Unilateral and Bilateral Pedicle Screw Fixation in Transforaminal Lumbar Interbody Fusion: Radiographic and Clinical Analysis

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Key words
- Foraminal height
- Lumbar spine
- Pedicle screws
- Plate fixation
- Transforaminal lumbar interbody fusion

Abbreviations and Acronyms
DH: Disc height
FH: Foraminal height
ISFP: Interspinous process fixation plate
PS: Pedicle screw
SF-36: Short Form-36
SSA: Segmental sagittal alignment
TLIF: Transforaminal lumbar interbody fusion

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BACKGROUND: **Transforaminal lumbar interbody fusion with bilateral segmental pedicle screw (PS) fixation is a widely used and well-recognized technique that provides fixation and load-bearing capacity, while restoring morphometric spine parameters and relieving symptoms in patients with degenerative disc disease. A supplemental interspinous process fixation plate (ISFP) as an adjunct to unilateral PS fixation allows for reduced invasiveness of this technique compared with bilateral PS placement. The biomechanical comparison results have been previously reported, but the significance of these findings has not been studied in clinical settings.**

METHODS: **A prospective cohort study with a supplemental retrospective chart review and radiographic analysis was performed. Patients were divided into 2 groups: bilateral PS fixation (n = 75) or unilateral PS fixation + ISFP (n = 96). Lateral lumbar standing radiographs were obtained for preoperative and postoperative foraminal height (FH), disc height, segmental sagittal alignment, and lumbar sagittal alignment measurements. Standardized questionnaires were used to compare postoperative clinical outcomes.**

RESULTS: **The estimated blood loss, duration of procedure, and length of hospital stay were significantly lower for 1-level and 2-level procedures in the unilateral PS + ISFP group. A statistically significant mean disc height increase was observed in both groups. Regardless of the disc height increase, a statistically significant FH loss was detected in the bilateral PS group (from 17.1 mm to 16.3 mm; 4.7% loss; $P = 0.04$) compared with FH height loss in the unilateral PS + ISFP group that was not statistically significant (from 19.0 mm to 18.4 mm; 3.2% loss; $P = 0.1$). The analysis of segmental sagittal alignment, lumbar sagittal alignment, clinical outcomes, and fusion rates did not demonstrate any statistically significant differences.**

CONCLUSIONS: **Significantly reduced surgical invasiveness was associated with unilateral PS + ISFP fixation, which represents the major advantage of this technique. Unilateral fixation was also associated with a slightly lower reduction in FH and was equally effective as bilateral PS fixation in regard to fusion rates, clinical outcomes, and other radiographic outcomes studied.**

INTRODUCTION

Transforaminal lumbar interbody fusion (TLIF) with bilateral segmental pedicle screw (PS) fixation is a widely used and well-recognized technique that provides fixation and load-bearing capacity, while restoring morphometric spine parameters and relieving symptoms in patients with degenerative disc disease. TLIF allows a unilateral paraspinal approach and is less invasive than other conventional posterior midline surgical techniques (2, 10). To minimize surgical exposure and iatrogenic morbidity further, several modifications of the technique have been explored (3, 4, 20). One modification, unilateral PS fixation, allows ipsilateral PS placement without the need to damage the contralateral muscles and soft tissues. Although several clinical reports demonstrated the effectiveness of this technique (3, 5, 14, 18, 23, 26, 29), some biomechanical studies noted off-axis rotational or coupled motions resulting from the construct asymmetry and inability to provide adequate rigidity, which could be detrimental to the promotion of fusion (1, 7, 8, 21, 22). A supplemental interspinous process fixation plate (ISFP) as an adjunct to unilateral PS fixation significantly improves stability in all planes and, based on a recent biomechanical study, may offer a good and less invasive alternative to bilateral PS fixation (15). The authors concluded that 2 methods of fixation that most closely reproduced the stability of the intact spine were bilateral PS fixation and ISFP as an adjunct to unilateral PS fixation. The significance of these findings and the ability of this technique to achieve the same goals have not been studied in clinical settings. The main objectives of this study were to evaluate surgical, radiographic, and clinical parameters in

patients who underwent TLIF with bilateral or unilateral PS fixation with ISFP and to compare the effectiveness of these techniques in restoring disc height (DH), foraminal height (FH), lumbar lordosis, and segmental sagittal alignment (SSA).

METHODS

A prospective cohort study with a supplemental retrospective chart review and radiographic analysis was performed. This study analyzed all consecutive cases that met the following inclusion criteria: 1-level or 2-level TLIF surgeries performed for painful degenerative disc disease at L3-S1 levels in the setting of symptomatic spinal stenosis or lateral recess stenosis requiring surgical decompression to the extent that would result in destabilizing the spine, unstable spondylolisthesis (grade II or less), no previous fusion surgeries, and availability of preoperative and postoperative (≥9 months) imaging studies. Patients were selected for surgery based on clinical symptoms, which included intractable low back pain and radiculopathy caused by spondylosis or disc herniation or both, foraminal or central stenosis (or both), and spondylolisthesis (Table 1). The surgeries included in this analysis were performed from May 2008 to November 2010. The patients were divided into 2 groups for further analysis: bilateral PS fixation (n = 75) or unilateral PS fixation + ISFP (n = 96). Figures 1 and 2 show spinal hardware constructs for comparison.

Choice of unilateral or bilateral PS fixation was based on surgeon preference. All unilateral PS + ISFP fixation surgeries were performed by the first author (A.T.V.), and bilateral fixation cases were performed by A.M. and E.L.N. except for 13 of 75 cases (performed by A.T.V.) in which the unilateral screws were not thought to have adequate purchase with regard to the bone-screw interface. The 13 intended unilateral cases were converted to bilateral PS fixation based on intraoperative findings with regard to screw purchase. In these cases, bilateral screws were placed in lieu of unilateral PS fixation and a spinous process plate. Clinical outcome assessment and radiographic measurements were performed by S.B. and B.J.S., respectively, who were not involved in patient care.

Table 1. Selected Demographic, Clinical, and Surgical Parameters

	Unilateral PS + ISFP	Bilateral PS	*P*
Patients (n)	96	75	
Sex (M/F)	42/54	39/36	0.4*
Age (years)	56.8 (20–91)	57.7 (27–81)	0.7
Previous surgeries			0.7*
MCD/×1	11 (11.5%)	4 (5.3%)	
MCD/×2	8 (8.3%)		
Foraminotomy		1 (1.3%)	
Laminectomy	2 (2.1%)	9 (12.0%)	
Clinical symptoms			
Radiculopathy	84 (87.5%)	64 (85.3%)	0.8*
Stenosis	48 (50.0%)	42 (56.0%)	0.5*
Spondylolisthesis	39 (40.6%)	36 (48.0%)	0.4*
TLIF levels			
L3-L4	2	—	
L4-L5	51	20	
L5-S1	21	17	
L3-L4 and L4-L5	14	7	
L4-L5 and L5-S1	8	31	
RhBMP-2 dose (mg)	5.2 (4.2–12.0)	4.8 (2.1–12.0)	0.169
EBL (mL)			
One-level	79.5 (25–300)	196.5 (50–450)	0.009
Two-level	217.9 (75–750)	337.5 (150–750)	<0.0001
Surgery time (minutes)			
One-level	128 (71–225)	190 (90–240)	<0.0001
Two-level	189 (149–221)	221 (180–266)	0.03
LOS (days)			
One-level	1.1 (0–6)	3.0 (1–6)	<0.0001
Two-level	1.4 (0–3)	3.4 (1–9)	<0.0001
Radiographic fusion assessment			0.13*
CT scans	35% (34)	24% (18)	
X-rays	65% (62)	76% (57)	

Values are presented as means (ranges) when appropriate. Student *t* tests were used for all calculations comparing the 2 groups except where noted (*).

MCD, microdiscectomy; PS, pedicle screw; ISFP, interspinous process fixation plate; M, male; F, female; TLIF, transforaminal lumbar interbody fusion; rhBMP-2, recombinant human bone morphogenetic protein-2; EBL, estimated blood loss; LOS, length of hospital stay; CT, computed tomography.

*χ^2 test.

Radiographic Outcome Measures and Analysis

Lateral lumbar standing radiographs were used for preoperative and postoperative FH, DH, SSA, and lumbar sagittal alignment measurements. The FH was measured as the maximum distance between the inferior and superior margins of the adjacent level pedicles. The intervertebral DH was measured at the anterior portion of the disc