

Maximal Outcomes Through Minimal Incision:

Advances in Minimally Invasive and Endoscopic Spinal Surgery

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Disclosures

- Consultant
 - Kyocera Spine





Goals of Minimally Invasive Spine Surgery

- Reduced tissue disruption
 - Preserves muscle and ligamentous envelope around the spine
 - Lower incidence of segmental degeneration
- Lower blood loss
- Smaller incisions
- Faster recovery time





Lumbar Herniated Disk/Stenosis

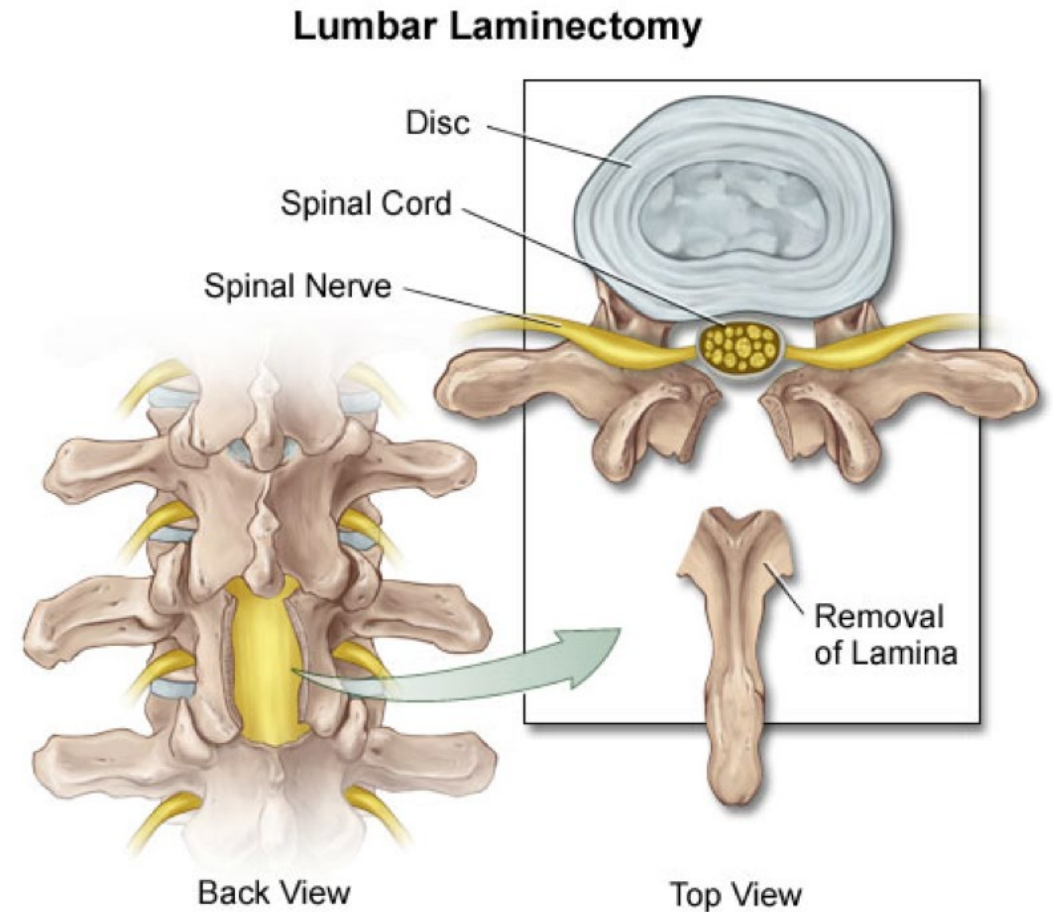




Lumbar Herniated Disk/Stenosis

The Old Way:

- Strip the muscle off the bony elements
- Remove the interspinous ligaments
- Resection of the spinous process and lamina





Lumbar Herniated Disk/Stenosis

Flat back syndrome

- Loss of lumbar lordosis due to disruption of the posterior elements of the spine
- May result in spinal deformity/worsening back pain
- May require advanced spinal reconstruction techniques



Fig. 1 Lumbo-pelvic indexes appear to be efficient to predict impact on treatment but preoperative planning cannot be reduced to lumbo-pelvic-indexes. In this case, LLI is 0.2 (<0.5) and $PI-LL = 36^\circ$ ($>28^\circ$). The spine was highly flexible and the sagittal malalignment corrected without a spinal osteotomy



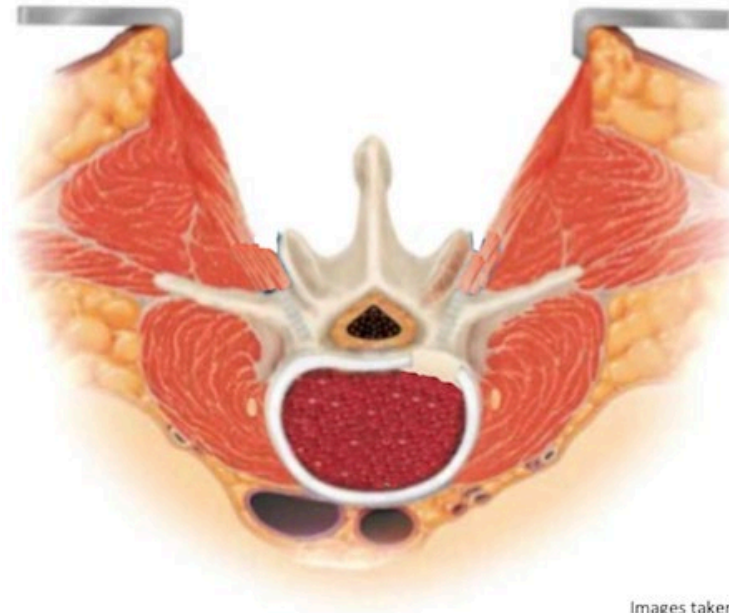
Lumbar Herniated Disk/Stenosis

Tubular MIS laminectomy

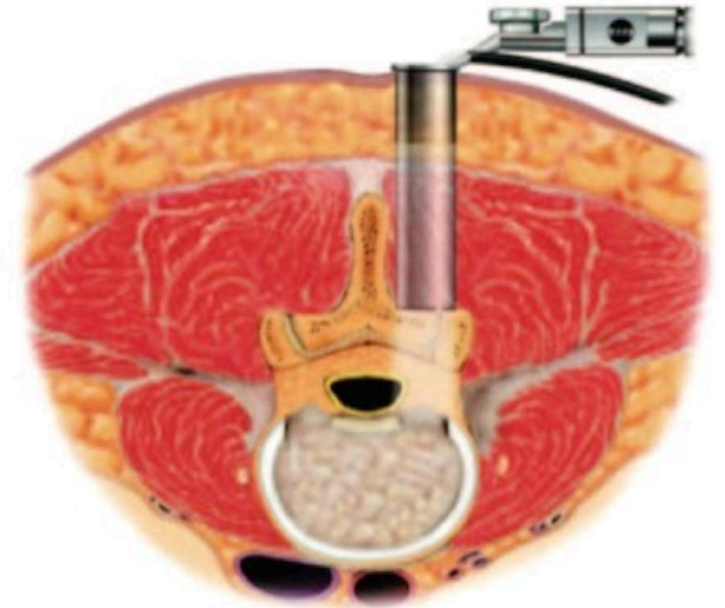
- Avoids stripping of muscular envelope
- Avoids resection of interspinous ligament
- Avoids resection of spinous process
- Significantly less exposure of the spine
- Smaller incision

Which Would You Prefer?

Open



Tubular MIS



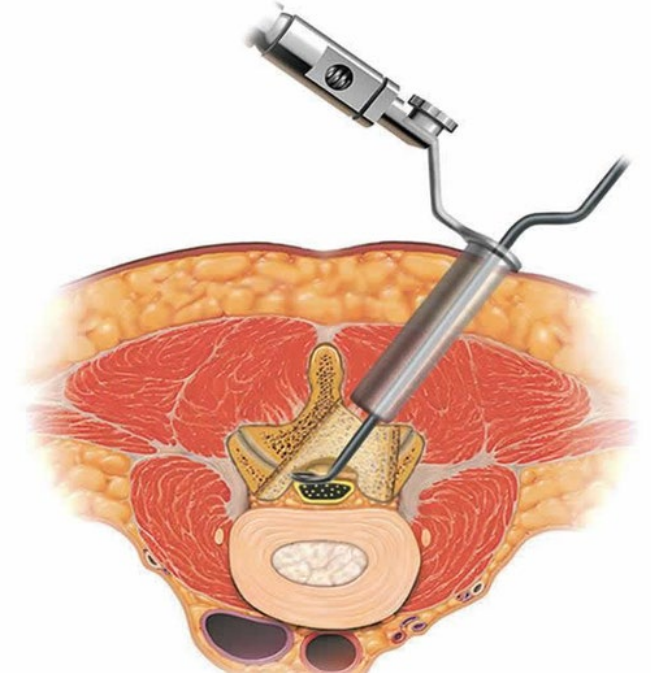
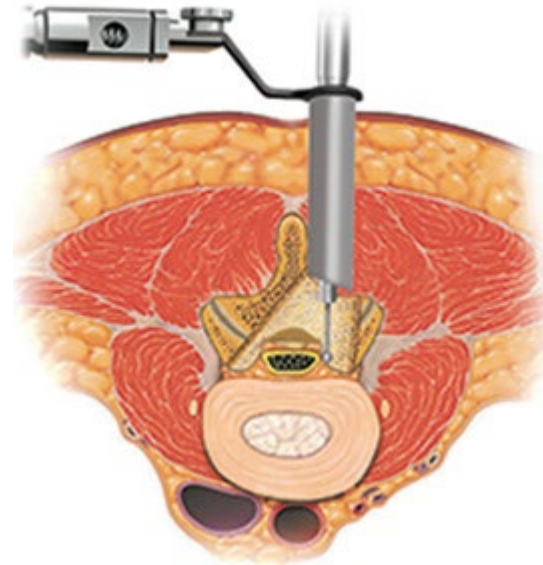
Images taken from Medtronic





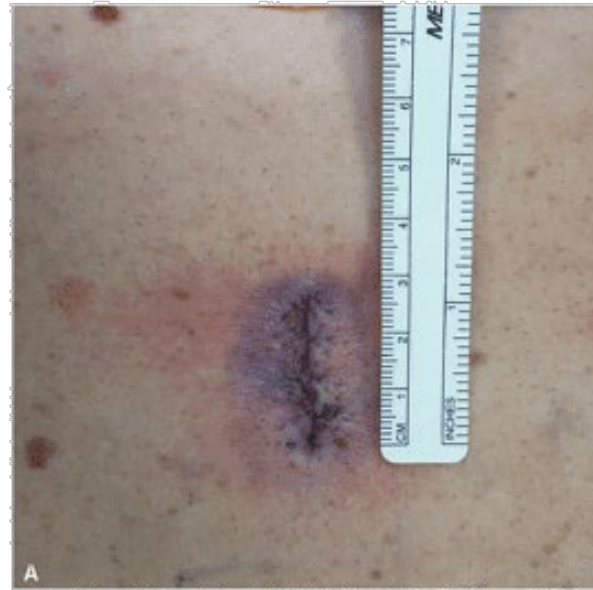
Lumbar Herniated Disk/Stenosis

Minimally invasive
bilateral decompression
via a unilateral approach





Lumbar Herniated Disk/Stenosis





Review

> [Spine \(Phila Pa 1976\)](#). 2016 Jan;41(2):E91-E100. doi: 10.1097/BRS.0000000000001161.

Minimally Invasive Versus Open Laminectomy for Lumbar Stenosis: A Systematic Review and Meta-Analysis

Methods: Relevant articles were identified from six electronic databases. Predefined endpoints were extracted and meta-analyzed from the identified studies.

Results: Satisfaction rates were significantly higher in the minimally invasive group (84% vs. 75.4%; $P = 0.03$), whereas back pain Visual Analog Scale scores were lower ($P < 0.00001$). Minimally invasive laminectomy operative duration was 11 minutes longer than the open approach ($P = 0.001$), however this may not have clinical significance. However, there was less blood loss ($P < 0.00001$) and shorter hospital stay (2.1 days; $P < 0.0001$). Dural injuries and cerebrospinal fluid leaks were comparable, but reoperation rates were lower in the minimally invasive cohort (1.6% vs. 5.8%; $P = 0.02$); however this was not significant when only randomized evidence was considered.

Conclusion: The pooled evidence suggests ULBD may be associated with less blood loss and shorter stay, with similar complication profiles to the open approach. These findings warrant verification in large prospective registries and randomized trials.

Level of evidence: 1.



Lumbar Fusion Surgery

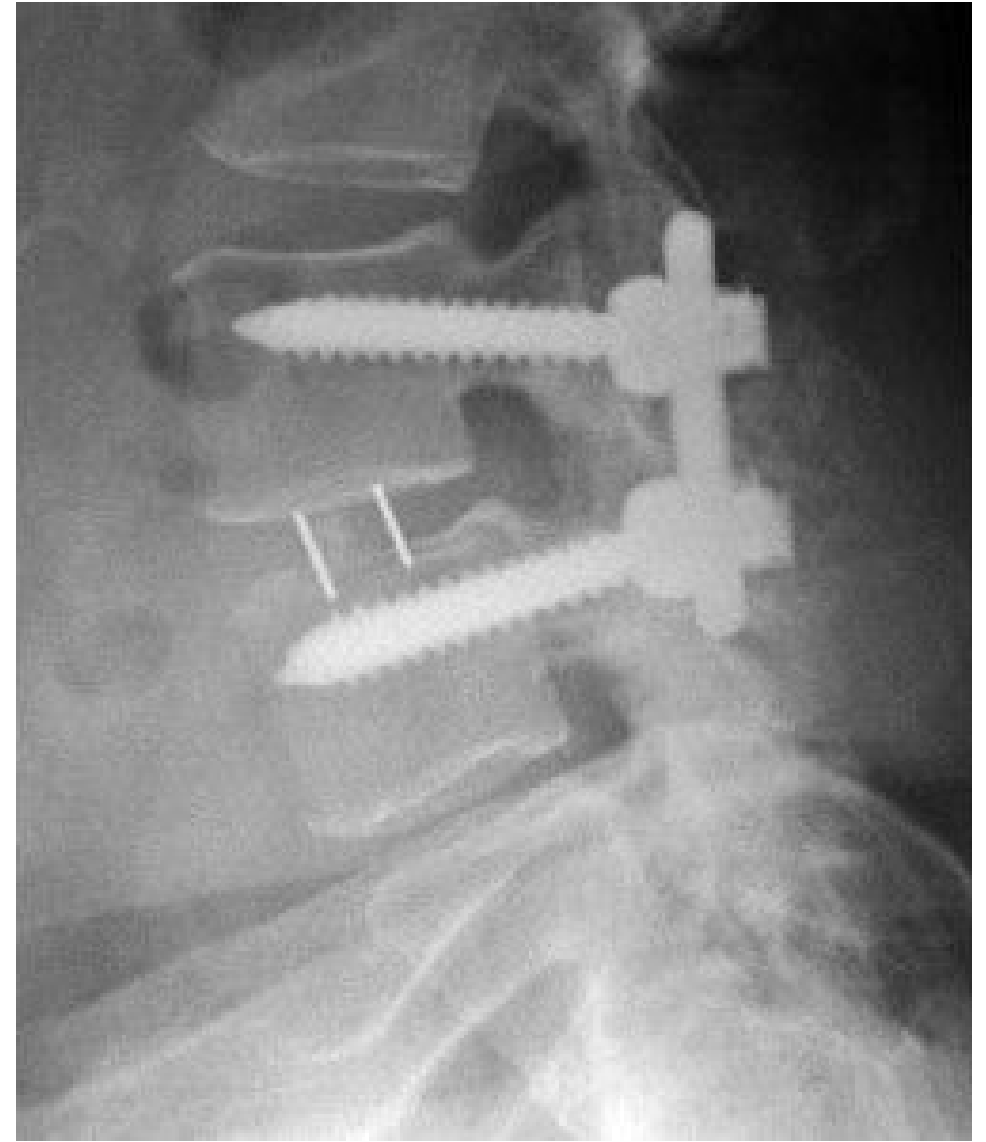
- Lumbar spondylolisthesis with stenosis
- Often presents with back and leg pain
 - Often requires decompression as well as fusion
 - TLIF is a common surgical solution





Lumbar Fusion Surgery

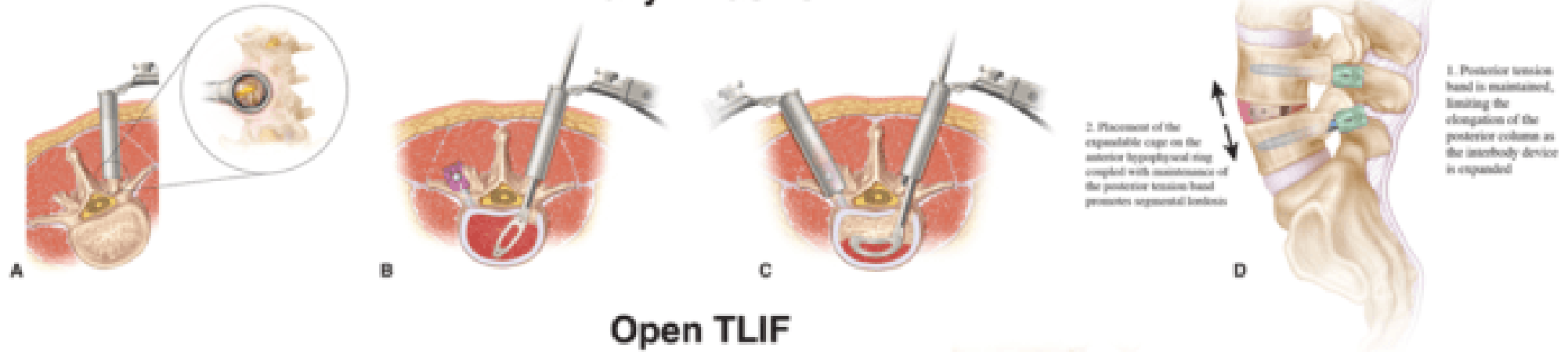
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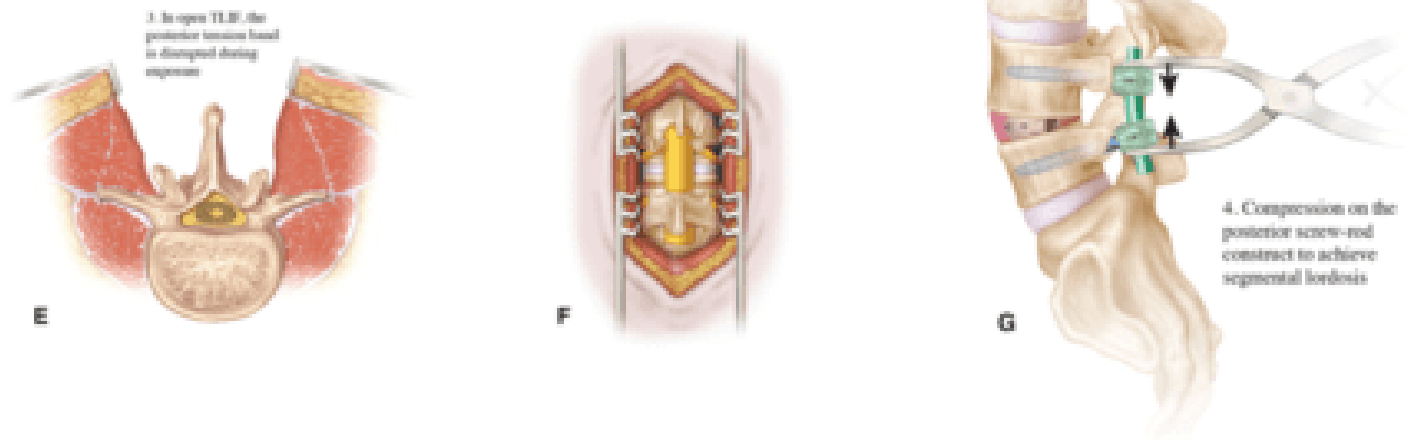


Lumbar Fusion Surgery

Minimally Invasive TLIF

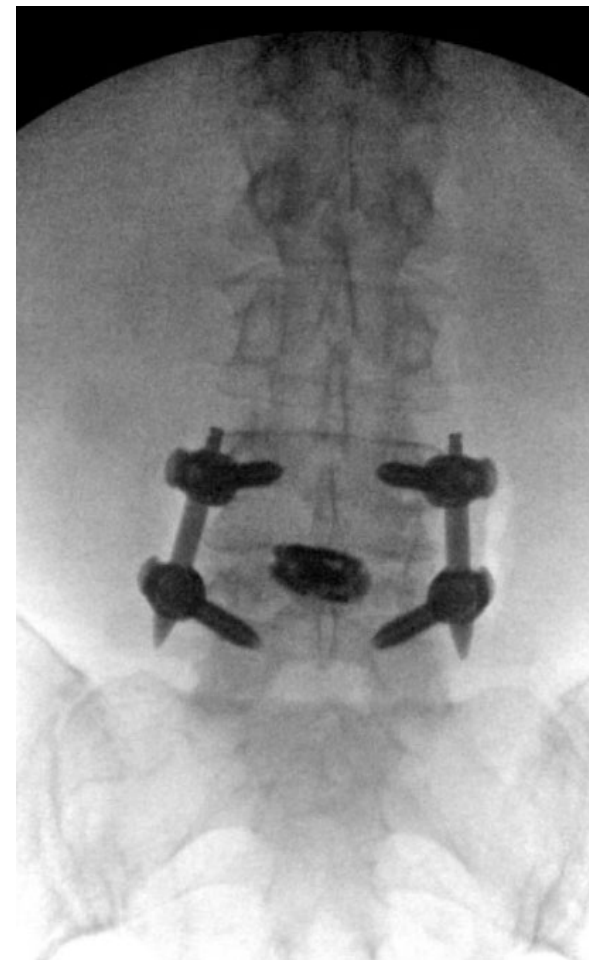
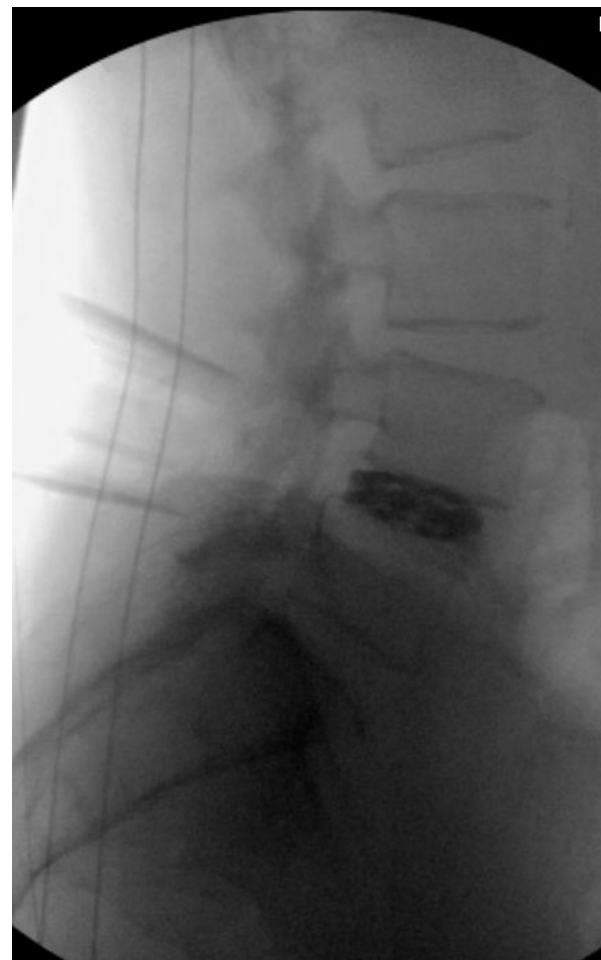


Open TLIF



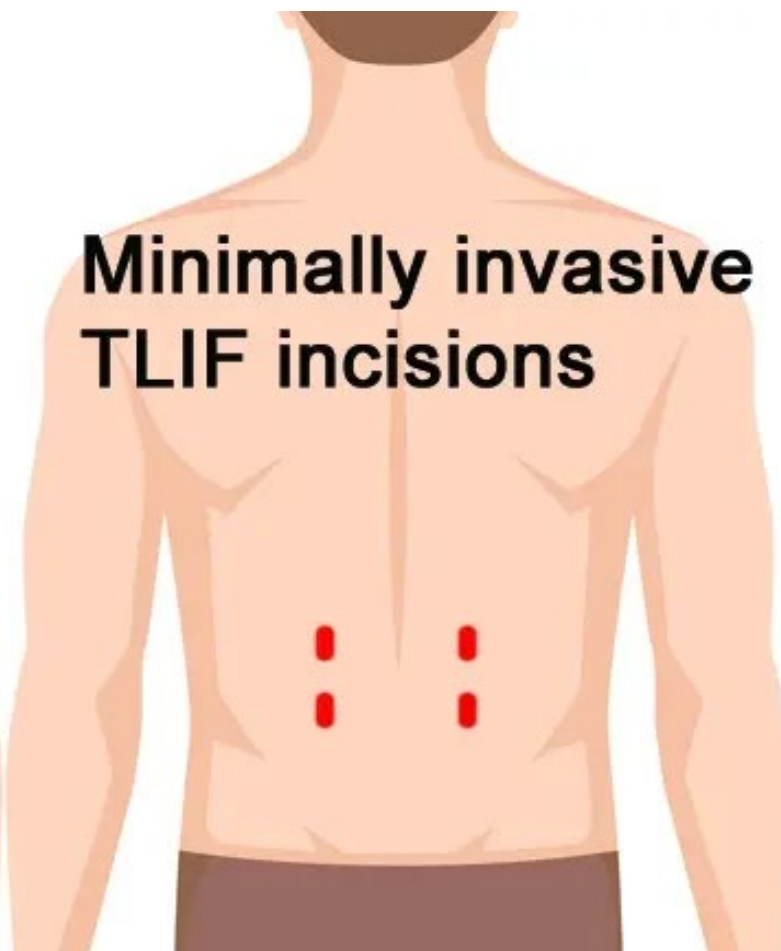
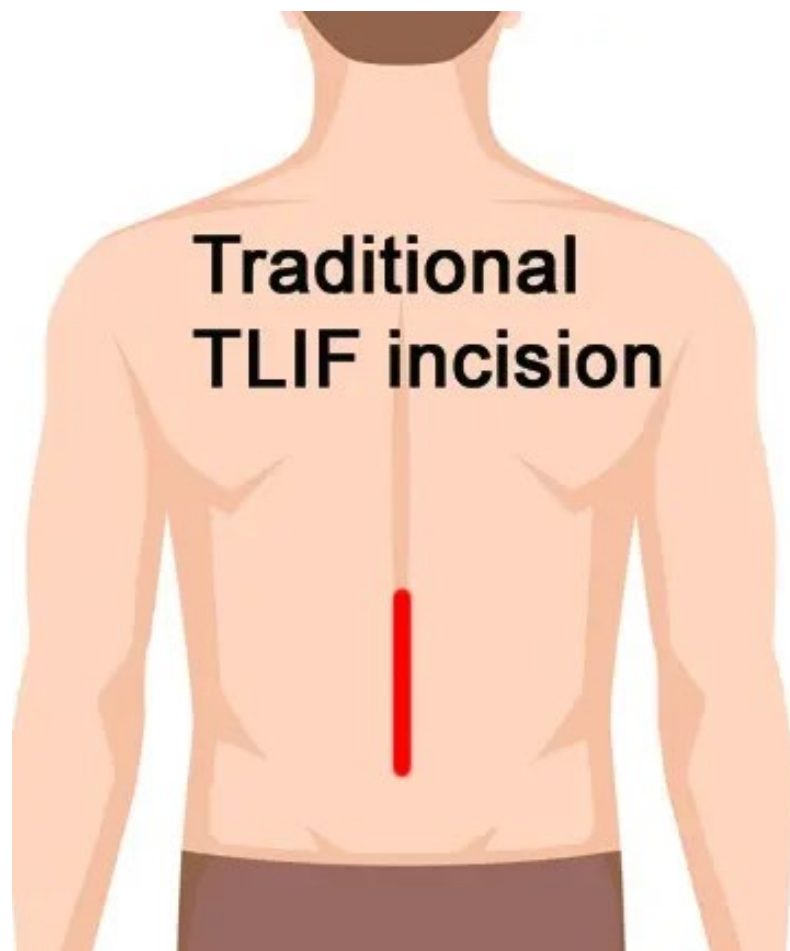


Lumbar Fusion Surgery





Lumbar Fusion Surgery





Lumbar Fusion Surgery

- Advantages of minimally invasive TLIF over open TLIF
 - Smaller incisions
 - Less muscle dissection -> less recovery time and less postoperative pain
 - Less chance of disruption of the facets of the adjacent level
 - Possibly leading to less adjacent segment degeneration
- Disadvantages of minimally invasive TLIF
 - Increased learning curve
 - Increased difficulty in repairing dural tears
 - Increased use of fluoroscopy



Minimally invasive versus open transforaminal lumbar interbody fusion for degenerative spondylolisthesis: comparative effectiveness and cost-utility analysis


Scott L Parker ¹, Stephen K Mendenhall ¹, David N Shau ¹, Scott L Zuckerman ¹, Saniya S Godil ¹, Joseph S Cheng ¹, Matthew J McGirt ²

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.



Minimally invasive versus open transforaminal lumbar interbody fusion for treatment of degenerative lumbar disease: systematic review and meta-analysis

[Kevin Phan](#) , [Prashanth J. Rao](#), [Andrew C. Kam](#) & [Ralph J. Mobbs](#)

European Spine Journal **24**, 1017–1030 (2015) | [Cite this article](#)

Methods

Electronic searches were performed using six databases from their inception to December 2014. Relevant studies comparing MI-TLIF and O-TLIF were included. Data were extracted and analysed according to predefined clinical end points.

Results

There was no significant difference in operation time noted between MI-TLIF and O-TLIF cohorts. The median intraoperative blood loss for MI-TLIF was significantly lower than O-TLIF (median: 177 vs 461 mL; (weighted mean difference) WMD, -256.23 ; 95 % CI -351.35 , -161.1 ; $P < 0.00001$). Infection rates were significantly lower in the minimally invasive cohort (1.2 vs 4.6 %; relative risk (RR), 0.27; 95 % CI, 0.14, 0.53; $I^2 = 0$ %; $P = 0.0001$). VAS back pain scores were significantly lower in the MI-TLIF group compared to O-TLIF (WMD, -0.41 ; 95 % CI -0.76 , -0.06 ; $I^2 = 96$ %; $P < 0.00001$). Postoperative ODI scores were also significantly lower in the minimally invasive cohort (WMD, -2.21 ; 95 % CI -4.26 , -0.15 ; $I^2 = 93$ %; $P = 0.04$).

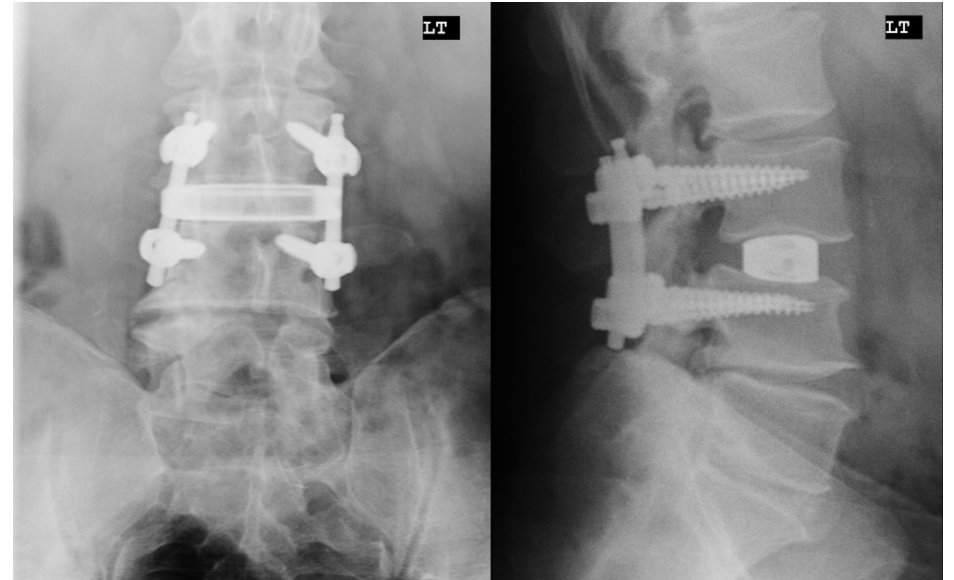
Conclusions

In summary, the present systematic review and meta-analysis demonstrated that MI-TLIF appears to be a safe and efficacious approach compared to O-TLIF. MI-TLIF is associated with lower blood loss and infection rates in patients, albeit at the risk of higher radiation exposure for the surgical team. The long-term relative merits require further validation in prospective, randomized studies.



Lumbar Fusion Surgery

- Other MIS solutions:
 - Lateral lumbar interbody fusion
 - Access through the psoas muscle to access the disk space



Lumbar Fusion Surgery

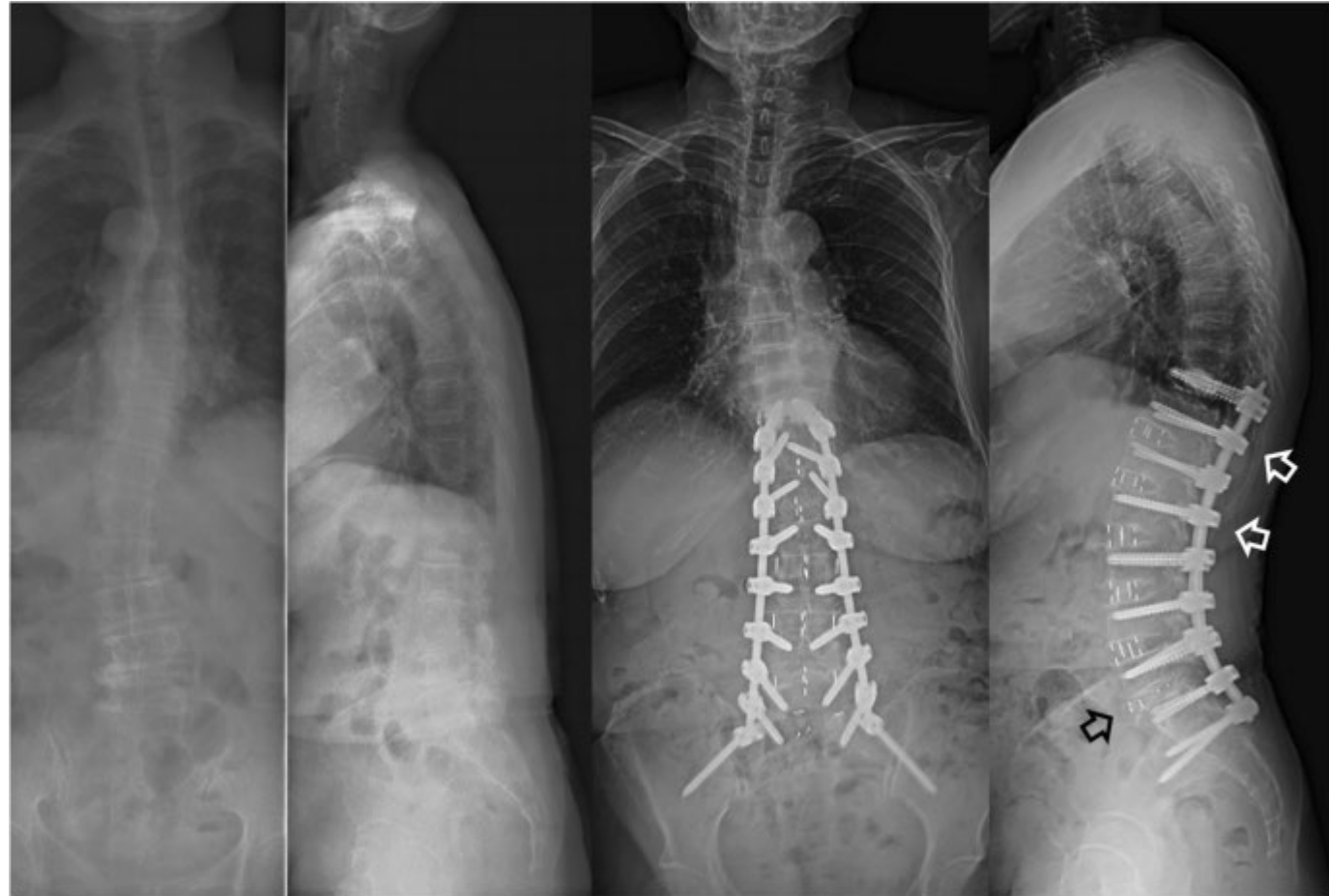
- Other MIS solutions:
 - Anterior lumbar interbody fusion
 - Retroperitoneal approach to the disc space





Spinal Reconstructive Surgery for Deformity

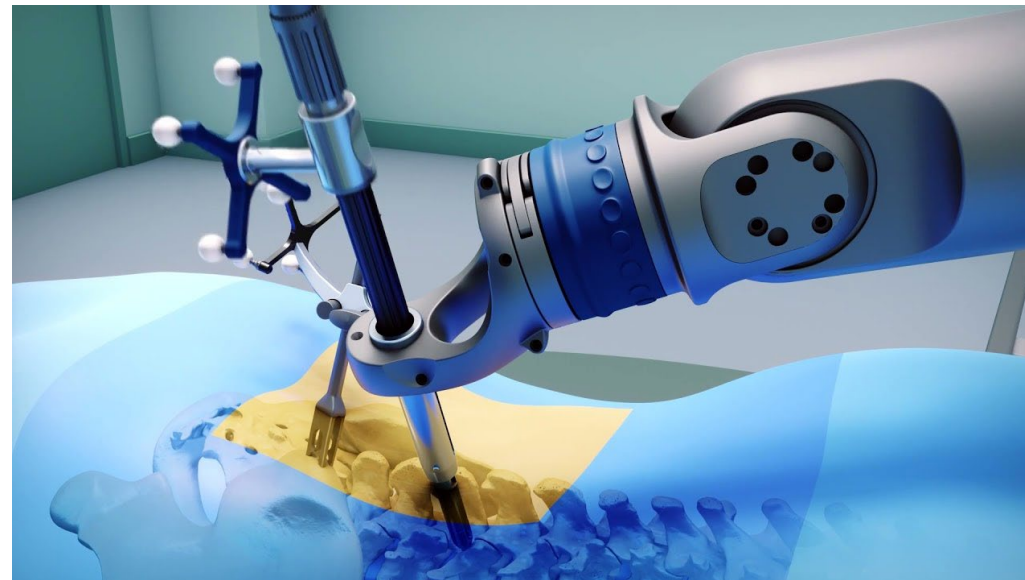
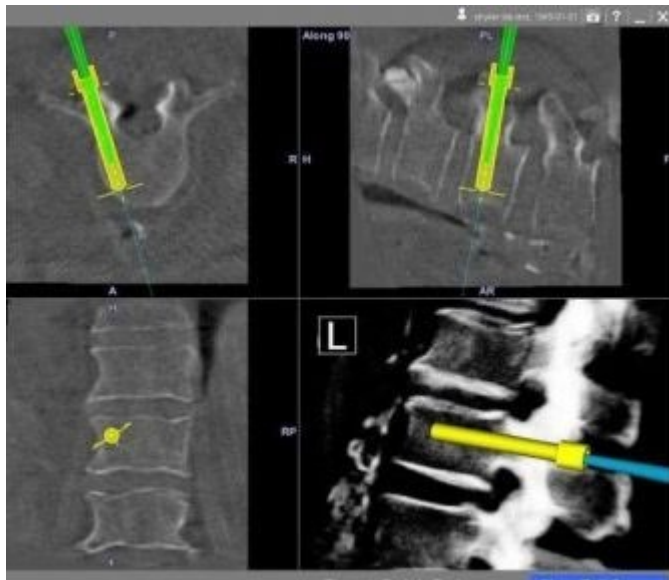
- Same principles are maintained for MIS
 - Avoidance of muscle/ligament/soft tissue envelope around the spine
 - Avoidance of adjacent facet joints
- Employ combination of MIS TLIF, ALIF, and TLIF for circumferential correction and fusion of the spine
- Pedicle screws placed posteriorly through stab incisions in skin/fascia





Spinal Reconstructive Surgery for Deformity

- Accuracy of percutaneous pedicle screws have significantly improved with:
 - Computer guided navigation
 - Robotic guided surgery





Spinal Navigation

Instrumenting the small thoracic pedicle: the role of intraoperative computed tomography image-guided surgery

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 FARIS SHWEIKEH, B.S.,¹ ERIC FRIEDMAN, B.A.,¹ ROBERT PASHMAN, M.D.,²
 J. PATRICK JOHNSON, M.D.,^{1,4} AND TERRENCE T. KIM, M.D.²

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 Medical School at Houston, Texas

Object. Traditionally, instrumentation of thoracic pedicles has been more difficult because of their relatively smaller size. Thoracic pedicles are at risk for violation during surgical instrumentation, as is commonly seen in patients with scoliosis and in women. The laterally based “in-out-in” approach, which technically results in a lateral breach, is sometimes used in small pedicles to decrease the comparative risk of a medial breach with neurological involvement. In this study the authors evaluated the role of CT image-guided surgery in navigating screws in small thoracic pedicles.

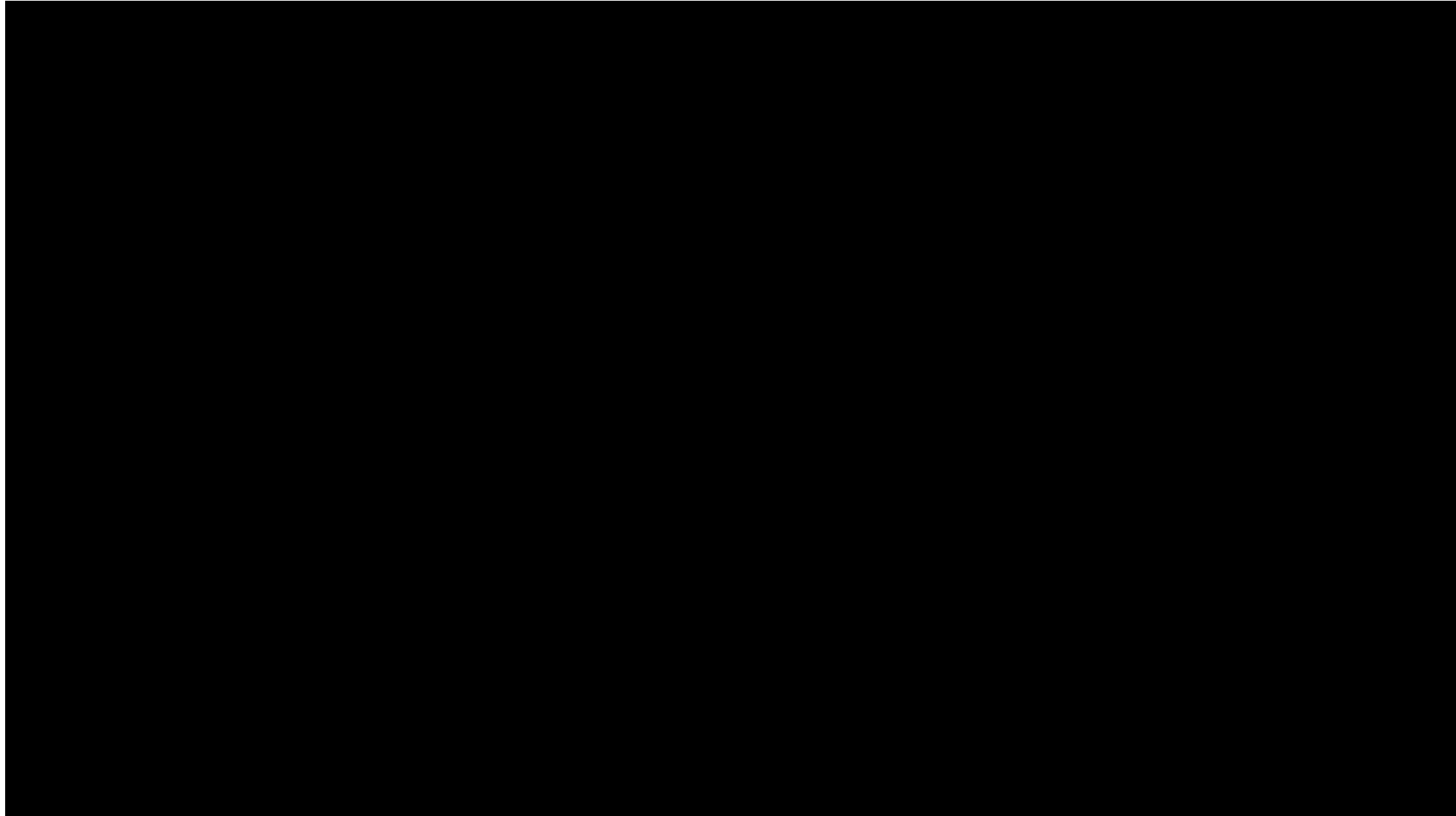
Methods. Thoracic (T1–12) pedicle screw placements using the O-arm imaging system (Medtronic Inc.) were evaluated for accuracy with preoperative and postoperative CT. “Small” pedicles were defined as those ≤ 3 mm in the narrowest diameter orthogonal to the long axis of the pedicle on a trajectory entering the vertebral body on preinstrumentation CT. A subset of “very small” pedicles (≤ 2 mm in the narrowest diameter, 13 pedicles) was also analyzed. Screw accuracy was categorized as good (< 1 mm of pedicle breach in any direction or in-out-in screws), fair (1–3 mm of breach), or poor (> 3 mm of breach).

Results. Twenty-one consecutive patients (age range 32–71 years) had large (45 screws) and small (52 screws) thoracic pedicles. The median pedicle diameter was 2.5 mm (range 0.9–3 mm) for small and 3.9 mm (3.1–6.7 mm) for large pedicles. Computed tomography-guided surgical navigation led to accurate screw placement in both small (good 100%, fair 0%, poor 0%) and large (good 96.6%, fair 0%, poor 3.4%) pedicles. Good screw placement in very small or small pedicles occurred with an in-out-in trajectory more often than in large pedicles (large 6.8% vs small 36.5%, $p < 0.0005$; vs very small 69.2%, $p < 0.0001$). There were no medial breaches even though 75 of the 97 screws were placed in postmenopausal women, traditionally at higher risk for osteoporosis.

Conclusions. Computed tomography-guided surgical navigation allows for safe, effective, and accurate instrumentation of small (≤ 3 mm) to very small (≤ 2 mm) thoracic pedicles.
 (<http://thejns.org/doi/abs/10.3171/2014.1.FOCUS13527>)



Robotic Spinal Surgery





Spinal Tumor/Trauma Surgery

- Traditional open approaches have required extensive instrumentation construction with invasive exposures
 - Often unstable/sick patients
 - Unable to tolerate significant blood loss
- Minimally invasive approaches allow:
 - Decreased blood loss
 - Faster mobilization for trauma patients
 - Increased recovery times for cancer patients so that they can proceed with radiation/systemic therapy

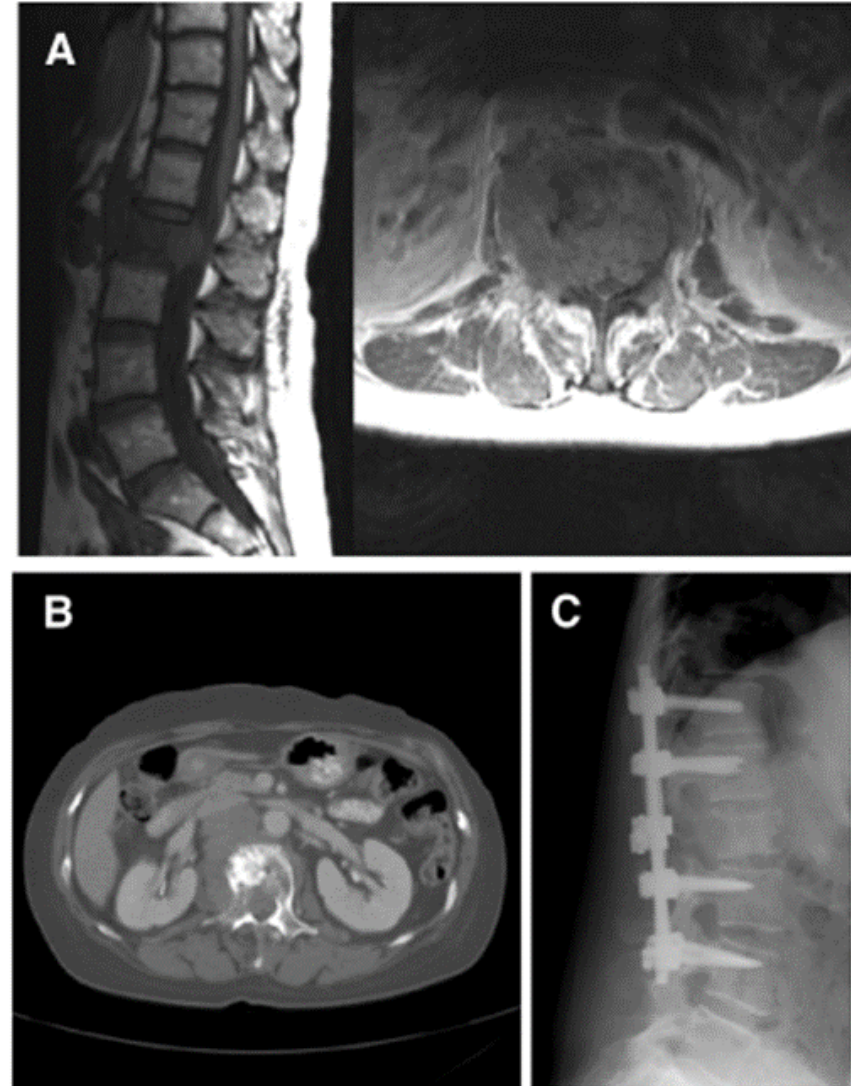




Spinal Tumor/Trauma Surgery

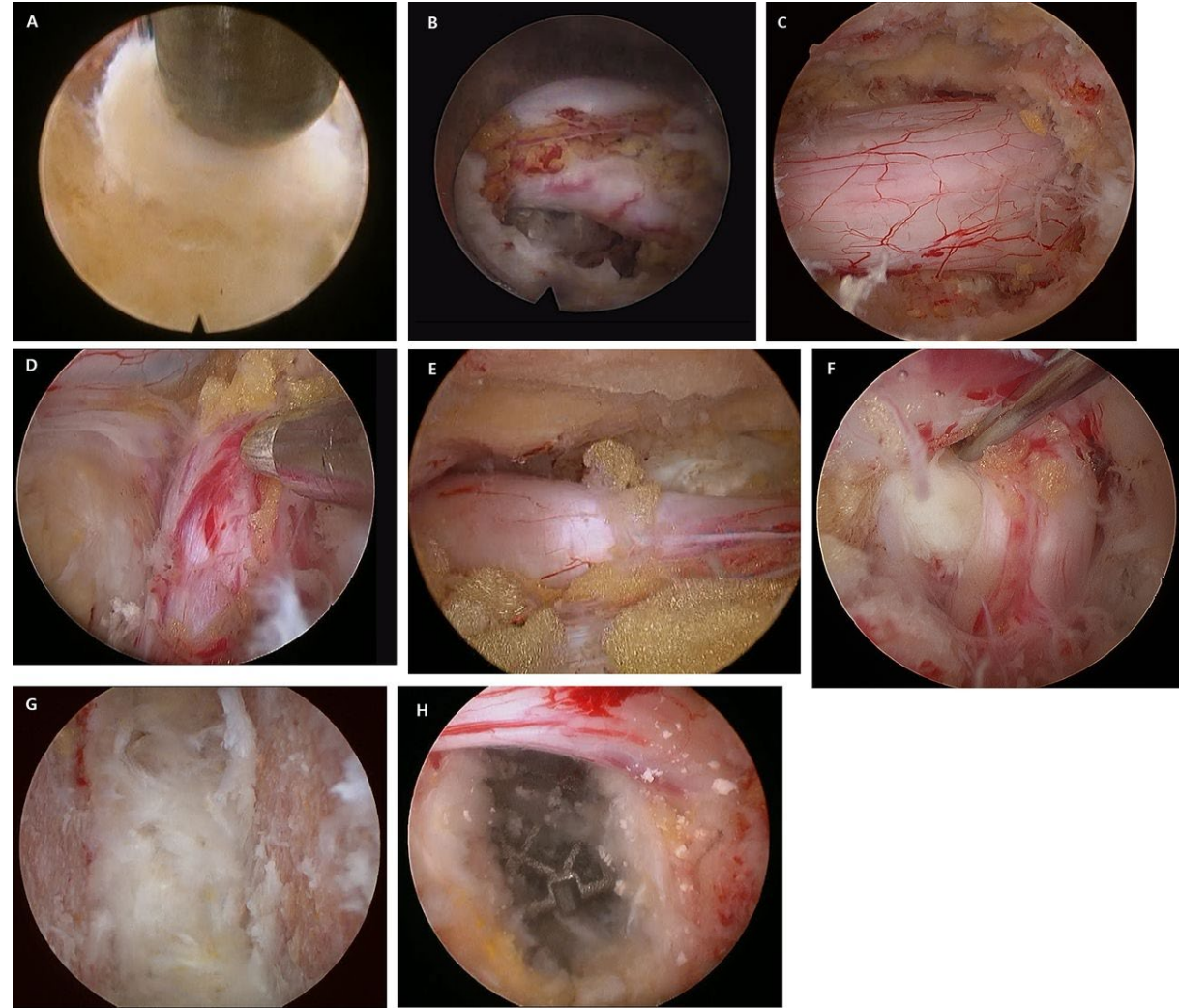
60 yo female with colon CA

- Metastatic lesion to L2 with posterior element involvement
- Severe mechanical pain
- No spinal cord compression
- T12-L4 minimally invasive performed
- Complete resolution of mechanical pain
- Postoperative SRS





Endoscopic Spinal Surgery





Endoscopic Spinal Surgery





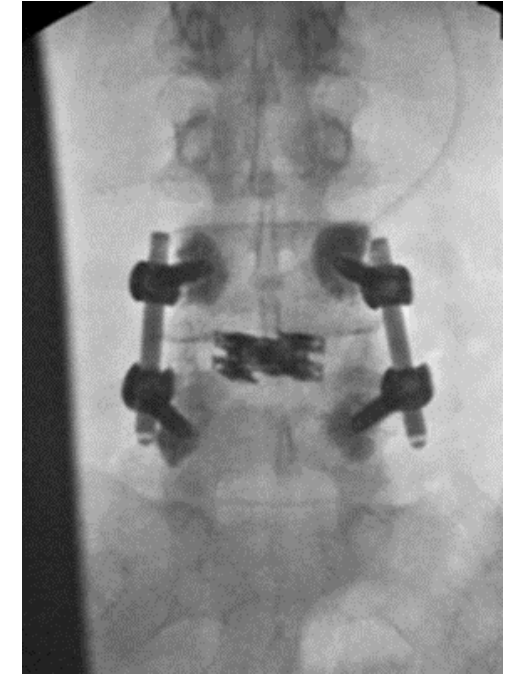
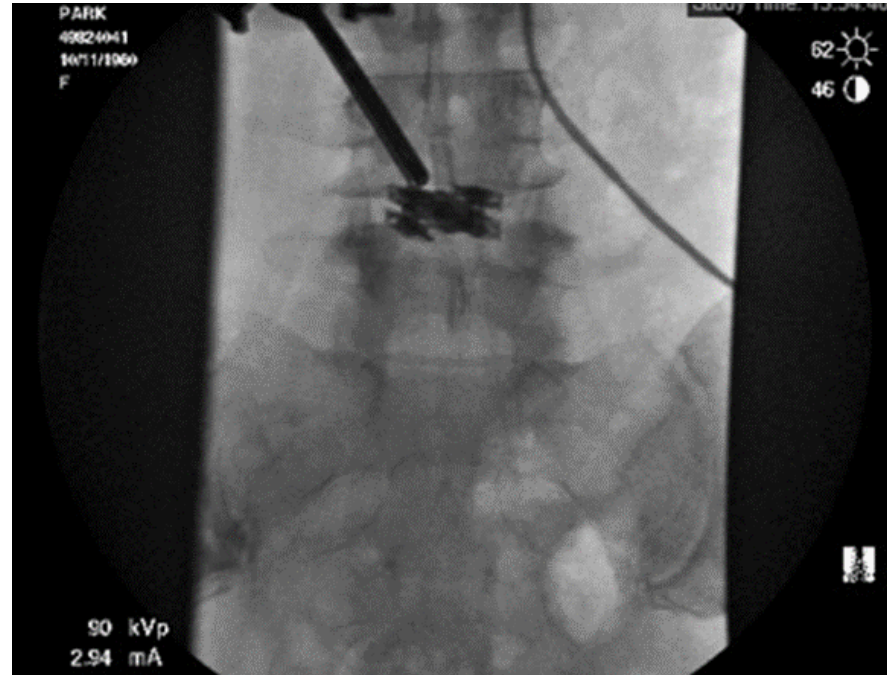
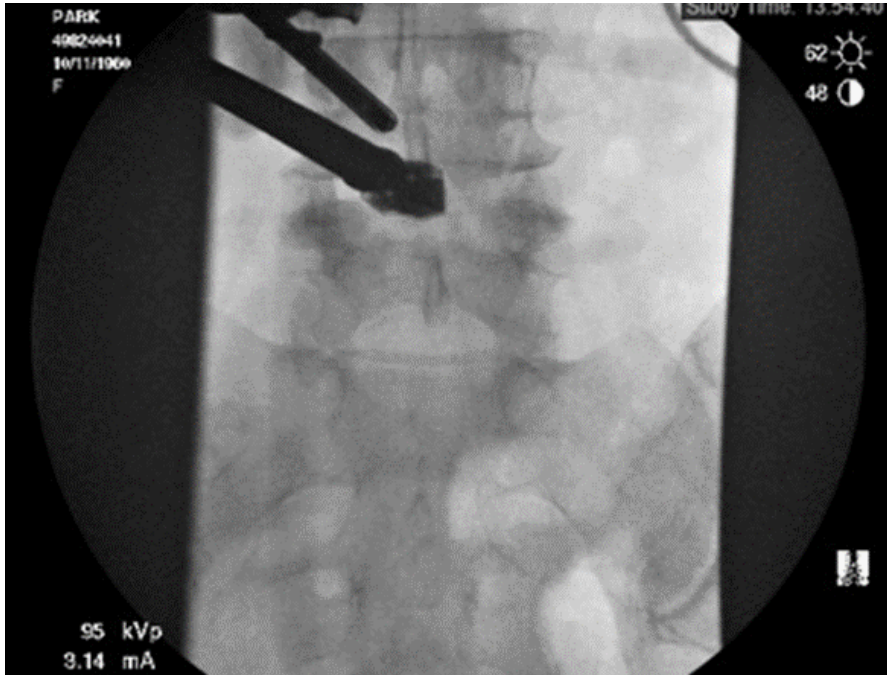
Endoscopic Spinal Surgery

- Advantages
 - Very small incisions
 - Very minimal soft tissue envelope disruption
 - Minimally blood loss
 - Surgical infection rate virtually zero
- Disadvantages
 - Steep learning curve
 - Operative management of dural tears very challenging





Endoscopic Spinal Surgery





Endoscopic Spinal Surgery

Incisions are usually 1cm
- Size needed to create a portal
for the endoscope





Clinical outcomes and complications after biportal endoscopic spine surgery: a comprehensive systematic review and meta-analysis of 3673 cases

Don Y Park^[1], Alexander Upfill-Brown^[2], Nora Curtin^[2], Christopher D Hamad^[2], Akash Shah^[2], Brian Kwon^[3], Yong H Kim^[4], Dong Hwa Heo^[5], Cheol Woong Park^[6], William L Sheppard^[2]

Affiliations + expand

PMID: 37079079 DOI: [10.1007/s00586-023-07701-9](https://doi.org/10.1007/s00586-023-07701-9)


Abstract

Purpose: Current literature suggests that biportal spinal endoscopy is safe and effective in treating lumbar spine pathology such as lumbar disc herniation, lumbar stenosis, and degenerative spondylolisthesis. No prior study has investigated the postoperative outcomes or complication profile of the technique as a whole. This study serves as the first comprehensive systematic review and meta-analysis of biportal spinal endoscopy in the lumbar spine.



Methods: A PubMed literature search provided over 100 studies. 42 papers were reviewed and 3673 cases were identified with average follow-up time of 12.5 months. Preoperative diagnoses consisted of acute disc herniation (1098), lumbar stenosis (2432), and degenerative spondylolisthesis (229). Demographics, operative details, complications, and perioperative outcome and satisfaction scores were analyzed.

Results: Average age was 61.32 years, 48% male. 2402 decompressions, 1056 discectomies, and 261 transforaminal lumbar Interbody fusions (TLIFs) were performed. Surgery was performed on 4376 lumbar levels, with L4-5 being most common(61.3%). 290 total complications occurred, 2.23% durotomies, 1.29% inadequate decompressions, 3.79% epidural hematomas, and < 1% transient nerve root injuries, infections, and iatrogenic instability. Significant improvement in VAS-Back, VAS-Leg, ODI, and Macnab Scores were seen across the cohort.

Conclusion: Biportal spinal endoscopy is a novel method to address pathology in the lumbar spine with direct visualization through an endoscopic approach. Complications are comparable to previously published rates. Clinical outcomes demonstrate effectiveness. Prospective studies are required to assess the efficacy of the technique as compared to traditional techniques. This study demonstrates that the technique can be successful in the lumbar spine.



Biportal Endoscopic Spinal Surgery versus Microscopic Decompression for Lumbar Spinal Stenosis: A Systematic Review and Meta-Analysis


Raymond Pranata ¹  , Michael Anthonius Lim ¹, Rachel Vania ¹, Julius July ²

Results

There were 383 patients from 5 unique studies. Meta-analysis of visual analog scale score for low back pain showed no significant difference at baseline ($P=0.49$), at 2–3 months ($P=0.69$), and at the final follow-up ($P=0.26$). There was no significant difference in visual analog scale score for leg pain and Oswestry Disability Index between the groups preoperatively ($P=0.76$ and $P=0.95$), at 2–3 months ($P=0.46$ and $P=0.92$), and at the final follow-up ($P=0.88$ and $P=0.58$). The mean operation time was similar in the BESS and microsurgery groups ($P=0.36$). The BESS group was associated with shorter length of stay (mean difference -2.60 days [$-3.39, -1.81$]; $P < 0.001$; $I^2=65\%$). Complications were similar in both groups ($P=0.26$). Individual studies have shown that BESS was associated with early ambulation and less need for opioids.

Conclusions

Current evidence shows a lack of significant differences in terms of efficacy and safety between BESS and microsurgery. Further studies are required before drawing a definite conclusion.



Comparison of Minimal Invasive Versus Biportal Endoscopic Transforaminal Lumbar Interbody Fusion for Single-level Lumbar Disease

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and Seung-Min Jee, MD†*

Clin Spine Surg • Volume 34, Number 2, March 2021



Pain and functional outcomes similar in both groups after 1 year
Initially postoperative back pain higher in the MIS TLIF group
Similar radiographic outcomes between both groups





Clinical Study

Full-endoscopic spine surgery diminishes surgical site infections – a propensity score-matched analysis

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RESULTS

In the nonpropensity-matched dataset, the endoscopic cohort had a significantly higher incidence of medical comorbidities. The SSI rates for nonendoscopic and endoscopic patients were 1.2% and 0.001%, respectively, in the nonpropensity match cohort (p-value <.011). Propensity score matching yielded 5936 nonendoscopic patients with excellent matching (standard mean difference of 0.007). The SSI rate in the matched population was 1.1%, compared to 0.001% in endoscopic patients with an odds ratio 0.063 (95% confidence interval (CI) 0.009–0.461, p=.006) favoring FESS.

CONCLUSIONS

FESS compares favorably for risk reduction in SSI following spinal decompression surgeries with similar operative characteristics. As a consequence, FESS may be considered the optimal strategy for minimizing SSI morbidity.

