

Bilateral Pedicle Screw Fixation versus Unilateral Pedicle and Contralateral Facet Screws for Minimally Invasive Transforaminal Lumbar Interbody Fusion: Clinical Outcomes and Cost Analysis

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Abstract

Study Design Retrospective clinical study.

Objectives Recent biomechanical studies have shown no differences in stiffness or range of motion following minimally invasive (MIS) transforaminal lumbar interbody fusion (TLIF) between unilateral pedicle and contralateral facet screw (UPFS) and bilateral pedicle screw (BPS) constructs. No studies have compared these two constructs based upon clinical outcomes.

Methods Twenty-six consecutive patients who had single-level MIS TLIF were retrospectively reviewed. Outcome measures collected for patients with BPS were compared with those with UPFS.

Results No associations were found between construct and length of stay ($p = 0.5$), operative time ($p = 0.2$), or Odom's criteria ($p = 0.7$); 79% of patients in the UPFS group as compared with 71.5% in the BPS group had good or excellent outcomes. Mean follow-up was 17.7 months for the UPFS group and 20.2 months for the BPS group. There was one complication in each group, including a seroma in the BPS group and a revision operation in the UPFS group. Implant costs for the BPS group were 35% greater than the UPFS group.

Conclusions The present study is the first to demonstrate that patients undergoing MIS TLIF with BPS as compared with UPFS for single-level degenerative lumbar disease had similar clinical outcomes.

Keywords

- ▶ minimally invasive surgery
- ▶ transforaminal lumbar interbody fusion
- ▶ Boucher facet screw
- ▶ clinical outcomes

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Transforaminal lumbar interbody fusion (TLIF) has gained popularity in the last two decades. It is currently used for a wide range of spinal disorders including degenerative disk disease, spinal stenosis, and degenerative spondylolisthesis. TLIF was initially popularized by Harms in 1982 and subsequent authors have reported high rates of fusion with this technique.¹⁻³ The application of bilateral posterior lumbar pedicle screw instrumentation has been shown to increase fusion rates and is now standard with this operation.⁴⁻⁹

With technological advancements and a greater understanding of the morbidity of prolonged muscle retraction, surgical trends have emphasized the minimization of exposure and tissue destruction.¹⁰ Minimally invasive surgical (MIS) techniques have done this while still allowing for successful implantation of instrumentation. It has been suggested that these tissue-preserving techniques may lead to better outcomes with reduced inpatient stays, less blood loss, decreased operative times, and greater patient satisfaction.¹¹ These advantages have spurred the development of competing MIS TLIF systems, all of which utilize an interbody graft and bilateral pedicle screws (BPSs).

The functional necessity of BPS fixation in TLIFs has been questioned recently. In a comparative study of 87 patients with degenerative spondylolisthesis, Suk et al demonstrated no significant differences in clinical outcomes and fusion rates between patients assigned to either unilateral or BPSs over a minimum follow-up of 24 months.¹² Smaller series have reported good outcomes with unilateral pedicle screw fixation.¹³⁻¹⁵ In contrast, Goel et al showed that unilateral constructs were consistently less rigid than bilateral constructs in an *in vivo* animal model.¹⁶ A recent *in vitro* biomechanical study using human lumbar spines comparing TLIFs instrumented with BPSs, unilateral pedicle screws, and unilateral pedicle screws with contralateral facet screws demonstrated that unilateral pedicle screw TLIF systems have significantly increased segmental range of motion, less stiffness, and increased off-axis movement.¹⁷ The unilateral construct provided only half of the improvement in stiffness compared with the other constructs tested. In contrast, the unilateral pedicle and contralateral facet screw (UPFS) construct was shown to have no measurable difference in either stiffness or range of motion in flexion/extension, lateral bending, and axial rotation when compared with BPS constructs.

In this study, we hypothesized that the MIS TLIF with unilateral pedicle and contralateral facet screws is clinically equivalent to BPS constructs. This is the first reported clinical comparison of the two systems. With increasing scrutiny on the rising cost of health care, a strong argument for reduced cost could be made if comparable clinical efficacy is found between these systems.

Materials and Methods

After receiving appropriate Institutional Review Board approval, we performed a retrospective review of 34 consecutive patients at a single institution who had undergone a

single-level MIS TLIF by the senior author between January 2006 and January 2011. Patients with BPSs placed at the time of TLIF were compared with those with a UPFS construct. Indications for surgery included degenerative disk disease, recurrent disk herniation, and degenerative spondylolisthesis. Patients included were between the ages of 30 and 70 at the time of operation and underwent an operation at any level between L2 and S1. Those with previous lumbar surgery were excluded.

All operations were performed by the same surgeon (M.P.S.). All operations utilized morselized autologous corticocancellous bone. Most of the operations utilized an additional bone graft substitute material such as demineralized bone matrix, calcium-phosphate (e.g., Vitoss, Stryker, Inc., Kalamazoo, MI), or bone morphogenetic protein. Cages placed in the surgeries were either carbon fiber or polyetheretherketone. Instrumentation was placed in a standard fashion with intraoperative imaging guidance used in the majority of cases. Facet screws were placed percutaneously using the technique described by Boucher and always contralateral to the side of the TLIF (►Fig. 1).¹⁸ Arthrodesis was performed interbody; none was performed in the contralateral facet joint or intertransverse space.

Primary outcome measures include inpatient length of stay, operative time, estimated blood loss, and clinical outcome as determined by Odom's criteria.¹⁹ Briefly, grading is rated either excellent, good, fair, or poor: *excellent* represents that all preoperative symptoms were relieved and that abnormal findings improved; *good* represents minimal persistence of preoperative symptoms and abnormal findings that remain unchanged or improved; *fair* is relief of only some preoperative symptoms and other symptoms that are either unchanged or slightly improved; *poor* is when the symptoms and signs are unchanged or



Fig. 1 Postoperative lumbar X-ray image for a patient who underwent a unilateral minimally invasive transforaminal lumbar interbody fusion with contralateral facet screw at L4-5.

exacerbated. An independent observer assessed the outcome in each case.

All data were analyzed using SAS v9.2 (SAS Institute, Inc., Cary, NC). For continuous variables, such as age, length of stay, blood loss, and operative time, independent sample *t* tests were used. Categorical variables, such as gender and Odom's criteria were assessed using Fisher exact tests, with *p* values of ≤ 0.05 considered statistically significant.

Results

Thirty-four patients were included in the study; 20 patients (mean age 55.3 years) underwent UPFS placement and 14 patients (mean age 51.1 years) underwent BPS placement with MIS TLIF. Mean length of follow-up was 26.7 months for the UPFS group and 23.6 months for the BPS group. In the UPFS group, 5 patients (25%) were operated at L5–S1, 13 (65%) at L4–5, 1 (5%) at L2–3, and 1 patient was operated at L4–5 and L5–S1. In the BPS group, 3 (21%) were operated at L5–S1, 9 (64%) at L4–5, 1 (13%) at L3–4, and 1 (13%) at L3–4 and L4–5. Descriptive statistics for the total sample and by screw type (group) are provided in ►Table 1. There were no significant differences between groups in age ($p = 0.2$) or gender ($p = 0.3$). Patients in the BPS group had significantly longer operative time (291 minutes versus 227 minutes, $p = 0.006$) and blood loss (443 versus 276 mL, $p = 0.05$) as compared with the UPFS group. No statistically significant differences were obtained for hospital length of stay, complications, or fusion rate (►Table 2).

Seventy-five percent (15/20) of patients in the UPFS group as compared with 71% (10/14) of patients in the BPS group had good or excellent outcomes. This was not statistically significant ($p = 0.99$). There was one complication in each group, including a seroma in the BPS group and a revision operation in the UPFS group. Implant costs as negotiated between the vendor and the institution were obtained from the hospital. The cost of implants for the BPS group was 35% greater than those for the facet screw group.

Discussion

The MIS TLIF has become increasingly popular with the development of innovative systems minimizing tissue disruption while allowing adequate access for decompression and instrumentation placement. With recent biomechanical data suggesting the equivalence of UPFS fixation to standard BPS constructs,¹⁷ the application of facet screws in the lumbosacral spine has seen a resurgence in interest, mainly for its percutaneous application and less potential risk of neurologic injury. Su et al recently performed an anatomic and radiographic study of lumbar facets, describing in detail the ideal starting point for percutaneous facet screw fixation in relation to anatomical landmarks, the angles of insertion, and specific radiographic guidelines for accurate and safe screw insertion.²⁰

Facet screws were originally described by King as a strategy for lumbosacral fixation.²¹ Short screws were placed transversely across the lateral articulations but were

Table 1 Demographic/operative characteristics

	UPFS	BPS	<i>p</i> value ^a
<i>n</i>	20	14	
Age (y)	55.3 ± 10.3	51.1 ± 8.7	0.2
Female	14 (70%)	7 (50%)	0.3
Diagnosis for operation			0.06
Degenerative disk disease	7 (35%)	1 (13%)	
Grade 1 spondylolisthesis	11 (55%)	12 (86%)	
Grade 2 spondylolisthesis	0 (0%)	1 (13%)	
Recurrent disk herniation	2 (10%)	0 (0%)	
Level			0.7
L2–3	1 (5%)	0 (0%)	
L3–4	0 (0%)	1 (13%)	
L4–5	13 (65%)	9 (64%)	
L5–S1	5 (25%)	3 (21%)	
L3, L4, L5	0 (0%)	1 (13%)	
L4, L5, S1	1 (5%)	0 (0%)	
Follow-up (mo)	26.7 ± 16.9	23.6 ± 21.1	0.6

Abbreviations: BPS, bilateral pedicle screw; UPFS, unilateral pedicle and contralateral facet screw.

Note: Results are mean ± standard deviation for continuous variables, count and percent for categorical variables.

^a*t* test for continuous variables, Fisher exact test for categorical variables.

Table 2 Comparison of outcome measures by screw type

	UPFS	BPS	p value ^a
Length of stay (d)	3.3 ± 2.6	3.4 ± 2.1	0.8
Operative time (min)	227.2 ± 52.7	290.5 ± 68.2	0.006 ^b
Blood loss (mL)	276 ± 174	443 ± 278	0.05 ^b
Complications	1 (5%)	1 (7%)	0.99
Fusion at last follow-up ^c	8 (67%)	4 (67%)	0.99
Clinical outcome			0.99
Excellent	8 (40%)	6 (42%)	
Good	7 (35%)	4 (29%)	
Fair	4 (20%)	3 (21%)	
Poor	1 (5%)	1 (7%)	

Abbreviations: BPS, bilateral pedicle screw; UPFS, unilateral pedicle and contralateral facet screw.

Note: Results are mean ± standard deviation for continuous variables, count and percent for categorical variables.

^at test for continuous variables, Fisher exact test for categorical variables.

^bStatistically significant: $p \leq 0.05$.

^cPercent is based on total number of patients with conclusive radiologic assessment of fusion (i.e., 12 patients in the UPFS group and 6 patients in the BPS group).

associated with a high incidence of failure. Boucher modified this technique in 1959 by using longer screws starting just medial to the lateral articulation and directed obliquely across the facet joints toward the medial root of the pedicle of the vertebra below to allow for better purchase.¹⁸ In 1984, Magerl described another technique of facet joint fixation, the translaminal facet screw.²² In this technique, the screw is inserted from the contralateral lamina into the ipsilateral facet joint. This latter technique initially enjoyed popularity with surgeons as it was thought to be a stronger screw, traversing more bone throughout its trajectory. However, this translaminal facet screw is technically more challenging and has been associated with neurologic injuries. Montesano et al reported an 11% incidence of transient neurologic deficits in a series of 36 patients,²³ and Jacobs et al reported an incidence of 7% in 33 patients.²⁴

In a direct comparison between bilateral facet and BPS fixation in human cadavers instrumented with interbody spacers, Ferrara et al were able to demonstrate no significant difference between the two after repetitive cycling.²⁵ Slucky et al also showed no difference in flexion/extension, lateral bending, or axial rotation when comparing BPS constructs to UPFSs in human cadaver TLIF specimens.¹⁷

With biomechanical data suggesting equivalence between the Boucher and Magerl techniques,²⁵ the former has regained popularity, particularly as a method for percutaneous posterior fixation following anterior lumbar interbody fusion in patients with degenerative disease who do not require posterior decompression.²⁶⁻²⁸ To date only small series have reported patients undergoing TLIF with unilateral pedicle screws and contralateral facet screws. Sethi et al reported a series of 19 patients who underwent open single-level TLIF with UPFSs.²⁹ In this retrospective study, there were no implant failures and there was a general trend of clinical improvement following surgery by Oswestry Disability Index

and visual analog scale for back and leg pain. There was no comparative group in this study. Jang et al similarly reported a series of 23 patients who underwent open single-level TLIF with unilateral pedicle screws and contralateral facet screws.³⁰ Oswestry Disability Index reflected improved status and satisfactory outcomes in 21 patients. More recently, Xue and colleagues randomized 80 patients to either receive unilateral or BPS instrumentation with TLIF.³¹ Similar to the findings of the present study, their patients receiving unilateral pedicle screws had significantly shorter operative time, less blood loss, and lower implant cost as compared with those receiving BPSs. They also found that there were no differences in postoperative outcomes as measured by Oswestry Disability Index, visual analog scale, and modified Prolo scores.

Some authors have challenged the analysis performed by Xue et al, in that they compared bilateral to unilateral fixation in 80 patients but those undergoing unilateral fixation had it via a MIS TLIF and those with bilateral fixation had it via an open TLIF.³² In the present retrospective study, we ensured that all patients had undergone a MIS TLIF, regardless of whether they received unilateral or bilateral fixation.

This is the first reported study comparing clinical outcomes between patients undergoing MIS TLIF with BPSs versus with UPFS system. Complications such as instrumentation failure seen in other studies were not evident in this study. For the primary clinical outcome measures studied here, there were no statistically significant differences between groups. No difference in clinical outcome has also been shown in two randomized controlled trials investigating unilateral versus bilateral fixation for posterolateral fusion.^{12,33}

Cost analysis comparing the two surgeries is difficult to perform due to differences in implant prices based on unique institutional contracts. Accordingly, for the purpose of this

study, we collected listed implant prices and reported the relative difference. We believe that this approximates the magnitude of difference and limits variations in contracted prices. At our institution, we found that the TLIF construct utilizing ipsilateral pedicle and contralateral facet screws was 35% less costly than BPSs. Others have reported this large difference in cost as well.^{29,31} Moreover, intuitively, the cost of bilateral fixation is greater than unilateral fixation, due to the greater instrumentation requirements of the former. We also found that those undergoing BPS fixation had longer operative time and blood loss, which further increases the direct and indirect costs of bilateral relative to unilateral fixation.

The present study has several limitations. These include the retrospective design, the small number of patients in each study group, and the use of the Odom's criteria, which is a nonvalidated clinical outcome assessment measure. The study is likely underpowered to detect small differences in clinical outcome and complication rate. However, we were able to demonstrate significant differences in blood loss, operative time, and cost between patients who received unilateral versus bilateral MIS TLIF. If differences do exist in clinical outcomes, we expect that they are likely small as they have not been identified in other, larger studies.³² Any potential clinical benefit using the bilateral approach would likely be marginal compared with the significantly increased morbidity and cost. Nonetheless, this is the first study to specifically compare patients who all underwent MIS TLIF with either BPSs or unilateral pedicle with contralateral facet screw. The study also included a patient follow-up with an average of greater than 2 years. All operations were performed by one surgeon at one institution, which limits the confounding of studies with multiple surgeons with varying skill levels.

Conclusions

The present study demonstrated that MIS TLIF with UPFS fixation leads to clinical outcomes that are not significantly different than the outcomes with BPSs for single-level degenerative lumbar disease. Despite similar clinical outcomes, the UPFS construct is associated with decreased operative time and reduced blood loss, and also costs substantially less than the BPS system. Although additional larger prospective analyses are required to further evaluate the outcomes of the two systems, these preliminary results indicate a clear advantage to the use of the UPFS construct for MIS TLIF.

Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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