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LLIF vs TLIF

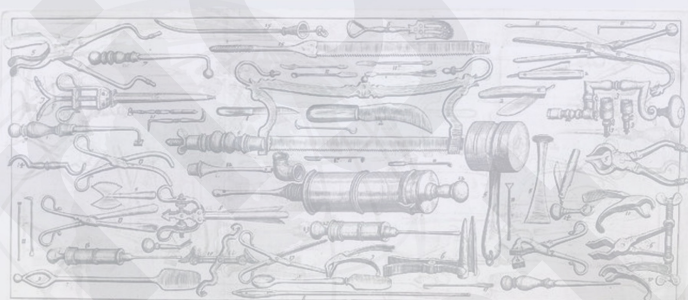
Mr M J H McCarthy
vs
Dr S Hegde

Fusion Portfolio Minimally Invasive Surgery Biomaterials Motion Preservation

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Armamentarium



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Indications for Surgery

- **What are you trying to achieve?**
 - Non-maleficence - "first, do no harm" (primum non nocere).
- **DO THE APPROPRIATE OPERATION FOR THE PATIENT AND THEIR PATHOLOGY AND YOUR SKILL / ABILITY**

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Indications for Surgery - DRS

- **Decompression**
 - Spinal cord / nerve roots
- **Realignment**
 - Correct deformity
- **Stabilisation**
 - Prevent / Treat
 - Neurological deficit / deformity / pain
 - (Non fusion technology form of "stabilisation")

All may require fusion

Require Instrumentation

Instrumentation increases fusion

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The 7 Ps

- Proper
- Planning and
- Preparation
- Prevents
- Piss
- Poor
- Performance



Attention to detail
Never let your guard down

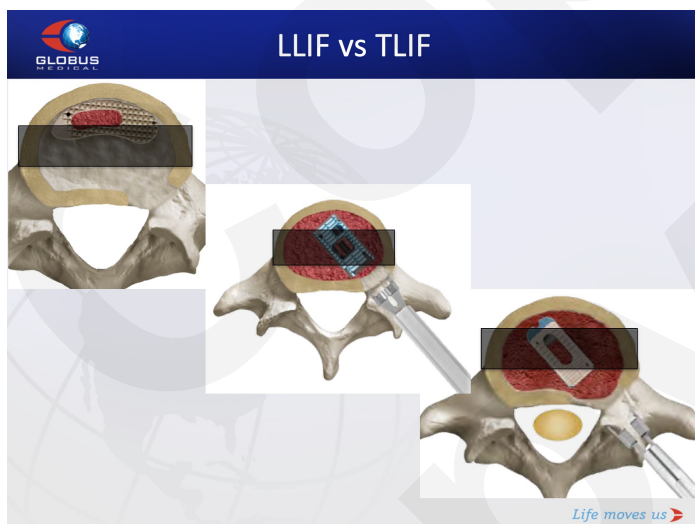
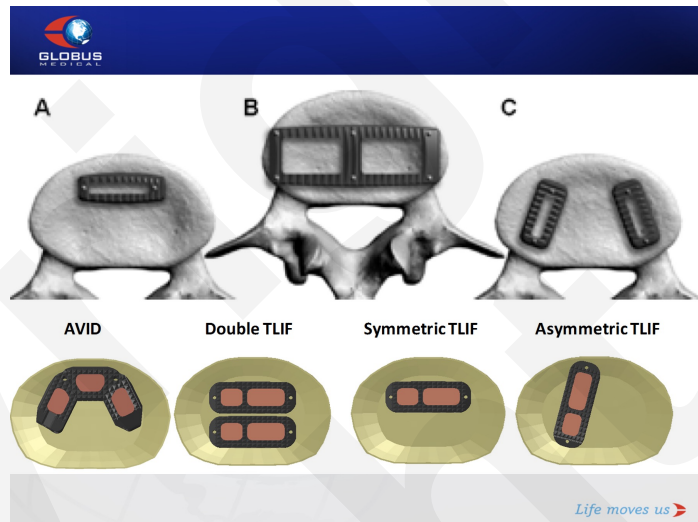
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Fusion

- **Fusion – think:**
 - α contact surface area ($1/\alpha$ subsidence)
 - $\uparrow$ compression $\downarrow$ tension
 - autograft > allograft > synthetic
 - vascular > avascular
 - structural graft > non structural
 - BMP...
 - And unfortunately fusion may not be α clinical outcome

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Surgical Options		
	Advantages	Disadvantages
PLIF	Bilateral access to canal, restores lordosis	Painful, infection, neural / dural injury scarring, limited higher up
Mini Open and MIS PLIF	Less painful, low infection, less blood loss, faster recovery	Fusion?, neural / dural injury scarring, limited higher up
Open TLIF	Access, fusion	Painful, infection, neural / dural injury scarring, endplate damage / subsidence
Mini Open TLIF	Less painful, low infection, fusion, less blood loss	Neural / dural injury scarring, disc preparation, endplate damage / subsidence
MIS TLIF	Even less pain, low infection, avoids paraspinal muscle damage, less blood loss, faster recovery	Fusion?, neural / dural injury scarring, disc preparation, endplate damage / subsidence
LLIF + Perc Post	Good fusion, less painful, low infection, T5-L5, avoids canal, less visceral vessel injury then ALIF, avoids paraspinal muscle damage, less blood loss, faster recovery	L4/5??, L5/S1 – No, endplate damage / subsidence, plexus injury, diaphragm injury, pneumothorax
ALIF + Perc Post	Best fusion, best restoration lordosis, less painful, low infection, avoids canal, avoids paraspinal muscle damage, mostly less blood loss than a TLIF	Access Surgeon, ilio-lumbar vein, visceral vessel injury, ileus, not above L3

LLIF

- LLIF
 - Tension intact ALL / PLL
 - Indirect decompression
 - Large surface area for fusion across strongest area of bone
 - Good for laterolisthesis > rotated spine
 - Multiple levels same incision
 - (Obese people - fat can be swept away)

LLIF Algorithm First Question

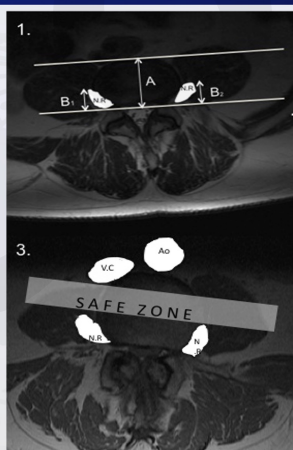
- Contraindications:
 - L5/S1
 - Low seated L4/5 (look at crests)
 - High grade slip
 - Retroperitoneal scarring / pathology
 - Medical comorbidities / contraindications to surgery
- Yes – then use other technique

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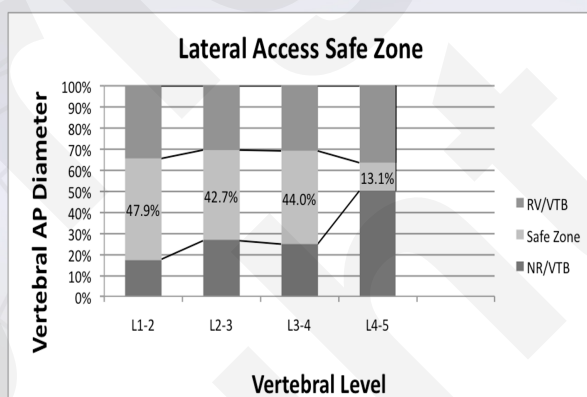
LLIF Algorithm Second Question

- Is direct decompression of spinal canal needed?
 - Yes
 - Consider single procedure / approach with TLIF / PLIF
 - Surgical philosophy / ability – 2 stages with LLIF may give better deformity correction / fusion

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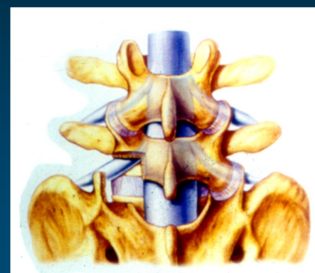
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1993 Jurgen Harms

- Transforaminal approach (TLIF)
- Two titanium cages



Transforaminal lumbar inter body fusion (TLIF) is not a single operation but a technique for fusion which may be applied to a variety of spinal pathology.

- Harms

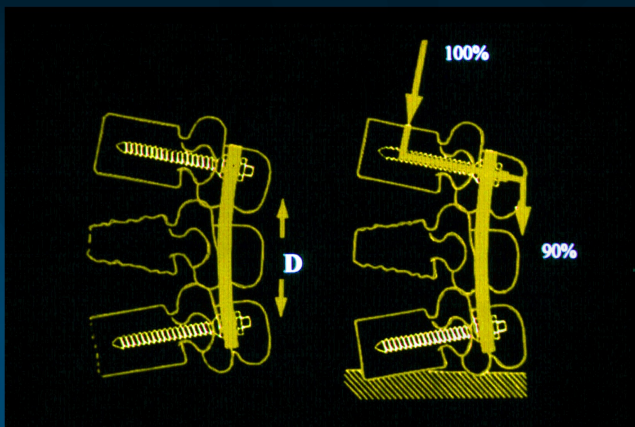
Load Sharing in Normal Spine



Functional anatomy of the Spine



Load Bearing Construct

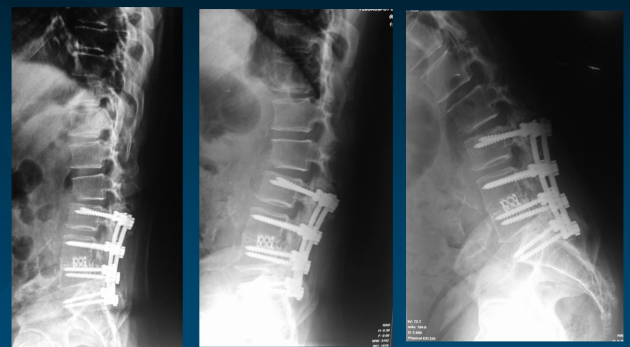
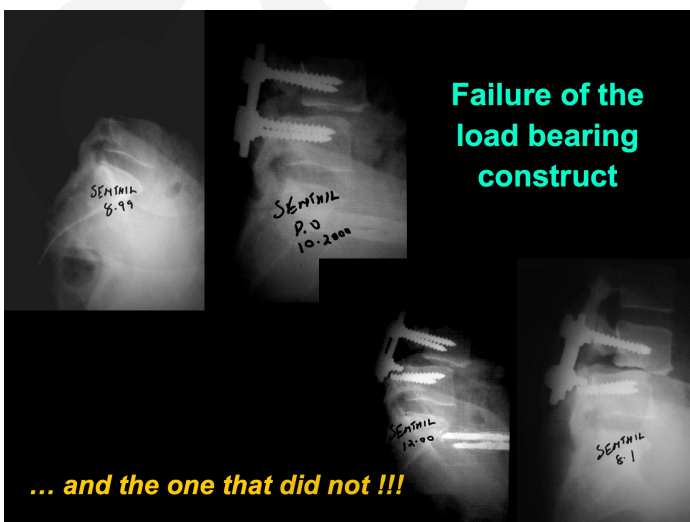


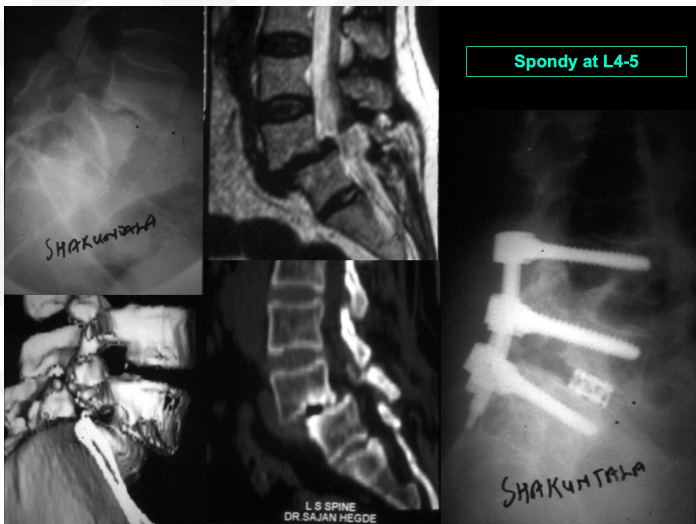
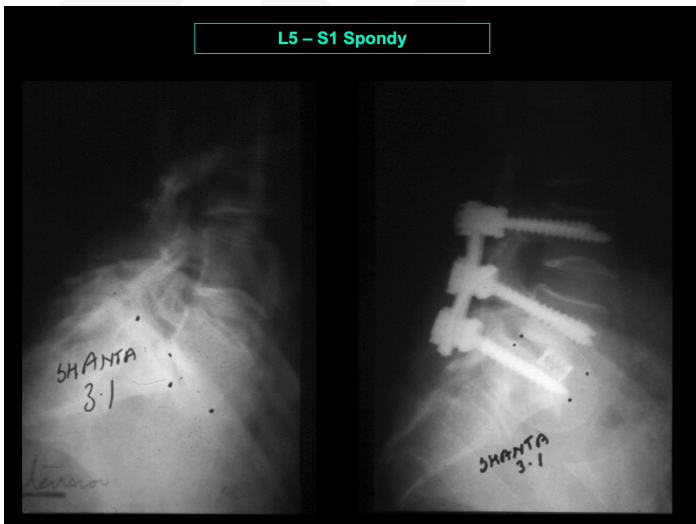
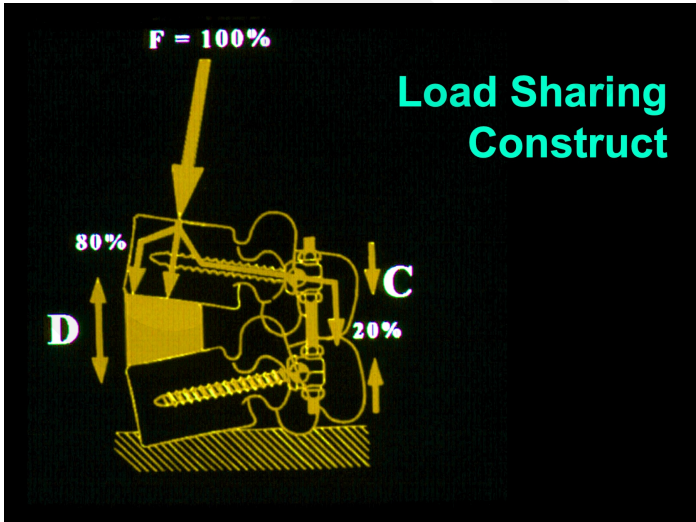
The Load Bearing Construct

The one that got away!!!

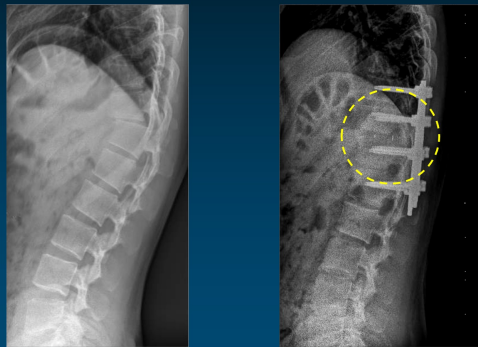


Failure of the load bearing construct





TLIF In Trauma (AO Type C)



L5-S1 Listhesis G-III



ADULT DEFORMITY

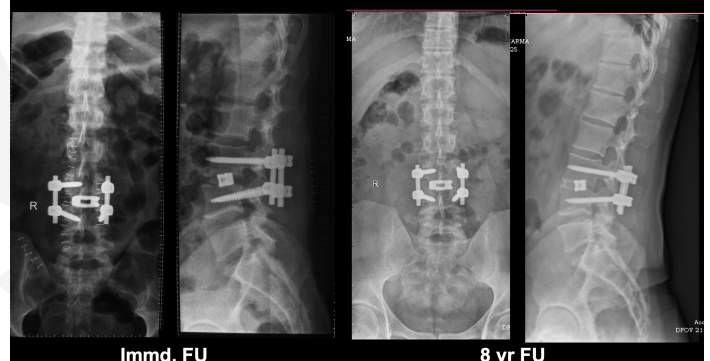


Salmonella Para Typhi A

26 y / M, history of typhoid,
lowback pain, non specific Tx

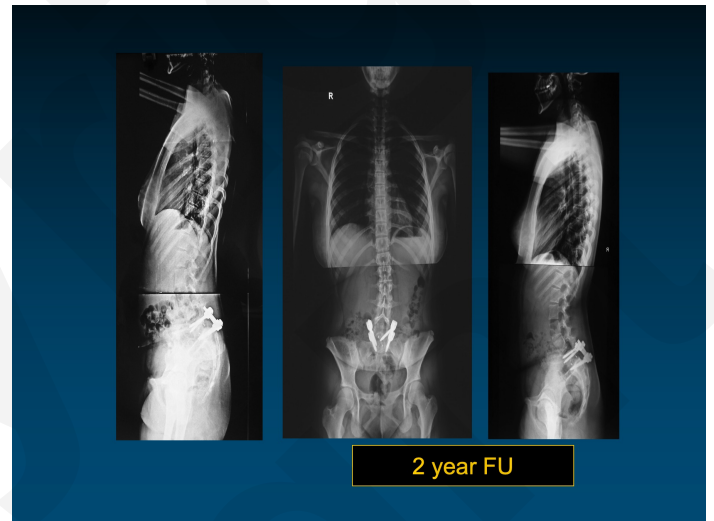
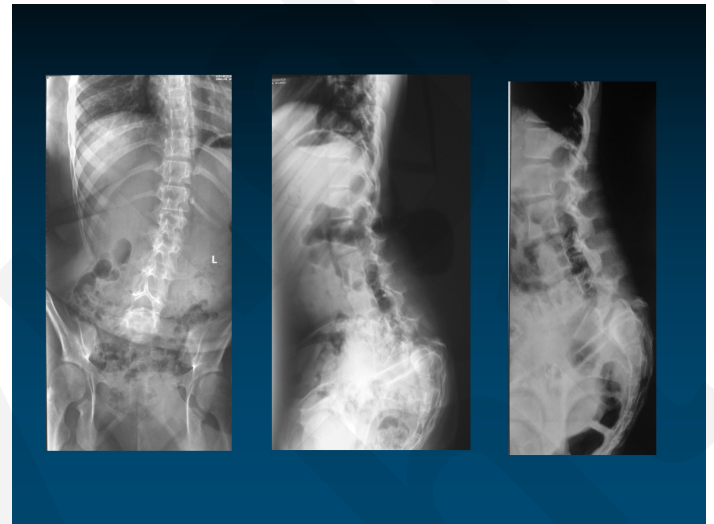
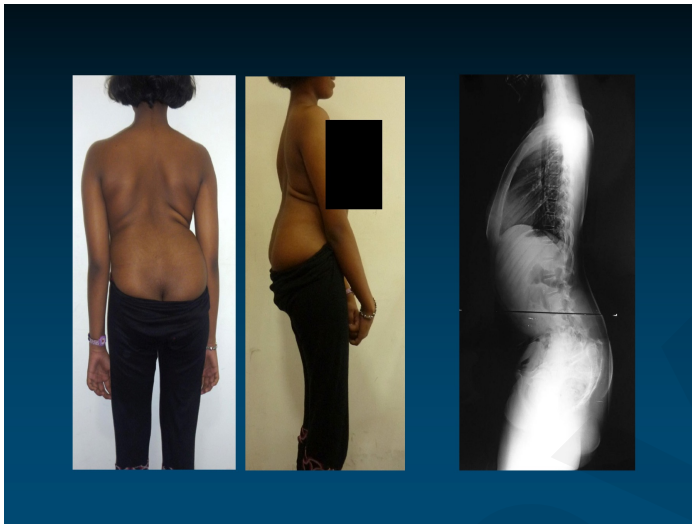


Salmonella Para Typhi A



Immnd. FU

8 yr FU



TLIF - Advantages

- TLIF allows the neural elements to be decompressed, as well as stabilization of the anterior column from a single posterior approach
- The benefits of the transforaminal approach **minimize the risk of neural compromise** due to the fact that the grafts can be put in without undue traction on either the exiting or traversing nerve root because the entire facet and pars are removed

- This technique provides the ability to **achieve and maintain reduction** by releasing the soft tissues circumferentially
- Pedicle screws are placed across the affected level, which **allows distraction** to occur while the disc space is being completely cleaned

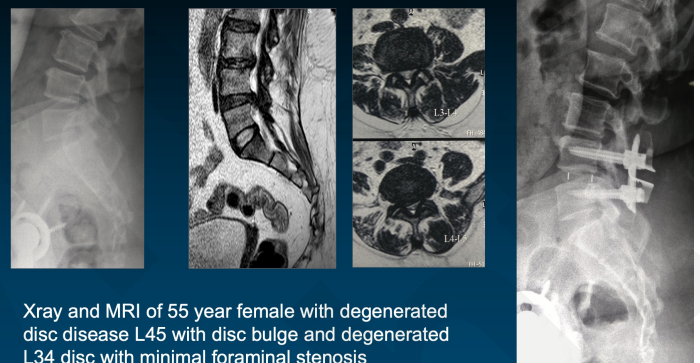
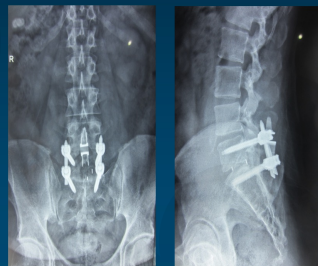
- The spine is realigned by bringing the cephalad vertebra back into alignment over the caudal vertebra and then compressing the construct, which **re-establishes the anterior column support**
- This allows patients to be **mobilized fairly quickly** without the use of a brace
- In obese individuals, the anterior column support can provide better spinal support and allow a more rapid rehabilitation, which minimizes some of the potential complications of individuals with such body habitus

TLIF with motion preservation

- **Topping up technique with the use of interspinous device above the level of fusion**
- **Transition rod**

L5S1 Degenerated disc disease with L4-5 early degeneration with retrolisthesis

2.5 year followup AP and Lateral Xray showing TLif at L5S1 with Coflex interspinous device at L45 showing restored posterior disc height and alignment



Xray and MRI of 55 year female with degenerated disc disease L45 with disc bulge and degenerated L34 disc with minimal foraminal stenosis

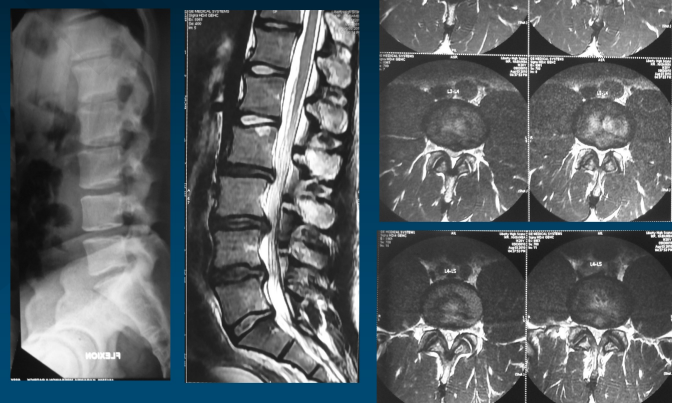
Postoperative Xray showing TLIF at L45 with interspinous device at L34 with restored posterior disc height at the adjacent segment

Prevention of adjacent level degeneration above a fused vertebral segment

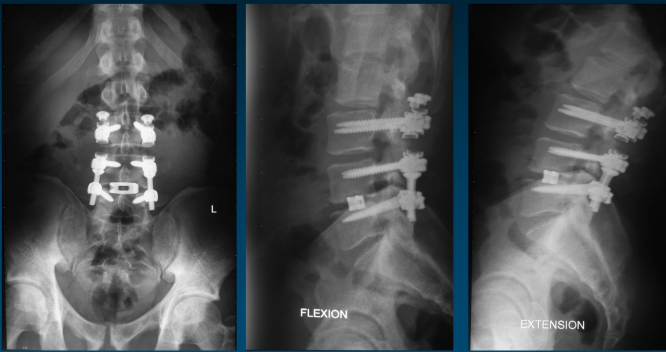
Long term effect, after a mean follow-up of 8.27 years, of the semi-rigid intervertebral fixation as a protective technique for pathological adjacent disc.

G. PERRIN, A. CRISTINI, Neurological hospital – Lyon, France
Presented at the IMAST 2003 (International Meeting for Advanced Spine Technologies)

A 22 year old football player with severe lowback pain



A solution to PJK
- Motion preservation



1 year FU



Transition at work !!

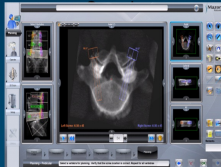
TLIF using the Mazor
Renaissance Robotic Surgical
Guidance System



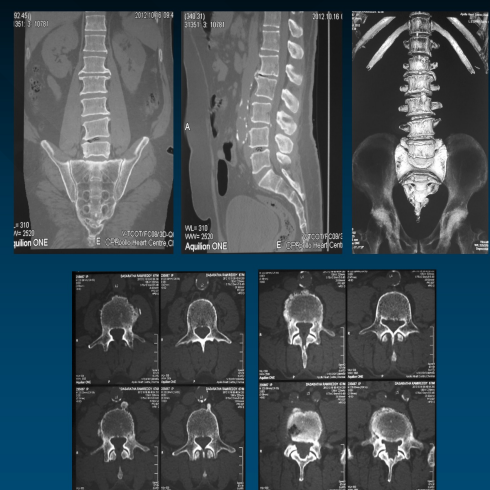
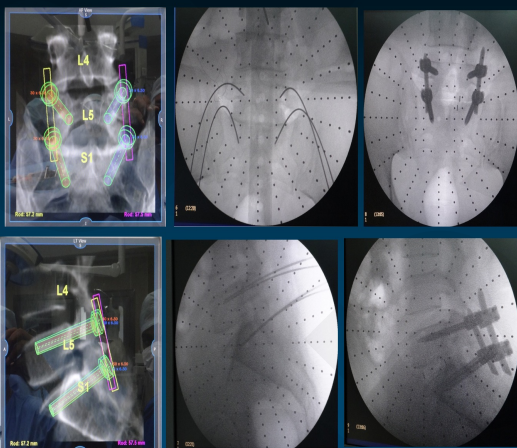
Surgical
Workstation

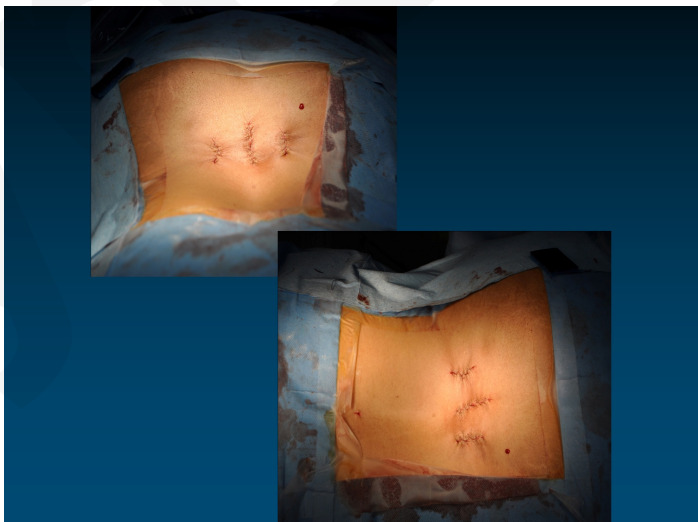
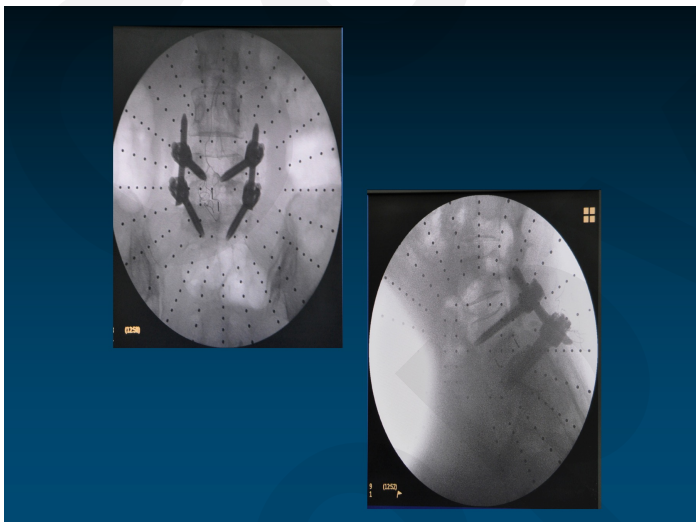
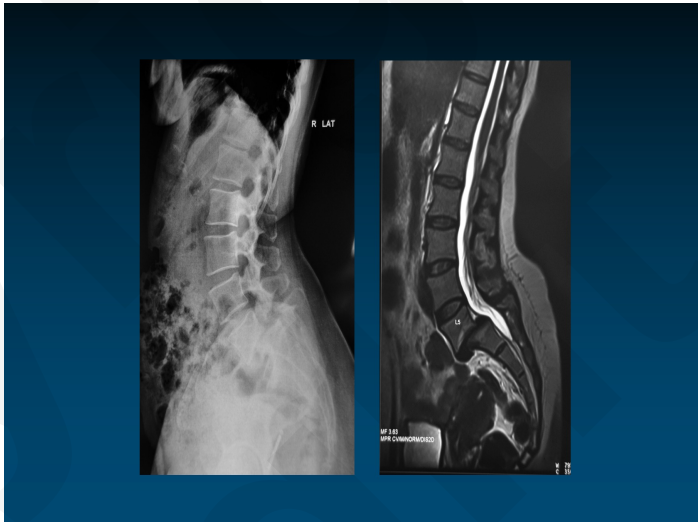
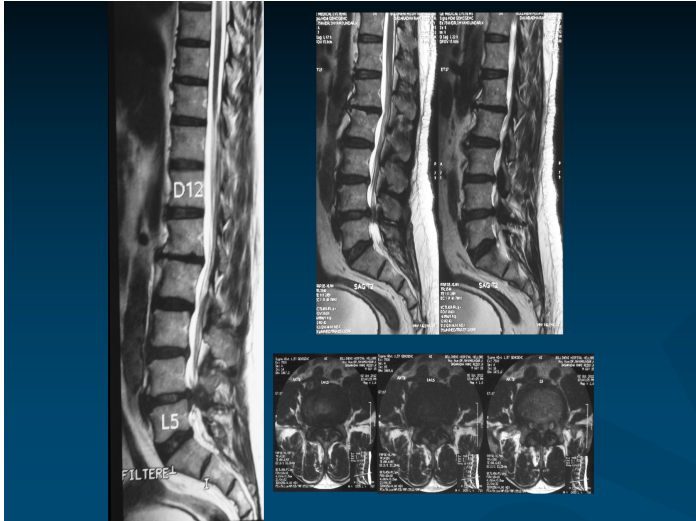


RBT Device and Guiding



CT-based 3D Planning
Software





IMAST-SRS 2015, Kualalumpur

Are minimally invasive robotic guided TLIFs more safe and accurate than free hand open TLIFs?

Vamsi Krishna Varma, Pramod Sudarshan,
Aditya Prasad Panda, Thirumalai Mohan,
Sankar Mohan, Aghilvendhan Paramasivam,
Sajan K Hegde

"The robotic guidance platform shows promise in improving clinical outcomes and to further extend the current indications for surgical MI interventions".

SPINE Volume 31, Number 15, pp 1693-1698
©2006, Lippincott Williams & Wilkins, Inc.

Clinical and Radiologic 2–4-Year Results of Transforaminal Lumbar Interbody Fusion in Degenerative and Isthmic Spondylolisthesis Grades 1 and 2

Sebastian Lauber, MD,* Tobias Ludger Schulte, MD,† Ulf Liljenqvist, PhD,†
Henry Halm, PhD,‡ and Lars Hackenberg, PhD†

- TLIF is a safe and effective method to treat low-grade spondylolisthesis, which can theoretically prevent typical complications of anterior and posterior lumbar interbody fusion.

LLIF

- Disadvantages include potential risks of lumbar plexus, psoas muscle and bowel injury, particularly at the L4/5 level.
- Vascular injury, if it occurs, may be difficult to control and represents another major risk of the lateral transpsoas approach.

Systematic Review

Lumbar Lateral Interbody Fusion (LLIF): Comparative Effectiveness and Safety versus PLIF/TLIF and Predictive Factors Affecting LLIF Outcome

Giuseppe M. V. Barbagallo¹ Vincenzo Albanese¹ Annie L. Raich² Joseph R. Dettoni² Ned Sherry²
Massimo Balsano³

¹Division of Neurosurgery, Department of Neurosciences, Policlinico University Hospital, Catania, Italy

²Spectrum Research, Inc., Tacoma, Washington, United States

³Regional Spinal Department, Alto Vicentino, OC Santorso, Vicenza, Italy

Address for correspondence: Giuseppe M. V. Barbagallo, MD, Division of Neurosurgery, Department of Neurosciences, Policlinico University Hospital, Via S. Sofia 78, Catania, Italy (e-mail: giuseppebarbagallo@hotmail.com).

Evid Based Spine Care | 2014;5:28–37.

- A systematic review of the literature was performed using PubMed and bibliographies of key articles - The search yielded **258 citations**

Conclusion

- There is **insufficient evidence** of the comparative effectiveness of LLIF versus PLIF/TLIF surgery.
- There is low-quality evidence suggesting that LLIF surgery results in fewer complications or reoperations than PLIF/TLIF surgery.
- And there is insufficient evidence that any preoperative factors exist that predict patient

J Neurosurg Spine 19:110–118, 2013
©AANS, 2013

Radiographic and clinical evaluation of cage subsidence after stand-alone lateral interbody fusion

Clinical article

LUIS MARCHI, M.Sc.,^{1,2} NITAMAR ABDALA, M.D., Ph.D.,¹ LEONARDO OLIVEIRA, B.Sc.,²
RODRIGO AMARAL, M.D.,² ETEVALDO COUTINHO, M.D.,² and LUIZ PIMENTA, M.D., Ph.D.^{2,3}

¹Department of Imaging Diagnosis, Universidade Federal de São Paulo; ²Department of Minimally Invasive Surgery, Instituto de Patologia da Coluna, São Paulo, Brazil; and ³Department of Neurosurgery, University of California, San Diego, California

- Subsidence was detected early (6 weeks), at which point it was correlated with transient clinical worsening, although progression of subsidence was not observed after the 6-week time point.
- Moreover, subsidence occurred predominantly (68%) in the inferior endplate.

CLINICAL CASE SERIES

Intraoperative and Early Postoperative Complications
in Extreme Lateral Interbody Fusion

An Analysis of 600 Cases

W. Blake Rodgers, MD, Edward J. Gerber, PA-C, and Jamie Patterson, BA

TABLE 2. Detailed List of Complications in 600 XLIF Surgeries

Type	n (%)	Description (n)	Consequence
Wound	2 (0.3)	Hernia (1), Subcutaneous hematoma (1)	Required repair,* drainage*
Neural	4 (0.7)	Quadriceps weakness (3), Anterior tibialis weakness (1)	None, all resolved within 3 mo
Vertebral	6 (1.0)	EP fracture (1), VB fracture/subsidence (1), OP fracture (1); adjacent-level compression fracture (2); iatrogenic HNP (1)	5/6 required reoperation (vertebroplasty/2,* decompression/1,* and/or PLF/2*)
Hardware	2 (0.3)†	Implant fracture/subsidence (1), screw break through endplate/subsidence (1)	Required revision (posterior pedicle screw fixation/2*)
GI	7 (1.2)	Ileus (6), gastric volvulus (1)	Repair of gastric volvulus*
Respiratory	7 (1.2)	Pneumonia (5), pulmonary embolus (2)	2 prolonged intubations, antibiotics, anticoagulation
Cardiac	6 (1.0)	Atrial fibrillation (5), MI at 6 wks (1)	None/medical treatment
Renal	2 (0.3)	Urinary retention (1), peritoneal catheter occlusion (1)	Revision of catheter*
Hematologic	1 (0.2)	Postoperative anemia (1)	Transfusion
Total	37 (6.2)		*11 reoperation

CASE REPORT

Aortic Perforation During Lateral Lumbar Interbody Fusion

Alexander Aichmair, MD,* Gary A. Fantini, MD,† Sean Garvin, MD,‡
James Beckman, MD,‡ and Federico P. Girardi, MD*

Study Design: A case report.

Objective: To report a unique case of aortic perforation during lateral lumbar interbody fusion (LLIF).

Summary of Background Data: Among the reported advantages of this minimally invasive transposas procedure is the avoidance of an anterior intraperitoneal approach to the lumbar spine, thus avoiding visceral and vascular injuries typically associated with the latter.

Methods: We report a single case of aortic perforation during LLIF, which occurred in the setting of an incidental endplate and anterior vertebral cortex violation.

Results: During the implantation of an interbody prosthetic device at the L3-L4 level, the proximal aspect of the implant broke which caused cage misplacement. During the attempt to

Conclusions: The distal endplate and anterior vertebral cortex violation can result in the formation of an anterior bony spur in close proximity to the major abdominal vascular structures, and despite the avoidance of an anterior approach to the lumbar spine, surgery-related injury to major abdominal vessels can occur during LLIF. Aortic perforation is a rare, yet potentially lethal intraoperative complication of LLIF, which requires emergency laparotomy and vascular suture repair.

Key Words: lateral lumbar interbody fusion, complication, vascular injury, aortic perforation, endplate fracture

(J Spinal Disord Tech 2015;28:71-75)

J Neurosurg Spine 21:794-798, 2014
©AANS, 2014

First report of major vascular injury due to lateral transposas approach leading to fatality

Case report

RACHID ASSINA, R.Ph., M.D., NEIL J. MAJUMDAR, B.S., YEHUDA HERSCHMAN, M.D.,
AND ROBERT F. HEARY, M.D.

Department of Neurological Surgery, Rutgers University–New Jersey Medical School, Newark, New Jersey

Extreme lateral interbody fusion (XLIF) has gained popularity among spine surgeons for treating multiple conditions of the lumbar spine. In contrast to the anterior lumbar interbody fusion (ALIF) approach, the minimally invasive XLIF approach affords wide access to the lumbar disc space without an access surgeon and causes minimal tissue disruption. The XLIF approach offers many advantages over other lumbar spine approaches, with a reportedly low complication profile. The authors describe the first fatality reported in the literature following an XLIF approach. They describe the case of a 50-year-old woman who suffered a fatal intraoperative injury to the great vessels during a lateral transposas approach to the L4–5 disc space.

As this approach gains more popularity and wider usage among experienced and nonexperienced spine surgeons, the real potential for injury to the great vessels must be recognized. This possibility is particularly worrisome if a tubular retractor system that has a detachable, nonfixed retractor blade anteriorly is used. A thorough understanding of the vascular anatomy in relation to the ALL is necessary, because a vascular injury is possible anytime the ALL is violated. This report also demonstrates the danger of performing an XLIF surgical procedure in an outpatient surgeon without immediate access to a vascular, endovascular, or general surgery back-up practitioner.

SURGERY

Contralateral Motor Deficits After
Lateral Lumbar Interbody FusionFadi Taher, MD,* Alexander P. Hughes, MD,† Darren R. Lebl, MD,† Andrew A. Sama, MD,†
Matthias Pumberger, MD,* Alexander Aichmair, MD,† Russel C. Huang, MD,† Frank P. Cammisia, MD,† and
Federico P. Girardi, MD†

Study Design: Retrospective case series.

Objective: To report on the rare finding of motor deficits contralateral to the transposas approach in patients who underwent lateral lumbar interbody fusion (LLIF).

Results: Of the patients reviewed, 2.9% (7/244) presented with a postoperative contralateral motor deficit, the most severe of which was a 1/5 weakness of the quadriceps muscle. An average of 3 levels (range: 2–4) was fused in 7 patients who developed a contralateral motor deficit, and in 3 of the 7 patients, an anterior lumbar interbody fusion (ALIF) was performed in addition to the LLIF. At 1 year follow-up, 3 patients presented with complete resolution of their muscle weakness, 1 patient still had mild weakness, 1 patient had decreased range of motion in the affected joint, and 1 patient had a 2/5 foot drop. One patient was lost to follow-up.

Conclusion: These data are among the largest reports of contralateral motor deficits after LLIF. Among possible underlying mechanisms are entrapment of the contralateral nerve root through translational correction of spondylolisthesis, front-to-back misalignment of the cage resulting in contralateral nerve root impingement, pressure on the contralateral peroneal nerve during positioning, and overdistraction neuropathia when using ALIF at L5-S1 concomitantly. Awareness of the possibility of this rare complication can play an important role in surgical consideration and preoperative patient counseling.

Nerve injury during the transposas approach for lumbar fusion

TABLE 1: Studies in the English literature reporting motor deficits in patients who underwent either DLIF or XLIF procedures*

Authors & Year	No. of Patients	Approach	Clinical Motor Deficits
Anand et al., 2010	28	DLIF/XLIF	2 patients (7.1%) had quadriceps palsies from which they recovered within 6 mos
Isaacs et al., 2010	107	XLIF	36 patients (33.6%) had some evidence of weakness after surgery; 29 had hip weakness, 6 patients had lasting weakness at 6-month follow-up
Kepler et al., 2010	13	XLIF	3 patients (23.1%) developed transient postop hip flexion weakness at 1-yr postop follow-up
Knight et al., 2009	58	DLIF	2 patients (3.4%) with L-4 nerve injury showed residual motor effects at 1-yr postop follow-up
Papanastassiou et al., 2011	32	XLIF	2 patients (6.25%) sustained contralateral psoas weakness; injury in 1 patient was caused by a displaced endplate fragment compressing the contralateral nerve root, the second patient had weakness from a far-lateral herniation after the XLIF procedure; both patients experienced resolution of their symptoms after reoperation 6 weeks after the initial surgery
Pimenta et al., 2011	36	XLIF	1 patient (2.8%) had weakness of the leg ipsilateral to the approach side, which lasted through the 3-month visit but was resolved by the 6-month visit; 1 patient (2.8%) had hypertrophy of the quadriceps contralateral to the approach side at the 12-month visit, which was resolved by the 2-yr visit
Rodgers et al., 2011	600	XLIF	4 patients (0.7%) exhibited transient postop neurological deficits
Tormenti et al., 2010	8	XLIF	2 patients (25%) suffered motor radiculopathy w/ 1 patient having persisting weakness at 3 mos following surgery
Youssef et al., 2010	87	XLIF	1 patient (1.1%) w/ leg weakness for 7 wks
Wang & Mummaneni, 2010	23	DLIF/XLIF/mini-open	7 patients (30.4%) w/ symptoms of thigh pain, numbness weakness, and dysesthesias, w/ 1 patient suffering prolonged symptoms requiring a gait-assist device

* Cadaveric or nonclinical papers were excluded.

Direct Lateral Lumbar Interbody Fusion for Degenerative Conditions Early Complication Profile

Reginald Q. Knight, MD, Paul Schwaegler, MD, David Hanscom, MD, and Jeffery Roh, MD

- **Major adverse events approximated 8.6% with approach-related complaints of nerve irritation nearing 3.4%.**
- **Mild complications occurred in 13.7%**

Spine J. 2014 Mar 1;14(3):552-9. doi: 10.1016/j.spinee.2013.08.060. Epub 2014 Jan 8.

Complications with the use of bone morphogenetic protein 2 (BMP-2) in spine surgery.
Tannoury CA¹, An HS².

- **This article discusses the wide spectrum of adverse outcomes related to rhBMP-2 use in the lumbar and the cervical spine**
- **Retrograde ejaculation, antibodies formation, postoperative radiculitis, postoperative nerve root injury, ectopic bone formation, vertebral osteolysis/edema, dysphagia and neck swelling, hematoma formation, interbody graft lucency, and wound healing complications are reviewed.**
- **Cost-related concerns, dosage considerations, and the ethical considerations**

Review Article

Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF

Ralph J. Mobbs^{1,2,3}, Kevin Phan^{1,2,3}, Greg Malham⁴, Kevin Seex⁵, Prashanth J. Rao^{1,2,3}

- **Suggested recommendations for ALIF/TLIF and LLIF**

L5/S1

- ALIF preferred method for discogenic LBP and lordosis restoration;
- PLIF and TLIF reasonable methods especially with central canal stenosis or recurrent disc herniation (89);
- PLIF preferred approach for Isthmic spondylolisthesis due to the high risk of L5 nerve injury (90);
- OLIF early data is promising; **LLIF not suitable.**

L4/5

- PLIF and TLIF good option for degenerative spondylolisthesis;
- ALIF/OLIF/LLIF all reasonable options for lordosis and deformity correction, however increased risk of lumbar plexus/psoas injury with LLIF.**

L2/3 and L3/4

- All techniques except for ALIF suitable;
- ALIF not recommended as high risk; need experienced vascular surgical assistance;
- For deformity correction, antero-lateral techniques preferred including LLIF/OLIF.

T12/L1 and L1/2

- ALIF not suitable;
- PLIF/TLIF difficult if cord or conus inhibits dural retraction for insertion of implant/s;
- LLIF good option especially for deformity correction.

Multilevel

- Multilevel usually involves deformity correction if performed for degenerative pathologies;
- Combination of anterior/lateral and posterior techniques provides powerful deformity correction;
- Multilevel ALIF/LLIF/OLIF provide sagittal and coronal correction but may require supplemental posterior fixation.

Spine

SURGERY

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Two-year Comparative Outcomes of MIS Lateral and MIS Transforaminal Interbody Fusion in the Treatment of Degenerative Spondylolisthesis

Part I: Clinical Findings

Jonathan N. Sembrano, MD,*¹ Antoine Tohmeh, MD,¹ and Robert Isaacs, MD²,
SOLAS Degenerative Study Group

- **Despite different mechanisms of action (indirect vs direct decompression), mid-term clinical outcomes between XLIF and MIS TLIF were similar.**

Comparison of complication rates of minimally invasive transforaminal lumbar interbody fusion and lateral lumbar interbody fusion: a systematic review of the literature

Jacob R. Joseph, MD, Brandon W. Smith, MD, MS, Frank La Marca, MD, and Paul Park, MD
Department of Neurosurgery, University of Michigan, Ann Arbor, Michigan

- While there was a **higher overall complication rate with LLIF**, MI-TLIF and LLIF both have acceptable complication profiles
- **LLIF had higher rates of sensory as well as temporary and permanent neurological symptoms**

More nerve root injuries occur with minimally invasive lumbar surgery, especially extreme lateral interbody fusion: A review

Nancy F. Epstein

- This review indicates that MIS (TLIF/PLIF/ALIF/XLIF) lumbar surgery resulted in a higher incidence of root injuries, radiculitis, or plexopathy versus open lumbar surgical techniques.
- Furthermore, even a cursory look at the XLIF data demonstrated the greater danger posed to neural tissue by this newest addition to the MIS lumbar surgical armamentarium
- The latter should prompt us as spine surgeons to



1. Have A Simple Strategy

- Is an interbody fusion required:
 - Restore foraminal height (up / down)
 - Improve fusion
 - Revision of failed posterolateral fusion
 - Restore lordosis / correct deformity
 - Biomechanics – shear / large disc height / entire facet removed / long construct involving L5/S1

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2. Have A Simple Strategy

- Is a direct posterior decompression required? (vs indirect ligamentotaxis)
- How many levels need to be fused?
- How long will it take?
- Is there a slip – how big / is it reducible?
- Etcetera...
- **DO THE APPROPRIATE OPERATION FOR THE PATIENT AND THEIR PATHOLOGY AND YOUR SKILLS / ABILITY**

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In Summary...



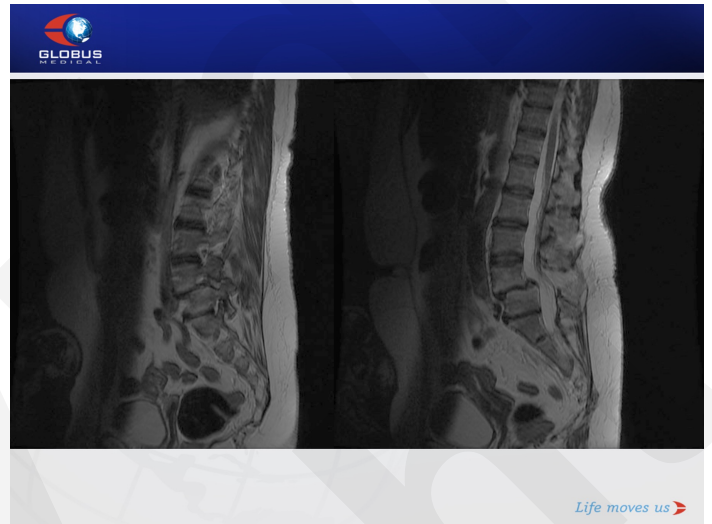
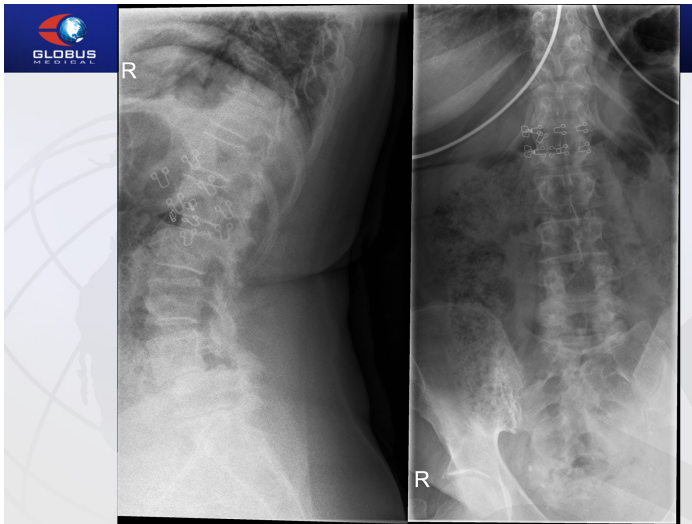
Pick Your Poison

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Some Cases

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- 60 year old man
- Progressive mid lumbar pain
- Some L3 pain
- Exhausted conservative measures

Life moves us

