Minimally invasive transforaminal lumbar interbody fusion with unilateral pedicle screw fixation

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Object. Posterior lumbar interbody fusion (PLIF) has been shown to be effective in the treatment of axial low-back pain. Minimally invasive spine surgery for arthrodesis has several advantages, including quicker patient recovery, less postoperative pain, and less destruction of adjacent tissue. The purpose of this paper is to evaluate the clinical outcomes after PLIF procedures in which unilateral pedicle screw fixation was used.

Methods. Prospective data were collected in 34 patients undergoing a one-level minimally invasive transforaminal lumbar interbody fusion (TLIF) in 2003. Conservative therapy, including physical therapy and aggressive multimodality pain management, had failed in all patients. Selection was based on magnetic resonance imaging studies demonstrating degenerative disc disease. All patients underwent a unilaterally TLIF procedure in conjunction with posterior unilateral pedicle screw fixation. Twenty patients in whom the follow-up duration was longer than 6 months were included in this study.

The follow-up duration in all patients ranged from 6 to 12 months. Seventeen (85%) of 20 patients had a good result, which was defined as a greater than 20-point reduction in the Oswestry Disability Index (ODI) score. The other three patients had no improvement. The mean preoperative ODI score of 57 improved to 25 after surgery ($p < 0.005$). In the 17 patients who demonstrated improvement, the mean ODI score improved from 57 to 18. The patients’ visual analog scale pain scores improved from 8.3 to 1.4 ($p < 0.005$) after surgery. In patients who received Workers’ Compensation, three (75%) of four improved. Follow-up computerized tomography scans were obtained in all 20 patients at 6 months. At that time, 13 of the patients demonstrated some degree of fusion, and no symptomatic pseudarthrosis was noted.

Conclusions. Minimally invasive TLIF in conjunction with unilateral pedicle screw instrumentation is an effective treatment for axial low-back pain in appropriately selected patients.

KEY WORDS • back pain • minimally invasive spinal fusion • transforaminal lumbar interbody fusion • outcome

LOWARD initially described lumbar interbody fusion without posterior instrumentation in 1953. Although his procedure was performed by others, it failed to be widely adopted and results were equivocal. The combination of lumbar interbody fusion and posterior lumbar instrumentation improved surgical outcomes for axial lumbar pain. Since these initial reports, the TLIF operation, which requires a one-sided approach to the intravertebral space, has become widely accepted. Several minimally invasive approaches for the TLIF procedure have been reported.

In this paper, we describe a modification of the minimally invasive TLIF technique in which unilateral pedicle screw instrumentation is used. The minimally invasive approach makes unilateral instrumentation particularly appealing. The purpose of this study is to evaluate clinical outcomes in patients undergoing a minimally invasive TLIF with unilateral instrumentation.

Clinical Material and Methods

Patient Characteristics

Prospective data were collected in 34 patients undergoing a one-level minimally invasive TLIF procedure. Twenty patients with 6 months or more of follow up were included in the study. The patients’ mean age was 49 years (range 33–55 years), and there were eight women and 12 men. Workers’ Compensation litigation was pending for four patients. The vertebral levels involved included L5–S1 (11 patients), L4–5 (eight), and L3–4 (one).
Patient Selection

Patients were carefully selected; according to their history, they had demonstrated mechanical axial lumbar pain. All patients had undergone extensive courses of physical therapy and pain management at a multimodality pain center for longer than 6 months, but conservative care had failed. For a patient to be included in the study, MR imaging had to demonstrate a single degenerative disc with low signal intensity on T2-weighted images as well as disc space narrowing and endplate changes within adjacent vertebral bodies (Fig. 1). Patients with previous lumbar fusions or multilevel disease were excluded from the study, but those with previous discectomies were included. Discography was not used for patient selection.

Surgical Procedure

The patients were positioned prone on a Jackson table. A 3-cm incision was made overlying the affected level and continued down through the posterior lumbar fascia. Sequential dilators were introduced until a 26-mm-wide retractor (X-tube; Medtronic Sofamor Danek, Memphis, TN) was placed and centered on the appropriate disc space. The X-tube was secured to the operating table by using an articulated arm device (Fig. 2).

The whole procedure was completed using a headlight and loupe magnification. First, a complete facetectomy was performed using a high-speed air drill. Then, the disc space was identified and epidural veins coagulated. An aggressive discectomy was performed under direct visualization, then osteotomes were used to remove the posterior osteophyte. The disc space was distracted using paddle interbody distracters (Fig. 3A). The INFUSE (Medtronic Sofamor Danek) was then placed anteriorly within the disc space and another sponge was placed within the interbody graft. Either a PEEK interbody graft (Capstone; Medtronic Sofamor Danek) or titanium interbody implant (Geo; Interpore-Cross, Irvine, CA) was used. Local bone derived from the facetectomy was placed within the disc space, and INFUSE was placed within the interbody implant. The pedicles were then directly visualized. Standard top-loading polyaxial pedicle screws (Legacy; Medtronic Sofamor Danek) were placed with fluoroscopic guidance (Fig. 3B), then a 30-mm rod was placed and secured using locking caps torqued to the manufacturer’s specifications (Fig. 4). The remainder of the available bone and INFUSE were placed laterally in the intertransverse process area. The wound was closed in a standard fashion, but with Dermabond in lieu of skin sutures.

Clinical Assessment

Follow-up visits were scheduled at 3 weeks, 3 months, 6 months, and 1 year. An ODI questionnaire was completed at each visit. Plain x-ray films were obtained at 3 months (Fig. 5), and at 6 months postoperatively axial CT scans with coronal and sagittal reconstruction were obtained (Fig. 6).

Statistical Analysis

Statistical analysis was performed using the unpaired t-test feature of the Microsoft Excel statistical package addition.

Results

The duration of follow up ranged from 6 to 12 months. In that period, 17 (85%) of the 20 patients in the series had a good result (defined as a > 20-point reduction in the ODI score), whereas the other three patients had no im-
Minimally invasive TLIF with unilateral pedicle screw fixation

The mean preoperative ODI score of 57 improved to 25 after surgery ($p < 0.005$). In patients demonstrating improvement, the ODI score went from 57 to 18 (Fig. 7). Patient pain scores improved from 8.3 to 1.4 ($p < 0.005$) after surgery. In patients who received Workers’ Compensation, three (75%) of four exhibited improvement at 6 months, and two of the four returned to work at that time. Thirteen of the 20 patients demonstrated some degree of fusion on CT scans obtained at 6 months.

The mean blood loss was 100 ml per surgery, and no transfusions were required. The mean operating time was 4.1 hours. In one patient, a new postoperative radiculopathy developed, and this individual returned on postoperative Day 3 for readjustment of an L-5 pedicle screw. No permanent neurological injury occurred, and there were no infections. An intraoperative cerebrospinal fluid leak was noted in two patients, but no direct suture repair was possible in either case. These leaks were managed with fibrin glue, and no further incidents were noted postoperatively. The mean duration of the postoperative hospital stay was 2.5 days.

Discussion

Back pain is a prevalent societal problem. Nonsurgical treatment modalities are ineffective in some patients, and surgical treatment of back pain has historically been considered incomplete. The combination of interbody fusion and posterior pedicle screw instrumentation has yielded excellent results in treating axial back pain. In a prospective study of this technique, Brantigan, et al., reported on a series of 221 patients. In this study, 86% of patients demonstrated good clinical outcomes at 2 years, and these investigators reported a fusion rate of 98.9%. Freeman, et al., also reported an 83% success rate after a 5-year follow-up period in 60 patients treated with a PLIF procedure in which posterior pedicle screws were used. Similar results have been described with TLIF procedures. Presumably, patients who fail to improve have this outcome either because of poor selection or inadequate surgical technique.

Patient selection in this study was based on an individual’s history, results of physical examination, and MR imaging findings. Discograms were not used for patient selection because results are equivocal when these tests are used to select patients for lumbar fusion. The changes demonstrated on MR imaging included disc narrowing, low signal intensity changes on $T_2$-weighted MR imaging, or endplate changes. Patients with no specific changes on MR imaging did not undergo surgery. Patients with multiple-level involvement were excluded from this study.

Minimally invasive posterior lumbar fusion performed using a tubular retractor offers several advantages over the standard PLIF or TLIF procedure. Less destruction of surrounding tissue potentially allows for less postoperative pain and a quicker recovery. Economic benefits may be realized with shorter hospitalizations and an earlier return to work. The clinical outcomes with minimally invasive lumbar interbody fusion have not been well documented.

Fig. 3. A: Fluoroscopic image demonstrating placement of the paddle distractor in the interspace, at an initial disc height of 6 mm. B: Fluoroscopic image demonstrating the anatomy after dilation and placement of a 10-mm interbody PEEK graft as well as pedicle screws.

Fig. 4. Intraoperative photograph of the view through a 26-mm-diameter tubular retractor, showing the pedicle screws in place after the TLIF procedure.
In this study we demonstrate an 85% rate of good outcome at 6 months as measured using the ODI. These results are similar to those in previously reported large series involving a standard TLIF or PLIF procedure. In follow-up evaluations, 13 of our patients had some degree of fusion demonstrated on a CT scan obtained 6 months postoperatively. Other studies have generally shown very high fusion rates for interbody constructs. The high fusion rate at 6 months also may be attributable to the use of INFUSE. In most cases the arthrodesis was limited to the inside of the interbody implant and may be expected to mature with time.

A unique aspect of the procedure described here is the use of unilateral pedicle screws inserted through the tubular retractor. A rod delivery system such as the SEXTANT (Medtronic Sofamor Danek) was not used. Screw placement and instrumentation in this study were similar to techniques used for open procedures, and therefore the learning curve was significantly easier. The placement of unilateral pedicle screws allows for a shorter operating time and reduced morbidity related to placement of instrumentation.

Suk, et al., randomized patients to groups treated with unilateral or bilateral pedicle screws. The outcome in both groups was similar, leading these investigators to conclude that unilateral pedicle screws were adequate for fixation in either one- or two-level constructs. Kabins, et al., demonstrated similar results in a retrospective study of unilateral compared with bilateral pedicle screw instrumentation. Zhao, et al., reported good clinical results with diagonally placed unilateral posterior interbody instrumentation. In their paper, the clinical results for a TLIF with unilateral pedicle screw placement are similar to reports in the literature of PLIF procedures with bilateral pedicle screw placement.

Conclusions
Minimally invasive TLIF performed in conjunction with unilateral pedicle screw instrumentation is an effective treatment for axial low-back pain in appropriately selected patients. A minimally invasive TLIF technique is uniquely well suited for unilateral instrumentation. Results are similar to published series of standard open PLIF/TLIF procedures.

References

Fig. 5. Lateral (A) and AP (B) plain x-ray films obtained at 3 months postoperatively. The lateral film shows the interbody PEEK implant and posterior unilateral pedicle screw fixation at L4–5, and the AP view shows the midline placement of the implant with unilateral pedicle screw fixation at L4–5.

Fig. 6. Sagittal reconstructed CT scan obtained at 6 months, revealing subsidence of the interbody graft. B: Axial CT scan demonstrating the typical transverse orientation of the interbody graft after a TLIF procedure.

Fig. 7. Bar graph showing clinical results at 6 months according to the ODI.
Minimally invasive TLIF with unilateral pedicle screw fixation


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