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SPINE

Minimally Invasive versus Open Transforaminal Lumbar Interbody Fusion for Degenerative Spondylolisthesis: Comparative Effectiveness and Cost-Utility Analysis

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Key words
- Comparative effectiveness
- Cost-utility
- Spondylolisthesis
- Transforaminal lumbar interbody fusion

Abbreviations and Acronyms
BP-VAS: Visual analog scale—back pain
DRG: Diagnosis-related group
ICER: Incremental cost-effectiveness ratio
IQR: Interquartile range
LP-VAS: Visual analog scale—leg pain
MCS: Mental component score
MIS: Minimally invasive surgery
ODI: Oswestry Disability Index
PACU: Postoperative anesthesia care unit
PCS: Physical Component Score
QALY: Quality-adjusted life year
SF-12: Short-Form 12
TLIF: Transforaminal lumbar interbody fusion

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■ BACKGROUND: **Minimally invasive transforaminal lumbar interbody fusion (MIS TLIF) for lumbar spondylolisthesis allows for the surgical treatment of back/leg pain while minimizing tissue injury and accelerating the patient's recovery. Although previous results have shown shorter hospital stays and decreased intraoperative blood loss for MIS versus open TLIF, short- and long-term outcomes have been similar. Therefore, we performed comparative effectiveness and cost-utility analysis for MIS versus open TLIF.**

■ METHODS: **A total of 100 patients (50 MIS, 50 open) undergoing TLIF for lumbar spondylolisthesis were prospectively studied. Back-related medical resource use, missed work, and quality-adjusted life years were assessed. Cost of in-patient care, direct cost (2-year resource use × unit costs based on Medicare national allowable payment amounts), and indirect cost (work-day losses × self-reported gross-of-tax wage rate) were recorded, and the incremental cost-effectiveness ratio was calculated.**

■ RESULTS: **Length of hospitalization and time to return to work were less for MIS versus open TLIF ($P = 0.006$ and $P = 0.03$, respectively). MIS versus open TLIF demonstrated similar improvement in patient-reported outcomes assessed. MIS versus open TLIF was associated with a reduction in mean hospital cost of $1758, indirect cost of $8474, and total 2-year societal cost of $9295 ($P = 0.03$) but similar 2-year direct health care cost and quality-adjusted life years gained.**

■ CONCLUSIONS: **MIS TLIF resulted in reduced operative blood loss, hospital stay and 2-year cost, and accelerated return to work. Surgical morbidity, hospital readmission, and short- and long-term clinical effectiveness were similar between MIS and open TLIF. MIS TLIF may represent a valuable and cost-saving advancement from a societal and hospital perspective.**

INTRODUCTION

Multiple lumbar interbody arthrodesis techniques have been reported with the aim of improving fusion rates, maintaining vertebral alignment, and relieving back and leg pain. In 1982, Harms and Rolinger first described the open transforaminal lumbar interbody fusion (TLIF) technique (12), a procedure that allows for circumferential fusion via a single posterolateral approach and has been performed for many years with good results (18, 19). However, multiple studies have reported the destructive effects of the extensive muscle dissection and retraction required for traditional open TLIF procedures (9, 24). In addition, protracted hospital stays and significant costs have been associated with open lumbar fusion procedures (21, 28).

Recently, minimally invasive (MIS) techniques for TLIF have been introduced with the goal of smaller operative wounds,

reduced trauma to adjacent tissue, and quicker postoperative recovery, which may translate to minimized blood loss, decreased length of hospitalization, and decreased rates of surgical site infection (17, 22, 25). Even with these theoretical advantages, similar long-term outcomes have been previously reported in the literature for MIS and open TLIF (4, 23, 25). However, the advantages of MIS TLIF may manifest primarily in the early recovery period rather than in long-term outcomes (20). In an initial pilot study, our group previously demonstrated that MIS TLIF was associated with a significantly shorter duration of postoperative narcotic use and an accelerated return to work after surgery compared with open TLIF (1). It has become apparent that a significant portion of the total cost of spine surgery results from indirect costs associated with missed work after surgery (2, 10, 31). Because of this, the accelerated return to work provided by MIS TLIF may result in a reduction of the overall cost of care.

Cost-utility analysis and various forms of value analysis are becoming more important to health care reform initiatives. To improve the efficiency and cost of health care delivery, value-based purchasing has emerged, and requires that more costly medical treatments prove their value by demonstrating a health benefit that is greater than its added cost. The cost-utility of MIS versus open TLIF in the treatment of spondylolisthesis remains unclear. In light of this, we performed a prospective 2-year comparative effectiveness and cost-utility analysis of MIS and open TLIF in patients with degenerative grade I lumbar spondylolisthesis.

METHODS

Patient Selection

One hundred patients with a diagnosis of grade I degenerative lumbar spondylolisthesis who underwent MIS (n = 50) or open (n = 50) TLIF at our institution during a 24-month period were included into our prospective registry. The institutional review board approved this study. To be included, a patient had to (1) have evidence on magnetic resonance imaging of grade I degenerative lumbar spondylolisthesis; (2) have mechanical low back pain and radicular symptoms; (3) be unresponsive to at least 6 weeks of conservative therapy; and (4) be between 18 and 70 years of age. Patients were excluded if they had (1) undergone a previous back operation; (2) an extraspinal cause of back pain or sciatica; (3) an active medical or workman's compensation lawsuit; (4) any pre-existing spinal pathology; or (5) were unwilling or unable to participate with follow-up procedures. Patients with notable associated abnormalities such as inflammatory arthritis or metabolic bone disease also were excluded. These 100 patients captured into the registry represented 90% of the TLIFs performed for grade I spondylolisthesis during this time frame.

For all included patients, each was thought to be appropriate for either MIS or open TLIF. MIS versus open TLIF was performed purely on the basis of the surgeon's preference. All open TLIFs were performed by the same two surgeons who preferred open approaches, whereas all MIS TLIFs were performed by the same two surgeons who preferred MIS approaches. In addition, the surgeons performing MIS and open TLIFs had nearly identical postoperative treatment paradigms. In all cases, regardless of MIS versus open technique, the surgeon recommended initiation of physical therapy at 4 weeks postoperatively and return to work as soon as the patient felt capable, as early as 3 weeks postoperatively.

Surgical Technique

MIS TLIF. Fluoroscopy was used to determine the operative level. TLIF procedure was performed on the side of radicular symptoms. For cases in which both legs were symptomatic, the approach was from the side of more severe pathology and the contralateral lamina and foramina were decompressed. Sequential soft-tissue dilators were then inserted through the incision down to the facet complex until the desired working diameter was achieved. A facetectomy was then performed with a high-speed drill from lateral to medial to expose the posterolateral aspect of the disk. Intradiscal distraction and disk space preparation were performed with standard interbody fusion instrumentation. The endplate scraper was used to remove cartilaginous material from the endplates. A polyetheretherketone interbody graft was then placed anteriorly and contralateral to the annulotomy within the interbody space. Fluoroscopy was used to ensure satisfactory placement of the interbody graft.

When necessary, the contralateral ligamentum flavum was resected to expose the contralateral exiting and traversing nerve roots. If needed, the tubular retractor was angled contralaterally so that a more extensive boney decompression could be carried out. Once the interbody fusion was performed, the tubular retractor was removed, and four pedicle screws were placed percutaneously immediately above and below the interbody segment to be fused. Compression was applied to the construct before final tightening, providing compression of the bone graft within the middle column, and maximizing lordosis. In all cases, local autogenous bone with or without bone extenders (i.e., demineralized bone matrix) was used for bone grafting. All wounds were copiously irrigated, and the wounds were closed in layers.

Open TLIF. A midline skin incision was used. The fascia was incised and the paravertebral muscles dissected from the spine. Radiographs were used to check the appropriate level. Bilateral pedicle screw-rod constructs were inserted and laminectomy and unilateral facetectomy was then performed at that level. This was followed by unilateral annulotomy, diskectomy, and placement of interbody graft. Similar to the MIS approach, cartilaginous material was removed from the endplates by use of the endplate scraper. A polyetheretherketone interbody graft was then placed anteriorly and contralateral to the annulotomy within the interbody space. Local autogenous bone with or without bone extenders (i.e., demineralized bone matrix) was used for bone grafting. The wound was copiously irrigated and closed in layers.

Hospital Course and Perioperative Quality. Length of surgery, estimated blood loss, perioperative complications, and length of hospital stay were recorded. Hospital readmission during the 90-day global period was recorded as was return to the operating room during the 2-year follow-up period. All morbidity and mortality occurring within the first 3 months after surgery was recorded.

Clinical Outcome Measures

Preoperative, 3-month, and 2-year postoperative pain, disability, and quality of life were assessed via phone interviews by an independent investigator not involved with clinical care. Duration of narcotic use and time to return to work was documented in