Perioperative Complications in Transforaminal Lumbar Interbody Fusion Versus Anterior–Posterior Reconstruction for Lumbar Disc Degeneration and Instability

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Objectives: Multiple different approaches are used to treat lumbar degenerative disc disease and spinal instability. Both anterior–posterior (AP) reconstructive surgery and transforaminal lumbar interbody fusion (TLIF) provide a circumferential fusion and are considered reasonable surgical options. The purpose of this study was to quantitatively assess clinical parameters such as surgical blood loss, duration of the procedure, length of hospitalization, and complications for TLIF and AP reconstructive surgery for lumbar fusion.

Methods: A retrospective analysis was completed on 167 consecutive cases performed between January 2002 and March 2004. TLIF surgical procedure was performed on 124 patients, including 73 minimally invasive and 51 open cases. AP surgery was performed on 43 patients. Patients were treated for painful degenerative disc disease, facet arthropathy, degenerative instability, and spinal stenosis.

Results: The mean operative time for AP reconstruction was 455 minutes, for minimally invasive TLIF 255 minutes, and open TLIF 222 minutes. The mean blood loss for AP fusion surgery was 550 mL, for minimally invasive TLIF 231 mL, and open TLIF 424 mL. The mean hospitalization time for AP reconstruction was 7.2 days, for minimally invasive TLIF 3.1 days, and open TLIF 4.1 days. The total rate of complications was 76.7% for AP reconstruction, including 62.8% major and 13.9% minor complications. The minimally invasive TLIF patients group had the total 30.1% rate of complications, 21.9% of which were minor and 8.2% major complications. There were no major complications in the open TLIF patients group, with 35.3% minor complications.

Conclusions: AP lumbar interbody fusion surgery is associated with a more than two times higher complication rate, significantly increased blood loss, and longer operative and hospitalization times than both percutaneous and open TLIF for lumbar disc degeneration and instability.

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Lumbar fusion is an effective and established treatment method of low back pain. According to the Agency for Health Care Research and Quality, the annual number of spinal fusion operations rose by 77% between 1996 and 2001. Although surgical interventions in spine care represent the last resort, studies such as the Maine Lumbar Spine Study[1,2] have demonstrated that improvements in symptoms, quality of life, and overall satisfaction can be considerably greater in patients treated surgically than conservatively at 4 years' follow-up. This was confirmed at 10 years' follow-up. This is despite the fact that surgically treated patients had more severe symptoms initially.

Various lumbar interbody fusion approaches are used to treat painful degenerative disc disease and spinal instability. Both anterior–posterior (AP) and transforaminal lumbar interbody fusion (TLIF) reconstructive surgeries provide a circumferential fusion. However, the TLIF approach is theoretically less invasive and simultaneously allows for decompression of the neural structures, relief of radicular pain, and stabilization of the motion segment without additional anterior approach.

The TLIF procedure is gaining in popularity.[3–9] The purpose of this study was to compare this surgical approach with AP reconstructive surgery by evaluating such clinical parameters as surgical blood loss, duration of the procedure, length of hospitalization, and complications.

MATERIALS AND METHODS

A retrospective review of the charts was completed by an independent reviewer. Our hypothesis was that the TLIF procedure would be less invasive than the AP surgery, thus requiring less operative time, lower blood loss, and fewer complications. A total of 167 one- or two-level lumbar interbody fusion surgeries performed between January 2002 and March 2004 at Boulder Community Hospital (Boulder, CO) were included in the analysis. TLIF was performed on 124 patients, including

73 minimally invasive and 51 open cases, and the AP procedure was performed on 43 patients.

Patient data were obtained from the medical records. Indications for surgery included painful degenerative disc disease with or without radiculopathy, instability, spinal stenosis, facet arthropathy, or degenerative spondylolisthesis. An extensive presurgical clinical work-up was performed. A diagnosis of degenerative disc was based on one or more of the following characteristics on magnetic resonance imaging (MRI): disc dehydration, decreased disc height, endplate destruction, Modic changes, and/or high-intensity zone lesions. MRI also helped to determine whether or not there was neural compression due to disc herniation and/or central stenosis. Lumbar instability was based on evidence of dynamic AP translation of 4 mm or more and/or angulation greater than or equal to 10° on flexion–extension films. Computed tomography myelography was used to evaluate for neural compression in a minority of cases that were indeterminant on MRI. This was usually related to the presence of existing hardware.

Clinical parameters such as surgical blood loss, duration of the procedure, length of hospitalization, and intraoperative and perioperative complications were assessed for TLIF and AP reconstructive surgeries. Complications were divided into two groups: major and minor. The major complications group included pedicle screw or allograft malposition that required reoperation, new or increased neurologic deficit that lasted more than 3 months, blood vessel damage, deep venous thrombosis, pulmonary embolus, infection, or other complications that required a patient's readmission to the hospital. The minor complications group included allograft or pedicle screw malposition that did not require repositioning, transient ($\leq$3 months) neurologic deficit, cerebrospinal fluid (CSF) leak, hematoma, and anemia. Complications were reported for the average duration of 3.2 months (range 2.5–5.6 months). Fusion rates, clinical outcome, or sagittal alignments were not evaluated in this work.

A total of 124 patients undergoing TLIF surgery were divided into four subgroups: one-level minimally invasive procedure, one-level open procedure, two-level minimally invasive procedure, and two-level open procedure. All TLIF patients underwent placement of interbody structural allografts and locally harvested autograft from the hemilaminectomy/facetectomy defect. Seventy-two patients (58%) in this group also received recombinant human bone morphogenetic protein-2. Supplemental posterior, posterolateral, or intertransverse fusion was performed using locally harvested autograft for a total of 28 patients (23%).

A total of 43 patients undergoing AP reconstructive surgery were divided into two subgroups: one- and two-level procedures. AP reconstructive surgery was performed on the same day, and all of these cases were performed using an open approach. Patients in the AP lumbar interbody fusion group had autograft implants with two separate incisions performed for autograft harvesting. The demographic data for all patient groups are presented in Table 1.

TABLE 1. Patient Demographics

Procedure	Patients (no.)	M/F (no.)	Age (y)	Prev. Surgeries (no.)
Minimally invasive TLIF				
One level	50	21/29	51 (19–82)	11 (22%)
Two level	23	12/11	45 (36–69)	2 (9%)
Total	73	33/40	48	13 (18%)
Open TLIF				
One level	32	10/22	58 (33–83)	15 (47%)
Two level	19	10/9	49 (34–74)	5 (26%)
Total	51	20/31	53	20 (39%)
AP				
One level	24	14/10	42 (23–63)	11 (46%)
Two level	19	4/15	47 (34–69)	10 (53%)
Total	43	18/25	44	21 (49%)

Values are given as means, with range in parentheses for age.

RESULTS

Clinical and Surgical Data for TLIF and AP Procedures

Operative time, estimated blood loss, and hospitalization time are presented for the TLIF and AP surgical procedures in Table 2. Compared with the AP surgery group, operative time was shorter by 233 minutes in the open TLIF group ($P < 0.0001$) and by 200 minutes in the percutaneous TLIF group ($P < 0.0001$). Blood loss was 126 mL lower in the open ($P < 0.03$) and 319 mL lower in the percutaneous ($P < 0.0001$) TLIF group as compared with the AP group. Length of stay was shorter by 3.1 days in the open ($P < 0.0001$) and by 4.1 days in the percutaneous ($P < 0.0001$) TLIF group compared with the AP group.

With the exception of significantly decreased blood loss ($P < 0.006$), operative time was not significantly increased ($P < 0.5$) and shorter hospitalization time was not quite statistically significant ($P < 0.09$) in the minimally invasive TLIF patient group compared with the open TLIF group (see Table 2).

TABLE 2. Patient Clinical and Surgical Data

Procedure	OR Time	EBL	LOS
Minimally invasive TLIF			
One level	203 (114–309)	170 (25–400)	2.8 (1–7)
Two level	307 (227–390)	292 (100–700)	3.5 (2–10)
Mean	255	231	3.1
Open TLIF			
One level	204 (141–309)	365 (100–1000)	3.6 (1–8)
Two level	241 (164–359)	483 (200–1000)	4.6 (2–11)
Mean	222	424	4.1
AP			
One level	448 (316–660)	535 (250–1200)	7.1 (3–22)
Two level	463 (206–640)	566 (400–900)	7.3 (5–31)
Mean	455	550	7.2

Values are given as means, with range in parentheses. OR time, operative time (min); EBL, estimated blood loss (mL); LOS, length of stay (d).

Complications

Complications are listed as major (Table 3) and minor (Table 4) according to the criteria described in Methods. The total rate of complications was 76.7% in the AP group, including 62.8% major and 13.9% minor complications. Patients in the open TLIF group had 35.3% minor complications and no major complications compared with 21.9% minor and 8.2% major complications rate in the minimally invasive TLIF group. Total number of complications was less than half ($P < 0.001$) in the open or percutaneous TLIF group (76.7% vs. 35.3% and 30.1%) as compared with the AP group. The minimally invasive TLIF procedure was related to a significantly higher rate of major intraoperative and perioperative complications compared with the open TLIF group.

One patient in the minimally invasive TLIF group required reoperation for screw repositioning. He had a 6-mm medial pedicle wall perforation at L5 and underwent reoperation for removal of the screw 1 day after the original surgery. There were another 13 patients with malpositioned screws in the TLIF groups. Because these were all asymptomatic lateral perforations of less than 2 mm, it was elected to leave the pedicle screws in place. These patients have not had any neurologic symptoms related to the malpositioning. All six patients with malpositioned screws in the AP group needed reoperation and were taken to the operating room on a separate day. There were two 5-mm and 4-mm medial perforations and four lateral perforations ≥ 4 mm.

There were five patients (6.8%) with transient neurologic deficits in the minimally invasive TLIF group: one patient (2.0%) in the open TLIF group and two (4.6%) in the AP patient group that were classified as minor complications that lasted less than 3 months and were successfully treated conservatively by physical therapy and/or steroid injections. There were three patients each in the minimally invasive TLIF (4.1%) and AP (7.0%) group with neural injury complications that lasted more than 3 months and were classified as major complications. These patients, despite extensive conservative treatment, remained symptomatic at the average 3.2 months' follow-up. There were no such complications as pulmonary embolus, deep venous thrombosis, blood vessel damage, allografts malpositioning, ileus, or anemia in the minimally invasive as open TLIF patients groups.

All infections were successfully treated with antibiotics in the TLIF and AP group. CSF leaks were repaired intraoperatively with 5–0 Prolene sutures and/or Gelfoam and two-component fibrin sealant Tisseal (Baxter AG, Vienna, Austria).

One hundred percent of patients in the AP fusion group experienced at least 3 days of postoperative paralytic ileus. Six patients (14%) had this condition for more than 3 days, including one patient who required a postoperative laparotomy and an additional hospitalization for another 2 days. Another patient was readmitted to the hospital 6 weeks after the surgery because of deep venous thrombosis and pulmonary embolization. Six of 43 (14%) patients had to be readmitted to the hospital because of complications for total of 52 days (range 2–17 days).

TABLE 3. Major Complications

Complications	TLIF		AP
	Open	Min. Invasive	
Allograft malposition with reoperation	None	None	2 (4.6%)
Pedicle screw malposition with reoperation	None	1 (1.4%)	6 (13.9%)
Neurologic deficit* (> 3 mo)	None	3 (4.1%)	3 (7.0%)
Infection	None	2 (2.7%)	4 (9.3%)
Ileus > 3 d	None	None	6 (13.9%)
Blood vessel damage	None	None	1 (2.3%)
Deep venous thrombosis	None	None	3 (7.0%)
Pulmonary embolus	None	None	2 (4.6%)
Total	0 (0%)	6 (8.2%)	27 (62.8%)

*Screw malposition not included.

TABLE 4. Minor Complications

Complications	TLIF		AP
	Open	Min. Invasive	
Allograft malposition w/o reoperation	None	None	None
Pedicle screw malposition w/o reoperation	5 (9.8%)	8 (10.9%)	None
CSF leak	10 (19.6%)	None	2 (4.6%)
Neurologic deficit* (< 3 mo)	1 (2.0%)	5 (6.8%)	2 (4.6%)
Hematoma	2 (3.9%)	3 (4.1%)	None
Anemia	None	None	2 (4.6%)
Total	18 (35.3%)	16 (21.9%)	6 (13.9%)

*Screw malposition not included.

DISCUSSION

Circumferential (360°) AP lumbar fusion is being used more routinely for cases of degenerative disc disease based on the theoretical biomechanical benefits of this technique. Biomechanically, 80% of load sharing in the lumbar spine involves the anterior column, and only 20% is associated with the posterior column.[10] Posterolateral fusion was the most frequently performed technique for lumbar fusion between 1979 and 2000, followed by circumferential interbody fusion combined with posterolateral fixation, PLIF, and finally anterior lumbar interbody fusion (ALIF).[11] Circumferential fusion resulted in the highest fusion rates (91%), whereas posterolateral and stand-alone anterior approaches were the lowest: 85% and 86%, respectively. The advantage of anterior column support in addition to the pedicle or translaminar fixation has become increasingly clear in patients with degenerative spinal disorders.[12–15]

Madan and Boeree[16] compared PLIF with posterolateral fusion. PLIF had better patient satisfaction scores and fusion rates and slightly better results in radicular and neurologic symptom improvement compared with posterolateral fusion. Posterolateral fusion does not support the anterior structures of the spine. The posterior bony base for bone graft is reduced after decompression. This may result in higher rates of pseudoarthrosis. In addition, posterolateral fusion alone may not adequately address discogenic pain in some cases. Suk et al[17] reported a 100% fusion rate in PLIF and 92.5% in posterolateral fusion in patients treated for spondylotic spondylolisthesis with symptomatic spinal stenosis along with a 41.6% and 28.3% reduction of translational listhesis, respectively.

Circumferential posterior or transforaminal interbody fusion theoretically achieves comparable results with a single posterior incision, less morbidity, and better score on variety of outcome measures. Mofidi et al[18] reported a 98% fusion rate and an 85% satisfaction rate following surgery with a mean follow-up of 4.4 years after PLIF and posterior fusion.

Transforaminal interbody fusion combined with posterior or posterolateral fixation provides a circumferential fusion through a single posterior approach, enabling stability of all three columns. In addition, adequate decompression of neural structures for relief of radicular pain can be performed, which is not achieved by stand-alone anterior approaches. TLIF enables reconstruction of the anterior column and restores or at least maintains lumbar lordosis and spine biomechanics. Lowe et al[19] reported a 29.6% increased lordosis for one-level and 13.6% for two-level surgically treated patients with TLIF.

Although pseudoarthrosis is sometimes related to worsened clinical results,[20] there are extensive data showing that excellent radiographic fusion does not necessarily correlate with relief of clinical symptoms.[21–23] Fusion rates and clinical outcome evaluation were not the intention of this study. The immediate and short-term advantages of TLIF over AP surgery have been revealed by comparing operative data, hospitalization time, and complication rate. AP reconstructive lumbar surgery is related to the increased blood loss, increased operative time, increased length of time in the intensive care unit, and overall hospital stay. This is without a doubt partially related to the requirement for two incisions. Although the AP approach has shown acceptable results (radiographic fusion rates, symptom resolution), we believe that the complication rates in this series are unacceptably high. Hee et al[24] compared AP fusion and TLIF: Pseudoarthrosis rate was 15% versus 6%, infection rate 11.3% versus 4.5%, and radiculopathy 9% versus 8% respectively. The total complication rates were 51% in the AP group and 28% in the TLIF group. These results are comparable with our study results. The total number of complications in the AP group was two times higher ($P < 0.001$) as compared with the open or percutaneous TLIF groups (76.7% versus 35.3% and 30.1%, respectively). There were no such complications as pulmonary embolus, deep venous thrombosis, blood vessel damage, allografts malpositioning, ileus, or anemia in the TLIF groups. In addition, there were no major complications in the open TLIF group compared with 62.8% major complications in the AP lumbar fusion group. The minimally invasive TLIF group had higher major complications rate compared with the open TLIF group ($P = 0.09$), mainly due to higher neural injury and pedicle screw malposition rates. We believe that the minimally invasive TLIF approach has a potential advantage over the open TLIF approach that has to do with smaller incisions, lower blood loss, less muscle trauma, and dissection. However, this technique seems to be more technically demanding and was associated with a higher rate of major intraoperative and perioperative complications in this series. This could be partially explained by a learning curve for this technically challenging surgical procedure. Screw malpositioning decreased from 16.4% to 12.3% and 8.3% when comparing the first 25 cases with the subsequent ones over a period of 26 months. A similar tendency was noted for the neural injury complication rate: 20.6% versus 8.2% versus 4.1%. There were no differences that stood out in the rate of hematoma occurrence, which was initially low and remained low.

Gertzbein et al[25] reported results for circumferential fusion with anterior approach and posterolateral fixation: 97% of patients had fusion and 77% had good clinical outcome. However, complications rates were high, and the authors concluded that this procedure should be reserved for the patients with an extremely high risk of pseudoarthrosis or other contraindication for posterior lumbar fusion. Our results are consistent with this study in demonstrating a two times higher complication rate in AP reconstructive surgery group.

Some of the published operative data are summarized in Table 5, demonstrating significantly shorter operative times, length of hospitalization and blood loss for TLIF patients compared with AP fusion patients. Previously published operative times for AP reconstruction range from 250 to 388 minutes (mean 295 minutes). Our retrospective analysis demonstrates an increased operative time by 160 minutes but with about half the blood loss; the mean blood loss in our study is 550.5 mL compared with 956 mL for the previously published data. The length of hospitalization did not vary significantly.

The percutaneous TLIF operative times did not have a significant difference and varied from 203 to 307 minutes (depending on the number of levels) in our study compared with 240 minutes reported in the literature. The blood loss was 170 mL and 292 mL (depending on the number of levels) in our study compared with 75–140 mL reported in the literature. The length of stay was 2.8–3.5 days in our study compared with 1.7–1.9 days in the published data.

Percutaneous surgical approaches theoretically minimize trauma to the surrounding anatomic structures and prevent extensive muscle dissection, retraction, and

TABLE 5. Operative Data Summary for Posterior Circumferential and AP Approaches

	Procedure	OR Time	EBL	LOS
Ray et al[34]	AP	289 + 22	729	5
	PLIF	159	280	5
Schofferman et al[35]	AP	388	1225	8.1
Whitecloud et al[36]	AP	269 + 38	969	6.1
	TLIF	213	489	3.3
Hacker at al[37]	AP	250	900	5.3
	PLIF	120	300	3.5
Hee et al[24]	AP	280	958	9
	TLIF	172	808	5.2
Foley et al[33,38]	MI ALIF	375	211	2.7
	MI TLIF	240	75	1.7
	MI PLIF	290	190	2.4
Schwender et al[9]	MI TLIF	240	140	1.9
Khoo et al[39]	MI PLIF	315	185	2.8

OR time, operative time (min); EBL, estimated blood loss (mL); LOS, length of stay (d); MI, minimally invasive.

denervation. Increasing evidence demonstrates that the reduction in muscle strength, decreased endurance, and increased pain are initiated by biochemical and morphologic reactions caused by muscle injury during the spine surgery.[26–29] Percutaneous posterior or transforaminal interbody fusion can be performed with minimal iatrogenic tissue injuries and still achieve the traditional goal of circumferential fusion. In addition to the previously presented comparisons of operative time, blood loss, and hospital stay, video-assisted or endoscopic AP interbody fusion has even higher rates of complications. This is especially true for the transperitoneal video-assisted approach. Escobar et al[30] reported an 18% incidence of neural injury and 25% incidence of retrograde ejaculation. Twenty-five (11%) cases had to be converted to open procedures because of intraoperative complications. Their complication rates were thought to be consistent with others presented in the literature for video-assisted techniques. Regan et al[31] reported a 19.1% complication rate for laparoscopic procedures versus 14.1% for open ALIF procedures. Zdeblick et al[32] reported significantly higher complication rates in the laparoscopic group: 20% versus 4% for open procedures for the patients operated at the L5–S1 level. Although Foley et al[33] found laparoscopic ALIF with percutaneous pedicle screw insertions to be safe and effective, they admitted that it takes longer to perform.

CONCLUSIONS

AP lumbar interbody fusion surgery is associated with more than two times higher complication rate, significantly increased blood loss, and longer operative and hospitalization times compared with both percutaneous and open TLIF for lumbar disc degeneration and instability.

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