Paramedian approach for transforaminal lumbar interbody fusion with unilateral pedicle screw fixation

Technical note and preliminary report on 47 cases

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✓ Lumbar fusion is a commonly performed procedure for a variety of pathological conditions, and it is frequently used in the treatment of degenerative lumbar instability that is refractory to medical management. Pedicle screws and interbody devices have been used for internal fixation to promote arthrodesis, prevent nonunion, and facilitate early mobilization. Recently, attempts have been made to reduce the morbidity associated with lumbar fusion by using a variety of minimally invasive techniques. Many minimally invasive lumbar fusion procedures require specialized retractors, implants, image guidance systems, or insertion instruments. Other minimally invasive techniques are primarily applied to an ideal patient population (thin, healthy, and with no previous surgery).

The authors describe their experience with a paramedian approach for minimally invasive transforaminal lumbar interbody fusion (TLIF) with unilateral pedicle screw (PS) fixation. This procedure requires only standard implants, instruments, and retractors, with direct visualization for all aspects of the procedure. The authors describe encouraging early results in a challenging patient population in which there was a high incidence of obesity, medical comorbidities, and previous surgery at the same level. The paramedian approach for TLIF performed using unilateral lumbar PSs has yielded successful outcomes in this series of 47 patients, and further study of this technique may help define its role as a minimally invasive procedure for spinal fusion.

KEY WORDS • transforaminal lumbar interbody fusion • pedicle screw • paramedian approach

With the increasing use of lumbar spinal fusion surgery, many innovations have emerged for which the goal has been to minimize invasiveness and improve outcome.8,31,32 Introduced in the US by Steffee, et al.,28 PSF has now become commonplace.1,9,24,25 Although Cloward4,5 and others19,23,29 have described the benefits of PLIF, and fusion rates and outcomes have improved, this procedure can be technically challenging, and it has been associated with nerve root injury and incidental durotomy.30 One technique that has gained attention recently in the literature is the TLIF procedure.2,6,10–14,16–18,21,26,27,33

Initially proposed in the early 1980s, TLIF has several advantages when compared with both ALIF and PLIF.13 The TLIF procedure minimizes thecal sac retraction, and when performed via a unilateral paramedian (parasagittal) approach, the posterior tension band can potentially remain intact.14 This approach addresses some of the shortcomings of the PLIF procedure, and has been associated with a reduction in the incidence of dural tears and postoperative neurological deficits as well as symptomatic epidural fibrosis, while preserving as much of the normal anatomy as possible.6,13,22 Compared with the ALIF procedure, TLIF is financially advantageous because it only requires one posterior procedure, and therefore no general or vascular surgeon is needed. It also provides a 360° stabilization without the potential for great vessel injury, retrograde ejaculation in male patients, or injury to peritoneal or retroperitoneal structures.3,7,14,15,20,33

We present data recorded in 47 patients who were not preselected to be ideal candidates for minimally invasive fusion, but who represent a cross-section of our spine practice. Our patient population included smokers, patients with diabetes, individuals with severe heart disease, and obese patients, as well as those who required revision lumbar surgery. Indications for surgery included single-level degenerative lumbar instability and eccentric herniated discs that were refractory to medical management. In each case we performed the TLIF with unilateral PSF via a paramedian approach, which we believe is a unique operation.34
Clinical Material and Methods

Patient Population

After appropriate Human Assurances Committee approval was granted, the medical records of 47 patients with single-level lumbar degenerative disease who were treated between February 2002 and November 2005 via the paramedian approach for TLIF with unilateral PSF were reviewed. There were 21 men and 26 women, whose mean age was 49.2 years (range 33–79 years). The mean height of patients included in the study was 1.72 m (range 1.52–1.98 m), the mean weight was 84.08 kg (range 49.4–126.5 kg), and the mean calculated BMI was 28.84 (range 20.05–47.85). The study included 19 smokers and six patients with diabetes. Additional data that were collected included pain scores, incision length, operating time, estimated blood loss during surgery, level fused, duration of hospital stay, and whether the operation was a revision. Patients with gross instability (motion on flexion–extension dynamic radiographs and active patients with bilateral spondylolysis with spondylolisthesis) were treated with bilateral PS constructs and were not included in this group. Likewise, patients who had previously undergone ALIF were not included in the study.

Surgical Procedure

The patient is placed prone on gel rolls in a manner that promotes normal lumbar lordosis. Although a paramedian skin incision had been used early in this series, the large number of patients with prior incisions at the midline resulted in our adoption of a midline skin incision followed by a paramedian fascial incision 1 to 2 cm lateral to the midline. Through the fascial incision, a muscle-splitting technique is used to gain access to the ipsilateral facet joint. Access is established with blunt finger or Cobb periosteal dissection at L4–5 and above. In some cases, and typically at L5–S1, we have found that longitudinal muscle splitting with electrocautery will also allow for exposure of the joint. Care is taken to avoid injuring the facet capsule at the rostral level, to reduce the possibility of future breakdown in the adjacent segment. Fluoroscopy is used to confirm the levels exposed. Once the facets are palpated and the capsule is accessible, the ipsilateral transverse processes and pars interarticularis as well as the caudal facet are exposed. Cerebellar retractors are sufficient in most patients, although a Williams or Meyerding retractor can be useful in others. The entire procedure is performed using direct visualization. At this point in the operation, we prefer to switch from loupe magnification to an operating microscope (Figs. 1–3).

The facet is removed with osteotomes and rongeurs as well as with a high-speed pneumatic drill. In recently treated patients, we have removed the facet in large pieces and stripped all cartilage and soft tissues from this bone, which is prepared as a local autograft. The decompression continues until a triangular working space is exposed at the inferomedial aspect of the neural foramen. The inferior leg of the triangle is the superior margin of the caudal pedicle. The medial edge is the dural sac, and the superolateral edge is the exiting nerve root. The disc space is identified within this triangle. If there has been previous surgery at this level, the epidural fibrosis typically is adherent to the traversing nerve root (medial edge of the dura mater) rather than the exiting nerve root, which is now exposed in the foramen.

After exposure of the posterior longitudinal ligament, the plane between the dura mater and the ligament can be developed rostral and caudal to the scar tissue, and the dura can be freed from where it may be adherent to the anulus. This allows for slight medial retraction of the dura and traversing nerve root. In most cases, this is sufficient for discectomy, endplate preparation, and insertion of the interbody cage. After a standard decompressive discectomy, the interbody space is prepared for fusion by removing much of the disc material and cartilaginous endplates with a series of curettes and scrapers. Bone graft material is placed anterior and lateral to the interbody cage, and then the device is inserted and released. We prefer to place a single cage in the center of the disc space, spanning the medial–lateral and the anterior–posterior midlines. Positioning of the cage is confirmed using fluoroscopy.

We know that some surgeons prefer to place a TLIF cage...
in the anterior rim of the interspace, at times removing anterior osteophytes with an osteotome. Anterior placement of the cage can be technically challenging, and risks great vessel injury. Although advocates of anterior placement cite the need to prevent subsidence of the cage into the endplates, this was not seen in any of our patients. If a directly impacted cage were to be used, initial insertion of the PSs with distraction may be required to maintain lordosis. We currently use a cage that is inserted horizontally and then turned up on end when inside the interspace. This allows the toothed convex ends to distract and engage the endplates. We have been able to maintain lordosis and obtain a secure fit for the cage without the need for initial insertion of the PSs. At this point, additional bone graft material is inserted around the cage. Iliac crest autograft was obtained in some cases through a separate fascial incision over the iliac crest. Typically, this did not require extension of the incision in patients who underwent surgery at the L4–5 and L5–S1 levels (Video 1).

Video 1. Video showing the surgical technique used for the TLIF procedure. Click here to view with Windows Media Player and a broadband connection, here to view with a dial-up connection, or here to view with RealPlayer.

The PS insertion is then performed on the ipsilateral side. After complete exposure of the foramen is attained, the rostral screw is typically inserted first. The inferior and medial margins of the pedicle are palpated with a Woodson elevator, and an awl hole is made at the base of the transverse process by using anatomical reference points. After the pedicle is sounded with a probe, the hole is tapped and inspected with a fine ball-tip probe and then a screw is inserted. The caudal PS is similarly inserted and is typically easier to place due to the complete exposure of the pedicle. The transverse processes are decorticated with an osteotome and bone graft is placed laterally after a rod has been secured. A Jackson–Pratt drain is placed as needed (infrequently). The fascia is closed with 0 Vicryl and the subcutaneous tissues are apposed with 2-0 Vicryl sutures. Either skin clips or liquid skin adhesive are used for the skin closure, and a sterile dressing is applied. Most patients are instructed to wear a soft lumbar corset when they are out of bed for periods longer than 5 minutes.

Results

The unilateral TLIF procedure with unilateral PS placement was performed in a patient population whose mean age was 49.2 years. The surgery lasted a mean of 178 minutes (range 86–414 minutes) and was performed through an incision with a mean length of 8.1 cm (range 3.6–15 cm).
The mean estimated blood loss was 304.8 ml (range 50–900 ml). The mean duration of hospital stay was 3 days (range 1–19 days), with 19 patients leaving by Day 2, and an additional 11 leaving on Day 3. The mean follow-up period was 8 months (range 1–36 months), with a mean improvement in the VAS pain score from 6.9 to 3.3. Preoperative VAS pain scores related to lumbar pain or associated radiculopathy ranged from 0 to 10, and postoperative scores ranged from 0 to 8; however, in 14 patients there was incomplete documentation of the pain score at presentation or on follow-up visits. There were 22 revision surgeries, and the other 25 procedures were initial operations. Twenty-seven operations were performed at the L5–S1 levels, 15 at L4–5, three at L3–4, and one each at L2–3 and L1–2.

The only follow-up data presented here are the VAS pain scores related by the patient and documented by the nurse or physician. Nevertheless, improvement was also recorded by the senior author (H.F.C.) based on the patient’s stated satisfaction and recovery of functioning.

Data related to the potential for postoperative complications were collected, and included the following points. These patients included 39.6% who were cigarette smokers and 33% who were obese (based on a BMI > 30). An additional 33% were overweight (BMI 25–30), the remaining 33% were normal weight, and no patient was underweight. As stated earlier, six patients suffered from diabetes mellitus.

There were four dural tears in this series, all of which were repaired at the time of surgery without additional sequelae. Four suspected wound infections were successfully treated with incision and drainage (no organisms were identified despite multiple cultures in two patients). In one patient a pseudarthrosis developed, which required revision surgery. No patient suffered new neurological deficits after surgery.

Discussion

As the costs of new technology and spinal implants continue to rise, a cost/benefit analysis of any new minimally invasive procedure must be performed. The value of a procedure is related to the number of physicians capable of performing it, the widespread availability of the technology, and, simply, the number of patients who may benefit from it. The derived benefit must then be evaluated in light of any added costs. The goal, of course, is a procedure that would be generally applicable to the population as a whole with a minimal increase, and preferably a decrease, in the overall expense and associated complications. To meet this goal, our unilateral TLIF and unilateral PSF procedure was performed with commonly available retractors and can use most PS systems. The procedure did not require disposable retractors, endoscopes, image guidance systems, percutaneous screw placement, cannulated screws, specialized instruments for rod delivery, or costly biological agents. Furthermore, any spine surgeon trained to implant PSs and interbody devices should be able to perform this procedure. Initial feasibility studies were performed in human cadavers in a microsurgery anatomy lab at the Medical College of Georgia.

Paramedian, muscle-splitting and muscle-stripping approaches have been used both in decompressive procedures and for the placement of PSs. Transmuscular approach-es may result in reduced blood loss and muscle retraction when exposing the facets and transverse processes, particularly when a unilateral approach is used, in comparison with midline and bilateral approaches to expose these structures. Although the results in this challenging patient population are preliminary, the data seem to indicate favorable outcomes when compared with traditional fusion techniques for these patients. After we had gained experience with this technique, patients treated later in the series tended to have shorter incisions and briefer hospital stays as well as decreased pain and blood loss after their surgeries.

Conclusions

In this technical note we describe the principles involved and our experience with this promising new combination of established procedures. The paramedian approach for TLIF with unilateral PSF represents a novel combination of well-described and accepted techniques. Comparison with traditional fusion strategies as well as with other minimally invasive procedures will require careful outcomes analysis. Our initial experience has encouraged us to design a prospective study with strict outcomes measures and longer follow-up periods. The goal of this study will be to determine the role of the paramedian approach for TLIF with unilateral PSF in the management of lumbar degenerative disease.

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References

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