Lateral Transpsoas Interbody Fusion (LTIF) With Plate Fixation and Unilateral Pedicle Screws

A Preliminary Report

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Study Design: Retrospective cohort study.

Objective: We present the radiographic and clinical outcomes of 13 patients who underwent lateral transpsoas interbody fusion (LTIF) stabilized by unilateral pedicle screw instrumentation and anterior instrumentation.

Summary of Background Data: LTIF is a surgical technique that permits anterior column lumbar interbody fusion via a direct lateral transpsoas approach. Because of the inherent stability of the implants used and the minimal disruption of stabilizing ligaments associated with LTIF, this technique may allow use of less invasive adjunctive fixation methods including unilateral pedicle screw fixation.

Methods: Information from medical records included patient demographics, medical comorbidities, clinical assessment, surgical time, blood loss, implant information, and complications. Oswestry Disability Index, Short Form-12, and visual analog pain scale scores were obtained. Postoperative imaging allowed assessment of fusion, subsidence, and alignment.

Results: Estimated blood loss averaged 225 mL and operative time averaged 261 minutes. No patients received a transfusion. Average length of hospital stay was 4.6 days. Oswestry Disability Index, Short Form-12, and visual analog pain scores demonstrated significant improvement. All patients with available 1 year postoperative imaging demonstrated solid fusion with average cranial and caudal subsidence of 1.8 and 0.8 mm, respectively. Two patients developed postoperative nondisplaced vertebral fractures through the anterior fixation screw tracts. Three patients developed transient postoperative hip flexion weakness and one also developed transient hypesthesia in the anterior thigh, likely approach related.

Conclusions: We report a series of patients treated with unilateral pedicle screw fixation with LTIF. Although the patient cohort is small, validated outcomes instruments were used and fusion was assessed by computed tomography scan in most cases. The data suggest that unilateral pedicle screw fixation may be adequate to achieve high fusion rates after LTIF surgery using anterior instrumentation. Applying this technique in patients with osteoporosis may lead to a significant risk of postoperative vertebral body fracture.

Key Words: lateral transpsoas interbody fusion, unilateral pedicle screw fixation, interbody fusion, XLIF, anterior plate instrumentation

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Lumbar interbody fusion has a well-established track record for efficacy and safety in the treatment of well-selected patients with symptomatic lumbar degenerative conditions. Currently, the most frequently used techniques for lumbar interbody fusion are anterior lumbar interbody fusion, posterior lumbar interbody fusion, and transforaminal lumbar interbody fusion (TLIF). The advantages of interbody fusion over posterolateral fusion include a higher anticipated rate of radiographically successful arthrodesis, indirect decompression of foraminal and subarticular lateral recess stenosis, the ability to control or restore lordosis and coronal alignment, and the removal and unloading of disc tissue in cases of discogenic pain syndromes. These clinical advantages should be weighed, however, against the increased surgical morbidity, operative time, blood loss, and potential for complications compared with posterolateral fusion.

Lateral transpsoas interbody fusion (LTIF) is a technique that permits anterior column interbody fusion via a minimally invasive direct lateral transpsoas approach. LTIF is intended to provide the clinical benefits of interbody fusion while minimizing surgical morbidity. A preliminary report demonstrated a low complication rate in a small cohort of patients,1 but no clinical or radiographic follow-up data were presented.

Because the cage is placed from a direct lateral approach, the biomechanical characteristics of LTIF constructs differ from those of other fusion constructs. LTIF cages are designed to span the entire width of the vertebral body so that the cage rests on apophyseal bone on either side. This provides a potential biomechanical advantage as the peripheral apophyseal bone is significantly stronger than central cancellous bone2,3 which is
used to provide support for anterior lumbar interbody fusion, posterior lumbar interbody fusion, or TLIF cages. Furthermore, LTIF cages have a larger footprint than other cage types, so that compressive loads are distributed over a larger surface area. Finally, in contrast to other interbody fusion techniques, LTIF allows preservation of the anterior and posterior longitudinal ligaments. Because of the LTIF implant’s inherent stability and minimal disruption of stabilizing ligaments, many surgeons have begun to use LTIF cages with less robust forms of fixation with the goal of minimizing operative time, blood loss, and soft tissue disruption.

The purpose of this study is to present the radiographic and clinical outcomes of a series of 13 patients who underwent LTIF using the extreme lateral interbody fusion (XLIF, Nuvasive Inc, San Diego, CA) cage stabilized by unilateral pedicle screw instrumentation and anterior instrumentation (XLP plate, Nuvasive Inc, San Diego, CA). We are unaware of other reports in the literature using this instrumentation construct.

**MATERIALS AND METHODS**

Between September 2007 and June 2008, 13 patients underwent 1-level interbody fusion at the L3-L4 (n = 2) or L4-L5 (n = 11) level using the XLIF cage with anterior instrumentation and unilateral pedicle screw fixation placed under the same anesthetic (Fig. 1). All patients had iliac crest bone graft harvested through the same skin incision used to perform the lateral approach. Diagnosis prompting fusion was spondylolisthesis with stenosis in 8 patients, disc collapse with up-down foraminal stenosis in 2 patients, adjacent level (juxtafusion) degeneration in 2 patients, and postdiscectomy degeneration in 1 patient. The cohort included 8 women and 5 male with an average age of 60.1 years (range: 43.7 to 76.8 y).

Clinical information was available for review for all patients from office charts, operative notes, and radiographic images. Information obtained from medical records included patient demographics, medical comorbidities, preoperative and postoperative clinical assessment, intraoperative findings, surgical time, operative blood loss, implant information, and postoperative complications including reoperation. Oswestry Disability Index (ODI), Short Form-12 (SF-12), and visual analog pain scale (VAS) scores were obtained before surgery and at each postoperative office visit (6 wk, 3, 6 mo, 1 y). Standing preoperative, immediate postoperative, and most recent radiographs at a minimum of 1 year postoperatively were measured for endplate angulation at the operated disc space in both the coronal (scoliotic angle) and sagittal (lordotic angle) planes. Interbody cage position was measured in the coronal and sagittal plane with reference to adjacent vertebral borders on immediate postoperative and final follow-up radiographs. Fusion was routinely assessed at 1 year postoperatively using CT (computed tomography) scan. CT images were also used to measure the amount of subsidence of the interbody cage into the superior and inferior endplates.

**Surgical Technique**

Lateral interbody fusion was performed using the technique described by Ozgur et al. Autograft bone was harvested from the lateral portion of the iliac crest in all cases using the same skin incision used for lateral fusion. XLIF cages were filled with autograft bone and a small amount of Grafton demineralized bone matrix putty which was used to extend the volume of autograft and also as an adhesive to keep the bone graft within the cage during implantation.

After placement of the interbody cage, anterior instrumentation (Nuvasive XLP plate) was placed via the LTIF incision. The XLP system uses a 5.5 mm fixed-angle screw placed into the vertebral bodies above and below the cage (Fig. 1).

Posterior surgery was performed under the same anesthesia using a 3 cm paramedian Wiltse approach on the side opposite the LTIF approach to place pedicle screw instrumentation on the side opposite the anterior instrumentation (Fig. 2). Microsurgical laminotomy decompression was performed when necessary (7 patients). Pedicle screws were placed using direct visualization of bony landmarks and fluoroscopy. Autograft bone was used to engraft the facet fusion bed along with Grafton demineralized bone matrix putty.

This study was approved by the institutional review board.
RESULTS

Perioperative Course

The mean operative time was 261 minutes (4.4 h) from the time that positioning of the patient in the lateral decubitus position began until the posterior wound was closed. Estimated blood loss averaged 225 mL. One patient received recovered autologous blood (150 mL) from the surgical field during the procedure but in most cases blood loss was too low to enable use of cell recovery devices. No patients received a transfusion during the procedure or the postoperative period. Average length of hospital stay postoperatively was 4.6 days.

Clinical Indices

VAS scores improved from a preoperative average of 8.6 to a postoperative average of 4.5, a statistically significant improvement of 4.1 points ($P = 0.003$).

Average ODI score improved from 45.0 to 19.0, a statistically significant improvement of 26.0 points ($P = 0.002$). Average SF-12 physical component summary scores improved from 28.6 to 40.1, a statistically significant improvement of 11.4 points ($P = 0.01$). Average SF-12 mental component summary scores improved from 37.8 to 44.9, a statistically nonsignificant improvement of 7.1 points ($P = 0.24$) (Table 1).

Radiographic Findings

Mean radiographic follow-up was 1.2 years (0.23 to 1.66 y). Four patients had sufficient clinical follow-up to be included in the study but were excluded from the radiographic portion of the study because available radiographic follow-up was < 1 year. All 9 patients with greater than 1 year of radiographic follow-up went on to successful fusion—fusion in 7 patients was verified by cross-sectional imaging (Fig. 3) and 2 patients had fusion assessed by radiography including flexion extension radiographs. No patients developed nonunion.

Measurement of metallic marker position with respect to the adjacent vertebral bodies demonstrated no cage migration in either the coronal or sagittal planes at final follow-up. There were no endplate fractures seen in either immediate postoperative or final follow-up radiographs other than the 2 patients discussed below with vertebral body fractures. Measurement of subsidence using CT scan demonstrated subsidence of at least 2 mm into the adjacent cranial vertebra in 56% of patients and subsidence into the adjacent caudal vertebral body in 33% of patients. Average subsidence distances were 1.8 and 0.8 mm into the cranial and caudal vertebral bodies, respectively. The highest subsidence was 5 mm and was seen in a patient with violation of the cranial endplate secondary to postoperative coronal plane fracture.

Complications

Three of the 13 patients (23%) developed transient postoperative hip flexion weakness of grade 3 or 4 on a 5-point scale ipsilateral to the side of the surgical

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MCS indicates mental component summary; PCS, physical component summary; ODI, Oswestry Disability Index; SF-12, Short Form-12; VAS, visual analog pain scale.

FIGURE 2. Postoperative anteroposterior (A) and lateral (B) standing lumbar radiographs demonstrating unilateral pedicle screws, an anterior plate, and an interbody cage.
approach. All 3 patients recovered full strength by 2 months after surgery. One of the patients with hip flexion weakness also developed postoperative hypoesthesia to light touch in the ipsilateral thigh which resolved spontaneously by 3 weeks after surgery. There were no other postoperative neurological deficits. Two patients developed atraumatic coronal plane vertebral body fractures through screw holes placed for application of the anterolateral plate within 6 weeks after surgery. One patient was treated conservatively whereas the other underwent kyphoplasty for pain relief soon after developing her fracture. Osteoporosis was suspected to have played a role in the development of the fractures—dual energy x-ray absorptiometry scans revealed T-scores of −3.6 and −2.6 for these 2 patients, respectively. Both patients went on to successful interbody fusion with complete resolution of preoperative leg pain.

DISCUSSION

This is the first report in the literature of a novel technique for anterior and posterior stabilization of a LTIF. Although the patient cohort is small, validated outcomes instruments were used, and fusion was assessed by CT scan in most cases. The data suggest that unilateral pedicle screw fixation may be adequate to achieve high fusion rates after LTIF surgery using anterior instrumentation. The data also suggest that applying this technique in patients with osteoporosis may lead to a significant risk of postoperative vertebral body fracture.

Ozgur et al\(^1\) reported on 13 patients who underwent LTIF stabilized by percutaneous pedicle screws. Unfortunately the authors did not report clinical or radiographic outcomes nor did they mention whether pedicle screws were placed unilaterally or bilaterally.

Unilateral posterior fixation has been reported previously after lumbar fusion. An early report on unilateral versus bilateral posterior fixation was published by Kabins et al\(^4\) using the variable screw placement system for posterior fusion without anterior column fusion. This study reported equivalent pseudoarthrosis rates in the unilateral and bilateral groups, with one occurrence in each group and no significant differences in operative time (291 and 275 min, respectively) or blood loss (952 and 992 mL, respectively). Fusion rate was reported to be 97% and was assessed using only plain radiographs, and therefore interpretation of these data is difficult.

With a similar study design and using modern instrumentation, Suk et al\(^5\) and Fernandez-Fairen et al\(^6\) both compared unilateral versus bilateral pedicle screws placement in patients undergoing decompression and posterolateral fusion for spinal stenosis and spondylolisthesis. Decreased operative time was reported in both studies but no significant differences were found between unilateral and bilateral groups with respect to operative blood loss, fusion rate, and complication rate.

Unilateral pedicle screw constructs have also been described in combination with TLIF in which a single paramedian approach lends itself to placement of interbody devices and unilateral pedicle screw fixation without violation of midline structures. Deutsch and Musacchio\(^7\) published a prospective series of 34 patients who underwent TLIF with unilateral pedicle screw instrumentation for "mechanical axial lumbar pain" with evidence on magnetic resonance imaging of single level degenerative disc disease. Operative time averaged 4 hours and the authors estimated an average of 100 mL in blood loss. Included patients demonstrated significant improvements in ODI and VAS. CT scans at 6 months postoperatively demonstrated fusion in 13 of 20 patients (65%). Although radiographic follow-up or indices such as ODI or SF-12 scores were not reported, Tuttle et al\(^8\) found similar improvement in VAS in a study of unilateral posterior fixation after TLIF with average operative time of 178 minutes and estimated blood loss of 305 mL.

The fusion rate in this series was 100% and is based largely on CT scans obtained regardless of a patient’s clinical course at 1 year after surgery. The fusion rate in this series is comparable to that reported in other studies described above using unilateral posterior fixation ranging from 90% to 100%\(^6,8\) with the exception of Deutsch and Musacchio\(^7\) who reported a fusion rate of 65% but this was based on follow up of only 6 months.

The operative time reported in our series is longer than that reported by Deutsch and Musacchio\(^7\) and Tuttle et al\(^8\) in the TLIF series described above but...
estimated blood loss in our series was intermediate between these 2 reports. The increased operative time is not surprising given the increased time required for 2 separate procedures and repositioning, prepping, and draping the patient between the lateral and posterior approaches. Although placing pedicle screws with the patient in a lateral decubitus position is feasible, this position makes use of the operating microscope impossible which is often used for microsurgical decompression.

Although VAS and ODI scores demonstrated significant improvement at final follow-up compared with preoperative scores with reductions of 4.1 and 26 points, respectively, some patients continue to experience low back pain. This is not a surprising finding in a cohort of patients whose primary surgical indication was radiculopathy and not axial back pain. With average final VAS scores of 4.5 and ODI scores of 19, it is difficult to separate the residual moderate disableity into operative level symptoms and symptoms from other spondylotic motion segments in the lumbar spine. In several of the series described above, study parameters were careful to exclude patient with multilevel disease to present a clearer picture of the results of surgical intervention. Regardless, our final average ODI score of 19 was marginally lower than that reported by Deutsch and Musacchio. Successful outcome and patient satisfaction after surgical decompression and fusion for stenosis at one level in the setting of degenerative changes at other adjacent levels relies on preoperative counseling to establish before surgery that patients trade the limited scope of a one level surgery for the possibility of residual symptoms postoperatively from other untreated levels.

A potential concern regarding use of unilateral posterior instrumentation is that the construct will not be stiff enough to prevent cage migration or subsidence. A recent report by Aoki et al regarding migration of TLIF cages in 3 patients, 2 of whom had undergone unilateral posterior fixation, raised concerns that unilateral posterior fixation may not be stiff enough to prevent graft migration. In our series, although modest in size, we saw no change in cage position in any patient postoperatively, suggesting that the unilateral instrumentation did provide enough support to allow for successful interbody fusion. Although longer follow-up and increased cohort size will be needed, this issue underscores a potential significant advantage of the XLIF cage which is its increased stability owing to the width of the cage which rests on apophyseal bone on either side of the vertebral body. An additional theoretical benefit of the combination of a broad cage and maintenance of the anterior longitudinal ligament is minimization of subsidence and the risk of cage extrusion when restoring disc space height to increase lordosis and indirectly decompress foraminal stenosis.

Our series included 2 patients with major postoperative complications which were instrumentation related. Both patients who developed coronal plane vertebral body fractures were osteoporotic women in their 70s who had sudden postoperative onset of low back pain without history of trauma. In these patients, the unilateral posterior instrumentation may have contributed to the development of fracture. A small degree of subsidence is common after the application of interbody cages. As the cage subsided in these cases, a fracture propagated through the screw hole from the fixed angle anterolateral plate, creating the coronal plane fracture pattern. Based on this experience, we no longer use anterolateral plating in patients with vertebral osteopenia.

Finally, our series had a 23% rate of transient postoperative hip flexor weakness. This may result from the direct surgical trauma to the psoas muscle inherent in the lateral approach. It is currently unknown whether the use of anterolateral instrumentation itself is associated with transient hip flexor weakness.

There are several limitations inherent to this study. The patient cohort was small. The study should be considered a preliminary report on a novel instrumentation technique and further studies using larger cohorts are needed. The fusion rate observed in our study was high, but whether the high fusion rate should be attributed to the pedicle screws, the anterior plate, or both is unknown. Further studies with other instrumentation permutations such as unilateral pedicle screws only, anterior plate only, or standalone XLIF are needed to clarify the need for anterior and/or posterior instrumentation.

REFERENCES