

What's New in Spine? Lateral Transpsoas Surgery

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No relevant disclosures to report

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What are the surgical goals?

- Resolve leg pain
- Restore coronal and sagittal alignment
- Minimize soft tissue disruption
- Promote fusion with large graft area
- Minimize complications
- Meet/exceed traditional results



Should we be doing Surgery?

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N Engl J Med. 2007 May 31; 356(22): 2257–2270. doi:10.1056/NEJMoa070302.

Surgical versus Nonsurgical Treatment for Lumbar Degenerative Spondylolisthesis

James N. Weinstein, D.O., Jon D. Lurie, M.D., Tor D. Tosteson, Sc.D., Brett Hanscom, M.S., Anna N.A. Tosteson, Sc.D., Emily A. Blood, M.S., Nancy J.O. Birkmeyer, Ph.D., Alan S. Hilibrand, M.D., Harry Herkowitz, M.D., Frank P. Cammisa, M.D., Todd J. Albert, M.D., Sanford E. Emery, M.D., M.B.A., Lawrence G. Lenke, M.D., William A. Abdu, M.D., Michael Longley, M.D., Thomas J. Errico, M.D., and Serena S. Hu, M.D.*

- Patients undergoing surgery fare better than those with nonsurgical treatment

Degenerative Spondylolisthesis

- Laminectomy and fusion does better than laminectomy alone.
 - Better reproducible clinical results
- Laminectomy alone can lead to progression of the spondylolisthesis and worsening deformity

Herkowitz HN, Kurz, L et al. *Degenerative lumbar spondylolisthesis with spinal stenosis: a prospective, randomized study comparing decompressive laminectomy and arthrodesis with and without spinal instrumentation.* Spine (Phila Pa 1976). 1997 Dec 15;22(24):2807-12.

Fox MW, et al . *Clinical outcomes and radiological instability following decompressive lumbar laminectomy for degenerative spinal stenosis: a comparison of patients undergoing concomitant arthrodesis versus decompression alone.* J Neurosurg. 1996;85:793–802.

Clinical Outcome

- Decompression/fusion is the apparent right choice
- Treatment options:
 - Lami + noninstrumented fusion
 - Lami + instrumented fusion
 - mTLIF/TLIF
 - ALIF/post fusion +/- lami
 - LLIF/post fusion +/- lami

- *Is fusion necessary?*
- *Does clinical outcome correlate with fusion success?*

Fusion

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Degenerative Lumbar Spondylolisthesis With Spinal Stenosis

A Prospective Long-Term Study Comparing Fusion and Pseudarthrosis

Martin B. Komblum, MD,* Jeffrey S. Fischgrund, MD,† Harry N. Herkowitz, MD,† David A. Abraham, MD,‡ David L. Berkower, DO,§ and Jeff S. Ditkoff||

- Long-term clinical outcome success favored successful arthrodesis

SPORT Data

- Early:
 - Outcomes equal across fusion methods.
- Two years:
 - Anterior/Posterior Fusion Patients are significantly better in SF-36 Back pain and Physical Function compared to posterolateral fusion with pedicle screws.
 - Back Pain = 39 vs 29; $p=0.003$
 - Physical Function = 32 vs. 25; $p=0.04$
 - A non-significant trend to worse outcomes in the posterolateral fusion group at 4 years.

Fusion Is Necessary

Solid Fusion

- Tsutsumimoto
 - Long term results JOA scores
 - Solid fusion group
 - Leg – 2.4 (p=0.018)
 - Back – 2.3 (p=0.035)
- Kornblum
 - Good to excellent results
 - 86% of patients (p=0.01)
 - 56% of patients with a pseudarthrosis (P 0.01).

Pseudoarthrosis

- Tsutsumimoto
 - Long term results JOA scores
 - Pseudoarthrosis group
 - Leg – 1.8 (p=0.018)
 - Back – 1.6 (p=0.035)
- Kornblum
 - Good to excellent results
 - 56% of patients with a pseudarthrosis (p= 0.01).

Why Lateral Surgery?

- Improve fusion rate
- Improve decompression
- Improve deformity correction
- Reduce complications

Posterolateral Fusion

- Fischgrund et al (1997)
 - 82% fusion rate
- Cammisa et al (2004)
 - Prospective trial, 120 patients
 - 52% ICBG vs 54% Grafton DBM
- Sengupta et al (2006)
 - Retrospective, 76 patients
 - 75% ICBG vs 67% local bone



Interbody Fusion: TLIF

- Potter et al (2006)
 - Retrospective review of 100 consecutive patients
 - 93% fusion rate
- Lee et al (2010)
 - 77% fusion rate
- Hartl et al (2010)
 - Meta-analysis of open vs MIS TLIF
 - MIS TLIF 94% (heavy BMP)
 - Open TLIF 90%



Minimally Invasive Transforaminal Lumbar Interbody Fusion (MI-TLIF) Surgical Technique, Long-Term 4-year Prospective Outcomes, and Complications Compared with an Open TLIF Cohort

Albert P. Wong, MD^a, Zachary A. Smith, MD^a,
James A. Stadler III, MD^a, Xue Yu Hu, MD^b, Jia Zhi Yan, MD^c,
Xin Feng Li, MD^d, Ji Hyun Lee, PA-C^e, Larry T. Khoo, MD^{e,*}

- Comparison of fusion rates for mTLIF (92%)
versus open TLIF (93%)

Interbody Fusion: Lateral

- Youssef et al (2010)
 - Review of LLIF literature
 - 91 to 100% fusion rates (primarily NON BMP)
 - CT based analysis
- Rodgers et al (2010)
 - Prospective CT assessment of fusion
 - 97% fusion rate
- Pimenta et al (2012)
 - 92% fusion rate
- Zavatsky et al (2014)
 - 98% fusion rate



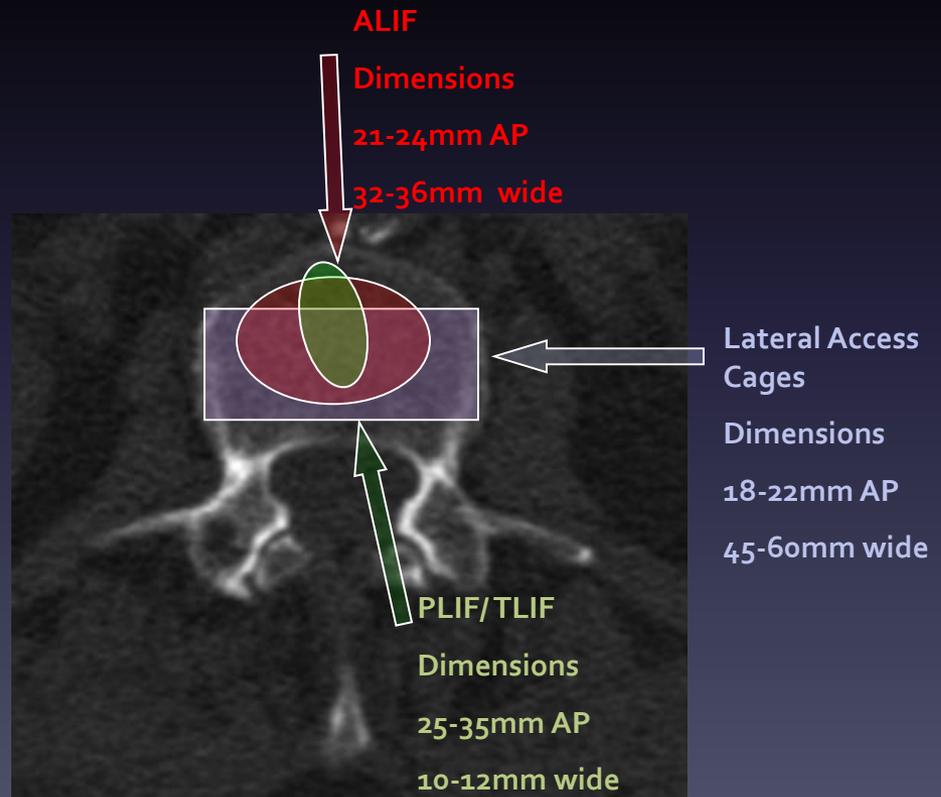
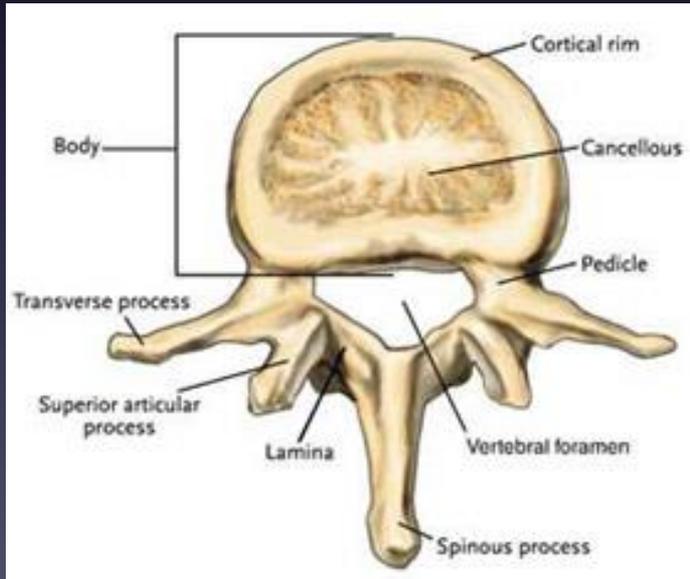
Summary of Fusion Data

- Posterolateral fusion: 50-85%
- TLIF/mTLIF: 78-93%
- LLIF: 91-100%

*If we believe FUSION = IMPROVED OUTCOME then
interbody fusion is the wiser choice*

Improve Fusion Rate

- Placement of large cage across apophyseal rings
 - *High fusion rates*
 - *Stable interbody cages*
 - *Lower subsidence rates*
 - *Indirect decompression*



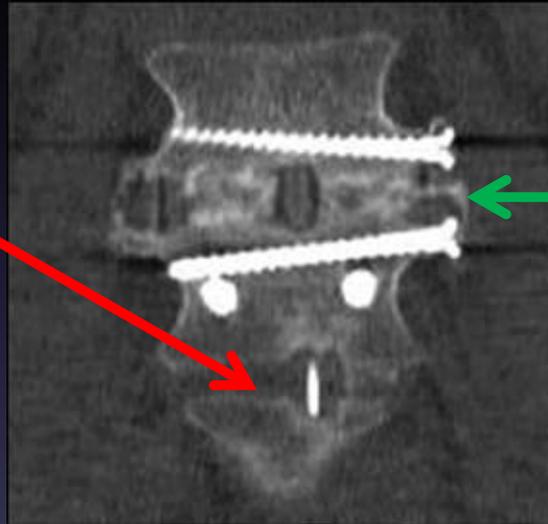
Does Spanning a Lateral Lumbar Interbody Cage Across the Vertebral Ring Apophysis Increase Loads Required for Failure and Mitigate Endplate Violation.

Briski DC¹, Goel VK, Waddell BS, Serhan H, Kodigudla MK, Palepu V, Agarwal AK, Zavatsky JM.

- Spanning ring apophysis increased mode to failure
 - 40% for intact endplates
 - 30% for decorticated endplates

TLIF / PLIF

22% Subsidence⁷



LLIF (22mm)

2% Subsidence⁸

≥30% endplate cage coverage = decreased subsidence

Lower subsidence rates compared to PLIF/TLIF

Le TV, Baaj AA, Dakwar E, Burkett CJ, Murray G, Smith DA et al. Subsidence of polyetheretherketone intervertebral cages in minimally invasive lateral retroperitoneal transpsoas lumbar interbody fusion. Spine 2012;37:1268-73.

Vaidya R, Sethi A, Bartol S, Jacobson M, Coe C, Craig JG. Complications in the use of rhBMP-2 in PEEK cages for interbody spinal fusions. J Spinal Disord Tech 2008;21:557-62.

Outcomes

Interbody Fusion

- Ha, et al.
 - Reduction in ODI
 - 42% +/- 18%
 - Reduction in VAS
 - 6 +/- 2
- Christensen, et al.
 - 5-9 years post op
 - ODI – 28 (p=0.004)
 - SF 36 (Physical) – 39 (p=0.005)
 - SF 36 (Physical) – 57(p=0.093)

Posterolateral Fusion

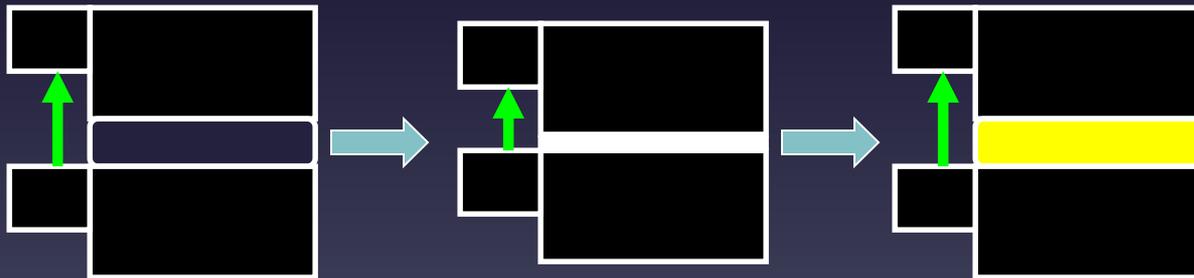
- Ha, et al.
 - Reduction in ODI
 - 22% +/- 16%
 - Reduction in VAS
 - 3 +/- 2
- Christensen, et al.
 - 5-9 years post op
 - ODI – 40 (p=0.004)
 - SF 36 (Physical) – 33 (p=0.005)
 - SF 36 (Mental) – 52 (p=0.093)

Why Lateral Surgery?

- Improve fusion rate
- **Improve decompression**
- Improve deformity correction
- Reduce complications

Indirect Decompression

- Central and foraminal
- Gains maintained with low subsidence
(apophyseal to apophyseal ring cage fit)

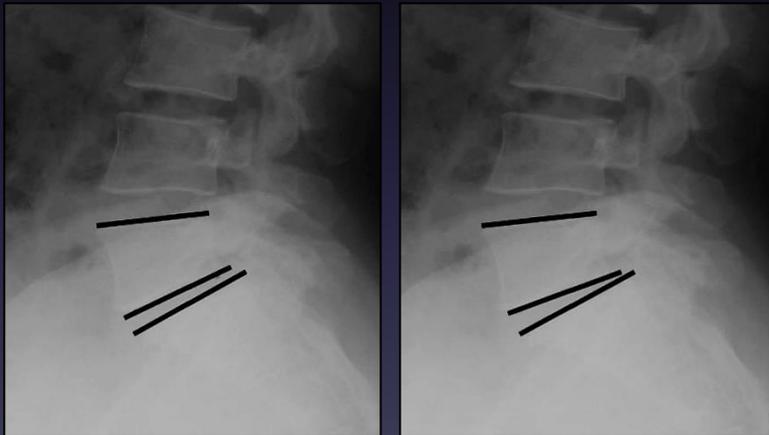


Powerful Indirect Decompression

Large LLIF cages help drive indirect decompression

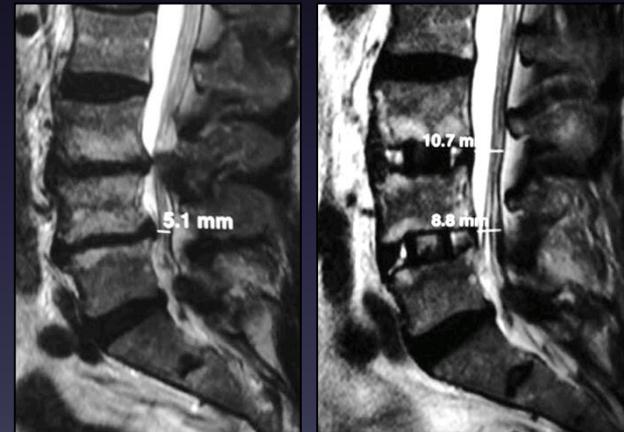
Average reported disc height gains:

TLIF



0.7mm (16%) (31)

LLIF/XLIF



3.0mm (41%) (27)

Evaluation of Indirect Decompression of the Lumbar Spinal Canal Following Minimally Invasive Lateral Transposas Interbody Fusion: Radiographic and Outcome Analysis

Authors

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Affiliations

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² Department of Neurosurgery, Roosevelt Medical Center, New York, USA

- 25 patients, grade 1 degenerative spondylolisthesis, leg pain and LBP
 - Evaluate Post op MRI:
 - ↑↑ *dural sac area* 143%
 - ↑ AP diameter 54%
 - ↑ M-L diameter 48%
 - VAS Back Pain: 8 → 2
 - VAS Leg Pain: 7 → 2
 - ODI: 55 → 16

Indirect Decompression

- 29 pts, pre- and post-op CTs; LBP/Leg pain
 - 10° lordotic cages +/- posterior instrumentation
 - ↑↑ Foramina → 135% of pre-op area
 - Disc heights:
 - Ant 6.2 → 9.8mm ; Post 3.7 → 6.3mm
 - ↑↑ Ave height 64%
 - Ant cage placement ↑↑ PCS score 13.4 vs 5 when cage placed posterior
 - Outcome predictors are multifactorial....
 - No correlation between FV and outcome

Kepler, et al, J Neurosurg Spine, 2012

Indirect foraminal decompression after lateral transposas interbody fusion

Clinical article

CHRISTOPHER K. KEPLER, M.D., M.B.A., AMIT K. SHARMA, M.D., RUSSEL C. HUANG, M.D., DENNIS S. MEREDITH, M.D., FEDERICO P. GIRARDI, M.D., FRANK P. CAMMISA JR., M.D., AND ANDREW A. SAMA, M.D.

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Object. Lateral transposas interbody fusion (LTIF) permits anterior column lumbar interbody fusion via a direct lateral approach. The authors sought to answer 3 questions. First, what is the effect of LTIF on lumbar foraminal area? Second, how does interbody cage placement affect intervertebral height? And third, how does the change in foraminal area and cage position correlate with changes in Oswestry Disability Index (ODI) and 12-Item Short Form Health Survey (SF-12) scores?

Methods. Included patients underwent LTIF with or without posterior instrumentation and received preoperative and postoperative CT scans. Disc heights, neural foraminal area between adjacent-level pedicles, and anteroposterior cage position were measured from sagittal CT images. Preoperative and postoperative ODI and SF-12 scores were matched with the change in foraminal area from the clinically most severely affected side for analysis of the relationship between outcomes instruments and change in foraminal area.

Results. Average foraminal area increased by 36.2 mm², or 35% of the preoperative area ($p < 0.01$), without statistically significant differences by side, level, or anteroposterior cage position. Preoperative anterior and posterior disc heights measured 6.2 mm and 3.7 mm, respectively, compared with postoperative measurements of 9.8 mm ($p < 0.01$) and 6.3 mm ($p < 0.01$), respectively, without significant differences by level or cage position. Despite significant overall improvement in ODI and SF-12 scores, there was no correlation with foraminal area increase.

Conclusions. Average foraminal area increased approximately 35% after cage placement without variation based on cage position. While ODI and SF-12 scores increased significantly, there was no significant association with cage position or foraminal area change, likely attributable to the multifactorial nature of preoperative pain. (<http://thejns.org/doi/abs/10.3171/2012.1.SPINE.11528>)

KEY WORDS • lumbar interbody fusion • indirect decompression • foraminal decompression • lateral approach surgery • extreme lateral interbody fusion • lateral transposas interbody fusion

FORAMINAL stenosis with nerve root compression is a common generator of pain in lumbar degenerative conditions. Foraminal stenosis frequently results from disc degeneration and collapse, which decreases the foraminal area until nerve root impingement occurs. In some cases, simple decompression and foraminotomy may not provide adequate nerve root decompression. Restora-

tion of disc and foraminal height via interbody fusion is a predictable technique for alleviation of foraminal stenosis, and therefore severe foraminal stenosis is one of the commonly cited indications for interbody fusion.

Lateral transposas interbody fusion is a minimally invasive surgical technique that permits anterior column lumbar interbody fusion via a direct lateral transposas approach, described in a preliminary report that demonstrated a low complication rate in a small cohort of patients.⁴ The polyetheretherketone cage used with the XLIF system (NuVasive Inc) has been specifically developed for use with this approach. This cage is placed from the lateral aspect of the vertebral body and is wide enough to span the entire width of the vertebra so that it rests on apophyseal bone on either side. This provides a potential biomechani-

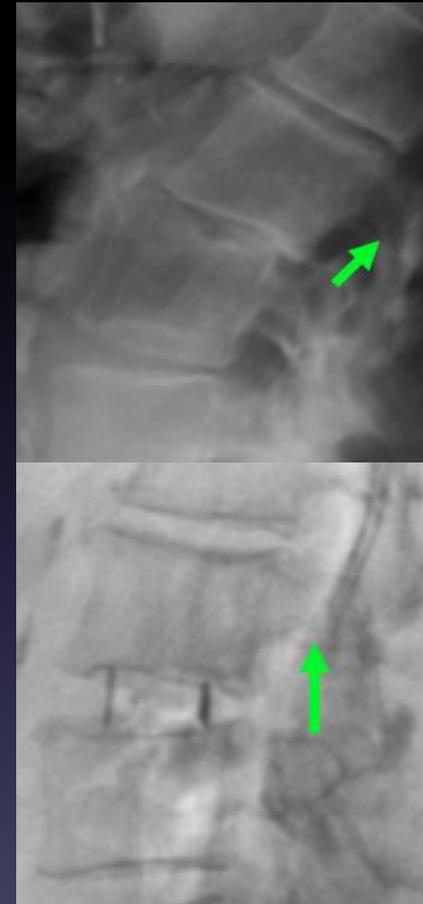
Abbreviations used in this paper: ACDF = anterior cervical discectomy and fusion; ICC = intraclass correlation coefficient; LTIF = lateral transposas interbody fusion; MCS = mental component subscore; ODI = Oswestry Disability Index; PCS = physical component subscore; PLIF = posterior lumbar interbody fusion; SF-12 = 12-Item Short Form Health Survey; XLIF = extreme lateral interbody fusion.

Why Lateral Surgery?

- Improve fusion rate
- Improve decompression
- Improve alignment and deformity correction
- Reduce complications

Interbody Fusion

- Better reduction of spondylolisthesis and deformities
 - Less local kyphosis
 - Improved biomechanics
 - Lower pseudoarthrosis rate.
- Indirect nerve decompression
 - 42% disk height increase yields:
 - 14% increase foraminal height
 - 25% increase foraminal area



Improved Alignment

- Fusion in physiologic alignment
 - Logically expect less stress on the adjacent segments
 - Lower rates of ASD



- Intuitively we know this will not do well long term

Why do we care?

- *ASD driven (in part) by malalignment!*
- Rothenfluh et al (ESJ, 2014)
 - Evaluate spinopelvic parameters in patients with ASD versus controls
 - 10x greater risk of ASD with PI/LL mismatch > 10 degrees

Segmental Alignment

- Laminectomy with PSF/fixation
 - No significant change in segmental parameters
 - Improve segmental alignment with interbody fusion (ALIF/LLIF)

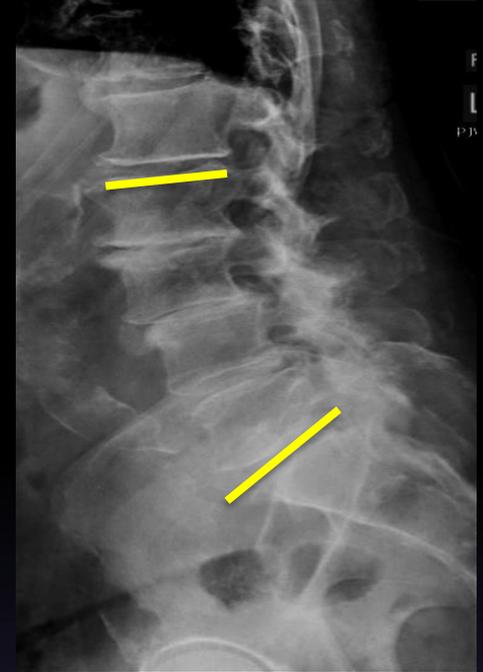


Segmental Alignment

- TLIF (open and/or MIS)
 - Lee et al (Neurosurg, 2008)
 - 2 degrees increase lordosis
 - Yson et al (2012)
 - Bilateral TLIF can restore up to 7-8 degrees
 - Wong et al (Neurosurg, 2014)
 - 5.6 degrees improvement

Alignment

- Significant improvements in segmental and global coronal and sagittal alignment
 - Anterior cage positioning ~ 7.4 deg/level (Kepler et al, 2012)
 - Increased correction with lateral interbody with osteotomies (Lee et al, 2014)
- Akbarnia et al (IMAST, 2010)
 - Significant increase in SRS-22, VAS, ODI at 2-yr
 - Average Cobb 47 → 17 degrees
 - Coronal L4 tilt 23 → 10 degrees
 - 45% coronal correction, 70% with posterior instrumentation
- Phillips et al (Spine, 2013)
 - Significant improvements: ODI, SF-36, VAS
 - 85% satisfaction score
 - LL improvement 28 → 34 degrees
 - Cobb correction 21 → 15 degrees
- Multiple hyperlordotic (>15 deg) options now available
- Greater focus on posterior fixation compression



Coronal and Sagittal Balance

- Significant improvement in coronal alignment
- Hyperlordotic transposas placed cages may improve segmental lordosis
 - Overall sagittal vertical alignment improved from 12cm to 6cm
 - Significant improved regional lordosis with open decompression + osteotomies (*Attanello et al 2013*)
- Correlation with slip angle
 - Restoration of slip angle associated with improvement in pain outcomes scores

Pimenta L. *Anterior elongation as a minimally invasive alternative for sagittal imbalance-a case series*. HSS J. 2012 Jul;8(2):122-7. doi: 10.1007/s11420-011-9226-z. Epub 2011 Dec 13.

Kong L, et al. *Radiographic Restoration of Sagittal Spinopelvic Alignment After Posterior Lumbar Interbody Fusion in Degenerative Spondylolisthesis*. J Spinal Disord Tech. 2014 Jun 5.

Why Lateral Surgery?

- Improve fusion rate
- Improve decompression
- Improve alignment and deformity correction
- Reduce complications

Complication Rates

Posterolateral/Open

- Carreon et al (2008)
 - Open posterolateral fusions in elderly (>65 y/o)
 - 80% complication rate
- Dekutoski et al (2010)
 - >500,000 open fusions for degen spondy
 - 14%

MIS TLIF

- Karikari et al (2010)
 - 7-25% rate (meta analysis)
- Hartl et al (2010)
 - MIS 7.5%, Open 12.6%

PLIF

- Okuda et al
 - 25% (> age 60)
- Benz et al
 - 41% (>age 70)

Complications in Lateral Interbody Fusion

- Isaacs et al (Spine, 2010)
 - 107 patients prospective, Level II
 - 12% rate of major complications
 - 9% MIS
 - 21% posterior open
 - 2.8% reoperation rate
- Rodgers et al (Spine, 2011)
 - Reviewed 600 cases (741 levels)
 - 69% include L4-5
 - 99% posterior instrumentation
 - Overall complication rate 6.2%
 - 1.5% surgery related
 - 2.8% medical events
 - No wound infections, deaths, or intraop visceral injury

MIS in Octogenarians

- Comparison of 20 open PLIFs vs 40 LLIFs
 - (Rodgers et al, Spine (2010))*
 - 92.5% MIS patients d/c home
 - ALL PLIF patients d/c to SNF
- Complication rate: 60% PLIF vs 7.5% LLIF
- Postop mortality related to: infection, complications, EBL
 - All significantly greater in PLIF

Neurologic Injury

- Mild transient psoas weakness – 20-25%
- LE weakness > than a few months – 6.5%
- Persistent weakness uncommon → 1 of 107
(↑↑ to 4/5 manual muscle strength at 6 mo)
- Lumbar plexus injury rare: 0.3% per level
 - Risk increases in proportion to # levels performed

*****Recommend neuromonitoring in all cases*****

Cost

- Initial cost
 - Interbody fusion is costlier \$47k vs 42k
- Long term (4-9 years)
 - Cost saving of circumferential fusion (TLIF or PLIF) compared with posterolateral fusion
 - Incremental Cost Utility Ratio \$49k/QALY
 - Due to lower revision rates

Tosteson et al. *Surgical Treatment of Spinal Stenosis with and without Degenerative Spondylolisthesis: Cost-Effectiveness after 2 Years*. Ann Intern Med. 2008 December 16; 149(12): 845–853.

Soegaard, et al. *Circumferential Fusion Is Dominant Over Posterolateral Fusion in a Long-term Perspective: Cost-Utility Evaluation of a Randomized Controlled Trial in Severe, Chronic Low Back Pain Spine Issue*: Volume 32(22), 15 October 2007, pp 2405-2414

SURGICAL GOALS	PLF	TLIF/PLIF	LLIF
RESOLVE LEG PAIN	✓	✓	✓
IMPROVE LEG PAIN	✓	✓	✓
RESTORE ALIGNMENT		+/-	✓
MINIMIZE COMPLICATIONS			✓
SUCCESSFUL FUSION		✓	✓
REDUCE ADJACENT DISEASE		+/-	✓
IMPLANT COSTS	✓		
EPISODE OF CARE COSTS			✓

Summary

- Lateral transpsoas interbody fusion affords an alternative to traditional open fusion techniques
 - Improved fusion rates
 - Indirect decompression
- Improved coronal and sagittal alignment maintenance and correction
- Decreases morbidity in patients at high risk from traditional open surgeries
 - Reduced EBL and mortality risk
 - Adhere to meticulous surgical technique to minimize procedural risks
- Continued expansion of technique indications
- Additional high quality studies needed for further evaluation

Thank You!



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