SPINE Volume 29, Number 15, pp 1681–1688

Endoscopic Lateral Transpsoas Approach to the Lumbar Spine

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Study Design. A description of a novel surgical approach to the lumbar spine and a prospective evaluation of the early surgical outcomes.

Objectives. Describe the early postoperative results and the operative technique of a new, minimally invasive transpsoas approach for anterior fusion of the lumbar spine that minimizes the risk to large vessels and other critical structures.

Summary of Background Data. Standard anterior endoscopic approaches to the lumbar spine require mobilization of the great vessels and sympathetic plexus. Vascular injury and retrograde ejaculation are complications clearly associated with this approach. A retroperitoneal, transpsoas approach to the lumbar spine may reduce these risks.

Methods. From 1996 to 2002, 21 patients (13 females, 8 males; mean age 50.0 years) underwent an endoscopic, retroperitoneal transpsoas approach for exposure of the lumbar spine. Surgical indications included discogenic pain in 14 patients, spinal instability at a level adjacent to a previous fusion in 3 patients, and progressive degenerative scoliosis in 4 patients. Data were reviewed to document the early postoperative results for this procedure. Illustrations were created to clearly describe this approach.

Results. Average operative time for the single level cases was 149 minutes (range 120–170 minutes); blood loss was 150 cc (range 50–650); postoperative hospital stay was 4.1 days. At long-term follow-up, visual analogue scale scores had decreased an average of 5.9. Mean follow-up was 3.1 years (range 2 months–6.0 years). Six patients (30%) experienced paresthesias in the groin/thigh region. Five of these same patients also complained of groin/thigh pain (27%). Two patients had symptoms that lasted longer than 1 month. One patient was converted to a mini-open lateral approach. There were no vascular injuries.

Conclusions. Early results show the endoscopic lateral transpsoas approach to the lumbar spine to be a safe, minimally invasive method for anterior fusion of the first through the fourth lumbar vertebrae. Although there is a risk of groin/thigh numbness or pain, and these symptoms are mostly transient. This approach allows for exposure of the lumbar spine without mobilization of the great vessels or sympathetic plexus.

Key words: endoscope, fusion, spine surgery, transpsoas. **Spine 2004;29:1681–1688**

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Acknowledgment date: March 29, 2002. First revision date: March 28, 2003. Second revision date: September 24, 2003. Acceptance date: September 29, 2003.
The manuscript submitted does not contain information about medical device(s)/drug(s).
No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.
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Anterior approaches for lumbar interbody fusion have been increasingly utilized in an attempt to lower the incidence of pseudoarthroses and to recreate the patient's normal sagittal alignment.[1–16] The majority of complications associated with anterior lumbar interbody fusion (ALIF) are associated with the surgical exposure. Most of these techniques usually require the presence of an experienced general or vascular surgeon due to the risk of serious complications.[17,18] Although low, the incidence of great vessel injury or sympathetic plexus is not negligible, and the consequences of such potential injuries can be debilitating for the patient.[9]

In 1998, McAfee *et al*[8] described a minimally invasive, endoscopic anterior retroperitoneal approach to the lumbar spine with an emphasis on the lateral BAK. This technique does not require CO_2 insufflations, Trendelenburg positioning of the patient, entrance into the peritoneum, or anterior dissection near the great vessels. Following entry into the retroperitoneal space, the trajectory of McAfee *et al*'s approach is anterior to the psoas muscle, requiring a considerable amount of retraction of the psoas posteriorly. This causes significant muscular swelling and weakness after surgery. The goal of this study was to describe the clinical results of a more direct, minimally invasive route to anterior lumbar interbody fusion through an endoscopic, transpsoas approach to the lumbar spine that has never previously been described.

Materials and Methods

Twenty-one patients underwent lumbar spinal fusion *via* a lateral endoscopic transpsoas approach between March of 1996 and August of 2002. Data were reviewed to determine the early postoperative results. The senior author (J.J.R.) performed all surgical cases. Six patients underwent surgery at the Texas Back Institute in Dallas, Texas, and 15 patients at Cedars-Sinai in Los Angeles, California. The study group consisted of 13 females and 8 males with a mean age of 50.0 years, ranging from 35 to 73 years.

Patient Selection. All patients were referred for lumbar spinal surgery from a multidisciplinary pain clinic having completed at least 6 months of nonoperative management with physiotherapy, pain medications, and epidural injections, in cases with radiculopathy. Routine psychological evaluation was performed in all patients before treatment. Patients with nonphysiological signs at the time of examination, those with drug-seeking behavior, or with secondary gain issues were excluded from treatment until those issues were resolved. Patient data including preoperative and postoperative evaluations were collected on a prospective basis. Any information that was found

Table 1. Etiology of Pain in 21 Patients Undergoing the Lateral Endoscopic Transpsoas Approach for Lumbar Spinal Fusion.

Etiology	No. of Patients (%)
Discogenic pain	14 (67)
Adjacent level instability*	3 (14)
Progressive degenerative scoliosis*	4 (19)
Total	21 (100)

*Please see text for a more detailed description.

to be missing from the database was collected by retrospective review of the medical records.

The indications for surgery are demonstrated in Table 1. The majority of patients underwent surgery for discogenic pain (67%). Three patients (14%) underwent surgery for instability at levels that were adjacent to previously fused levels. Four patients (19%) underwent surgery for progressive degenerative scoliosis. In these patients, flexion–extension lateral radiographs demonstrated more than 3.5 mm of translation and anteroposterior radiographs showed 10° or more of scoliosis disc space collapse with "vacuum disc sign." Patients with discogenic pain were selected for surgery based on a history of mechanical symptoms and failed conservative therapy. In all patients, magnetic resonance imaging (MRI) demonstrated loss of disc space height and decreased T2 signal intensity (Figure 1).[19] All patients with discogenic pain were screened with discography. An absolute requirement for surgery was a positive discogram at the operated level with negative controls at the adjacent levels. Detailed methods for the objective evaluation of discograms have been published previously.[20,21] Patients in whom low back pain was the sole complaint and had no objective findings on discography were not treated with this surgery.

Surgical Technique. Following the induction of general endotracheal anesthesia, the patient is turned in a right lateral decubitus position (left side up) on a bean bag and utilizing a radiolucent, graphite, Jackson Maximum lateral access Table (O.S.I. Corporation, Union City, CA). A left-sided approach to the surgery is preferred to a right-sided approach because it is easier to dissect the aorta off the spine than to dissect around the more friable inferior vena cava. Anteroposterior and lateral intraoperative fluoroscopy is then utilized to verify the approximate level of the desired disc space with a metal marker on the skin in the midaxillary line (Figure 2). This method optimizes the placement of the working portal directly over the desired disc space. The patient is prepared and draped in the standard fashion. A 1 cm incision is made at the level of the disc space. The Optiview optical trocar (Ethicon Endosurgery, Cincinnati, OH; Figure 3) is then inserted. The 10 mm laparoscope is then inserted into the Optiview dissecting trocar and focused on the subcutaneous tissue. The trocar has 2 "winged keel" cutting surfaces that will not penetrate a fascial layer such as the peritoneum unless the trochar is twisted. The 3 abdominal muscular layers overlying the peritoneum are penetrated in sequence under direct visualization until the preperitoneal fat is encountered. One or a combination of 3 different techniques may be used at this point to create a potential space that is superficial to the peritoneum (the retroperitoneal space). The endoscope is used as a dissecting device under direct visualization until the laterally oriented fibers of the psoas major muscle are viewed.

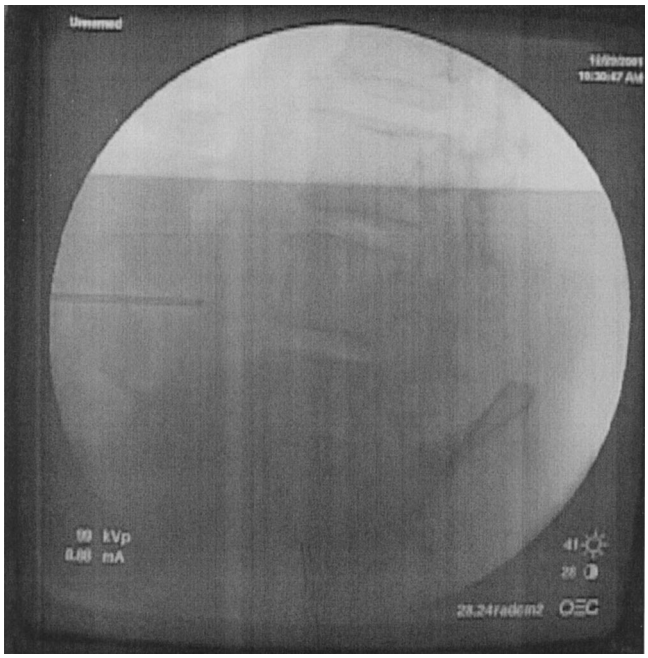

Figure 2. The surgeon is utilizing intraoperative fluoroscopy in order to verify the location of the desired disc space prior to drawing the incision and prepping the patient.

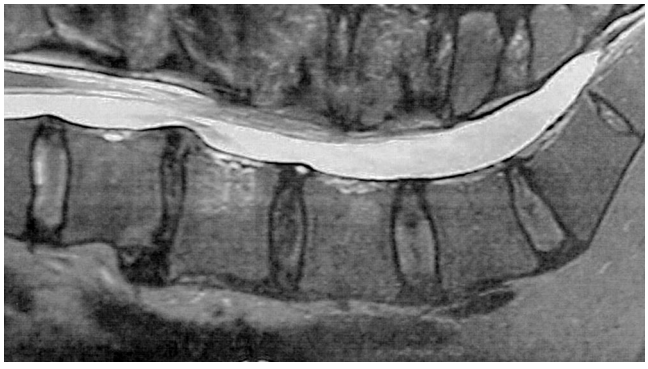

Figure 1. Sagittal T2-weighted MRI demonstrating loss of disc space height and decreased T2 signal intensity at the L2–L3 interspace.

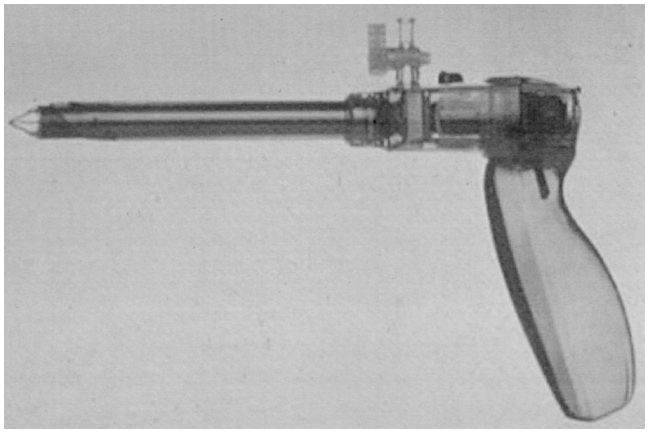

Figure 3. Optiview trochar.

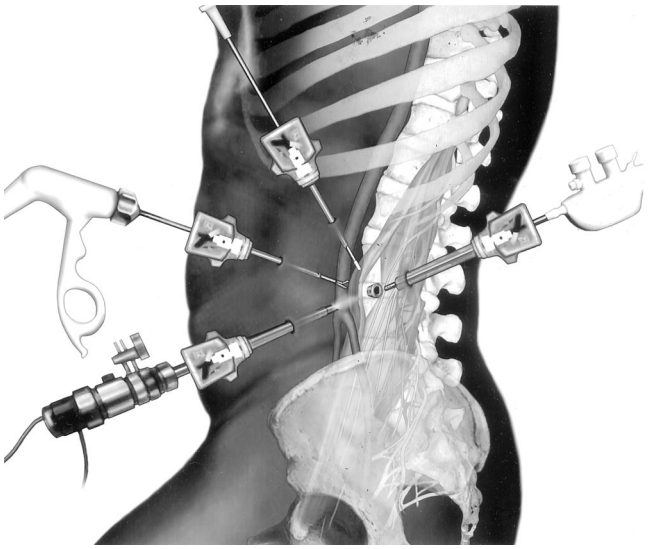

Figure 4. Portal positioning for endoscopic, transpsoas approach to lumbar disc space.

Blunt finger dissection can then be used to increase this space. A dissection balloon (Origin, Menlo Park, CA) can be filled with 1 L of air in order to dissect the retroperitoneal space, more correctly referred to as the retrotransversalis fascia. Alternatively, carbon dioxide insufflation can be utilized in the retroperitoneal cavity up to a pressure of 20 mm of mercury to create a working space.[14] The longitudinal fibers of the psoas major muscle are then identified. The genitofemoral nerve is usually visualized on the surface of the psoas muscle.

Following enlargement of the retroperitoneal space, 2 additional 1 cm incisions are made. The original portal, which is directly orthogonal with the disc space, is utilized as the working portal for use of the high-speed drill, curettes, and Kerrison and pituitary rongeurs. The second portal is necessary for the 10 mm laparoscope. A third portal is used for retraction of the psoas muscle fibers and a fourth 5 mm portal is required for suctioning (Figure 4). The dissection is carried in a longitudinal fashion in line with the muscle fibers and through the anterior two thirds of the psoas muscle. The relatively avascular intervertebral disc space can often be palpated through the psoas muscle and is exposed first (Figure 5). The respective midportions of the adjacent vertebral bodies are then exposed. If necessary, the lumbar segmental vessels are ligated and divided. In most cases, this is not necessary.

Once the vertebral level is confirmed fluoroscopically, the transversalis fascia, perinephric fascia, and retroperitoneal contents are retracted anteriorly. A harmonic scalpel (Ethicon Endosurgery, Cincinnati, OH) is used to mark the intervertebral disc space. At this point, it is important for the surgeon to have access to various methods of hemostasis. We most frequently utilize the harmonic scalpel, but also have available to us bipolar endoscopic electrocautery, Endo-Avitene Microfibrillar Collagen (Humacao, Peurto Rico) and Gelfoam (Upjohn Corp., Kalamazoo, MI) soaked in Thrombin (GenTrac Corp., Middletown, WI). If necessary, the segmental vessels are dissected from the underlying bone and elevated with a right-angled clamp. It is important to use 2 vascular clips or an endoloop on the high-pressure side of the vessels; the vessels are divided with endoshears. The segmentals are ligated and divided in the anterior half of the vertebral body to allow maximal possible collateral circulation to the neural foramen and spinal cord. The disc space is incised using the harmonic scalpel. Graduated endoscopic curettes and pituitary rongeurs are used to perform a complete discectomy (Figure 6). The disc space height is restored by using a distraction plug; placed from the side. A drill tube is placed over the distraction plug. The position of the distraction plug is monitored with anteroposterior and lateral fluoroscopy. The center of the distraction plug will correspond with the center of the BAK interbody fusion cage.[2] It is important to countersink the cage and pack additional bone graft superficial to the cage. The presence of a solid trabecular bone bridge in this location allows for confirmation of the arthrodesis after approximately 6 months following surgery. The BAK or carbon fiber cages are packed with autogenous iliac graft obtained through a separate incision over the ipsilateral anterior iliac crest.

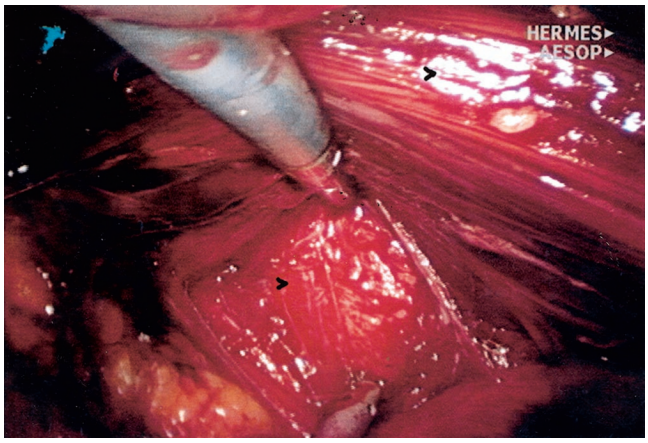

Figure 5. Endoscopic exposure of the intervertebral disc space through the psoas muscle. Upper arrow, Psoas muscle. Lower arrow, Intervertebral disc.

All patients are then repositioned prone for pedicle screw instrumentation. Patients performed at Cedars Sinai Medical Center underwent percutaneous pedicle screw placement utilizing the Sextant system (Sofamor Danak, Memphis, TN).

Clinical Follow-up. Following surgery, patients were examined on a daily basis while in the hospital and then at 1 week and 6 weeks after discharge. Follow-up was then conducted at

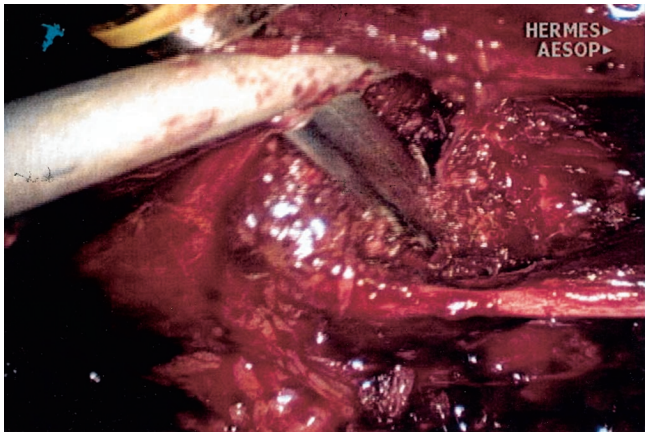

Figure 6. Graduated endoscopic curettes and pituitary rongeur used to perform complete discectomy.

Table 2. Exposed Lumbar Levels via the Lateral Endoscopic Transpsoas Approach for Lumbar Spinal Fusion

Level Treated No. (%)	No. (%)
L1–L2	4 (14)
L2–L3	10 (36)
L3–L4	14 (50)
Total	28 (100)

*Three patients underwent a 3-level procedure; 1 patient underwent a 2-level procedure

3- to 6-month intervals for the first year and annually thereafter. The last 6 patients in this study were included only in the early postoperative results (follow-up 2–6 months), to describe the operative and perioperative findings. The remaining 15 patients were observed for a mean of 3.1 years (range 6 months–6 years).

Evaluations of preoperative and postoperative pain levels were based on the administration of a visual analog scale (VAS).[22] Pain severity was rated from 0 to 10. The patient before surgery determined the level of pain present during the routine preoperative work-up. After surgery, the patient again documented the level of pain present during each clinic visit. If the patient lived in another town, a disinterested third party physician who was not involved with the presurgical screening, the actual surgery, or postoperative care evaluated the level of pain by telephone interview. For those patients who experienced postoperative groin/thigh pain, similar scores were recorded after surgery and the date of resolution was documented.

■ Results

Seventeen (81%) of 21 patients underwent surgery for a single level. One patient (5%) underwent a 2-level fusion and 3 patients (14%) underwent surgery on 3 levels. Fourteen (50%) of 28 levels operated on were performed on L3–L4, 10 (36%) on L2–L3, and 4 (14%) on L1–L2 (Table 2). All patients underwent left-sided approaches. In 16 of 21 patients (76%), 4 portals were placed. Average operative time for the single-level cases was 149 minutes (range 120–170 minutes), which does not include posterior instrumentation. Average blood loss for these cases was 150 cc (range 50–650); average postoperative hospital stay was 4.1 days. A single laterally placed cage was used in all disc spaces in all patients. The long axes of the cages were in the transverse direction (Figure 7). In all cases, the cages were packed with autogenous iliac bone graft that was obtained through a separate incision.

Average duration of symptoms for all patients before surgery was 13 years, ranging from 36 months to 30 years. Three patients had undergone prior discectomies at the level that was being operated on. Five patients had undergone prior fusions at other levels.

All 21 patients were available for postoperative assessments in person or by telephone. Fifteen patients were included in long-term follow-up with a mean of 3.1 years (range 6 months–6 years). Six patients were observed less than 6 months (2 months–6 months). One patient was converted to a mini-open approach due to scarring in the retroperitoneal space due to previous surgery at lower levels and was excluded from data analysis.

Early postoperative results showed that 17 of the 20 patients (84%) had immediate clinical improvement in their preoperative pain as determined by a standard VAS pain scale.[22] Average preoperative VAS was 8.3 (range 6–10). Average postoperative VAS on the first postoperative visit approximately 1 week after discharge from the

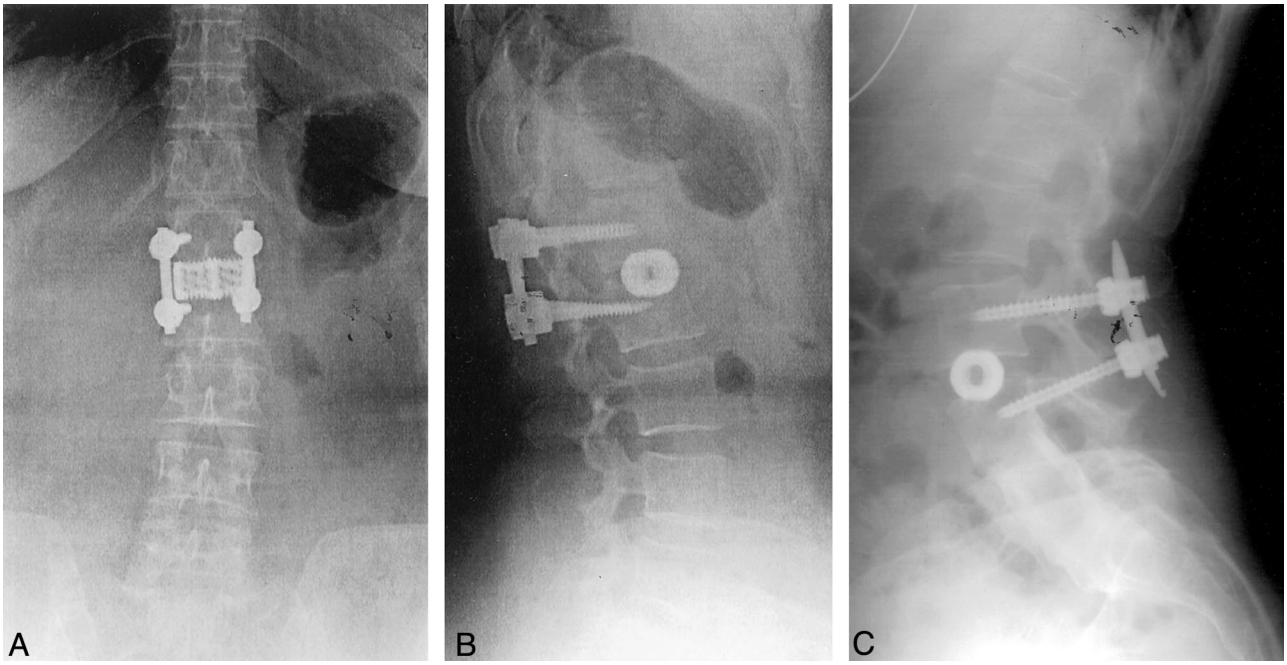

Figure 7. **A** and **B**, Postoperative x-rays illustrating final cage positioning. **C**, Postoperative lateral radiograph using percutaneous pedicle screws above a previous 2-level fusion.

hospital was 2.2 (range 1–5).[22] However, all patients in the study were taking narcotic analgesics during the first postoperative visit.

Of the 15 patients followed greater than 6 months, the average postoperative VAS was 3.2 (range 0–5); VAS scores had decreased an average of 5.9 for all patients relative to their preoperative status. At the time of this review, 9 of 15 patients (60%) thought they had an excellent outcome from their preoperative pain and would undergo the surgery again for the same relief. Three of 15 patients (20%) had what they considered a good overall result and would probably undergo the surgery again. Three other patients (20%) had fair outcomes and were not sure whether they would undergo the surgery again for the same result. One of these patients had further degeneration of an adjacent level (L2–L3) after undergoing an endoscopic lateral transpsoas fusion at L3–L4. His MRI demonstrated loss of disc space height and desiccation following surgery at the adjacent level. He had a positive discogram at what was presumably a new pain generator and subsequently underwent an intradiscal electrothermal therapy (IDET) procedure at this new level (L2–L3) with minimal relief. At the time of this review, he is currently scheduled for fusion at L2–L3 in the near future. The other 2 patients with fair results both had decreases in their VAS scores (9 to 6 and 9 to 7, respectively) but continued to complain of persistent back pain. One other patient who was considered to have a good result had persistent postoperative discomfort from her bone graft site. However, with respect to her low back pain, her VAS went from 10 before surgery to 1 after surgery at long-term follow-up.

Overall, 11 of 13 patients (84%) who were under the age of 65 had returned to their preoperative occupation. Of the other 2 patients, one was going through occupational rehab at the time of this review and had intentions of returning to work in the near future. The other case involved a worker's compensation claim. This patient had applied for disability before surgery and has no desire to return to work. The other 2 patients who were over the age of 65 said they could work after surgery but were retired.

There were no cases of implant migration or pseudarthrosis. No patients developed a radiolucent interface between the implant and the vertebral body. There were no cases of subsidence more than 1 mm, and there was trabecular bony bridging across the adjacent vertebrae laterally in 14 of 15 cases followed for a minimum of 6 months.

Operative Complications

There was no mortality associated with surgery. There were no vascular injuries. Six patients (30%) developed transient postoperative groin/thigh paresthesias. Five of these patients also complained of groin/thigh pain in the postoperative period. All but 2 of these patients had resolution of symptoms within 4 weeks. Both of the patients with persistent groin/thigh pain had undergone a 3-level procedure for scoliosis. One patient is 11 months postoperation and has persistent dysesthetic pain in his anterior thigh on the side of surgery. He is being treated with Neurontin. Although this patient has persistent genitofemoral nerve dysesthesias, his VAS with respect to his low back pain went from a preoperative 6 to a postoperative 1 at long-term follow-up. The other patient is currently 4 months postoperation and has improving left groin/thigh numbness. The other 2 scoliosis patients treated through this approach denied similar complaints.

There were no cases of persistent iliopsoas weakness or motor weakness in the L3, L4, or L5 distribution. Anatomic correction of sagittal plane or scoliotic deformities was achieved in all patients who underwent this lateral endoscopic approach.

Patients with postoperative groin/thigh pain were found to have a mean VAS score of 4.3 (range 2–8) for this site. This dropped to 1.5 (range 0–4) at 8 weeks postoperation.

One patient developed a postoperative hematoma in the psoas muscle that was managed conservatively. One other patient developed a superficial wound infection that was treated successfully with oral antibiotics. There were no infections or fractures at the iliac graft site.

One patient was converted to mini-open, lateral technique intraoperatively when adequate endoscopic exposure in the retroperitoneal region was not safely possible due to adhesions from previous surgery at adjacent lower levels.

■ Discussion

There has been a recent surge in the use of laparoscopic approaches to the lumbar spine for interbody fusion using threaded cages. These techniques are attractive in that they offer the potential for less perioperative pain and morbidity, shorter hospital stays, quicker recovery times, and a faster return to work and the patient's normal lifestyle. We describe a minimally invasive, retroperitoneal approach to L1 through L4 that has several potential advantages over traditional techniques. It should be understood that this technique is not meant to be a substitute for the open or endoscopic anterior transperitoneal approaches. Although the standard anterior transperitoneal approaches are more suitable for the L4–L5 and L5–S1 levels, the lateral approach is not. The laparoscopic transperitoneal approach to L5–S1 is below the bifurcation of the great vessels, requiring minimal mobilization of the iliac vessels. Using the technique described here at L4–L5 and L5–S1, it is sometimes necessary to remove part of the iliac crest or place a docking portal through the iliac wing in order to be orthogonal to the disc space.[9,14,23] In addition, it may be necessary to mobilize a large mass of psoas muscle containing lumbosacral plexus nerve roots laterally or to place the implant more anterior or posterior or at a 45° angle.[8] The advantage of this technique over the standard anterior transperitoneal and retroperitoneal approaches is in the ease of access to the upper lumbar spine (L1–L4). Standard

approaches to this region are frequently complicated by the location of the great vessels.

Vraney *et al* reported that access to the L4–L5 disc space *via* an endoscopic transperitoneal approach would be readily accessible in only about 33% of patients and in others would require significant dissection.[17] This was based on a review of computer-generated series' of abdominal arterial studies and not actual surgical cases or directly observed anatomy. Regan *et al*[11,16] reviewed the results of 58 consecutive patients that underwent laparoscopic ALIF at the L4–L5 level using BAK cages in an attempt to describe variations in the approach used to address anatomic variations in the location of the great vessel bifurcation when approaching this region. The L4–L5 disc space was accessed above the great vessel bifurcation in 30 patients, below the bifurcation in 18 patients, and between the vessels in the remaining 10 patients. There were no statistically significant differences in the operative time, blood loss, or length of hospitalization with respect to the approach used. However, 3 patients were converted to open procedures as a result of bleeding from segmental veins. In 2 patients, successful endoscopic repair of segmental vein avulsion from the vena cava was performed using endoscopic loop ligatures. One patient subsequently required a secondary procedure to remove a cage that was causing nerve irritation, and one patient suffered from retrograde ejaculation following a 2-level fusion. Another patient developed a postoperative cerebrospinal fluid (CSF) leak. This group concluded that the laparoscopic transperitoneal approach to L4–L5 for insertion of threaded fusion cages is feasible and that variations in vascular anatomy did not prevent successful insertion of two threaded fusion cages.

Tiusanen *et al*[24] reported a 5.9% incidence of retrograde ejaculation following anterior transabdominal lumbar interbody fusion. There were 12 cases (5%) of retrograde ejaculation that occurred as a complication of laparoscopic BAK interbody fusion and stabilization in the first series of 240 patients submitted to the Food and Drug Administration (FDA).[16] The retroperitoneal exposure is associated with a much lower incidence of this postoperative complication.[6,14]

Retroperitoneal lumbar fusion and stabilization in general offers several potential advantages over conventional anterior transperitoneal approaches to the lumbar spine.[4] Retroperitoneal approaches obviate the risk of small bowel obstruction or postoperative intraperitoneal adhesions.[25,26] Because the autonomic plexus is not dissected, there is a reduced risk of retrograde ejaculation as compared with transperitoneal laparoscopic approaches.[5,9,14] Additionally, the lateral decubitus position facilitates exposure of the lumbar spine, as gravity helps in pulling the abdominal contents anteriorly. It is also easier to position a trocar orthogonal to the disc space with a laterally directed interbody fusion device, as opposed to the supine Trendelenburg position required for transperitoneal laparoscopy. Unlike standard anterior approaches, the anterior longitudinal ligament and posterior longitudinal ligament are not violated with the lateral retroperitoneal approach. This confers a significant biomechanical advantage. Moreover, with the transperitoneal approach, if the surgeon reams, taps, or drills too deeply, the spinal canal contents are at risk. With the lateral retroperitoneal approach, these activities are directed toward the contralateral psoas muscle instead of the spinal canal contents.[4,9] In the FDA laparoscopic BAK study,[16] the incidence of iatrogenic intraoperative disc herniation in patients undergoing surgery at 1 level was 2.8% (3 of 25 patients). Overall, for BAK implants inserted *via* a straight anterior-to-posterior direction, the incidence of reoperation for iatrogenic penetration or for pushing intervertebral disc material into the spinal canal was 2.3%.

In 1997, Mayer[6] reported on 20 patients who underwent retroperitoneal, microsurgical anterior lumbar interbody fusion. This technique utilized an extensive quadrilateral retraction frame. In this series, we describe the results of a novel approach to lumbar (L1–L4) spinal fusion in 21 patients. Fifteen of these patients are included in long-term follow-up. The surgical dissection is carried in a longitudinal fashion in line with the muscle fibers and through the anterior two-thirds of the psoas muscle. This results in minimal muscular retraction and bleeding with excellent visualization of the relatively avascular intervertebral disc space. In the immediate postoperative period and within 1 week of discharge from the hospital, patients had a significant decrease in their VAS scores. At long-term follow-up, the average decrease in postoperative VAS scores was 5.9 for all patients relative to their preoperative status. At long-term follow-up, 9 of 15 patients (60%) thought they had an excellent outcome from their preoperative pain and would undergo the surgery again for the same relief. Three of 15 patients (20%) had what they considered a good overall result and would also undergo the surgery again. Three other patients (20%) had fair outcomes and were not sure whether they would probably undergo the surgery again for the same result. In the 3 patients who had fair results, 1 had adjacent level degeneration resulting in persistent recurrent low back pain. The other 2 had persistent complaints of low back pain despite a significant reduction in their VAS scores when compared to that before surgery.

Six patients were included in this study with less than 6 months follow-up. Although long-term results are not yet available, including their operative and perioperative findings, this is valuable information regarding the safety of the procedure itself.

Using the technique described here, there may be difficulty in placing 2 cages. We placed single transversely oriented cages in all disc spaces in all patients. Others[8] have advocated placing 2 cages in each disc space. However, biomechanical studies (unpublished data) found no statistical difference when comparing the characteristics of a single transversely oriented cage with 2 anteriorly

oriented cages. The BAK system confers biomechanical stability because it uses preinsertional distraction *via* distraction plugs, which results in better ligamentotaxis. The BAK system also employs a tap, which cuts threads into the 2 adjacent vertebral end plates, reducing strain and micromotion on the bone graft contained within the cage.[27]

Posterior instrumentation was utilized in all patients. Stand-alone anterior lumbar interbody fusion remains controversial, and we feel that providing a posterior tension band reduces the pseudarthrosis rate significantly. We utilized pedicle screw fixation without posterior fusion for this purpose. Currently, our practice is to perform percutaneous pedicle screw placement using the Sextant system. This minimally invasive posterior pedicle fixation compliments the endoscopic anterior approach.[28]

Six patients in this series developed groin/thigh discomfort after surgery. These symptoms are consistent with the cutaneous innervation of the genitofemoral nerve. This presumable 30% incidence of genitofemoral nerve palsy is of some concern. However, these symptoms resolved within 4 weeks in 4 of the 6 patients who developed them after surgery. Both patients experiencing longer-lasting symptoms underwent a 3-level procedure. Two other patients underwent multilevel fusions without similar complaints. At this point, it is unclear to us whether or not this technique is appropriate for multilevel cases. It is difficult to draw firm conclusions regarding the incidence of complications given the relatively small number of patients. In most of the cases performed, the genitofemoral nerve was identified but necessitated retraction to access the disc space.

The lateral retroperitoneal approach obviates the need to dissect and mobilize the common iliac vein and artery, as is necessary with transperitoneal exposure. Dissection of the sympathetic plexus is also excluded through this approach.

The genitofemoral nerve arises from the L1 and L2 roots. It passes obliquely through the substance of the psoas and emerges from its inner border at a level corresponding to the L3–L4 interspace. It then descends on the surface of the psoas muscle, normally under the cover of the peritoneum, and divides into the genital and femoral branches. The genital branch passes outward on the psoas major and pierces the fascia transversalis or passes through the internal abdominal ring. It then descends along the back par of the spermatic cord to the scrotum, and supplies, in the male, the cremaster muscle. In the female, it accompanies and ends in the round ligament. The femoral branch of the genitofemoral nerve descends on the external iliac artery, sending a few branches to it and, after passing beneath the Poupart ligament to the thigh, supplies the skin of the anterior aspect of the thigh down about midway between the pelvis and knee.

The authors recommend staying in the anterior one-third of the psoas muscle to avoid nerve root injury. Visualization and protection of the genitofemoral nerve should avoid permanent paresthesias in the anterior thigh. Intraoperative neurologic surveillance may also provide added benefit in avoiding the exiting nerve roots, especially at L4–L5, where the L3 nerve root can cross the disc space and may be at risk if the approach is in the anterior one-half of the psoas muscle. The electromyograph (EMG)-based Neurovision (Nuvasive, San Diego, CA) is designed to provide real time detection of proximity to the nerve root.

These early results show the lateral endoscopic transpsoas approach to the lumbar spine to be a safe, minimally invasive method for anterior fusion of L1 through L4. Although there is a risk of groin/thigh numbness or pain, these symptoms are mostly transient. The risk of serious vascular injury is minimized, as this approach does not require mobilization of the great vessels.

■ Key Points

- Standard anterior endoscopic approaches to the lumbar spine require mobilization of the great vessels and sympathetic plexus. These are associated a relatively high incidence of complications.
- The endoscopic lateral transpsoas approach to the lumbar spine is a minimally invasive technique for anterior fusion of the lumbar spine that minimizes the risk to large vessels and other critical structures.
- There is a risk of transient groin/thigh numbness and pain, probably due to manipulation of the genitofemoral nerve, which runs along the anterior surface of the psoas muscle.

References

1. Obenchain TG. Laparoscopic lumbar discectomy. Case report. *J Laparoendo Surg* 1991;1:145–9.
2. Bagby G. Arthrodesis by the distraction-compression methods using a stainless steel implant. *Orthopaedics* 1988;11:931–4.
3. Brantigan JW, McAfee PC, Cunningham BW, et al. Interbody lumbar fusion using a carbon fiber cage implant versus allograft bone: an investigational study in the Spanish goat. *Spine* 1994;19:1436–44.
4. Goldstein JA, Parker LM, McAfeej PC. Minimally invasive endoscopic surgery of the lumbar spine. *Oper Tech Orthop* 1997;7:27–35.
5. Jansen R. FDA Submission. 240 BAK Laparoscopic Procedure. 1997.
6. Mayer MH. Mini ALIF. A new microsurgical technique for minimally invasive anterior lumbar interbody fusion. *Spine* 1997;6:691–700.
7. McAfee PC. Complications of anterior approaches to the thoracolumbar spine: emphasis on Kaneda instrumentation. *Clin Orthop* 1994;306:110–19.
8. McAfee PC, Regan JJ, Geis WP, et al. Minimally invasive anterior retroperitoneal approach to the lumbar spine. Emphasis on the lateral BAK. *Spine* 1998;23:1476–84.
9. McAfee PC, Regan JR, Zdeblick T, et al. The incidence of complications in endoscopic anterior thoracolumbar spinal reconstructive surgery: a prospective multicenter study compromising the first 100 consecutive cases. *Spine* 1995;20:1624–32.
10. Olinger A, Hildebrandt U, Mutschler W, et al. First clinical experience with an endoscopic retroperitoneal approach for anterior fusion of lumbar spine fractures from levels T12 to L5. *Surg Endosc* 1999;13:1215–19.
11. Regan JJ, Aronoff RJ, Ohnmeiss DD. Laparoscopic approach to L4–5 for interbody fusion using BAK cages: experience in the first 58 cases. *Spine* 1999;24:2171–4.

12. Regan JJ, Guyer RD. Endoscopic techniques in spinal surgery [review]. *Clin Orthop* 1997;335:122–39.
13. Regan JJ, McAfee PC, Guyer RD. Laparoscopic fusion of the lumbar spine in a multicenter series of the first 34 consecutive patients. *Surg Laparos Endosc* 1996;6:459–68.
14. Regan JJ, McAfee PC, Mack MJ. *Atlas of Endoscopic Spine Surgery*. St. Louis, MO: Quality Medical Publishing Inc; 1995.
15. Regan JJ, Yuan H. Minimally invasive approaches to the spine [review]. *Instr Course Lect* 1997;46:127–41.
16. Regan JJ, Yuan H, McAfee PC. Laparoscopic fusion of the lumbar spine: minimally invasive spine surgery. A prospective multicenter study evaluating open and laparoscopic lumbar fusion. *Spine* 1999;24:402–11.
17. Vraney RT, Phillips FM, Wetzel FT, et al. Peridiscal vascular anatomy of the lower lumbar spine. An endoscopic perspective. *Spine* 1999;24:2183–7.
18. Vollmar B, Olinger A, Hildebrandt U, et al. Cardiopulmonary dysfunction during minimally invasive thoraco-lumboendoscopic spine surgery. *Anesth Analg* 1999;88:1244–51.
19. Smith BM, Hurwitz EL, Solsberg D, et al. Interobserver reliability of detecting lumbar intervertebral disc high-intensity zone on magnetic resonance imaging and association of high-intensity zone with pain and annular disruption. *Spine* 1998;23:2074–80.
20. Guyer RD, Collier R, Stith WJ, et al. Discitis after discography. *Spine* 1988; 13:1352–4.
21. Sachs BL, Vanharanta H, Spivey MA, et al. Dallas discogram description. A new classification of CT/discography in low-back disorders. *Spine* 1987;12: 287–94.
22. Hukkison S. Visual Analogue Scale. In: Melzack R, ed. *Pain Measurement, Assessment*. New York, NY: Raven Press; 1983:33–40.
23. Osman SG, Marsolais EB. Endoscopic transiliac approach to L5-S1 disc and foramen. A cadaver study. *Spine* 1997;22:1259–63.
24. Tiusanen H, Seitsalo S, Osterman K, et al. Retrograde ejaculation after anterior interbody lumbar fusion. *Eur Spine J* 1995;4:339–42.
25. Lajer H, Widecrantz S, Heisterberg L. Hernias in trocar ports following abdominal laparoscopy: a review. *Acta Obstet Gynecol Scand* 1997;76: 389–93.
26. Levrant SG, Bieber EJ, Barnes RB. Anterior abdominal wall adhesions after laparotomy or laparoscopy. *J Am Assoc Gynecol Laparosc* 1997;4:353–6.
27. Kanayana M, et al. An in vitro biomechanical analysis on the stability and stress-shielding effect of interbody fusion implants. Presented at: Annual Meeting of the Scoliosis Research Society; September 25, 1997; St. Louis, Missouri.
28. Ordway NR, et al. Effect of cage orientation and posterior instrumentation on the initial stability of the bovine lumbar spine following interbody fusion. Presented at: Annual Meeting of the International Society for Study of the Lumbar Spine; June 6, 1997; Singapore.