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Single-Level Lumbar Spine Fusion: A Comparison of Anterior and Posterior Approaches

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Summary: This study is a retrospective review of 122 patients who underwent single-level lumbar spine fusion. The objectives were to directly compare perioperative morbidity and early results of single-level anterior interbody *versus* posterolateral intertransverse process lumbar spine fusion and to provide objective findings that may be useful in selecting surgical method. Lumbar spinal fusion is a well-recognized surgical treatment of intractable low back pain resulting from DDD or spondylolisthesis. Assessments of techniques, results, and outcomes have been published, but detailed head-to-head comparisons of anterior *versus* posterior approaches with objective operative and postoperative data are not available in the literature. A retrospective review of 122 patients who underwent either an anterior interbody or posterolateral intertransverse process (average follow-up 22 and 26 months, respectively) single-level instrumented lumbar spinal fusion was performed. Surgical, perioperative, and follow-up data were obtained directly from medical records. The findings compared included estimated blood loss, need for blood transfusion, number of units transfused, operative time, number of days in hospital, need for transitional facility care, complications, need for further surgery, radiographic fusion, and clinical results. There was significantly less blood loss, need for transfusion, amount of blood transfused, operative time, and hospital stay for patients with anterior fusion procedures ($p < 0.01$). There was no significant difference in need for transitional facility care, complication rates, and given follow-up period in radiographic fusion rate and clinical outcome. Clinical results were significantly worse for those undergoing revision *versus* primary fusion ($p < 0.01$). The anterior approach to single-level lumbar fusion is associated with less morbidity than the posterolateral approach. This may in turn affect surgical outcome and hospital cost. However, both approaches to single-level lumbar fusion produce similar early fusion rates and clinical results. Revision fusions had poor early results regardless of approach. **Key Words:** Fusion—Lumbar spine—Anterior interbody fusion—Posterolateral fusion.

INTRODUCTION

Lumbar spine fusion is a well-recognized surgical treatment of intractable low back pain secondary to a number of causes (1–5). However, the indications for the operation, surgical approach, and results still remain controversial (6,7). Assessments of techniques, results, and outcomes have been published but are difficult to interpret because of many confounding factors such as psychiatric distress, compensation claims, and subjectivity in clinical and radiographic assessment (8–11). Furthermore, a review of the literature reveals a dearth of direct comparisons of morbidity between approaches with objective operative and perioperative data (7,12–15). Two commonly used techniques are anterior interbody fusion and posterolateral intertransverse process fusion. Both approaches have been performed for a number of indications, with good success cited in the literature. However, no consen-

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sus advantage of one over the other has been demonstrated in prior studies for a single-level spinal fusion.

There is no shortage of studies in the literature arguing for or against each of these approaches. Proponents of posterior spinal fusion cite the technical ease of short segment fixation and the allowance of direct decompression of the nerve root (8,16–19). Proponents of anterior approach consider the disc to be the primary source of the pain, which is removed during fusion and instrumentation of the motion segment (12,15,20–22). They also point out the indirect decompression of the nerve root via distraction of the intervertebral space. Moreover, with an anterior approach, potential injury to the posterior ligaments, spinal cord, and nerve roots is largely avoided.

The current case–control study is a direct comparison of the early results and morbidity of anterior interbody *versus* posterolateral intertransverse process single-level lumbar spine fusion. It is hoped that the objective data provided will help in selecting the patient-appropriate surgical approach, reducing patient morbidity and medical cost.

METHODS

A retrospective review was done of 122 patients who underwent either an anterior or posterolateral single-level instrumented lumbar spinal fusion at our institution. Simultaneous iliac crest bone autografting was performed for all procedures. The indication for operating on these patients was intractable low back pain secondary to a single-level pathologic process at L4–L5 or L5–S1. The underlying pathology encountered in this study was degenerative disc disease (DDD), spondylolisthesis/instability, pseudarthrosis (in those having revision surgery), or combinations thereof (Table 1). Patients with DDD and spondylolisthesis were the vast majority of the sample group.

Standard operative techniques in accordance with instrument manufacturers' guidelines were used for both approaches. BAK cages (Sulzer Spine-Tech, Minneapolis, MN, U.S.A.; two per level) were used for all anterior spinal fusions. Instrumentation used for the posterior spinal fusions consisted of bilateral pedicle screw fixation at both levels. Others list an array of possible complications in spine fusion surgery (23,24). In this study "operative complications" were defined to include dural tears, big vessel perforations, bowel perforations, nerve damage, malposition of instrumentation (fracture or cut-out from bone), and hemodynamic instability during surgery. "Postoperative complications" were defined to include bladder recatheterization (in excess of 2 days after discontinuation of intravenous pain medication), prolonged ileus (nausea or vomiting lasting >4 days), gastrointestinal bleed, wound infection, diarrhea with *Clostridium difficile* bacterial colonization, deep venous thrombosis or pulmonary embolism, retrograde ejaculation, and new or worsening radiculopathy, pain, numbness, or weakness.

TABLE 1. *Diagnoses treated by anterior or posterolateral single-level lumbar fusion*

Diagnosis	No. of patients	ASF	PSF
DDD + spondylolisthesis/instability	51	20	31
DDD	50	33	17
Spondylolisthesis/instability	17	4	13
Pseudarthrosis[a]	4	1	3
Total	122	58	64

DDD, degenerative disc disease; ASF, anterior spinal fusion; PSF, posterior spinal fusion.

[a]Presence of pseudarthrosis implies a revision surgery was performed and may include the other diagnoses mentioned.

Objective surgical data were obtained directly from the surgeons' dictated operative notes, anesthesia notes, and operating room records. This included estimated blood loss, need for blood transfusion, number of units of blood transfused, operative time, and intraoperative complications. Perioperative in-hospital data were gathered from patients' charts. This included need for transfusion, number of units of blood transfused, length of hospital stay, need for transitional facility care, and postoperative complications.

After the initial postoperative visit, patients were followed up in clinic every 3 months until at least 2 years after the operation. At each office visit the clinical symptoms were recorded, physical examination was conducted, and radiographic assessments were made. The radiographic criteria for fusion were based on visual evidence of trabecular continuity and absence of intersegmental motion at the fusion site on flexion–extension views. This was supplemented by CT scans as necessary. Clinical results were rated using subjective criteria defined in physician-administered questionnaires at the most recent follow-up (Table 2). The rating accounted for patient satisfaction, pain relief, activity limitations, and analgesic usage (15). Although the primary objective of this study was to compare perioperative morbidity, these early follow-up data were available to us and served to illustrate the comparability of the two surgical methods in the same population.

Statistical comparisons were made using the Student's t test and χ^2 test, with adjustments made for age, gender, diagnosis, and previous surgeries. Although the primary objective of this study was to compare the anterior and posterolateral fusion groups, comparisons were also made between the primary and revision groups, between the anterior and posterolateral subgroups within each primary and revision group, and between the primary and revision

TABLE 2. *Criteria for the clinical ratings after single-level lumbar spine fusion*

Clinical rating	Criteria
Excellent	1. Satisfied
	2. Nearly complete relief of pain
	3. No physical limitations
	4. No analgesics
Good	1. Fairly satisfied
	2. Relief of most pain
	3. Slight limitation of activities, but return to work
	4. Occasional analgesics
Fair	1. Not very satisfied
	2. Only partial relief of pain
	3. Significant limitation of activities, and work limited to light duty
	4. Frequent analgesics
Poor	1. Not satisfied
	2. Little to no pain relief or worse
	3. Great limitation of activities, and unable to work
	4. Regular use of analgesics
	5. Needs more surgery

subgroups within each anterior and posterolateral group. A p value <0.05 was considered statistically significant, with the understanding that some comparison subgroups may have limited numbers.

RESULTS

Demographics

Of the 122 patients, 58 (48%) underwent anterior interbody fusion with a titanium cage implant, and 64 (52%) underwent posterolateral instrumented fusion. Primary fusion was done on 77 (63%) of the patients, and revision fusion was performed on 45 (37%) patients. In the primary fusion group, 43 (56%) patients had anterior fusion and 34 (44%) had posterolateral fusion. In the revision fusion group, 15 (33%) had anterior fusion and 30 (67%) had posterolateral fusion. Patients from a total of four different surgeons were sampled, with all surgeries having been performed at our institution (Table 3).

Sample demographics revealed 51 (42%) male and 71 (58%) female patients. The average age of patients undergoing anterior fusion was 49 years (range 25–83 years), and of those undergoing posterior fusion was 43 years (range 20–70 years). Average follow-up for the anterior fusion group was 22 months (range 19–48 months), and for posterior fusion patients was 26 months (range 22–50 months) (Table 4).

Statistical analysis revealed no significant difference in the gender and average age distribution of patients between the anterior and posterolateral fusion groups. Similarly, the mean lengths of follow-up between the anterior and posterolateral groups, or between primary and revision groups, were not statistically different.

TABLE 3. *Breakdown of single-level lumbar spinal fusion surgeries by type and approach*[a]

Primary surgery (n = 77)		Revision surgery (n = 45)	
Anterior fusion	Posterior fusion	Anterior fusion	Posterior fusion
43	34	15	30

[a]All surgeries were performed at the UCLA Medical Center, Los Angeles, CA.

Operative Data

Comparing operative and perioperative in-hospital data (Table 5) revealed less average estimated blood loss in anterior fusion (227 mL; range 15–400 mL) *versus* posterolateral fusion (632 mL; range 125–2,500 mL). This difference was statistically significant ($p < 0.01$) and remained so regardless of whether the surgery was primary or revision (anterior and posterolateral subgroups were compared within primary or revision surgery groups). Subsequent need for blood transfusion was also lower for anterior fusion ($p < 0.01$), 17 of 58 (29%) anterior cases needing transfusion compared with 52 of 64 (81%) posterolateral cases. However, there was no statistically significant difference in transfusion requirements between the primary and revision subgroups within the anterior or posterolateral groups. Transfusion was based on medical need only, determined by the surgical or the consulting medical teams, even if autologous blood was available.

Operative time was less in anterior fusions (165 minutes; range 75–239 minutes) compared with posterolateral fusion (257 minutes; range 116–389 minutes). This difference was statistically significant ($p < 0.01$) and remained so regardless of whether the surgery was primary or revision (anterior and posterolateral subgroups were compared within primary or revision surgery groups). However, operative times between primary and revision cases were not statistically different (when comparing all cases, or as subgroups within anterior and posterolateral groups).

Hospital stay was significantly shorter ($p < 0.01$) for patients having anterior fusion compared with posterolateral fusion (4.7 days, range 3–10 days *vs.* 6.3 days, range 3–20 days). Primary or revision status (when comparing

TABLE 4. *Breakdown of patients by surgical approach, gender, age, and follow-up period*

	Anterior fusion	Posterior fusion
Male	17	34
Female	41	30
Average age [years (range)]	49 (25–83)	43 (20–70)
Average follow-up [months (range)]	22 (19–48)	26 (22–50)

TABLE 5. *Analysis of results of anterior versus posterior single level lumbar spinal fusion*

	Anterior lumbar fusion			Posterior lumbar fusion			
	Primary	Revision	Total	Primary	Revision	Total	p value[a]
Avg age of patient (years)	42	45	43	52	47	49	NS
Avg follow-up (months)	23	20	22	25	28	26	NS
Avg EBL (mL)	200	311	227	634	629	632	<0.01
Transfusion (% patients)	28	33	29	82	80	81	<0.01
Avg units transfused	0.4	0.5	0.4	1.7	1.7	1.7	<0.01
Avg surgery time (minutes)	162	175	165	261	252	257	<0.01
Avg hospital stay (days)	4.7	4.6	4.7	6.1	6.6	6.3	<0.01
Need for rehabilitation placement (% of patients)	0	6.7	1.7	11.8	10.0	10.9	0.024
Operative complication rate (% of patients)	4.7	0	3.4	2.9	3.3	3.1	NS
Postoperative complication rate (% of patients)	7.0	20	10.3	11.8	13.3	12.5	NS
Need for further surgery (% of patients)	16.3	6.7	13.8	8.8	23.3	15.6	NS
Radiographic evidence of fusion (% of patients)	95	93	95	91	93	92	NS
Clinical rating of good to excellent (% of patients)	79	60	74	91	53	73	NS

Avg, average; EBL, estimated blood loss; NS, not significant ($p > 0.01$).
[a]p values are for comparison between totals within anterior and posterolateral fusion groups.

all cases, or as subgroups within anterior and posterolateral groups) did not seem to affect length of hospital stay. The need for transitional care after hospital discharge appeared less for the anterior fusion group (1.7% *vs.* 10.9%). This difference was statistically significant ($p = 0.024$). Primary or revision status did not affect this need either (when comparing all cases, or as subgroups within anterior and posterolateral groups).

The operative and postoperative complications were not statistically significantly different between the anterior and posterolateral fusion groups, or between primary or revision subgroups within these groups. Operative complications, as defined above, occurred in 2 of 58 (3.4%) patients who underwent anterior fusion, compared with 3 of 64 (4.7%) patients who underwent posterolateral fusion. The operative complications in the anterior fusion group both occurred in primary cases. One was a case of cage protrusion laterally, which was fixed with redirection and bone grafting. The other was a case of congestive heart failure secondary to fluid overload, which was managed medically postoperatively. Operative complications in the posterolateral fusion group consisted of dural tears in two revision cases, which were repaired successfully, and one congestive heart failure resulting in fluid overload in a primary case, which was again managed medically postoperatively.

Postoperative complications, as defined above, occurred in 6 of 58 (10.3%) patients with anterior fusion and 8 of 64 (12.5%) patients with posterolateral fusion. Postoperative complications in the anterior fusion group consisted of three cases of prolonged ileus (one in a primary case and two in revision cases), one recatheterization in a primary case, one increased back pain in a primary case (which eventually required revision), and one femoral nerve palsy in a revision case (which resolved by time of discharge). Postoperative complications in the posterolateral fusion group consisted of two wound infections in revision cases (treated with antibiotics), two pulmonary emboli occurrences in revision cases (mild symptoms; treated with medical support), two recatheterizations in primary cases, one *Clostridium difficile* colonization in a primary case (treated with antibiotics), and one increased radiculopathy in a primary case (which eventually required revision). Lastly, the need for further surgery (for any reason) was not statistically different between the anterior and posterior fusion groups (8 of 58 [13.8%] *vs.* 10 of 64 [15.6%]), or between primary and revision subgroups within these groups.

Radiographic Fusion Rates

Radiographic signs of fusion were evident in 55 of 58 (95%) patients who underwent anterior fusion *versus* 59 of 64 (92%) patients who underwent posterolateral fusion. The radiographic criteria for fusion were based on visual evidence of trabecular continuity and absence of intersegmental motion at the fusion site on flexion–extension views, as read by an attending spine surgeon and an attending radiologist. CT scans were also used in ambiguous cases. In the primary group 62 of 77 (81%) patients had radiographic fusion *versus* 32 of 45 (71%) in the revision group. Within the anterior group, 41 of 43 (95%) in the primary subgroup had radiographic fusion *versus* 14 of 15 (93%) in the revision subgroup. Within the posterolateral group, 31 of 34 (91%) in the primary subgroup had radiographic fusion *versus* 28 of 30 (93%) in the revision subgroup. Within the primary group, 41 of 43 (95%) in the anterior subgroup had radiographic fusion *versus* 31 of 34 (91%) in the posterolateral subgroup. Within the revision group, 14 of 15 (93%) in the anterior subgroup had radiographic fusion *versus* 28 of 30 (93%) in the posterolateral subgroup. There were no statistically significant differ-

ences in radiographic fusion rates between any of these groups or subgroups.

Radiographic studies are limited in their ability to diagnose pseudarthroses. The assumption here is that this is equally true in both approaches. Cases in which radiographically the patient was fused but poor clinical results warranted an exploratory surgery were listed as failed fusions. These numbers were not significantly different between the two approaches (Table 6).

Clinical Results

Comparing clinical ratings at follow-up, patients were considered significantly improved if the ratings were in the "good" or "excellent" categories (Table 6). In the anterior fusion group, 43 of 58 (74%) patients *versus* 47 of 64 (73%) in the posterolateral fusion group of patients were judged to be significantly improved and doing well. There was no statistically significant difference between the two groups. Within the primary group, 34 of 43 (79%) in the anterior subgroup were considered to be significantly improved *versus* 31 of 34 (91%) in the posterolateral subgroup. Within the revision group, 9 of 15 (60%) in the anterior subgroup were considered significantly improved *versus* 16 of 30 (53%) in the posterolateral subgroup. There was no statistical significance to the differences between any of these groups or subgroups.

In other interesting comparisons, between two surgeons who performed the majority of the surgeries (102 of 122), the significant clinical improvement rate of 87% *versus* 80% was not significantly different (54 of 62 *vs.* 32 of 40). Also, in comparing approaches within the group with a dual diagnosis of DDD and instability, thus partially negating surgeon bias in approach to treat either diagnosis, the significant improvement rate was not significantly different.

However, comparing results of primary *versus* revision surgeries did reveal significant statistical differences in the clinical ratings ($p < 0.01$). The revision cases did uniformly worse than the primary cases, regardless of the approach. A total of 65 of 77 (84%) patients who underwent primary fusion were judged to be significantly improved *versus* 25 of 45 (56%) of those who had revision surgery. Within the anterior group, 34 of 43 (79%) in the primary subgroup were significantly improved *versus* 9 of 15 (60%) in the revision subgroup. Within the posterolateral group, 31 of 34 (91%) in the primary subgroup were significantly improved *versus* 16 of 30 (53%) in the revision subgroup. All these differences were statistically significant ($p < 0.01$).

TABLE 6. *Breakdown of clinical rating by type of surgery*

	Primary surgery		Revision surgery	
Clinical rating[a]	Anterior fusion	Posterior fusion	Anterior fusion	Posterior fusion
Excellent	18	23	4	5
Good	16	8	5	11
Fair	7	2	4	9
Poor	2	1	2	5
Total	43	34	15	30

[a]Patient responses categorized according to criteria in Table 2.

DISCUSSION

Spinal fusion has been used since the late 19th century for the treatment of various disorders (1,3). Hadra (25) first reported its use for posterior stabilization of the cervical spine in 1891. In the second half of the 20th century, fusion began to be used for the treatment of degenerative disorders throughout the spine (3,5). The advent of modern internal fixation to augment the fusion mass has led to increased fusion rates.

Lumbar spinal fusion is now a common procedure; yet its indications are controversial and at times confusing (2,7,16,26,27). Most reports in the literature describe patients with variable or confounding characteristics who have spine surgery for a variety of conditions, and outcomes that are measured by nonstandardized methods. Initially, it was used for the management of infection, scoliosis, and trauma. Now it is also used to control pain attributed to unstable motion or mechanical insufficiency brought on by degenerative changes. Lumbar spinal fusion has been advocated for a variety of conditions that affect the spine (7,16,20,27–29), including prevention of deformity, correction of deformity, eradication of local disease process, stabilization of the spine after trauma or other destabilizing destructive process, treatment of painful motion segments (segmental instability) secondary to degenerative processes, and discogenic pain. Sonntag and Marciano (7) in 1995 stated that definite indications for lumbar spine fusion were trauma, tumor, infection, iatrogenic instability, and isthmic spondylolisthesis. They described relative indications as degenerative spondylolisthesis, abnormal movement on dynamic radiographs with pain or neurologic deficit, and mechanical pain. Hanley (11) in 1995 described a few different indications, including degenerative scoliosis, degenerative segmental instability, disc-related low back pain, and failed previous surgery. Lumbar fusion is rarely indicated for routine discectomy, abnormal radiographs without clinical findings, or stable spinal stenosis.

Debate about the superiority of anterior *versus* posterolateral approach to lumbar spine fusion also abounds in the literature. In certain situations the nature of the pathology dictates whether an anterior, posterior, or combined ap-

proach is best used. Considerations may include soft tissue release for deformity correction, osteotomy for deformity correction, site of levels, number of levels, infection of disc or endplates, and site of neural compression. However, these considerations are of less value when the pathology is confined to a single level or motion segment. The proponents of the posterolateral approach cite an easily achieved short segment fixation and direct decompression of the nerve root as major advantages (8,16–19). However, proponents of the anterior approach consider the disc to be the prime source of pain and that an anterior approach allows direct restoration of the intervertebral disc space and ligamentous tension (7,9,12,13,20–22,30,31). They also cite an indirect decompression of the nerve root through widening of the intervertebral space.

Posterolateral fusion is historically the more commonly used approach. As first described by Watkins (19) in 1953, it involves the facet joints, par interarticulares, and the bases of the transverse processes. In 1962, Wiltse (3) modified the technique to include the laminae. A sacrospinalis muscle splitting or a midline approach may be used. The main disadvantage of this posterior approach is the injury to the stabilizing posterior muscles of the spine and their nerve supply. This may be a source for continued pain and loss of function.

Anterior interbody fusion is becoming more widely used. Harmon (31) early in the 1960s reported the advantage of avoiding damage to the posterior supporting muscles and ligaments, as well as the spinal cord, and nerve roots with an anterior approach. He also described reduced transfusion need, reduced hospital stay, eradication of pain, and high fusion rates as other advantages but did not offer any objective comparisons. Kim et al. (17a) in 1993 showed that anterior interbody fusion corrects alignment, reduces anterior slippage, restores disc height, and resolves nerve compression by enlargement of the stenotic canal. It also allows for better access to the anterior and middle columns and better correction of kyphosis. There is evidence to suggest that late spinal stenosis adjacent to a fusion is more likely to occur with posterior fusions (16). Most often an anterior retroperitoneal rather than a transperitoneal approach is used. The abdominal muscles are split and the iliac vessels are mobilized. This usually involves the assistance of a vascular surgeon. The disadvantages are the increased risks of damage to the iliac vessels, damage to the presacral plexus causing retrograde ejaculation, and damage to the sympathetic chain causing lower extremity symptoms, although none of these complications was observed in this series.

The limitations of this study are recognized. All surgeries were done at one institution and by more than one surgeon. Even though the statistical analysis included adjustments for patient demographics, diagnoses, and previous surgeries, the surgeons' bias was not eliminated because treatment selection was not randomized. For example, one may infer from Table 1 that our surgeons favor a posterolateral approach for spondylolisthesis/instability and an anterior approach for DDD. Fortunately, the largest diagnosis group includes both DDD and instability, diluting this bias. The follow-up time period in the study was considered adequate because of the excellent early fusion rates compared with those reported in the literature (16,17) and because the focus of the study was on perioperative morbidity. Early clinical and radiographic results were included because they were available to us and provided additional information on the comparability of the two approaches, especially because the study group was the same. The sample size of 122 patients, although enough to illustrate considerably large differences in results, does limit the power of the study. In this limited group the surgeons were fortunate not to encounter any catastrophic complications (e.g., large vessel damage, direct nervous tissue damage) that may have skewed the results one way or the other. Also, although different types of posterior instrumentation had no significant effect in operative time in our study, it is conceivable that the surgeon's unfamiliarity with a particular system can increase the operative time and concomitant problems.

This study provides good objective data comparing the early morbidities of the two approaches. The sample demographics are comparable, and exposure is limited to a single specific level. However, the clinical results are more difficult to interpret. To date, there have been no randomized controlled studies comparing one fusion technique with another. Because influences such as compensation and psychologic disturbance have been found to have a profound effect on outcome, and in one study even on the fusion rate (32–34), it is difficult and probably unreliable to draw many conclusions from the current literature. To truly answer the question of which approach is better, a randomized, multicenter study must be undertaken.

CONCLUSION

The principal conclusion from this study is that anterior interbody fusion with cages, for single-level lumbar pathology, is associated with significantly less operative and perioperative morbidity compared with posterolateral intertransverse process fusion with pedicle screws. This included less blood loss, lower need for blood transfusion, shorter operative time and hospital stay, and possibly lower need for transitional facility care after discharge from the hospital. However, the early results from the two approaches are similar. These include radiographic fusion rates, clinical ratings, and need for further surgery. The

operative and postoperative complication rates are also comparable. It was also noted that results of revision surgery do not compare favorably with those of primary surgery, regardless of approach. These factors certainly have the ability to affect surgical results and medical costs. Because decisions on surgical approach are to date subjective and dependent on the patient as well as surgeon, the findings presented here may be useful in making such decisions.

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