Minimally Invasive Lumbar Transfacet Screw Fixation in the Lateral Decubitus Position After Extreme Lateral Interbody Fusion

A Technique and Feasibility Study

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Study Design: Prospective evaluation of 10 patients undergoing minimally invasive lumbar interbody fusion for degenerative disk disease and radiculopathy.

Objective: To assess the feasibility of percutaneous lumbar transfacet screw fixation in the lateral decubitus position after lateral interbody fusion.

Summary of Background Data: Lumbar interbody fusion is commonly performed for the treatment of degenerative disk disease with associated radiculopathy due to foraminal stenosis or disk protrusion. Minimally invasive techniques, such as the lateral interbody fusion, have been developed to achieve this while reducing operative morbidity. Subsequent vertebral fixation is best achieved with a pedicle screw and rod construct in the prone position. Transfacet screw placement has been shown to have near biomechanical equivalence and may reduce operative time and morbidity if placed while the patient remains in the lateral decubitus position.

Methods: Ten patients with back pain and radicular pain due to single-level degenerative disk disease at L3-L4 or L4-L5 underwent minimally invasive lateral interbody arthrodesis with placement of bilateral percutaneous transfacet screws in the lateral decubitus position. Patients had close perioperative follow-up including recordings of intraoperative blood loss, operative time, and hospital length of stay. Clinical outcome measures including visual analog scores (VAS) were assessed preoperatively and at last follow-up with a minimum of 6 months. Dynamic radiographs were obtained at last follow-up to evaluate the instrumentation and fusion rate.

Results: The procedure was well tolerated by all patients. Mean operative time was 2 hours and 42 minutes. Mean blood loss was 26.5 mL. Mean hospital length of stay was 46.5 hours. Nine of 10 patients had good-to-excellent relief of their preoperative back pain and leg pain. Mean preoperative VAS score for back pain was 8.9 and for leg pain was 8. At a mean follow-up of 8.2 months, mean postoperative VAS score for back pain was 0.9 and for leg pain was 0.9. There were no complications. One patient suffered persistent mild leg dysesthesias. There were no instances of graft or screw dislodgement on follow-up imaging.

Conclusions: Minimally invasive percutaneous transfacet screw fixation can be performed safely and effectively in the lateral decubitus position. This is an attractive option for posterior percutaneous fixation that can lead to a reduction of operative time and surgical morbidity in select cases.

Key Words: transfacet screw, lateral interbody fusion, minimally invasive, degenerative disk disease

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Spinal fusion for degenerative disease of the lumbar spine has been shown to be superior to conservative management for debilitating back pain.[1] Intervertebral fusions are being performed with increasing frequency and have several important advantages over traditional posterolateral fusions. The increased surface area for fusion and ability to place the graft material under compressive forces help to facilitate arthrodesis. In addition, the ability to reestablish normal disk space height helps to indirectly decompress central and in particular foraminal stenosis.

The first description of an intervertebral fusion was by Capener[2] in the 1930s. This was an anterior lumbar interbody fusion (ALIF) for the management of spondylolisthesis. In 1953, Cloward[3] introduced the posterior lumbar interbody fusion (PLIF) through a midline posterior approach. A posterolateral variation on the PLIF, the transforaminal interbody fusion (TLIF), was introduced by Harms and Jeszenszky[4] in 1998. He described an interbody fusion performed through a posterolateral trajectory, decreasing potentially harmful retraction on the neural elements. In an effort to preserve the posterior osteoligamentous structures while avoiding a true abdominal approach, Pimenta and Colleagues introduced the extreme lateral interbody fusion technique in 2001.[5] This is a less disruptive modification on the traditional retroperitoneal approach to the lumbar spine.

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The lateral lumbar interbody fusion is a true lateral approach through the retroperitoneal space to the spine. This technique offers many of the same advantages of an ALIF while decreasing some of the inherent risks of an anterior approach to the lumbar spine, notably the risks of injury to the great vessels and hypogastric plexus. The use of tubular retractors with this minimally invasive technique allows for a smaller incision, minimizes tissue dissection, and substantially decreases blood loss. This approach also preserves normal spinal anatomy to the greatest degree when compared with the ALIF, PLIF, or TLIF. It does not disrupt the anterior or posterior longitudinal ligaments and preserves the integrity of the facet joints and posterior paraspinal musculature.

Despite the minimally disruptive nature of this technique, it is prudent to supplement the interbody fusion with vertebral fixation particularly in those patients who have a higher risk of pseudoarthrosis or graft subsidence such as smokers, diabetics or those with osteoporosis. Although lateral plating is commonly performed, the gold standard for lumbar internal fixation has long been the pedicle screw and rod construct. This generally requires prone repositioning after lateral interbody graft placement due to the challenges inherent in pedicle screw insertion in the lateral position.

Posterior transfacet screw placement represents another established option to facilitate arthrodesis after interbody graft insertion. A number of studies have demonstrated clinical efficacy with favorable biomechanical data.[6–9] This technique has only been described with patients in the prone position. The present study describes and assesses the feasibility of the technique of percutaneous transfacet screw placement in the lateral decubitus position after lateral interbody fusion.

MATERIALS and METHODS

Patient Population

Ten consecutive patients underwent surgical treatment of single-level lumbar degenerative disk disease (Table 1). Preoperative evaluations included detailed neurological physical examinations, dynamic and static radiological studies of the lumbosacral spine and lumbosacral magnetic resonance imaging (MRI) or computed tomography (CT). These imaging studies revealed single-level degenerative disk disease with moderate-to-severe disk space collapse and foraminal stenosis that correlated with the patient's symptoms. Patients were candidates for surgery if they presented with severe back pain with radiculopathy that failed to respond to conservative treatment such as bed rest, nonsteroidal anti-inflammatory medication, selective nerve root injections, and physical therapy. The operative time, blood loss, and length of hospitalization were recorded for each patient. Postoperative results were recorded with the visual analog scale and classified according to the criteria set forth by MacNab, as follows: excellent, complete resolution of symptoms; good, marked improvement but occasional pain; fair, some improvement, with a need for pain medications and significant functional restrictions; poor, no change in symptoms or worsening. Fusion was defined by the absence of malalignment and motion on dynamic radiographic imaging at last follow-up and/or bridging trabecular bone on CT.

Study Design

Preoperative and postoperative outcome data were obtained prospectively at each clinic visit. Data analysis from this study was performed after retrospective chart reviews of patients who underwent minimally invasive lateral lumbar interbody fusion by a single spine surgeon (J.M.V.) at Georgetown University Hospital, Washington, DC and Calvert Memorial Hospital in Prince Frederick, MD.

Operative Technique

Lateral Interbody Fusion

The technique for lateral interbody fusion (extreme lateral interbody fusion technique or direct lateral interbody fusion) has been described elsewhere.[5,10] Briefly, the surgical technique begins by placing the patient in the lateral decubitus position and securing the chest and legs to the operating table with tape. The table is then flexed to provide greater access and exposure to the lower

TABLE 1. Patient Data

Patient	Age/Sex	Level	Operating Room Time (min)	Blood Loss (mL)	Length of Stay (h)	Complications	VAS-Back Pre	VAS-Back Post	VAS-Leg Pre	VAS-Leg Post	Outcome (Follow-up)
1	66/M	L4-L5	240	25	45.5	Leg dysesthesias	10	0	10	0	Good (13 m)
2	39/F	L4-L5*	240	50	49	None	8	5	8	5	Fair (6 m)
3	61/F	L4-L5*	200	25	46	None	10	0	10	0	Excellent (7 m)
4	63/F	L3-L4	150	25	19	None	10	0	5	0	Excellent (12 m)
5	56/F	L3-L4	165	30	75	None	9	1	9	1	Good (12 m)
6	56/F	L4-L5	150	20	87	None	10	0	10	0	Excellent (8 m)
7	72/F	L3-L4*	95	25	48	None	9	0	9	0	Excellent (6 m)
8	58/M	L4-L5	160	25	24	None	6	2	4	3	Good (6 m)
9	50/F	L4-L5	110	20	26	None	8	0	8	0	Excellent (6 m)
10	63/F	L3-L4	105	20	46	None	0	0	7	0	Excellent (6 m)

*Previous lumbar decompressive surgery.
VAS indicates visual analog scores.

lumbar disk spaces. After anteroposterior (AP) and lateral fluoroscopic images are optimized, a single 2.5-cm lateral incision centered over the disk space of interest is made and access to the retroperitoneal space is obtained with blunt dissection through the abdominal wall musculature. Once the psoas muscle is visualized, continuous electromyographic monitoring is used to allow safe passage of sequential dilators through the psoas muscle. An appropriately sized working channel is ultimately inserted and fixed to the table and the inner dilators are removed. Soft tissue within the channel is carefully inspected for the presence of neural structures with a nerve probe. The working channel is then expanded and a shim inserted into the disk space to secure the retractor to the spine. A thorough discectomy is then performed in the traditional manner and the contralateral annulus is released. After appropriate endplate preparation, an interbody graft (polyetheretherketone) is then packed with osteoinductive and conductive material and inserted into the disk space. Satisfactory placement of the graft is confirmed with AP and lateral fluoroscopy. The working channel is then removed and the incision is closed in the standard manner.

Transfacet Screw Fixation

For posterior fixation, the patient remains in the lateral decubitus position and the table is realigned. A 1.5-cm midline incision is planned over the spinous process 2 levels above the disk space of interest. Fluoroscopic images are optimized such that in the AP view the inferior endplate of the superior vertebra appears as a single line. On this AP view, the entry point lies at the intersection of a vertical line drawn at the medial aspect of the pedicles with the inferior endplate of the superior vertebra being fused (Figs. 1A, 2B). The lateral view is used to confirm the proper angle of the Jamshidi needle through the facet joint and into the pedicle of the inferior vertebra (Fig. 1B). The trajectory of the screw in the lateral plane is directed so the tip of the screw will end at the transition point of the pedicle and vertebral body and at the inferolateral corner of the pedicle in the AP plane (Figs. 1A, B). This should result in an approximately 30-degree caudal angulation and a 15-degree lateral angulation of the screw.[11] Once the incision is made, the fascia adjacent to the spinous process bilaterally is opened with bovie electrocautery. A Jamshidi needle is docked onto the aforementioned entry point using AP and lateral fluoroscopic imaging and secured in position with a mallet. The inner stylet is removed and a Kirschner (K) wire is driven across the facet joint and inferior pedicle using AP and lateral views. A series of dilators are inserted over the K-wire and the outer dilator is kept in situ. A cannulated drill and tap are passed over the K-wire followed by the insertion of the cannulated transfacet screw (Perpos, Interventional Spine, Figs. 2A, C, D). After x-ray imaging confirms proper positioning, the K-wire is removed and the contralateral transfacet transpedicular screw is inserted through the same incision. The wounds are then closed in the standard manner.

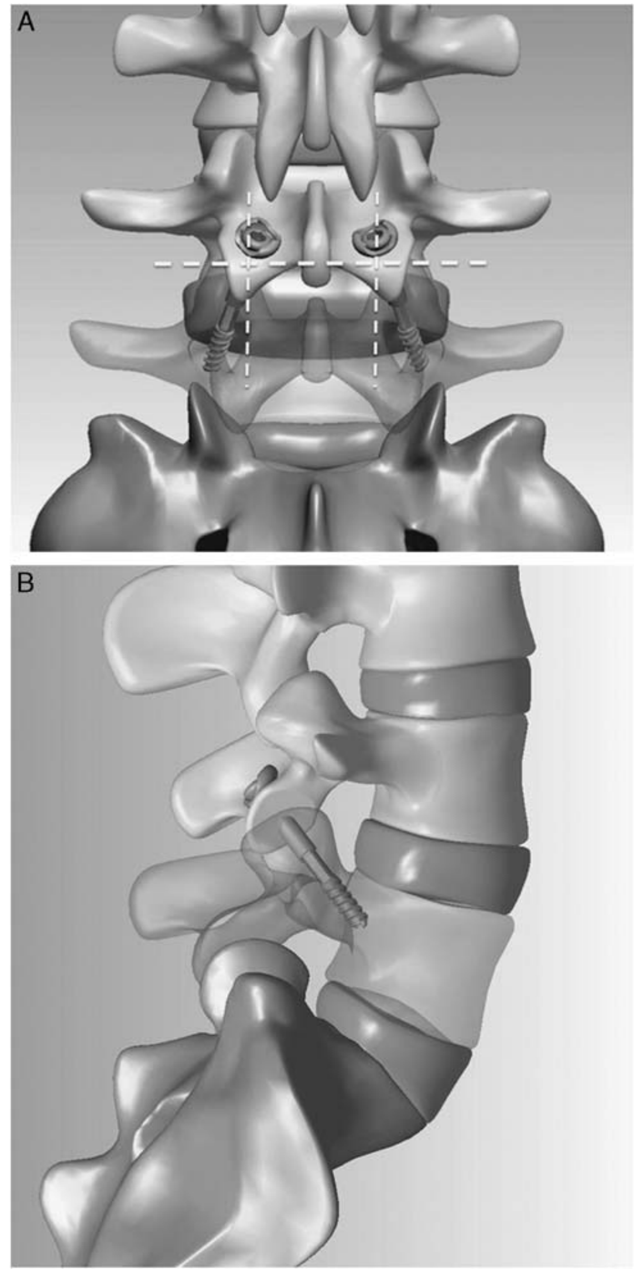

FIGURE 1. Anteroposterior (AP) (A) and lateral (B) schematic illustrations demonstrating transfacet screw insertion at L4-L5. The starting point of screw insertion lies at the intersection of the inferior endplate line of the vertebra above with a vertical line drawn at the medial aspect of the pedicles on an AP view (A, dashed lines).

Case Illustration #1

A 63-year-old woman presented with severe right-sided leg pain of 6 months duration refractory to conservative measures (patient #10, Table 1). Her symptoms were exacerbated with standing and walking and significantly limiting ambulation. Her leg pain radiated into the right groin and anterior thigh. Her physical examination was notable for a depressed right quadriceps

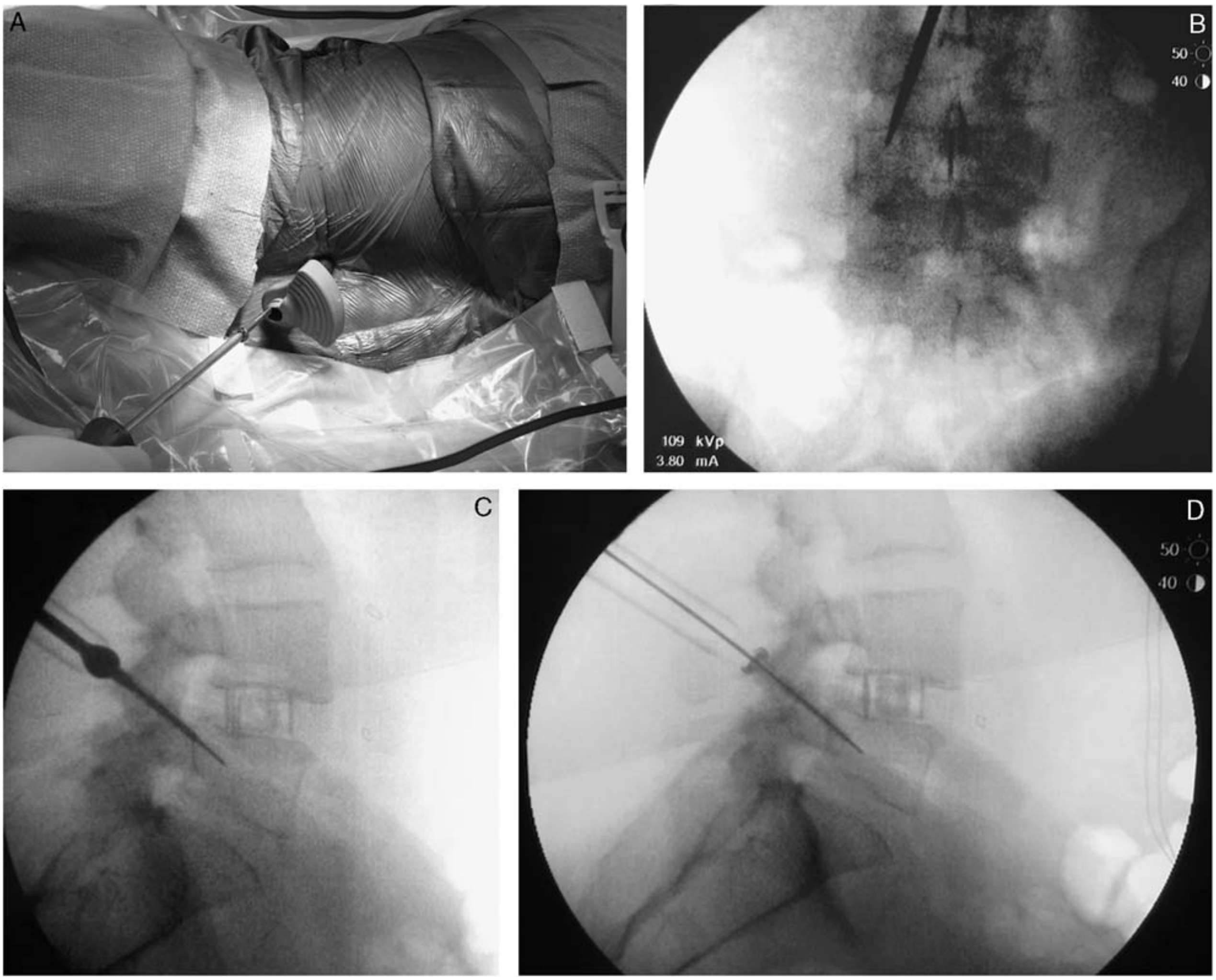

FIGURE 2. A, Intraoperative view with the patient in the lateral decubitus position with the right side up (head to the left). An unattached tubular dilator is in place from a midline incision. The transfacet screw is inserted over a Kirschner wire. Intraoperative anteroposterior (B) and lateral (C, D) fluoroscopic views demonstrating guidewire (B), drill (C), and screw (D) insertion at L4-L5.

reflex. MRI studies revealed severe right-sided lateral recess and foraminal stenosis at L3-L4 with evidence of right-sided facet arthrosis and associated disk space collapse (Figs. 3A–C). Dynamic x-rays revealed no instability. She subsequently underwent an L3-L4 lateral interbody fusion, restoring disk and foraminal height and allowing indirect decompression of the L3 nerve root. This was supplemented with bilateral percutaneous transfacet screws placed with the patient remaining in the lateral position (Figs. 3D–F). She enjoyed complete resolution of her leg pain after surgery at the time of her 6-month follow-up.

Case Illustration #2

A 61-year-old morbidly obese woman presented with chronic back pain and associated right leg pain in an L5 distribution (patient #3, Table 1). She previously underwent 2 right L4-L5 discectomies several years prior but unfortunately suffered recurrent leg symptoms and increasing mechanical low back pain. A course of conservative management including 5 epidural steroid injections provided no relief of her symptoms. Her physical examination was remarkable for diminished sensation to pinprick along the lateral aspect of the right calf with weakness on dorsiflexion. Plain x-rays and MRI demonstrated L4-L5 degenerative disk disease with associated foraminal stenosis on the right, a recurrent right disk herniation, and associated epidural scarring (Figs. 4A, B). She subsequently underwent an L4-L5 lateral interbody fusion with bilateral percutaneous transfacet screw placement (Figs. 4C, D). At her 7-month follow-up, she enjoyed complete resolution of both her back and leg pain as well as her leg numbness and weakness.

RESULTS

Ten patients underwent minimally invasive single-level lumbar interbody fusion at either L4-L5 (n = 6) or L3-L4 (n = 4). The patient characteristics are presented

FIGURE 3. Patient #10 (Table 1). Preoperative parasagittal T2-weighted magnetic resonance imaging (MRI) demonstrating degenerative disk disease with severe foraminal stenosis causing compression of the exiting dorsal root ganglion on the right (A, arrow). Axial view (B) showing right-sided lateral recess stenosis (arrow). Coronal MRI showing unilateral disk space collapse (C, arrow). Postoperative lateral and anteroposterior x-rays demonstrating graft and screw placement (D, E). Postoperative incisions (F, white arrows).

in Table 1. Mean age was 58.4. There were 8 women and 2 men. Three of 10 patients had undergone a previous laminectomy and medial facetectomy. The mean estimated blood loss was 26.5 mL. The mean operative time was 2 hours 42 minutes. Two patients were morbidly obese (patient #2 and 3, Table 1) with a body mass index of 41 and 50 kg/m^2, respectively, which made proper fluoroscopic imaging difficult and extended operative time. The mean operating time has been shortened significantly with greater experience with the last 4 surgeries performed at a mean of $<$ 2 hours (1 h 58 min). Patients were discharged home with a mean of under 2 days (mean length of stay: 46.5 h, Fig. 5).

All patients enjoyed significant improvement in both back and leg pain. At a mean follow-up of 8.2 months, mean visual analog scores (VAS) score for back pain was 0.9 compared with 8.9 before surgery. The mean VAS score for leg pain was 0.9 compared with 8 before surgery. Nine of 10 patients had an excellent-to-good score based on MacNab's criteria. One patient (patient #2) had a fair improvement in her symptoms. Her residual complaints were confounded by her history of fibromyalgia. Postoperative MRI was performed revealing no evidence of stenosis or nerve impingement. Patient #1 (Table 1) developed leg dysesthesias that persisted at 13 months' follow-up. This was due to retraction of the visualized genitofemoral nerve during the transpsoas discectomy at L4-L5. The patient stated that these symptoms were far less significant compared with his resolved preoperative back and leg pain. One patient (#8, Table 1) had limited improvement in leg pain due to coexisting severe peripheral neuropathy. There were no intraoperative or immediate postoperative complications. There was no evidence of screw back-out or pull-out on follow-up imaging studies. There were no instances of graft dislodgement. Dynamic x-ray imaging studies at last follow-up and CT (obtained for those patients followed for 12 mo or more) demonstrated no evidence of instability, malalignment, or pseudoarthrosis (Figs. 6A, B).

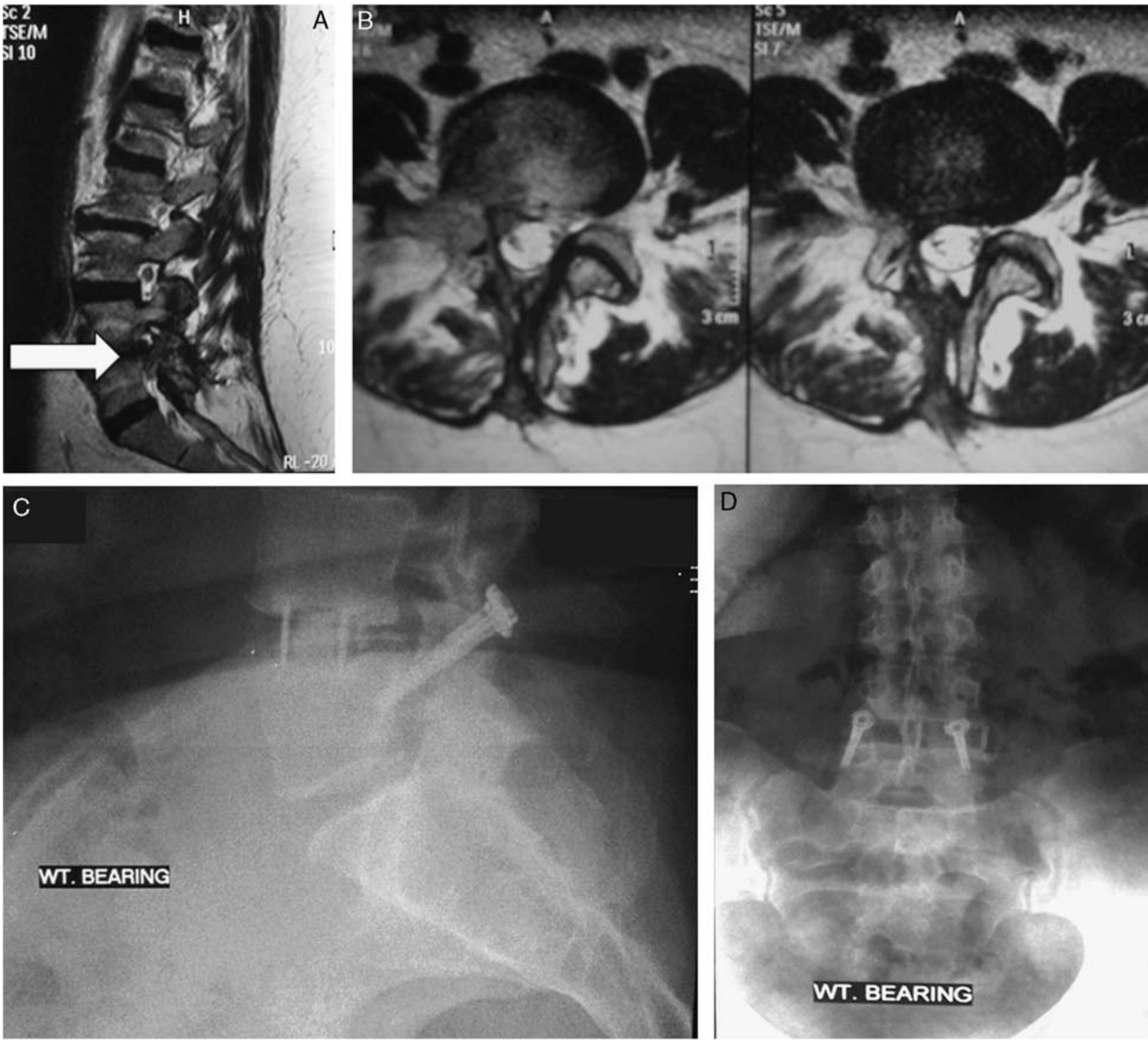

FIGURE 4. Patient #3 (Table 1). Preoperative parasagittal T2-weighted magnetic resonance imaging demonstrating degenerative disk disease with severe foraminal stenosis (A, arrow). Axial views (B) showing right lateral recess stenosis from a recurrent disk herniation and epidural scarring from her previous surgeries. Postoperative lateral (C) and anteroposterior x-ray (D) showing an intervertebral graft at L4-L5 with bilateral transfacet screws restoring disk space and foraminal height. A more lateral starting point was chosen on the right side due to her previous medial facetectomy.

DISCUSSION

Minimally invasive lateral lumbar interbody fusion offers several advantages over traditional lumbar interbody fusion techniques. The lateral approach avoids retraction of the neural elements within the spinal canal when compared with posterior (TLIF, PLIF) approaches. It preserves all dorsal osteoligamentous structures in addition to both the anterior and posterior longitudinal ligaments. It also permits the insertion of a large intervertebral graft that maximizes the surface area for fusion while restoring disk space height and achieving indirect foraminal decompression.

There are several drawbacks to this approach. The lateral interbody fusion technique should not be used in patients with severe canal stenosis unless a separate decompressive laminectomy in the prone position is planned. The presence of the iliac crest precludes an approach to L5-S1. Tubular dilation through the psoas muscle can produce postoperative psoas weakness and dysesthetic thigh pain particularly at L4-L5.[12] Finally, there is a learning curve for the surgeon that can increase operative time and complications early in the experience.[13]

Continued motion at the level of the intervertebral segment being treated can lead to displacement of the

FIGURE 5. Preoperative images of patient #4 (Table 1). A 63-year-old woman with severe left-sided low back and leg pain. Preoperative anteroposterior view (A) showing unilateral disk space collapse with coronal deformity (white arrow). Sagittal T2-weighted magnetic resonance images. (B) Magnetic resonance imaging showing severe degenerative disk disease at L3-L4. She was discharged on postoperative day 1 and enjoyed complete resolution of both back and leg pain at 1 year.

interbody graft and possible pseudoarthrosis if supplemental instrumentation is not used. Despite the minimally disruptive nature of the approach, it is prudent to use instrumented fixation to maximize the fusion potential especially in patients with medical comorbidities placing them at increased risk for pseudoarthrosis. Several lateral plate and screw constructs are commercially available and can be placed at the same setting after graft insertion. However, recent biomechanical data have shown that lateral plating systems provide poor resistance to both flexion and extension compared with pedicle screw instrumentation.[14] Furthermore, additional dissection and retraction of the psoas muscle is frequently necessary for plate fixation, which can increase the risk of psoas and nerve injury particularly at L4-L5. Posterior fixation systems are advantageous because they provide superior resistance to flexion/extension forces. There are several posterior fixation techniques to choose from.

Pedicle screw fixation was first described in 1969 by Harrington and Tullos.[15] This was followed by Roy-Camille's incorporation of the pedicle screw and plate constructs.[16] These methods have since been improved upon and gained wide acceptance as the gold standard for spinal instrumentation. The pedicle screw and rod system achieves fixation along all 3 columns, resisting motion in all directions. Complications associated with pedicle screw fixation, include screw misplacement, carrying with it the potential for nerve root compression, and cerebrospinal fluid leak. Pedicle screws are traditionally inserted in the prone position and are now routinely placed percutaneously.[17,18]

Translaminar facet screw fixation was first described by Magerl[19] in 1984. This technique involves the insertion of a long screw beginning at the contralateral spinolaminar junction and passing it through the ipsilateral facet joint to terminate at the base of the transverse process. This is a low profile fusion construct that crosses the facet joint surfaces bicortically and can achieve a solid supplemental construct after interbody graft placement. As a result of the long path of the screw dorsal to the spinal canal, there is an increased risk of neural compression. Insertion of a screw along the lamina into the facet requires a wide angle of insertion, necessitating a broad surgical field. This makes this stabilization technique difficult to achieve in the lateral position using percutaneous methods and would also require 2 separate incisions.

Transfacet fixation has gained popularity in recent years. This technique achieves vertebral segment fixation with the placement of bilateral low profile screws. It avoids potential disruption of the facet joints of the superior articulating vertebrae as seen in pedicle screw fixation and could decrease the potential for adjacent segment instability. The trajectory of placement minimizes the potential for canal violation and nerve injury or durotomy. The lag screw design helps to compress the facet joint, theoretically increasing construct stiffness and the potential for facet arthrodesis. Transfacet screws can be placed throughout the lumbar spine although the increasing sagittal angulation of the facet joints rostrally can present a challenge at L2 and above. CT imaging with 3-dimensional reconstruction is useful to study facet orientation in these circumstances. Care must be taken during lateral decubitus positioning to plan for the angle of screw insertion. The patient's natural thoracic kyphosis may complicate screw placement particularly at more rostral levels.

In a study reported by Benzel and colleagues in 2003, the stabilization performance of transfacet screws was assessed in both short-term and long-term cycling. Transfacet pedicle screw fixation was found to be biomechanically equivalent to pedicle screw fixation in resisting flexion-extension forces.[6] Jang and Lee performed a retrospective study evaluating ALIF with translaminar facet screw fixation performed on 44 patients and ALIF with pedicle screw fixation performed on 40 patients. There was no significant difference in clinical outcome and fusion rates.[7] In a biomechanical study reported by Kim and colleagues in 2004, 3 fusion constructs were compared as supplemental instrumentation for anterior lumbar interbody fusion. It was found that the pedicle screw and rod, the translaminar facet screw, and transfacet pedicle screw constructs were all comparable fixation techniques, except in lateral bending, where the transfacet transpedicular screw fixation was inferior.[8] Another biomechanical comparison study of a transfacet fixation

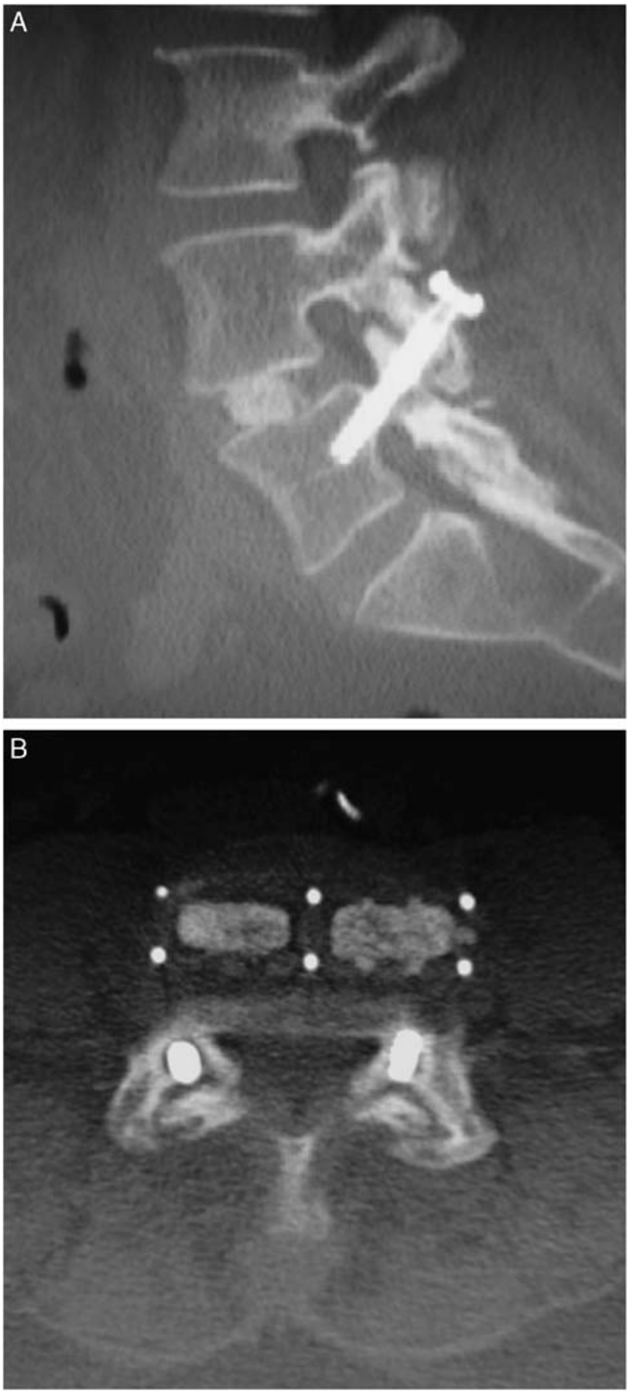

FIGURE 6. Parasagittal computed tomography reconstruction demonstrating transfacet transpedicular screw placement with restoration of foraminal height from intervertebral graft placement (A). Axial view (B).

device demonstrated similar stability to a pedicle screw system.[9]

The percutaneous placement of transfacet screws has several advantages. A single 1.5-cm midline incision is required for bilateral placement. The use of tubular dilators minimizes tissue dissection through the paraspinal musculature, makes blood loss negligible, and mitigates postoperative pain. Screw placement in the lateral position further adds to the learning curve but can be easily adopted after a small number of cases. Bilateral screw placement with experience routinely takes less than an hour regardless of patient size, facet pathology, or previous surgery at the level of interest. This significantly shortens operative time when compared with prone repositioning for pedicle screw placement. A single midline incision compared with 4 incisions for percutaneous pedicle screw insertion also minimizes tissue dissection and should diminish immediate postoperative pain. Although percutaneous pedicle screws can be placed in the lateral decubitus position after lateral interbody fusion, the added potential risk due to a greater degree of technical difficulty may not justify its use.

The biomechanical strength of transfacet screw fixation combined with its percutaneous insertion in the lateral position through a single incision makes it an ideal means of stabilization after a minimally invasive lateral lumbar interbody fusion. Nine of 10 patients in this feasibility study had a good-to-excellent clinical outcome with profound reduction in back and leg pain. These significant improvements by VAS can be attributed to careful selection criteria. The symptoms of all patients were directly referable to the pathologic condition and correlated with imaging findings. All patients had predominantly isolated and unilateral back and leg symptoms. There were no patients involved in worker's compensation. There were no patients on oral narcotics for >6 months preoperatively.

Although the patients in this report had degenerative disk disease without instability, the senior author (J.M.V.) has since treated patients with grade-1 spondylolisthesis without significant stenosis or severe facet arthropathy with this technique. Lateral decubitus positioning followed by graft insertion frequently reduces a mobile listhesis. Early results have been promising but greater follow-up is necessary. Patients with significant instability (grade 2 or greater), severe facet arthropathy, or deformity are not good candidates for transfacet screw fixation.

CONCLUSIONS

The placement of percutaneous transfacet screws in the lateral decubitus position for patients with lumbar degenerative disk disease is feasible and safe after lateral interbody fusion. Blood loss was minimal with short hospital stays and no complications. This is an attractive alternative to lateral plating or percutaneous pedicle screw placement that achieves posterior fixation while avoiding the need for prone repositioning. Longer follow-up is needed to confirm clinical efficacy and favorable fusion rates without graft or screw dislodgement.

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