Original Article

A Comparison Study of Three Posterior Fixation Strategies in Transforaminal Lumbar Interbody Fusion Lumbar for the Treatment of Degenerative Diseases

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Abstract

Background: There are various posterior fixations utilized with transforaminal lumbar interbody fusion (TLIF). Previous studies have focused on the comparison of two fixation techniques. **Materials and Methods:** Sixty five patients with single-level lumbar disease were included in this retrospective study. Group A was treated by TLIF with bilateral pedicle screw (BPS), Group B treated by TLIF with unilateral pedicle screw (UPS), and Group C treated by TLIF with UPS plus contralateral translaminar facet screw (UPSFS). The operative time, blood loss, Oswestry disability index (ODI), Japanese Orthopaedic Association Scores (JOA), and visual analog scores (VAS) were recorded. Radiographic examination was used to assess fusion rates and incidence of screw failure. **Results:** The blood loss and operative times were 188.69 ± 37.69 ml and 132.96.5 ± 8.69 min in BPS group, 117.27 ± 27.11 ml and 99.32 ± 12.94 min in UPS group, and 121.50 ± 22.54 ml and 112.55 ± 9.42 min in UPSFS group; UPS and UPSFS were better than BPS ($P < 0.05$). The mean followup time was 38.2 months. Fusion rates were – BPS group: 95.6%, UPS group: 90%, UPSFS: 95% ($P > 0.05$). Screw and/or rod failures were found in three groups (BPS group: 1, UPS group: 2 and UPSFS: 1, $P > 0.05$). The average postoperative VAS, ODI, and JOA scores of BPS, UPS, and UPSFS were improved significantly in each group compared to preoperative scores ($P < 0.05$); there were no significant differences between any two groups at each followup time point ($P > 0.05$). **Conclusion:** UPSFS with TLIF is a viable treatment option that provides satisfactory clinical results; the clinical outcome and the complication rate were comparable to BPS. In addition, the invasive of UPSFS cases was comparable to UPS and better than BPS cases. For UPS, it could be used in suitable patients.

Keywords: *Clinical outcome, lumbosacral degenerative disc disease, posterior fixation, transforaminal lumbar interbody fusion, translaminar facet screw*

Introduction

Transforaminal lumbar interbody fusion (TLIF), which was initially described by Harms and Rolinger in 1982, has become a prevalent surgical procedure in treating lumbosacral degenerative disc disease (LDD) and spinal instability.[1] To enhance the stability and fusion rate, there are various posterior fixation methods utilized to assist in patients who undergo TLIF. Conventionally, bilateral pedicle screw (BPS) are used and represent the "gold standard" instrumentation strategy to provide rigid fixation and achieve a high fusion rate.[2] However, this approach requires dissection of paravertebral muscles on both sides to place BPS, which is invasive, and requires increased time and expense. Furthermore, the use of BPSs may cause the construct to be over-rigid, contributing to degeneration of adjacent segments, device-related osteoporosis, and absorption of bone graft.[3-5] Recently, unilateral pedicle screw (UPS) fixation has been advocated by some authors, after studies showed that UPS provides comparable clinical results to BPS constructs.[6-9] However, biomechanical studies have demonstrated that compared with BPS, UPS is less stable in lateral bending and axial torsion.[2,10,11] UPS plus contralateral translaminar facet screw (TLFS) was employed to overcome the limitations of UPS and has demonstrated good clinical outcomes and satisfactory fusion rates.[12-14] Biomechanical study[15] has suggested that unilateral pedicle screw plus facet screw (UPSFS) constructs provide immediate and long term stability equivalent

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to traditional BPS, making UPSFS a reasonable alternative to BPS. Previous studies of different stabilization strategies have focused on the comparison of two fixation techniques. The goal of this retrospective study was to compare the three different posterior fixation instrumentation constructs described above in the treatment of LDD.

Materials and Methods

Patient population

Sixty five patients (32 men and 33 women) with single-level lumbar disease between January 2010 and July 2015 were included in this retrospective study. Patients had a chief complaint of low back pain and unilateral radicular pain, which had persisted despite at least 6 months of conservative management before surgery was performed. Lumbar radiographs, flexion–extension X-radiograph, computed tomography (CT), and magnetic resonance imaging (MRI) were examined. All the patients were diagnosed by two reviewers independently. If their decisions were different, they would discuss with the third reviewer and make a consistent diagnosis. All included patients were diagnosed with degenerative lumbar disc herniation with adjacent spinal instability and severe spinal stenosis that need decompression and fusion. Instability was defined as >3 mm of translation or 15° of angular motion on preoperative flexion–extension radiographs.[8] Patients with lumbar surgery history, active infection, trauma, severe osteoporosis, or spinal malignancy were excluded. Patients were divided into three groups. According to the fixation techniques, Group A was treated by TLIF with BPS, Group B was treated by TLIF with UPS, and Group C was treated by TLIF with UPSFS. The patients' demographic characteristics and procedure data are listed in Table 1 and there was no significant difference among three groups.

Surgical techniques

The patient was placed in a prone position on a radiolucent operation table after general anesthesia was induced. The operative segments were identified using a C-arm machine and skin was marked to localize incisions. A midline approach was used in all groups. All operations were performed by the same surgical team. In Group A, bilateral paraspinal muscles were split from the spinal process to expose the facet joint and lumbar lamina, and then BPSs were inserted. Unilateral facetectomy and partial laminectomy were performed on the symptomatic side to decompress the nerve roots and the bone was kept for use as an autograft during the interbody fusion. Ligamentum flavum, bone spur, and fatty tissue were removed to decompress the nerve root. Moreover, rectangular window on the annulus fibrosus was created using a sharp-points knife. Disc materials and endplate were completely removed by pituitary rongeurs, rasps, and curettes through this window. The nerve root was considered to be decompressed if 1-cm nerve root could be seen. Interbody cages were filled with autograft bone and placed into the center of disc space after the discectomy was finished. In Group B, unilateral paraspinal muscle on the symptomatic was elected and ipsilateral facet joint and laminae were exposed. Ipsilateral pedicle screws were inserted and TLIF procedure was performed as described above for Group A. Group C utilized the same procedures except for the addition of placement of TLFS. For the placement of TLFS, a passage was created from the base of the ipsilateral spinous process, directed through the contralateral lamina to traverse the contralateral facet joint and end at the base of the transverse process.[16] The lateral angles and caudal angles for the screw placement were measured before the surgery on the lumbar CT scan. After placing a Kirchner (K)-wire in this trajectory using the C-arm machine and confirmed the passage was safety, a cannulated screw was inserted over the guide K-wire.

A drain was placed and the incision was closed in a standard fashion in all patients. Patients were allowed to ambulate at 2–3 days postoperatively, and a brace was recommended for 2–3 months after surgery.

Table 1: Patient data for three treatment groups

Parameters	BPS	UPS	UPSFS	*P*
Number of cases	23	22	20	
Age (years)	49.78±10.86	48.09±10.62	48.00±9.4	0.868
Male/female	10/13	11/11	11/9	0.750
Segment				
L3-L4	6	5	3	0.761
L4-L5	7	10	9	0.747
L5-S1	10	7	8	0.762

BPS=Bilateral pedicle screw, UPS=Unilateral pedicle screw, UPSFS=UPS plus contralateral translaminar facet screw

Assessment

We recorded the operative time and estimated blood loss to compare intraoperative courses. Outcomes measures included Oswestry disability index (ODI), Japanese Orthopaedic Association scores (JOA), and visual analog scores (VAS). Every patient was followed up at the 3rd, 6th, and 12th month after surgery and yearly thereafter. VAS of every patient was recorded 3 days after operation and every followup visit, and ODI and JOA were used to quantify the functional outcome at the same time points. Radiographic examination was taken to assess fusion status, screw failure, and general complications [Figure 1]. CT with three-dimensional reconstructions and flexion–extension radiograph was used to accurately evaluate fusion status at 12th month; identification of continuous osseous trabeculations with a Cobb angle difference in the flexion–extension radiograph of no >3°, which were taken as proof of successful fusion. All the patients were evaluated by two reviewers independently. If their decision were different, they would discuss with the third reviewer and make a consistent diagnosis.

Statistical analysis

SPSS 18.0 (SPSS Inc., Chicago, Illinois, USA) was used to carry out statistical analysis. Continuous data, such as age, VAS, ODI, and JOA, were analyzed using a Student's *t*-test between groups and by a paired *t*-test within each patient's scores at different time points. Summary statistics, such as proportions, fusion rates, and complication rates, between groups were compared by Chi-square or Fisher's exact tests. A $P < 0.05$ was considered statistically significant.

Results

For the three groups, there were no significant differences between groups in terms of patient demographics [Table 1]. The estimated blood loss and operative time were 188.69 ± 37.69 ml and 132.96.5 ± 8.69 min in BPS group, 117.27 ± 27.11 ml and 99.32 ± 12.94 min in UPS group, and 121.50 ± 22.54 ml and 112.55 ± 9.42 min in UPSFS group. UPS and UPSFS were associated with significantly less blood loss and a significantly shorter operative time than BPS, while no significant differences existed between UPS and UPSFS. Fifteen patients were lost because of different reasons, others (77%) were followed up, and the averaged followup time was 38.2 months (29–50 months). With respect to fusion rate, although there was no significant difference between the three groups, radiologic evaluation showed that fusion rate in the UPS group (90%) was slightly lower than the fusion rates in BPS group (95.6%) and UPSFS group (95%). Screw/rod failures were found in all three groups (BPS group 1; UPS group 2; UPSFS group 1) [Table 2], but no instrumentation failure had obvious clinical manifestations. The average postoperative VAS, ODI, and JOA scores of the BPS, UPS, and UPSFS groups are listed in Table 3. Each group demonstrated significant improvements for each measure compared to preoperative scores ($P < 0.05$), but no significant difference existed between any two groups at any followup visit ($P > 0.05$) [Table 3]. Moreover, the intervertebral space height (H) was measured from lumbar radiograph [Figure 2]. The result showed that the intervertebral space height was improved significantly compared to preoperative, and there was no significant difference existed between any two groups at any followup visit ($P > 0.05$) [Table 4].

Discussion

In lumbar fusion surgery, various posterior fixation strategies are currently used with little guidance to distinguish between the efficacies of alternate techniques. BPS constructs have great stability and high rates of fusion but may be more invasive and provide too much rigidity.[17-19] Several studies have suggested that UPS was associated with good clinical outcomes which were not significant different than those associated with BPS instrumentation.[20,21] A meta-analysis performed by Ren *et al*.[21] suggested that both BPS and UPS fixations result in similar fusion and complication rates, but UPS procedures had less blood loss and operative time. Biomechanical study, however, has demonstrated that UPS fixation is less stable in lateral bending and axial torsion compared with BPS.[15] The TLFS technique was first introduced by Magerl[16]

Table 2: Perioperative parameters and fusion rates among three groups

Parameters	BPS	UPS	UPSFS
Blood loss (ml)	232.17±95.30	158.18±89.12#	147.75±86.70#,*
Operation time (min)	141.83±21.87	106.45±17.30#	120.50±20.28#,*
Fusion rate	22/23	20/22	19/20
Complication			
Screw/rod failure	1/23	2/22	1/20

Data are presented as mean±SD or number. *Represents no significant difference compared with the UPS group (P>0.05), #Represents a significant difference compared with the BPS group (P<0.05). BPS=Bilateral pedicle screw, UPS=Unilateral pedicle screw, UPSFS=UPS plus contralateral translaminar facet screw, SD=Standard deviation

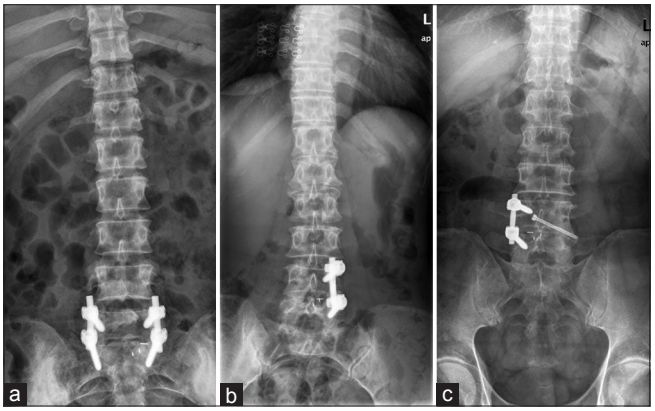

Figure 1: X-ray exams after the operations. (a) Transforaminal lumbar interbody fusion with bilateral pedicle screw fixation; (b) transforaminal lumbar interbody fusion with unilateral pedicle screw fixation; (c) transforaminal lumbar interbody fusion with UPSFS fixation

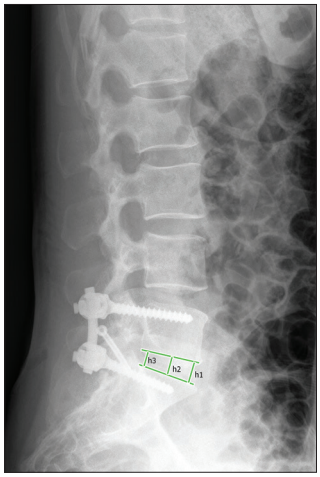

Figure 2: Intervertebral space height (H) was measured as the average of H1, H2, and H3, which was measured at the initial, median and distal of the disc intervertebral space

Table 3: Data of visual analog scores (leg and back), Oswestry disability index and Japanese Orthopaedic Association Scores

Parameters	Peroperation			Postoperation			3 months/postoperation			Last-follow up		
	BPS	UPS	UPSFS	BPS	UPS	UPSFS	BPS	UPS	UPSFS	BPS	UPS	UPSFS
VAS	8.2±2.7	7.8±2.1	7.7±1.8	2.1±0.7	2.3±0.8	2.6±1.2	1.6±0.6	1.8±0.8	2.0±0.5	1.2±0.7	1.4±0.8	1.3±0.6
ODI	47.2±16.2	48.2±15.8	47.6±7.1	18.2±6.5	19.2±5.6	18.7±7.1	11.3±5.6	12.9±6.5	12.1±7.4	7.8±3.2	8.9±4.1	8.3±2.1
JOA	10.8±5.6	9.9±6.2	10.3±5.8	24.3±7.1	23.2±5.3	23.5±6.8	27.1±5.3	26.6±6.1	26.9±6.7	28.3±4.3	27.8±6.5	28.1±6.3

Data presented are mean±SD. No significant difference (P>0.05) existed between groups at any time, Significant difference (P<0.05) existed before and after operation for VAS, ODI, and JOA at each time point in these groups. BPS=Bilateral pedicle screw, UPSFS=UPS plus contralateral translaminar facet screw, UPS=Unilateral pedicle screw, VAS=Visual analog scores, SD=Standard deviation, ODI=Oswestry disability index, JOA=Japanese Orthopaedic Association Scores

Table 4: Data of intervertebral space height (H) of patients among three groups

Parameters	Peroperation	Postoperation	3 months/postoperation	Last-follow up
BPS	9.28±1.96	11.63±1.55	11.52±1.51	11.43±1.45
UPS	9.31±1.9	11.66±1.61	11.56±1.62	11.32±1.53
UPSFS	9.30±1.85	11.59±1.49	11.50±1.54	11.39±1.60

No significant difference (P>0.05) existed between groups at any time, Significant difference (P<0.05) existed before and after operation. UPS=Unilateral pedicle screw, BPS=Bilateral pedicle screw, UPSFS=UPS plus contralateral translaminar facet screw

in 1984 and intended to be performed as a minimally invasive procedure with minimal soft tissue exposure.[22] Biomechanical study[23] demonstrated that TLFS can provide equivalent stability in lateral bending and axial torsion as BPS. A finite element analysis showed that UPSFS fixation was superior to UPS or BPS in terms of overall stability and reducing stress.[24] Although research[20] has demonstrated no significant differences in the clinical outcome when comparing UPS and BPS, there is no literature reporting comparisons of UPS, BPS, and UPSFS. This deficiency in the literature motivated our study to compare these three posterior fixations.

In our study, all patients were treated for degenerative lumbar disease with TLIF and supplemental posterior fixation. We identified no significant differences between the groups with respect to patient demographics [Table 1]. We found that TLIF plus UPS or UPSFS was associated with significantly less surgical time and less blood loss compared with BPS fixation. Both UPS and UPSFS procedures were accomplished through a single paramedian muscle, while BPS fixation required bilateral paramedian incisions. Based on these results, it can be inferred that UPS and UPSEF groups were less invasive and would lead to faster recovery of muscle function and less incisional pain compared with patients undergoing BPS. All patients underwent radiographs immediately after surgery and at followup time points. To identify successful fusion, CT examination was obtained [Figure 3]. The fusion rate was 90% for patients who underwent UPSFS and BPS and 95.6% in patients treated with UPS, a result consistent with previous study.[9,14,22] Although there was no significant difference in fusion rate between the three groups, our study may be underpowered for this purpose.

We found complications related to screw/rod failure in all three groups. Although the UPS group had a higher rate

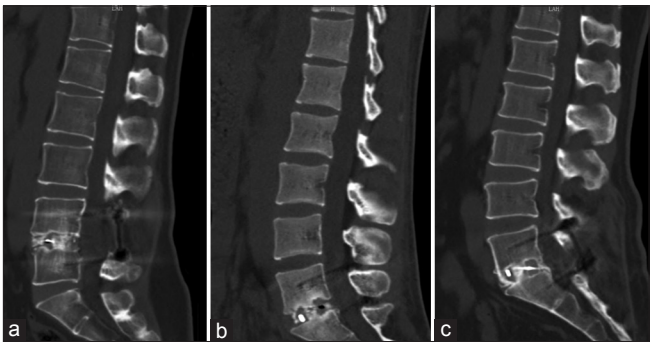

Figure 3: Three dimensional computed tomography at last followup in these groups, all showed solid fusion. (a) in bilateral pedicle screw group; (b) in unilateral pedicle screw group; (c) in UPSFS group

than the BPS and UPSFS groups, this was not significantly different. Anecdotally, would found that implant failure often happened in patients who began exercising before they were cleared to increase activity level, all these four patients began exercising or did heavy labor before they were able to increase activity level. Fortunately, none of the patients with instrumentation failure had associated symptoms or required revision surgery. With respect to pain scores and functional outcome measures, the VOA, JOA, and ODI scores in all groups were significantly improved compared to before surgery and no significant difference existed between groups at any time point [Figure 4]. In summary, we could identify no significant differences between groups for any outcome measure, suggesting that UPSFS may strike an advantageous balance by limiting invasiveness while still providing sufficient stabilization.

UPSFS was suggested to be used in single- or two-level lumbar degenerative diseases, such as lumbar disc herniation with adjacent spinal instability, degenerative spondylolisthesis, or spinal stenosis, and also could be a reserved technique for some revision surgery.[12-14] In revision

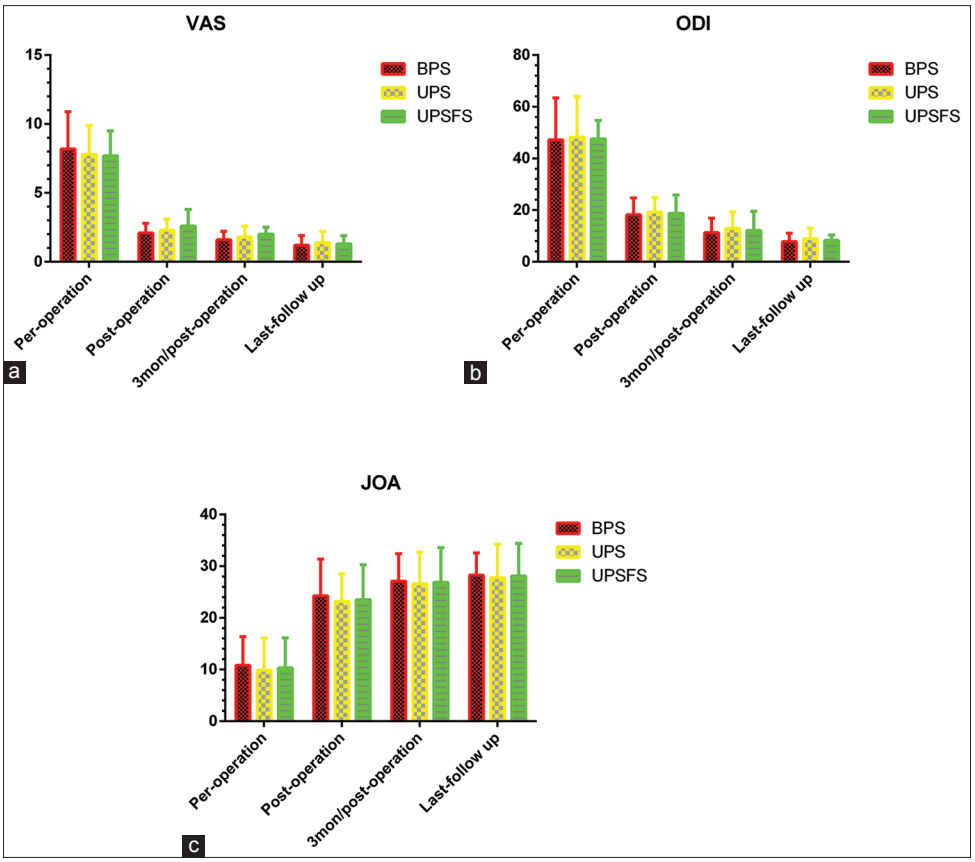

Figure 4: The visual analog scores, Oswestry disability index, and Japanese Orthopaedic Association Scores graphs. (a) The bar graph of visual analog scores of three groups; (b) the bar graph of Oswestry disability index of three groups; (c) the bar graph of Japanese Orthopaedic Association Scores of three groups

surgery, it was difficult to dissect cicatricial tissue to set screw; UPSFS could provide contralateral fixation without dissection of contralateral tissues. However, TLFS needed to transverse contralateral lamina and facet, which would limit the application of UPSFS in the patients who had to remove more laminar to decompress the nerve roots. For osteoporosis patients, Park *et al*.[25] reported a followup study about anterior lumbar interbody fusion combined with percutaneous TLFS fixation in elderly patients older than 60 years of age with severe osteoporosis, and they suggested that in patients undergoing a multilevel operation or in those with severe osteoporosis, more substantial posterior augmentation should be considered. In our study, the stability of UPSFS was better than TLFS alone; we suggested that it could be used in single-level operation patients with osteoporosis but should be cautious to use in patients undergoing multilevel operation or severe osteoporosis. Hence, the utilization of UPSFS with TLFS was not suitable in some patients.

UPS was a more minimally invasive fixation than UPSFS, the clinical outcome was satisfactory.[7-9] However, it could only provide unilateral fixation, which was suggested to be applied in lateral lumbar disc herniation with lumbar instability, unilateral herniated intervertebral disc root canal stenosis, lumbar spondylolisthesis (degree I) with unilateral symptom.[7] For patients with severe lumbar instability, severe osteoporosis and lumbar stenosis or lumbar foramen stenosis needing bilateral decompression or multilevel operation, more substantial posterior fixation should be considered. Moreover, UPS was also not suitable for lumbar spondylolisthesis patients required restoration. Hence, UPS was a minimally invasive fixation but should be used in suitable patients.

Our study has some limitations. First, the sample size of each group is relatively small. Second, all patients underwent single-level surgery for degenerative conditions which prevents us from drawing conclusions about treatment of multilevel disease. Finally, the followup period which averaged 38.2 months is too short to draw long term conclusions. Studies with larger study populations and longer followup are needed to adequately determine the clinical and radiographic significance of fixation techniques in patients who undergo TLIF.

Conclusion

The use of UPSFS with TLIF is a viable treatment option that provides satisfactory clinical results. The clinical outcomes and complication rate were statistically comparable to BPS and treatment using UPSFS was associated with less surgical time and blood loss than the use of BPS.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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