIP data, that the 30-day complication rate for 1395 patients undergoing instrumented posterolateral fusions was 11.47%: <65 it was 9.04% versus >65 it was 14.05%.^[4] Although this difference was not statistically significant, they concluded that older patients had significantly higher complication rates after lumbar fusions versus younger patients.

Clinical and surgical outcomes of 500 patients after lumbar laminectomy

Bydon *et al.* in 2015 retrospectively evaluated the outcomes for 500 patients undergoing initial 1–3 level laminectomies for degenerative lumbar disease (e.g., excluding discectomy, complete facetectomy, and fusion) over an average of 46.79 months [Table 3].^[5] Patients exhibited statistically significant improvement in all modalities. Although durotomy occurred in 10% of patients, only 1.6% exhibited a postoperative cerebrospinal fluid leak. At least one postoperative complication was noted in 5.60% of patients. Notably, 72 patients (14.40%) required reoperations for ASD over an average of 3.40 postoperative years; 55.56% underwent secondary decompression only, whereas 44.44% required decompressions/posterolateral fusions. There was an 8.0% overall reoperation risk requiring a fusion after an original lumbar laminectomy.

Comments: In this study, outcomes for 500 patients undergoing initial 1–3 level laminectomies for degenerative lumbar disease, 72 patients (14.40%) required reoperations for ASD at an average of 3.40 years later; 55.56% decompressions alone versus 44.44% decompressions/posterolateral fusions.^[5] Notably, this reoperation rate was substantially lower than the 80% incidence of secondary surgery at 5 postoperative years for ASD as noted in Nakashima *et al.*'s. PLIF instrumented

fusion series.^[16] I would also ask why so many were secondarily considered candidates for fusions?

Adjacent segment disease after posterior lumbar interbody fusion (PLIF): 10 years of follow-up

Nakashima *et al.* in 2015 evaluated 101 patients undergoing PLIF [Table 3].^[16] Of these, 10 (9.9%) patients required second operation for ASD at 1 postoperative year, while 80% required additional surgery for ASD at 5 postoperative years. The typical indication for reoperations were for more cephalad versus caudad disease.

Comments: This is one of the most ground-breaking studies regarding the high risk of ASD for patients undergoing PLIF instrumented fusions; 9.9% at 1 year, but a staggering 80% at 5 postoperative years.^[16] Why have so few other interbody TLIF/PLIF series not picked up on this extraordinarily high risk for ASD?

Low reoperation rate following 336 multilevel lumbar laminectomies with noninstrumented fusions

Epstein in 2016 evaluated 336 patients who had undergone at an initial average of 4.7 level lumbar laminectomies with an average of 1.4 level noninstrumented fusions over an average of 7.1-year period (range 2.0–16.5 years) [Table 3].^[9] Nine (2.7%) of 336 patients required reoperations, including addressing ASD, an average of 6.3 years (range 2–15 years) later when they averaged 66.3 years of age. First and second operations, respectively, warranted an average of 2.9 and 4.8 level (range 3–6) laminectomies/decompressions and an average of 1.0 and 1.1 level noninstrumented fusions. In addition, patients exhibited Grade I (7 patients) or Grade II (1 patient) spondylolisthesis, new disc herniations (2 patients), and/or a synovial cyst (1 patient).

Comments: The reoperation rate following multilevel laminectomy with noninstrumented fusion in this series was 2.7%: 9 of 336 patients an average of 6.3 years postoperatively required secondary surgery.^[9] These numbers were similar to Park *et al.* study in which 5.2–5.6% of patients undergoing laminectomy alone/laminectomy noninstrumented fusion required additional surgery for ASD at an average of 44.8 months (3.73 years) postoperatively.^[17]

SUMMARY

The risk of reoperation, including for ASD, following laminectomy with noninstrumented fusion remains lower than for instrumented fusions.^[1-3,8-10,13-17] The reoperation rates for laminectomy/noninstrumented fusion ranged from 1.3% to 5.6%. whereas reoperations rates following laminectomy/instrumented fusions ranged from 12.2% to 18.5% for TLIF/PLIF to 80% at 5 postoperative years for PLIF.^[18,9,16,17] Although several studies cited similar fusion

rates with noninstrumented (68–76%) versus instrumented fusion (78–81%) or even documented higher rates of fusion with instrumentation, several authors concluded that there was no benefit for adding instrumentation to elective degenerative lumbar procedures and found higher reoperation rates and poorer outcomes for failed instrumented fusions.^[1-3,10,14] In addition, higher risks/complication rates for instrumented interbody fusions (TLIF/PLIF; root injuries 2–7.8%; durotomy 9–17%) led others conclude that interbody fusions should only be considered when traditional posterolateral instrumented fusions would not suffice.^[6,13,15] Overall, the conclusion is that multilevel laminectomy with noninstrumented fusions leads to lower reoperation and complication rates when compared with instrumented fusions appears to be correct. Now, how can we get more of our colleagues to listen to reason?

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Conflicts of interest

There are no conflicts of interest.

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