Original Article

Transforaminal lumbar interbody fusion using unilateral pedicle screw fixation plus contralateral translaminar facet screw fixation in lumbar degenerative diseases

Fubing Liu, Chun Jiang, Yuanwu Cao, Xiaoxing Jiang, Zhenzhou Feng

Abstract

Background: Transforaminal lumbar interbody fusion (TLIF) has been used in lumbar degenerative diseases. Some researchers have applied unilateral fixation in TLIF to reduce operational trauma without compromising the clinical outcome, but it is always suspected biomechanically unstable. The supplementary contralateral translaminar facet screw (cTLFS) seemed to be able to overcome the inherent drawbacks of unilateral pedicle screw (uPS) fixation theoretically. This study evaluates the safety, feasibility and efficacy of TLIF using uPS with cTLFS fixation in the treatment of lumbar degenerative diseases (LDD).

Materials and Methods: 50 patients (29 male) underwent the aforementioned surgical technique for their LDD between December 2009 and April 2012. The results were evaluated based on visual analogue scale (VAS) of the leg and back, Japanese Orthopedic Association (JOA) score and Oswestry Disability Index (ODI) were recorded. The radiographic examinations in form of X-ray, computed tomography (CT) or magnetic resonance imaging was done preoperatively and 1 week, 3 months, 6 months, 12 months and 24 months postoperatively. The student *t*-test was used for comparison between the preoperative values and postoperative counterparts. $P < 0.05$ was considered to be statistically significant.

Results: Among 50 patients, 22 received one level fusion and 28 two level's, with corresponding operation time and estimated blood loss being approximately 90 min, 150 ml and 120 min, 200 ml, respectively. No severe complications happened perioperatively. The mean VAS (back, leg) scores dropped from (7.6, 7.5) preoperatively to (2.1, 0.6) at 12 months' followup, ODI from 49.1 preoperatively to 5.6 and JOA score raised from 10.6 preoperatively to 28.5, all $P < 0.001$, suggesting of good clinical outcome. From the three-dimensional reconstructed CT, 62 out of 70 segments displayed solid fusion with fusion rate of 88.6% at 12 months postoperatively.

Conclusions: TLIF using uPS fixation plus cTLFS fixation is a safe, feasible and effective technique in the treatment of one or two level lumbar degenerative diseases short termly.

Key words: Lumbar degenerative diseases, transforaminal lumbar interbody fusion, translaminar facet screw

MeSH terms: Lumbar vertebra, degenerative disease, bone screw

Introduction

Over the past 20 years, transforaminal lumbar interbody fusion (TLIF) has earned popularity among spinal surgeons in the treatment of lumbar degenerative diseases (LDD) since its first use by Harms and Rolinger.[1] It has a lot of advantages over posterior lumbar interbody fusion (PLIF) such as less bleeding and dural laceration, diminished nerve root and other neural injuries, less pseudarthrosis.[2-4] Besides traditional TLIF, many modified techniques emerged as new instruments developed and orthopedists' perception toward spinal fusion updated. For example, unilateral pedicle screw (uPS) fixation TLIF. Although, it has got satisfactory short term clinical outcome, many other surgeons remained suspicious of its capability to provide sufficient strength, which necessitates solid fusion.[3,5-9] The TLFS assisting in uPS TLIF seems a suitable option. TLFS, first used by Magerl in 1984, is inserted at the base of spinous process, traversing contralateral lamina, crossing the facet joint and ending at the base of the transverse process, thus providing stiffness and immobilization of spinal motion segments.[10] We evaluated the safety, feasibility and efficacy of this modified TLIF procedure - TLIF using uPS plus contralateral translaminar

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facet screw (cTLFS) fixation to treat one or two level LDD in a short term followup [Figure 1].

Materials and Methods

50 patients with back or leg discomfort (pain or numbness), underwent TLIF using uPS plus cTLFS through single paramedian approach for their LDD between December 2009 and April 2012. The work was approved by the Institutional Review Board of our hospital. These patients, including 29 men and 21 women, whose age ranged from 19 to 79 years (mean 60.18 years), suffered from 1 (n = 22) or 2 (n = 28) level lumbar pathological changes. The history and physical examination was done at the time of admission. Anteriorposterior (AP) X-ray, lateral X-ray, flexion extension lateral X-ray, computed tomography (CT) or magnetic resonance imaging (MRI) scan were performed preoperatively. The involved segments were L3-L4 (n = 2), L4-L5 (n = 9), L5-S1 (n = 11), L3-L5 (n = 17) and L4 -S1 (n = 11) [Table 1] besides, eight patients with bilateral symptoms were subjected to bilateral decompression.

The indication for this procedure included recurrent lumbar disc herniation, degenerative lumbar spinal stenosis (DLSS), low grade (Grade I or II) spondylolisthesis, while the contraindication were severe osteoporosis or posterior structural deficiency owing to congenital deformity or prior surgeries.[10] All patients received at least 3 months' conservative treatments before considering for surgery. The diagnosis of DLSS was established by either CT or MRI scanning, which identified the presence of a narrowed canal and compression of neural structures.[11,12] Low grade (Grade I or II) spondylolisthesis was defined as forward displacement (<50% slippage) of a proximal vertebra in relation to its adjacent caudal vertebra and instability was justified from dynamic flexion extension lateral X-ray with over 3 mm translation and above 5° angulation.[13]

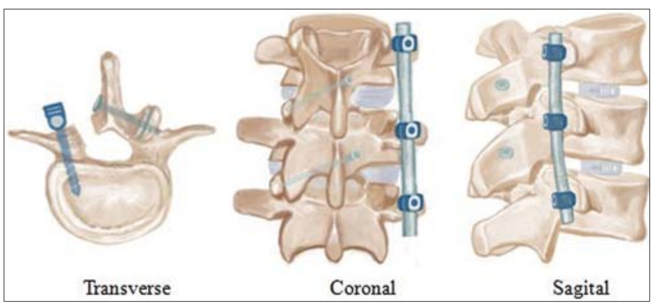

Figure 1: A line diagram showing different planes showing unilateral pedicle screws and contralateral translaminar facet screws instrumentation (cTLFS). TLFS enters through the base of the spinous process, traverses the contralateral lamina and crosses the facet joint

Table 1: Patient demography

Item	Patient number
Gender (male, female)	(29, 21)
Age (range, mean) years	(19-79, 60.18)
Involved level (one, two)	(22, 28)
L3-4, L4-5, L5-S1	2, 9, 11
L3-5, L4-S1	17, 11
Diagnosis	
LDH	6
DLSS	18
Spondylolisthesis	14
COTD	12

LDH=Lumbar disc herniation, DLSS=Degenerative lumbar spinal stenosis, COTD=Complex of these disorders

Operative procedures

Under general anesthesia, the patient was placed in a prone position on an X-ray translucent table. After locating the involved level by C-arm machine, a 4 cm (monosegmentally) or 6 cm (bisegmentally) longitudinal paramedian skin incision was made 2 cm away from the midline at the side, which has more severe symptoms or radiographic manifestations. After dissecting the subcutaneous tissue with and spliting the sacrospinalis, expose the ipsilateral facet joint, transverse process and lamina. Insert uPS and then remove the inferior and superior articular processes and part of the vertebral lamina to expose the underlying disk space. The nerve root was decompressed by removal of the ligamentum flavum and bone spur. A sharp knife was used to create a rectangular window on the annulus fibrosus. The disk materials and endplate cartilage were completely removed and one appropriate cage filled with morselized local bone, coming from resected bony structure, was inserted. Then the placement of contralateral TLFS was started by selecting an entry point at the base of spinous process, usually the midpoint of the base. A 1.5 mm K-wire/guide wire was crossed through the contralateral lamina, penetrated the articular surface of the facet joint on the other side and ended at the base of the transverse process of the lower vertebra. A selected cannulated screw (3.5 mm or 4.5 mm) was inserted over the guide/K-wire until its head reached the base of spinal process. Fluoroscopic confirmation was made if necessary to ensure the instrumentation was in the desired position.

If the patient had bilateral symptoms, we applied contralateral decompression through this single paramedian approach through the space between the contralateral dura and the lamina.[5] The contralateral thickening ligamentum flavum and proliferated osteophytes were ground and removed using high-speed drills, curettes and Kerrison rongeurs. Care must be taken in completing contralateral decompression when using a high-speed drill. For these patients, the TLFS should be inserted at a higher point to bolt the contralateral facet joint, as the contralateral lamina became thinner after contralateral decompression, leaving the TLFS easily intruding into the canal. In addition, the higher placement of TLFS could avoid iatrogenically narrowing of the contralateral decompressed recess.

The wound was irrigated with saline and one continuous negative suction draining was placed as needed. The incision was closed in layers. Patient was ambulated with a corset when the drain was removed (after 2 days). The patient was discharged at 4th postoperative day.All the surgeries were performed by senior surgeon (JXX).

We assessed operation time, estimated blood loss (EBL), duration of hospital stay and intra or postoperative complications. The clinical parameters assessed were visual analogue scale (VAS), Japanese Orthopedic Association (JOA) and Oswestry Disability Index (ODI) scores preoperatively and at 1 week, 3, 6, 12 and 24 months postoperatively. The radiographic assessment included anteroposterior (AP) X-ray, lateral X-ray, dynamic flexion extension lateral X-ray, CT and MRI preoperatively, AP with lateral X-ray at 1 week, 3, 6, 12, 24 months postoperatively and three-dimensional (3-D) CT or MRI at 6, 12, 24 months postoperatively. The fusion rates were calculated at 12 months' followup from 3-D CT reconstruction and flexion extension lateral X-ray. Larsen *et al*.[14] pointed out, solid fusion was defined as continuous bridging bone between adjacent vertebral from CT. These datas were compared between preoperative ones and postoperative ones, respectively. The statistical analysis was performed by Stata 9.1 (StataCorp LP, Texas, USA). The student *t*-test was used for comparison between the perioperative values and postoperative counterparts. $P < 0.05$ was considered to be statistically significant.

Results

The mean incision length was about 4 cm in case of one level and 6 cm of two levels, with corresponding operation time and EBL being approximately 90 min, 150 ml and 120 min, 200 ml, respectively. The mean hospital stay was 7.5 days, ranging from 5 to 10 days. There were no severe neurologic injuries (ASIA scale of A, B or C), dural tearing, over bleeding (bleeding over 800ml), cerebrospinal fluid leakage or other complications intraoperatively. Three patients suffered from aggravated pain (postoperative VAS greater than preoperative one) postoperatively. Two got relieved by using mannitol, steroids and analgesics for 3 days. In one patient facet screw penetrated into spinal canal, with thread compressing the contralateral nerve root, underwent secondary surgery of removing the wrongly placed TLFS and got complete remission.

The mean followup period was 17.02 months (range 6-30 months). The mean VAS (back, leg) scores dropped from (7.6, 7.5) preoperatively to (2.1, 0.6) at 12 months' followup, ODI from 49.1 preoperatively to 5.6 and JOA score raised from 10.6 preoperatively to 28.5, all $P < 0.001$, suggesting of good clinical outcome [Table 2 and Figure 2].

One 3.5 mm L4-L5 TLFS was found broken at 3 months postoperatively without neurological symptoms. None of the patients showed screw loosening, implants shifting and cages subsidence in the followup. From the 3-D reconstructed CT, 62 out of 70 segments displayed solid fusion with fusion rate reaching 88.6% at 12 months postoperatively [Figures 3 and 4].

Discussion

Spinal fusion has become an important procedure in the management of spine degenerative disorders since its first application by Albee in 1911. And a variety of fusion patterns developed such as posterolateral fusion, anterior lumbar interbody fusion (ALIF) and PLIF. TLIF, transforaminal lumbar interbody fusion for short, has become the standard technique in the management of LDD nowadays, using bilateral pedicle screw (PS) system through a midline approach. Compared with ALIF, it not only provides anterior column support and a posterior tension band but also avoid neurovascular complication related with anterior approach; compared with PLIF, it reduced EBL and dural laceration, diminished nerve root and other neural injuries, decreased pseudarthrosis rate and so on.[2-4] However, the researchers' efforts to minimize surgery related trauma and maximize the efficiency of surgery never stopped. Some researchers proposed that it may be too strong for short segment interbody fusion using bilateral PS fixation system and they purported TLIF with uPS fixation as a preferable option.[3,5-8] A series of clinical studies revealed unilateral fixation in TLIF was as effective as bilateral fixation with less invasiveness.[6-8] However, the biomechanical study of unilateral pedicle fixation seemed not so optimistic, which showed that uPS system were less stable than bilateral ones in flexion/extension, lateral bending and axial rotation.[15-17] So many spinal surgeons refused to adopt this less invasive unilateral technique.

Table 2: Preoperative and postoperative VAS (leg and back), ODI and JOA

Items	Preoperative	Postoperative				
		1 week	3 months	6 months	12 months	24 months
VAS (leg)	7.5±2.7	2.0±2.2	1.4±3.1	0.6±1.6	0.6±0.9	0.8±0.4
VAS (back)	7.6±2.0	2.4±1.9	2.2±1.3	2.0±1.7	1.6±1.1	1.6±0.9
ODI	49.1±16.1	15.1±7.3	7.2±10.1	7.8±9.1	5.6±8.0	5.1±6.4
JOA	10.6±6.1	25.1±6.0	26.8±6.4	28.5±3.3	28.0±2.2	28.5±2.3

VAS=Visual analogue scale, ODI=Oswestry disability index, JOA=Japanese orthopedic association

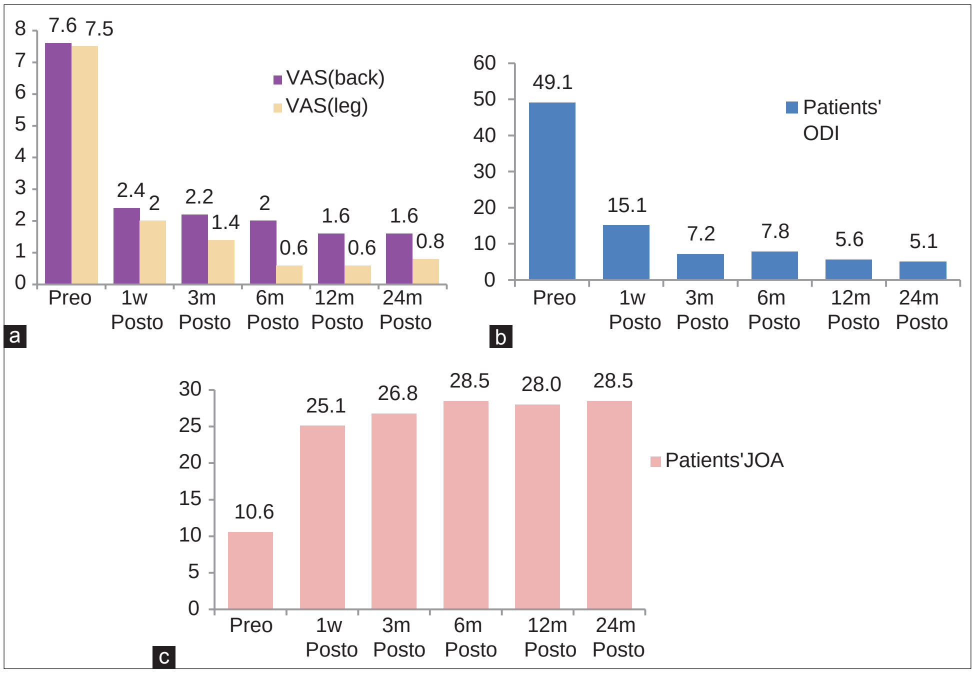

Figure 2: A bar diagram showing comparison of patient scores for visual analogue scale (VAS), Oswestry Disability Index (ODI) and Japanese Orthopedic Association (JOA), (a) VAS, (b) ODI and (c) JOA. Preo: Preoperation; Posto: Postoperation after weeks (w) or months (m)

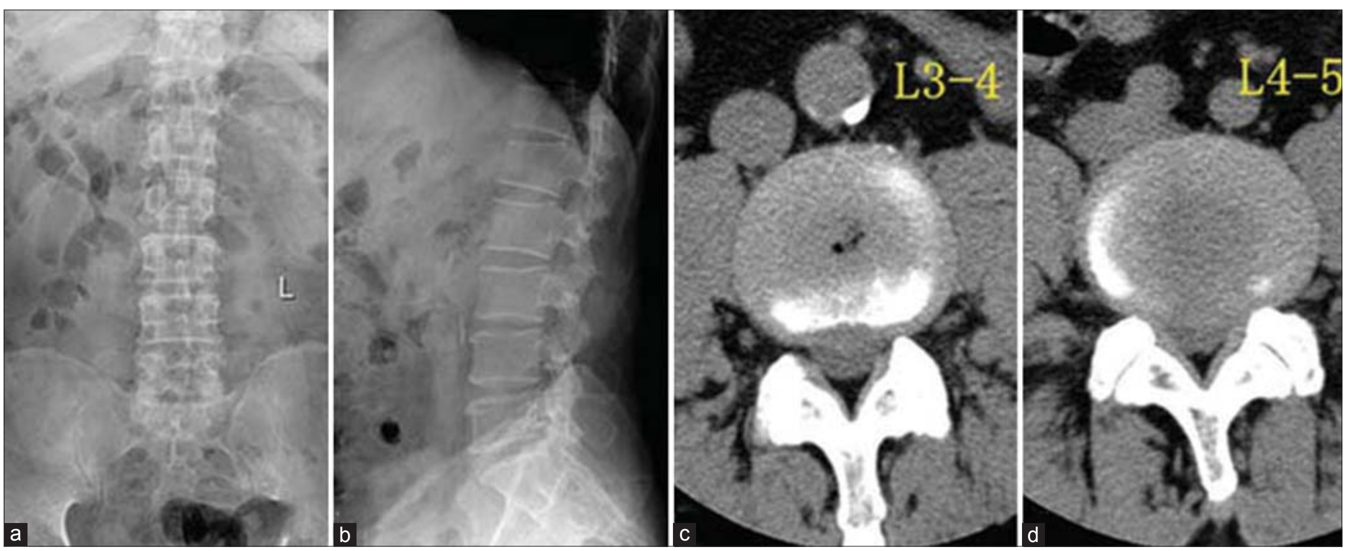

Figure 3: One illustrative case, male, 53-year-old. (a and b) preoperative anteroposterior and lateral X-ray, showing degenerative changes of lumbar spine; (c and d) showed L3-L4 and L4-L5 disc herniation on computed tomography scan, respectively, resulting in spinal stenosis

So we introduced amelioration of unilateral TLIF, adding a contralateral translaminar facet joint screw. Translaminar facet joint screw, also known as Magerl's screw, has become an alternative posterior instrumentation for PS since its first application in 1984.[9] It is inserted from the base of the spinous process on the one side, through the contralateral lamina to traverse the facet joint in a plane perpendicular to the joint surface and ending at the base of the transverse process. We can see that TLFS function as a threaded bolt, which prevents movement in the respective motion segments without producing compression across the facet joints. As the facet joint is the only true articulation in the lumbar spine, it is reasonable to fix the facet joints and achieve segmental stabilization of the concerned segment.[9] Biomechanical and clinical studies have demonstrated that TLFS could provide initial posterior stabilization similar to PS and was a safe, effective and inexpensive technique to treat LDD.[18-23]

In our study, the hybrid of ipsilateral PS and contralateral translaminal facet screw in TLIF was able to minimize the approach associated trauma and address the problem of insufficient stability at the same time. Compared with bilateral PS fixation, our technique utilized one paramedian incision, avoiding disrupting the paraspinal muscles on

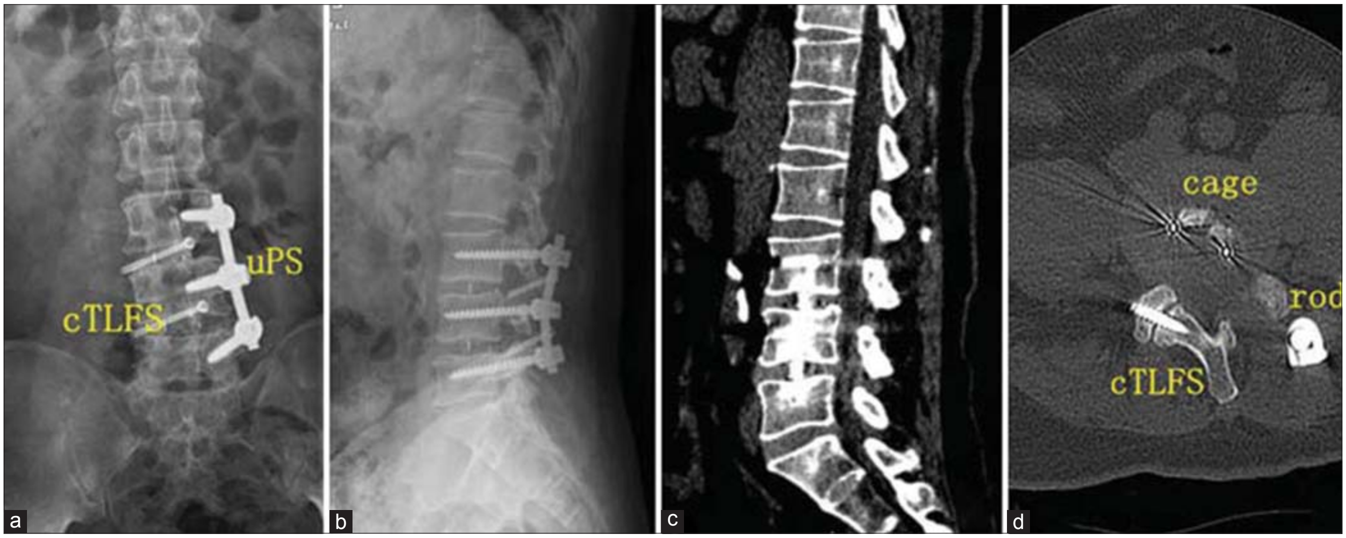

Figure 4: Radiography at 12 months' postoperatively. (a and b) showing instrumentation of unilateral pedicle screw + contralateral translaminar facet screw (cTLFS) transforaminal lumbar interbody fusion; (c) sagittal plane CT scan of lumbar spine, showing bony fusion of L3-L4 and L4-L5; (d) Axial plane CT showing placement of cTLFS and cage, the cTLFS crossed facet joint, functioning as a bolt

the other side, thus reducing operation time and EBL. In addition, the placement of TLFS took advantage of the same incision and didn't have to make another stab wound, which was necessary in percutaneous instrumentation, thereafter being more convenient and less invasive. As far as biomechanics was concerned, for one-level fusion, Slucky *et al*.[24] performed an *in vitro* biomechanical study and showed unilateral posterior instrumentation allowed for significantly increased segmental range of motion (ROM), less stiffness and produced off-axis movement, however, there were no measurable differences in either stiffness or ROM between biPS and uPS + cTLFS in flexion/extension, lateral bending and axial rotation. In another biomechanical study conducted by Sethi *et al*.,[25] uPS + cTLFS significantly reduced ROM in flexion extension and lateral bending compared with the intact specimen and in axial rotation, the ROM of uPS + TLFS (2.2° ± 1.1°) was lower than that of intact spine (3.24° ± 1.1°), although with no statistical significance. Based on these biomechanical studies, there were also clinical cases utilizing ipsilateral PS and contralateral TLFS fixation to treat LDD with encouraging results. Jang and Lee[26] followed 23 patients with for 19 months and found that with satisfactory clinical outcome, 22 of 24 fusion sites exhibited osseous union, reaching the fusion rate of 91.67%. Sethi *et al*.[27] in their study have also reported the similar results in 19 patients for single-level lumbar degenerative pathologies, they selected traditional midline approach and made an extra stab incision approximately 8 cm lateral to the midline for the placement of TLFS. All patients showed radiographic evidence of fusion from 9 to 26 months (mean 19) following surgery, reaching fusion rate almost 100%.

To the best of our knowledge, there were few reports concerning uPS + cTLFS in TLIF of two-level fusion biomechanically and clinically. However, some published clinical studies comparing unilateral PS fixation with bilateral PS fixation in two-level fusion, concluded that bisegmental unilateral PS fixation could achieve similar results with bilateral PS fixation.[6,28,29] Theoretically, the supplementary cTLFS would additionally stabilize the other side of spinal segments. What's more, we have finished the finite element analysis of uPS + cTLFS two-level in TLIF and found that uPS + cTLFS in two-level TLIF were even stronger than biPS fixation. The results of which were wait to be published.

In our study, 28 patients (56%) across two segments were enrolled and utilized 56 cTLFS. Only one 3.5 mm TLFS were broken down during followup owing to its weaker strength than 4.5 mm TLFS. So after that we totally selected 4.5 mm cannulated screw as TLFS. As the TLFS goes through contralateral lamina, it would not compress the nerve root if correctly placed. Besides, eight patients with bilateral symptom successfully underwent bilateral decompression procedures without using microscope. The space between contralateral dura and the lamina was enough for the surgeon to decompress the contralateral side. For these patients, the TLFS should inserted higher to bolt the contralateral facet joint, as the contralateral lamina was usually ground thinner and the medial part of proliferated facet joints were resected. In addition, the higher placement of TLFS could avoid narrowing the contralateral decompressed recess. The fusion rate of a year reached 88.6%, showing no significant decrease comparing with the common fusion rate obtained from the standard TLIF with bilateral PS fixation (90-97.5%).[11,30]

The limitations of the study are that firstly, it is a retrospective study which inevitably has selection and recall bias, despite the fact that we collected and analyzed the data meticulously; Secondly, the followup period of our study (mean 17.02 months, range 6-30 months) appears a little too short which can only provide a short term outcome, so long term followup needs to be done in the future. In addition, the sample size is small, which makes our study not as illustrative as expected.

To conclude, TLIF using uPS fixation plus cTLFS is a safe, feasible and effective technique to treat one or two segment lumbar degenerative diseases.

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