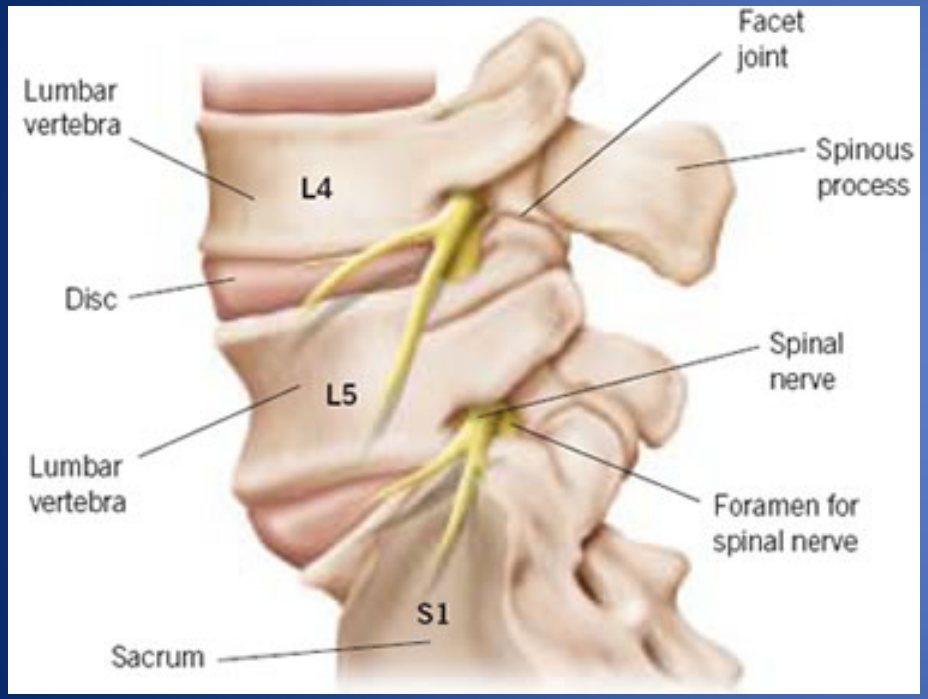
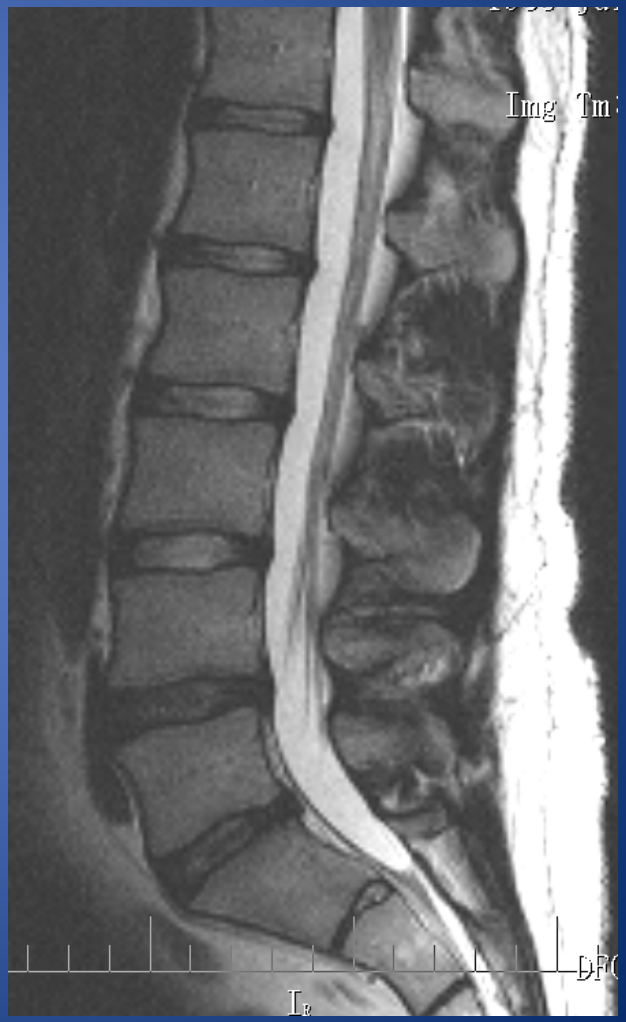
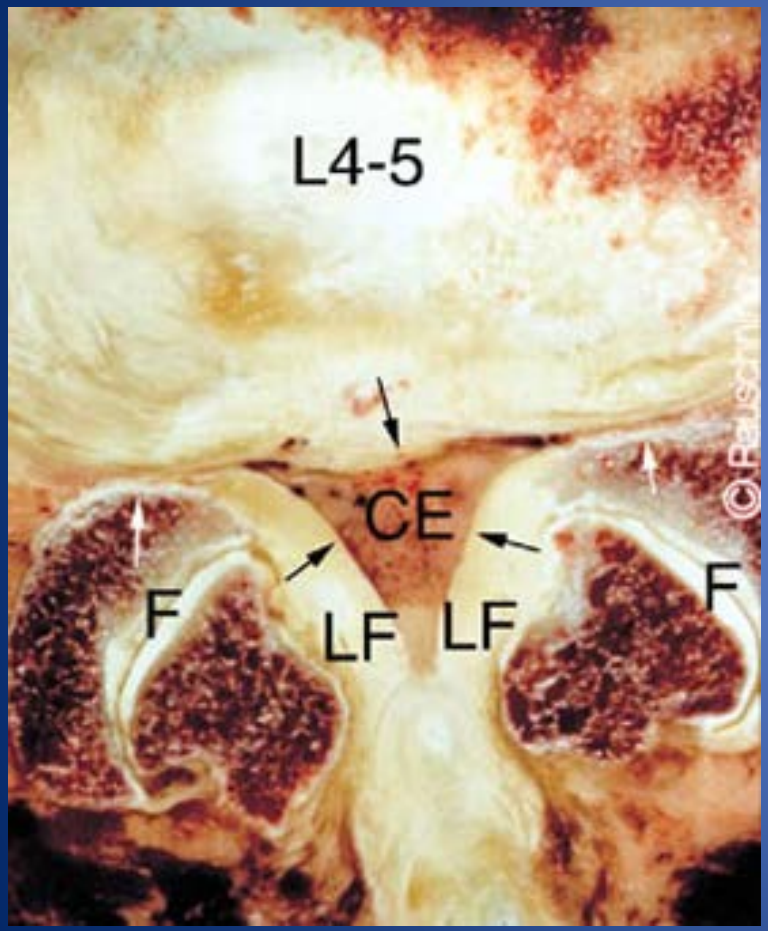
Minimally Invasive Spine Surgery

David H Strothman, M.D.

The Lumbar Spine






L4-5
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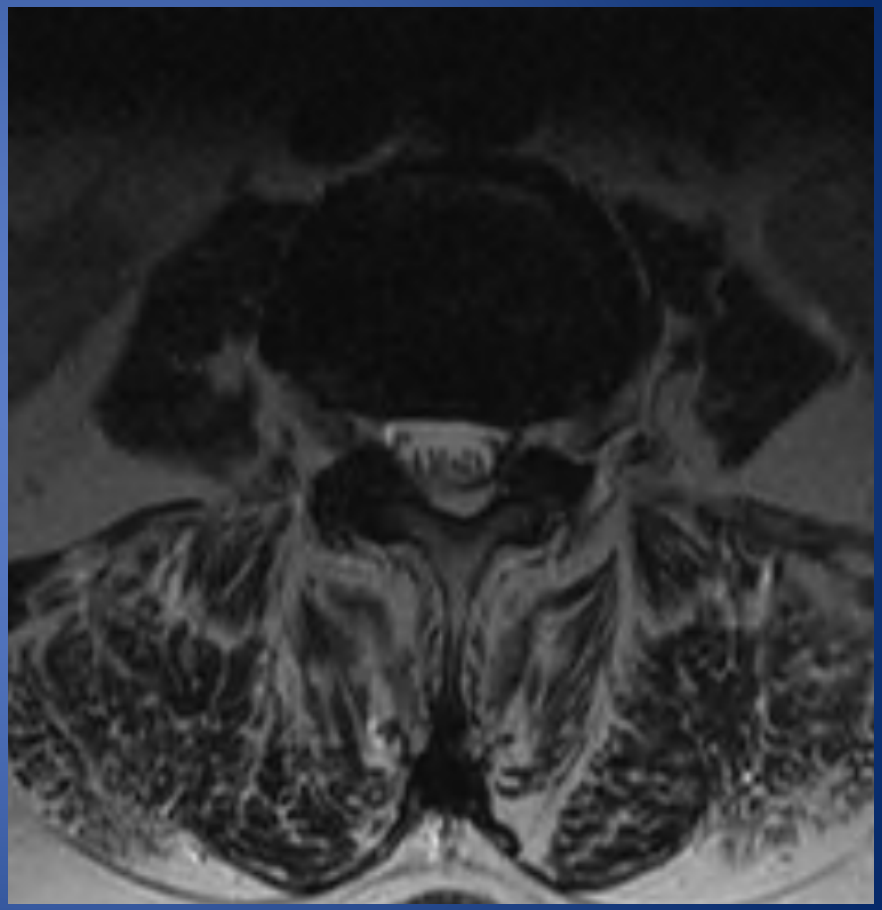
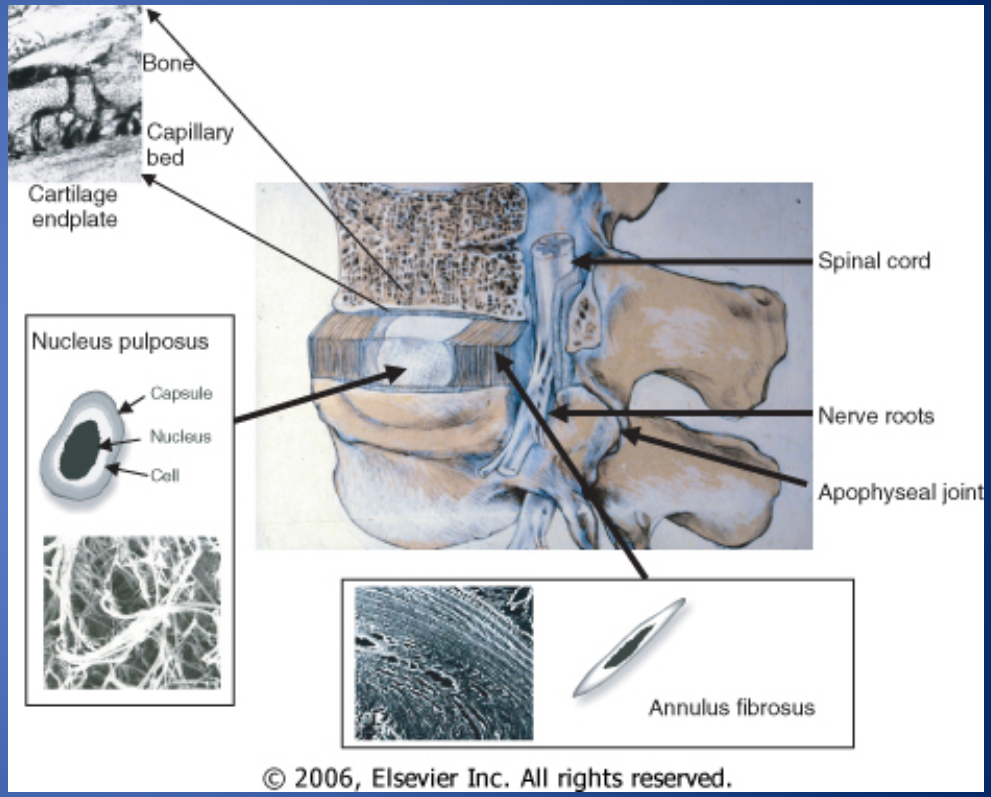


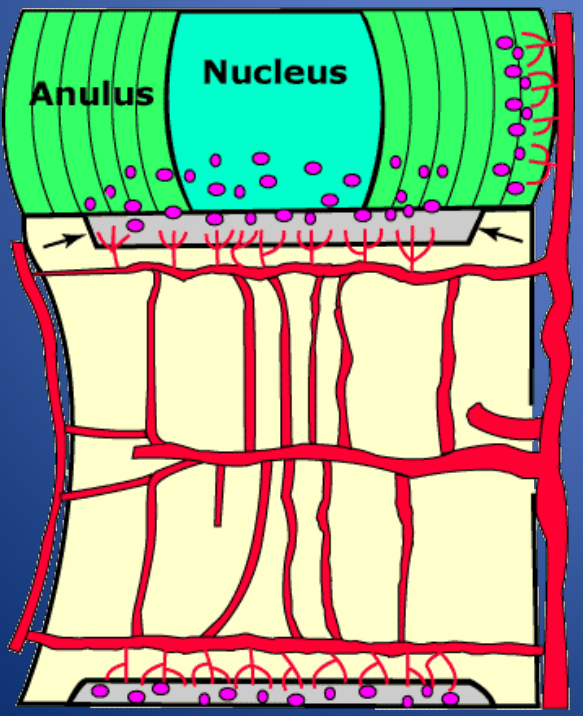
Lumbar Disc

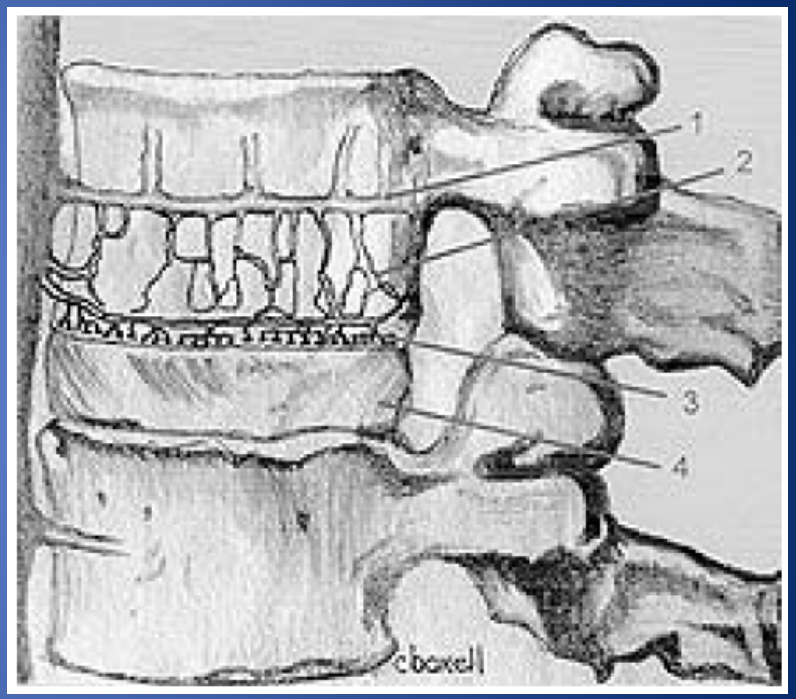
- Annulus Fibrosus
  - High collagen content
  - Concentric layers of intertwined annular bands
- Nucleus Pulposus
  - Hydrated
  - Proteoglycans



Blood Supply

- Capillary beds of endplate
- Nutrition by diffusion





Disc Degneration

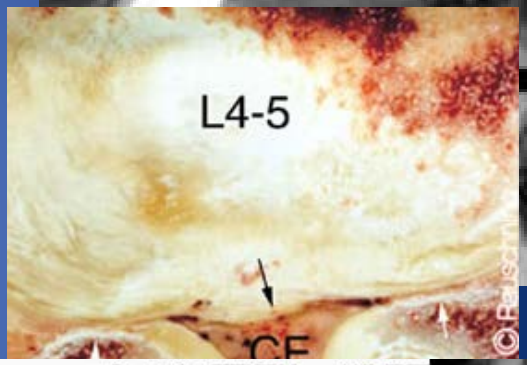
Narrowing | Settling

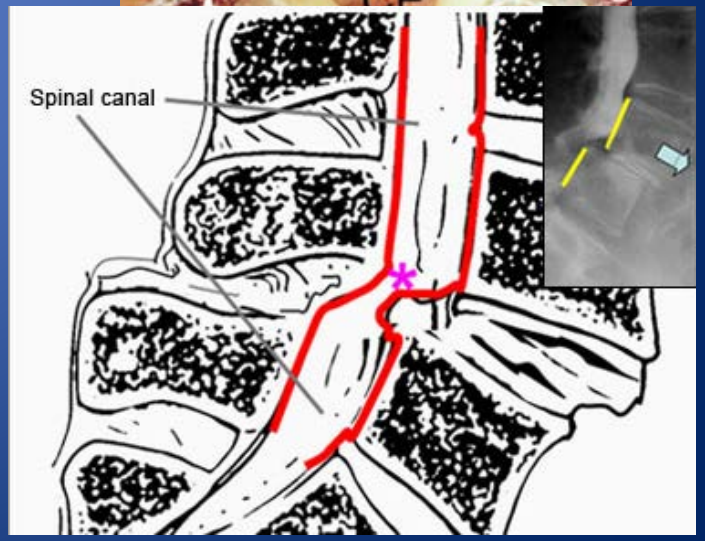
Spinal Stenosis

Facet hypertrophy | Ligamentum infolding

Spondylolisthesis

Stable | Unstable

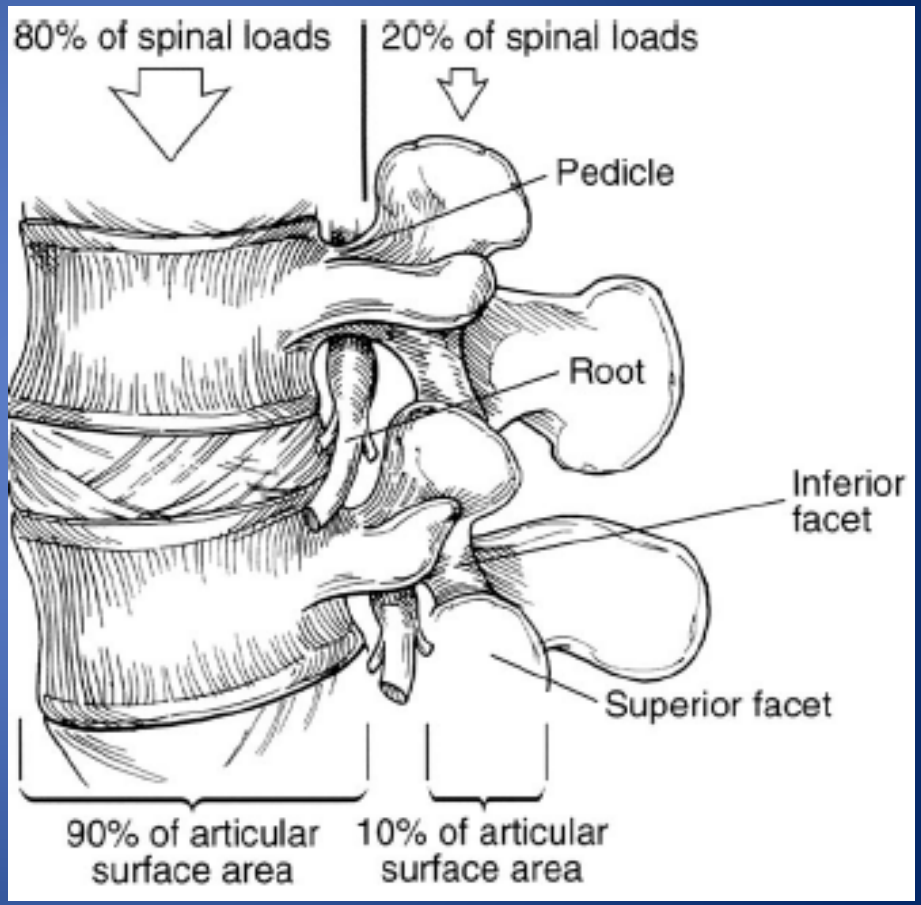




Pain Generators

- Disc - annulus
- Facet Joints
- Nerve compression

- 80% mechanical stress through disc
- 20% through posterior elements



Pain Patterns

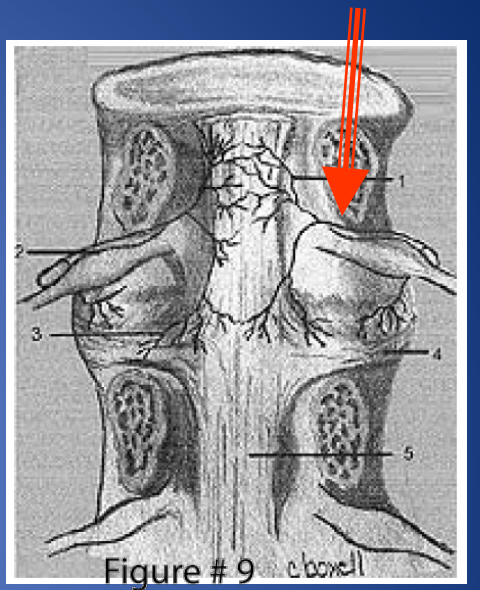
Nerve Compression

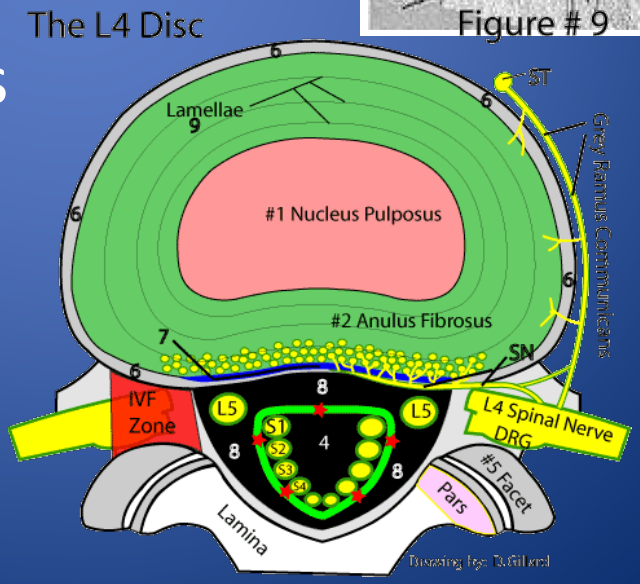
Facet Degeneration and DDD

BUT

Sinuvertebral Nerve

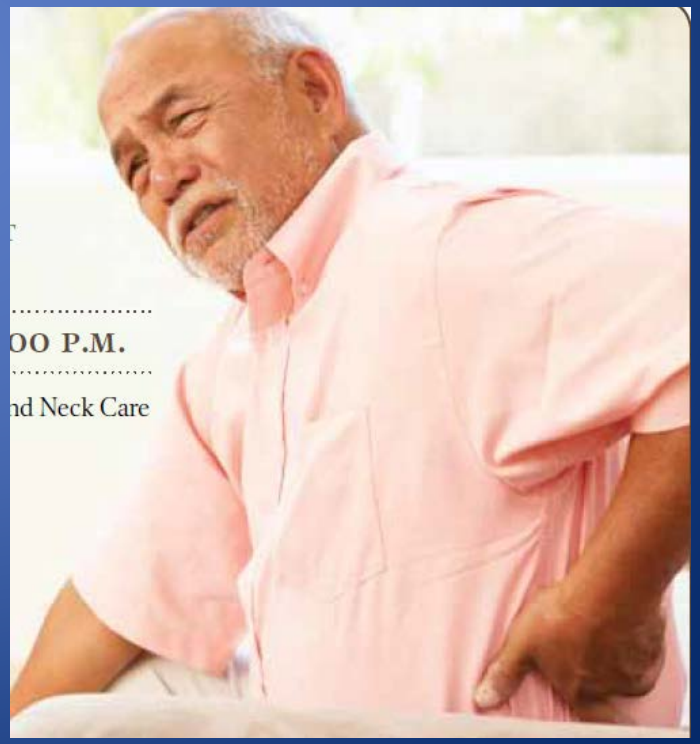
- Outer annulus innervated
- Nucleus pulposus not innervated
- ALL and PLL also innervated by branches from DRG





Low Back Pain

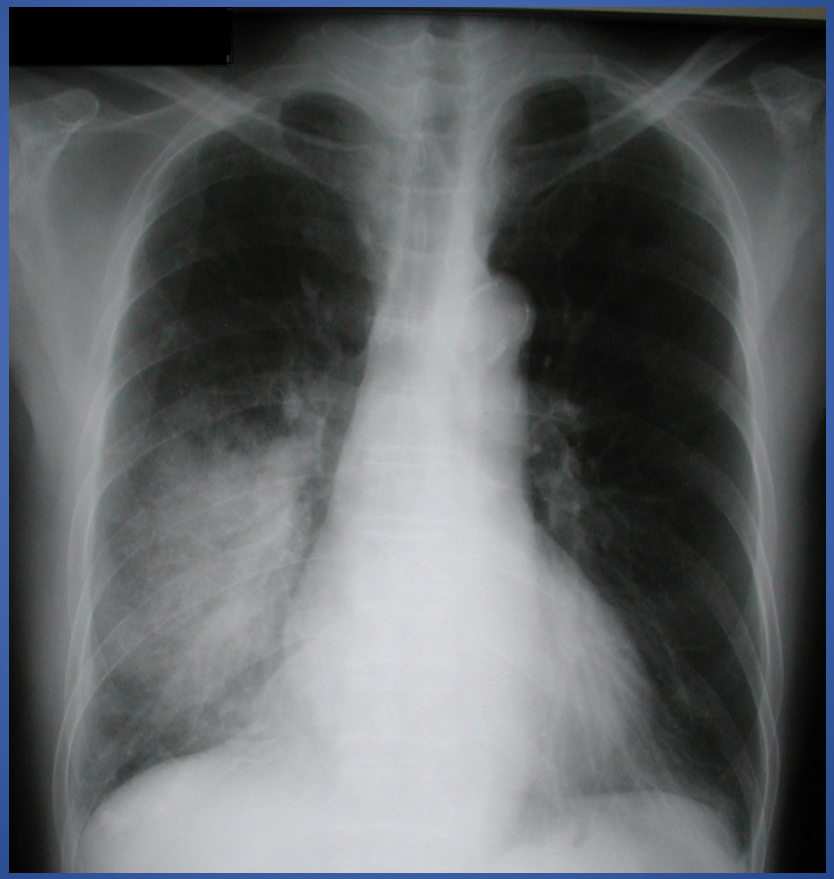
- Muscle pull or strain
- Degenerative Disc Disease
- Facet degeneration / arthritis
- Tumor
- Infection
- Fracture
- Pinched Nerves
  - Spinal Stenosis
  - Spondylolisthesis
  - Herniated Disc



THE NATIONAL DEBATE

LOW BACK PAIN

Shortness of Breath
Treatment: Antibiotics



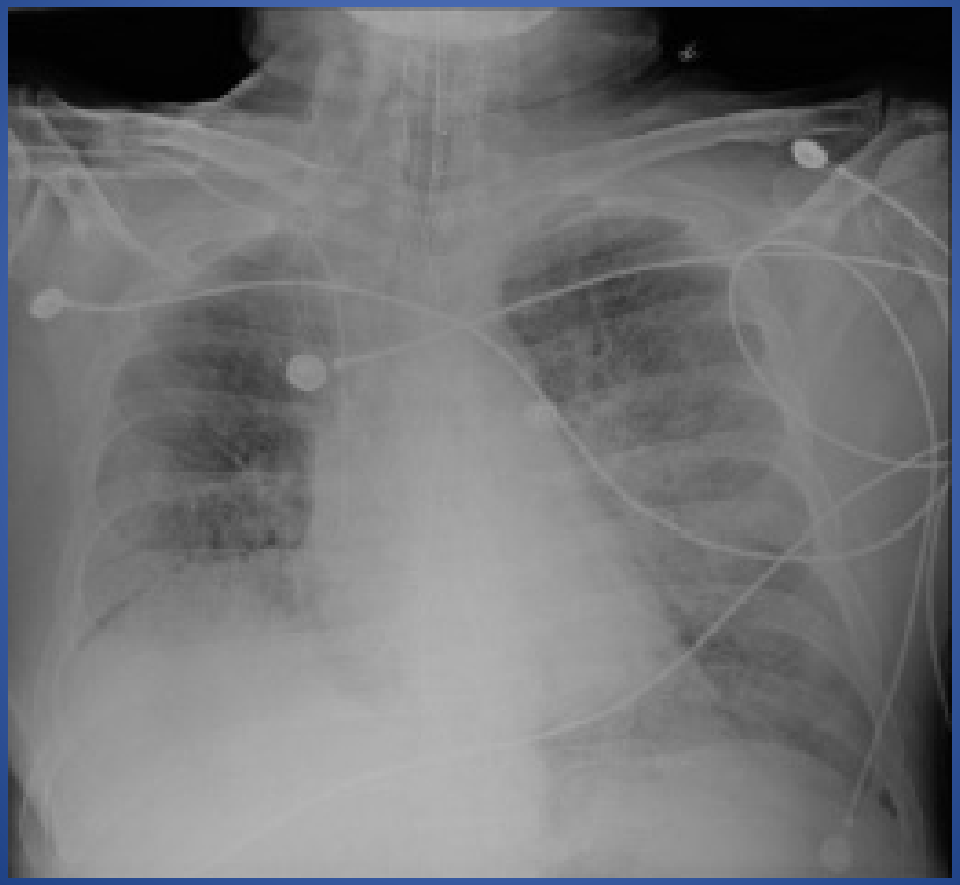
Pneumonia

SUCCESS

Because you too can own this face of pure accomplishment

DIY.DESPAIR.COM

Shortness of Breath
Treatment: Antibiotics



Congestive Heart Failure

FAILURE

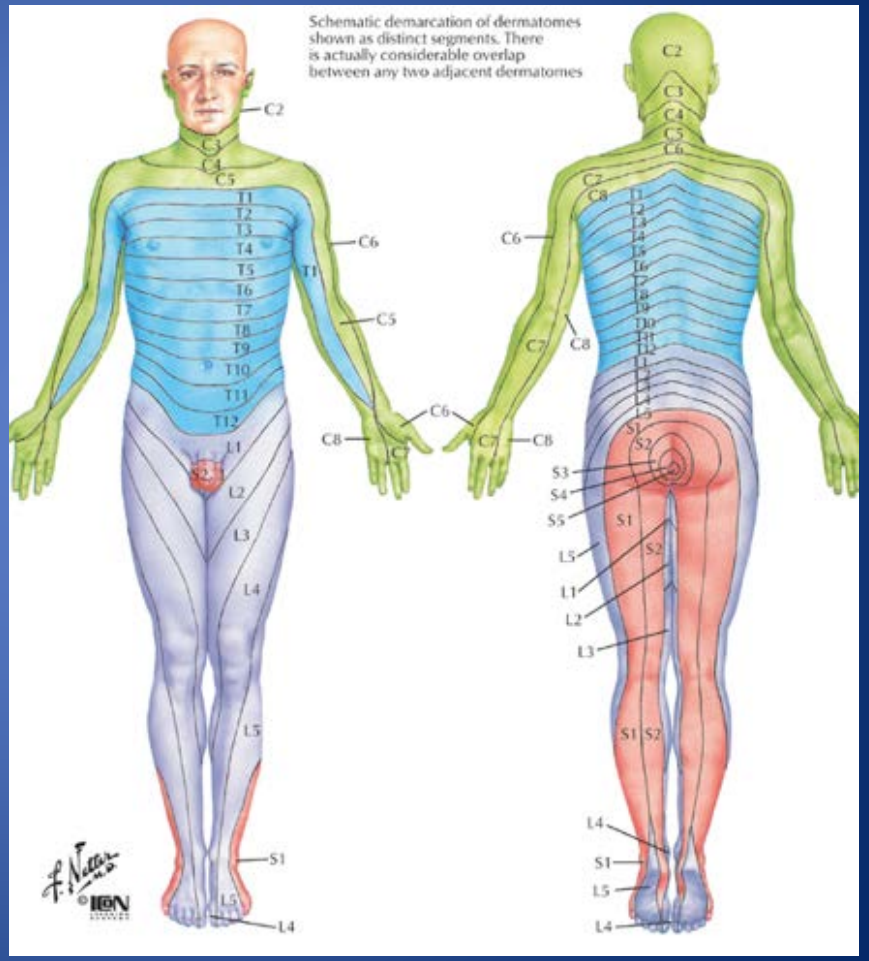
Sometimes you can see it coming around the bend

Common Spine Conditions

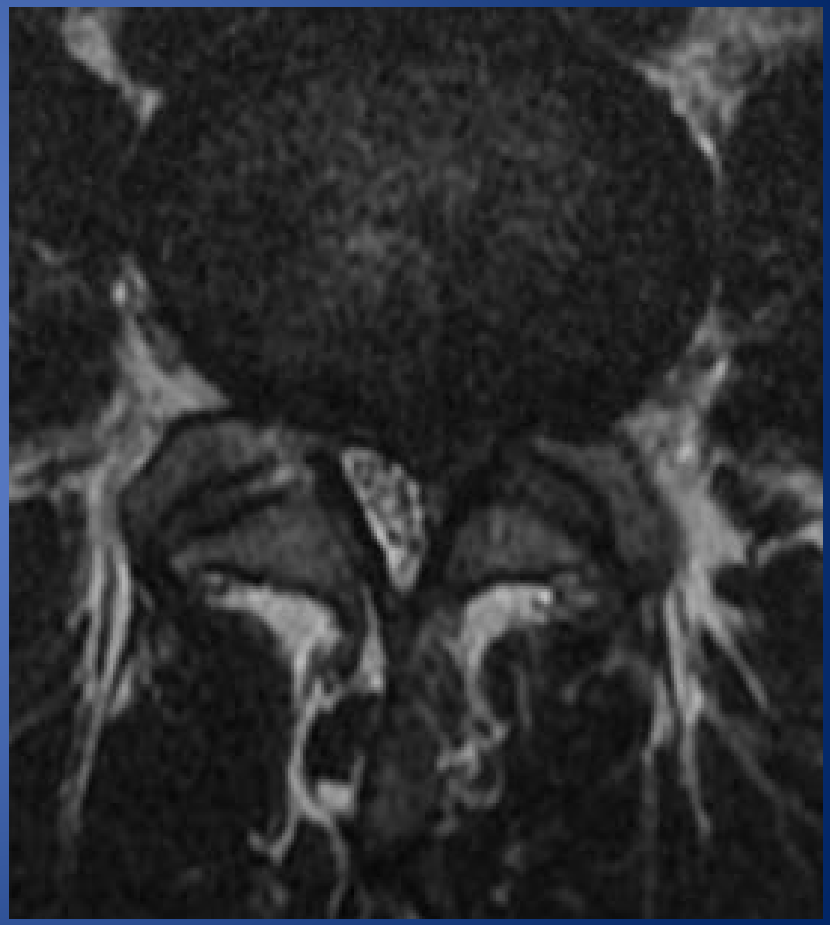
- Herniated Discs
- Degenerative Disc Disease
- Spinal Stenosis
- Spondylolisthesis

Disc Herniation

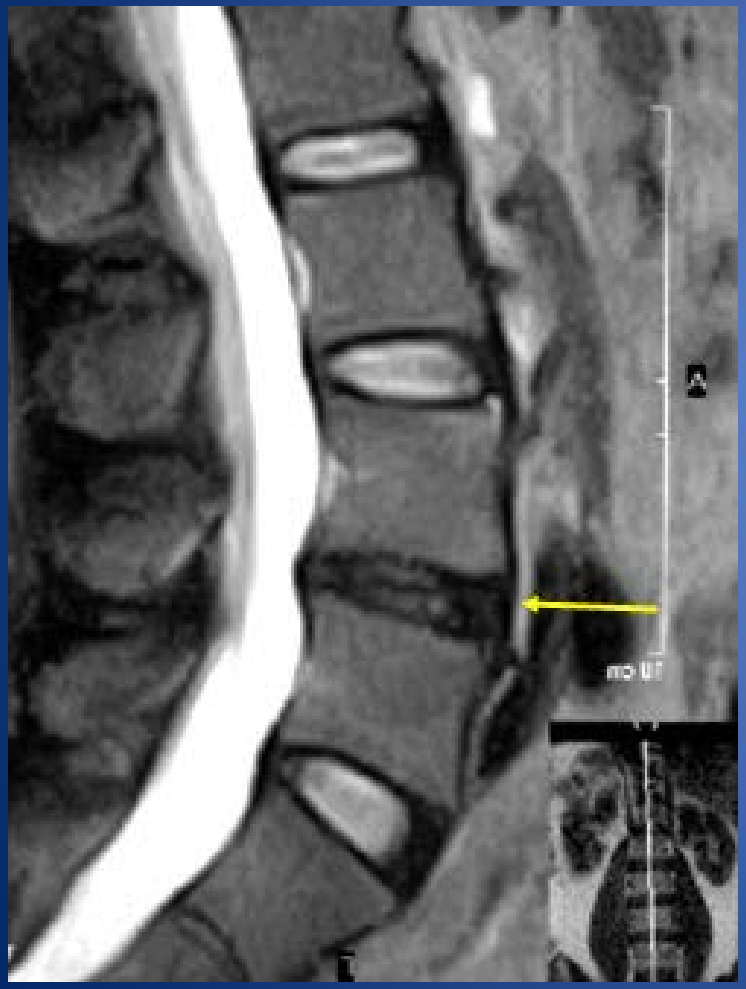
- Sudden severe pain
- Typically legs > LBP
- Unilateral
- Radicular
- Positive tension signs



Disc Herniation

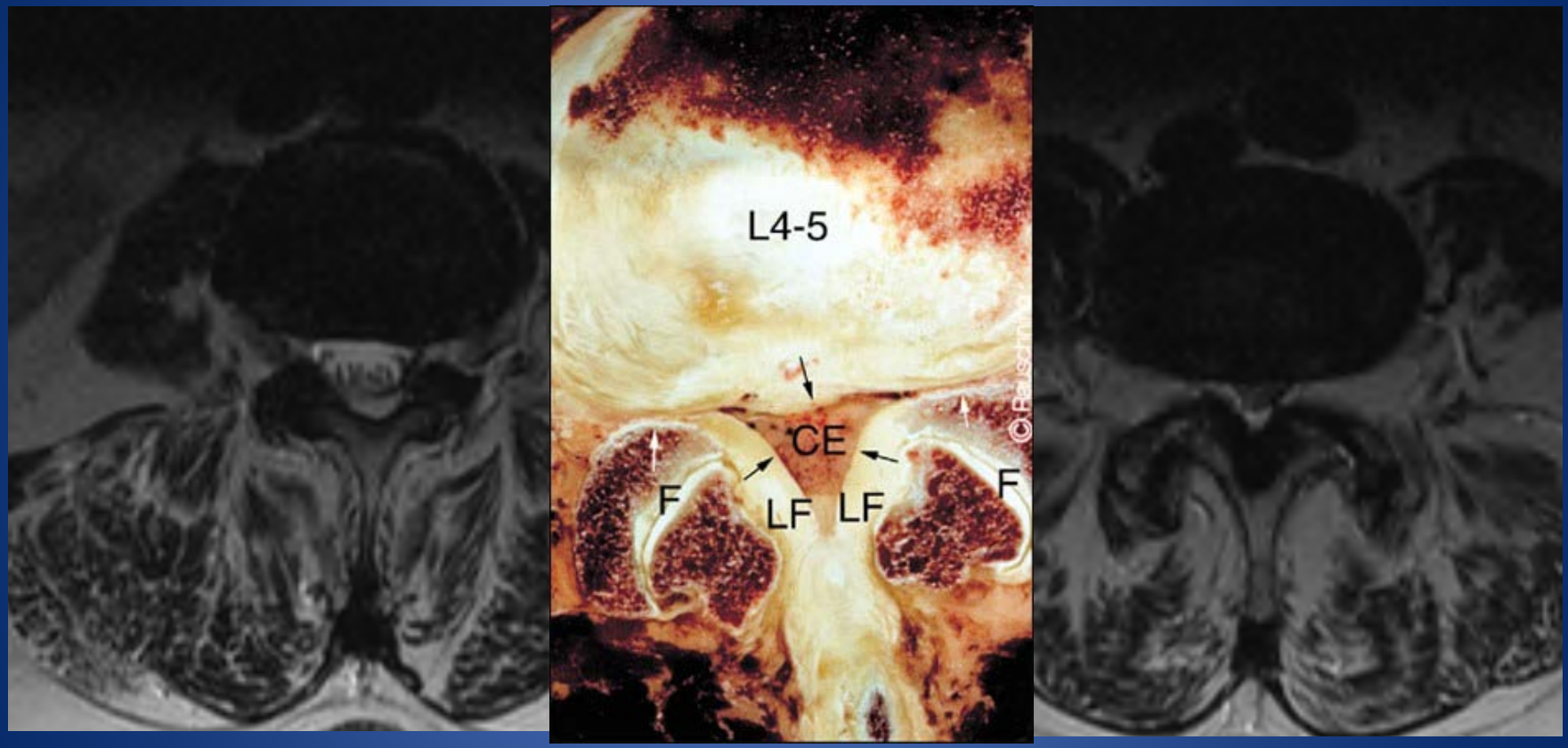


Clinical Presentation
Symptomatic Disc Degeneration



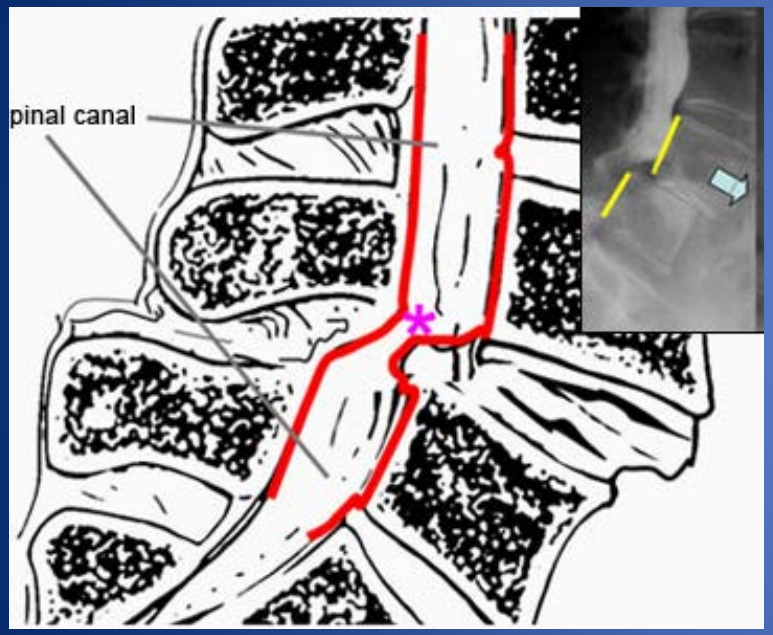
Pain worst with sitting
Constantly shifting to get comfortable

Spinal Stenosis



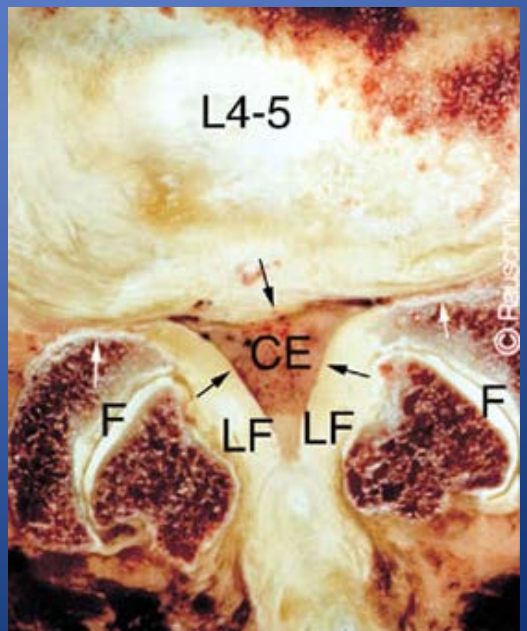
Clinical Presentation: Spinal Stenosis

Degenerative Spondylolisthesis



NORMAL

SPONDYLOLISTHESIS

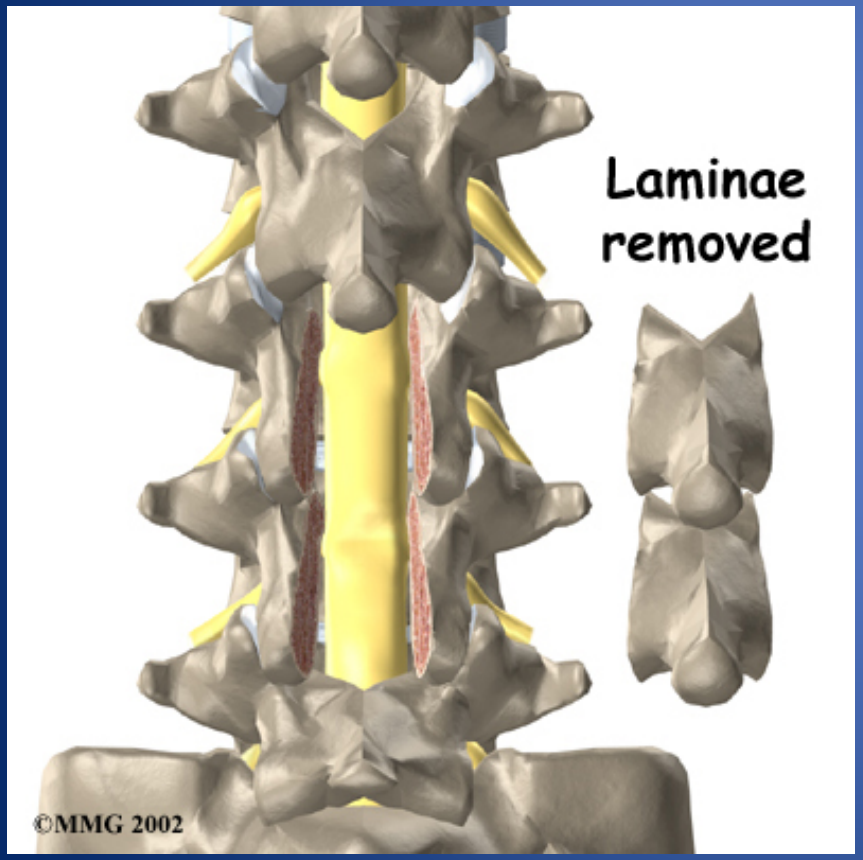


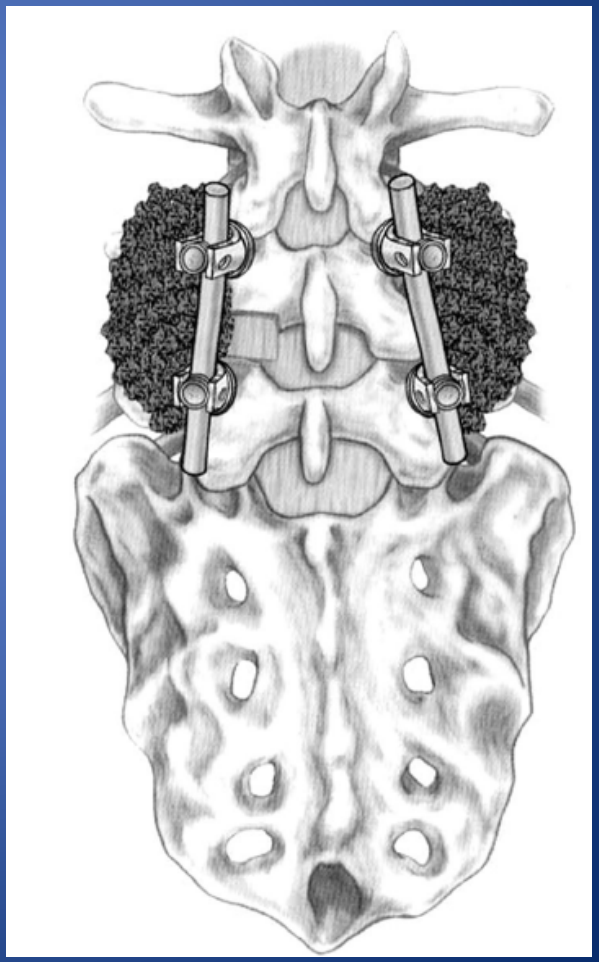
Clinical Manifestations
Degenerative Spondylolisthesis

+/-

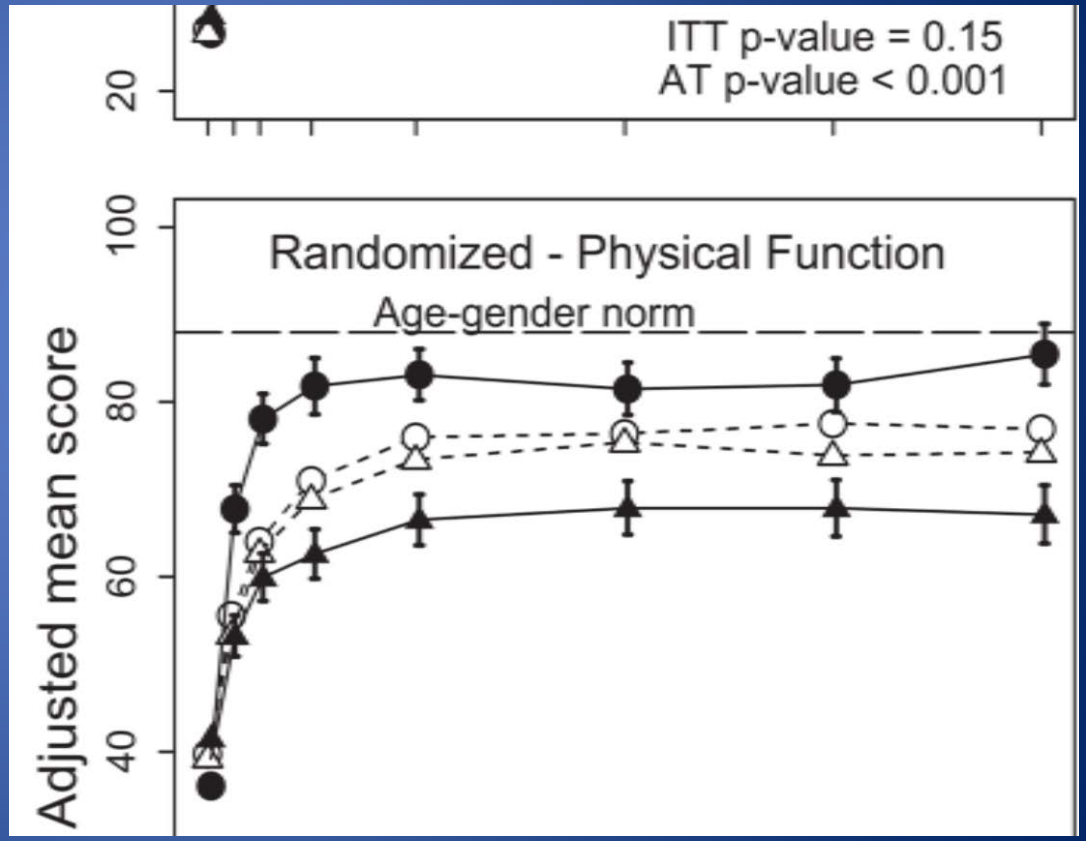
Worst with standing and walking
Initial relief with sitting
Better pushing a cart

Surgical Treatment Options
Decompression vs Fusion





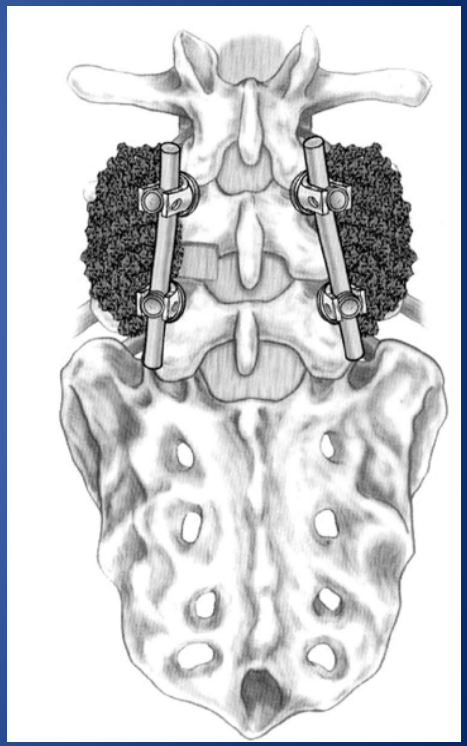
Surgical Treatment Options
Discectomy



Surgical Treatment
Symptomatic Disc Degeneration

- Disc Replacement

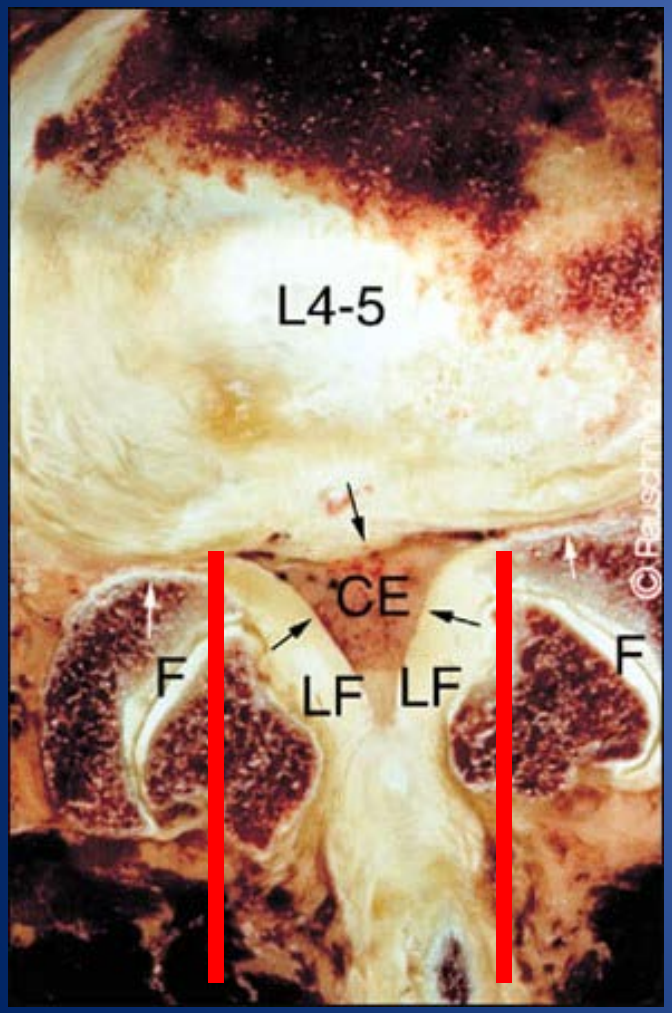
- FUSION
  - Anterior
  - Anterior and Posterior
  - Posterior alone

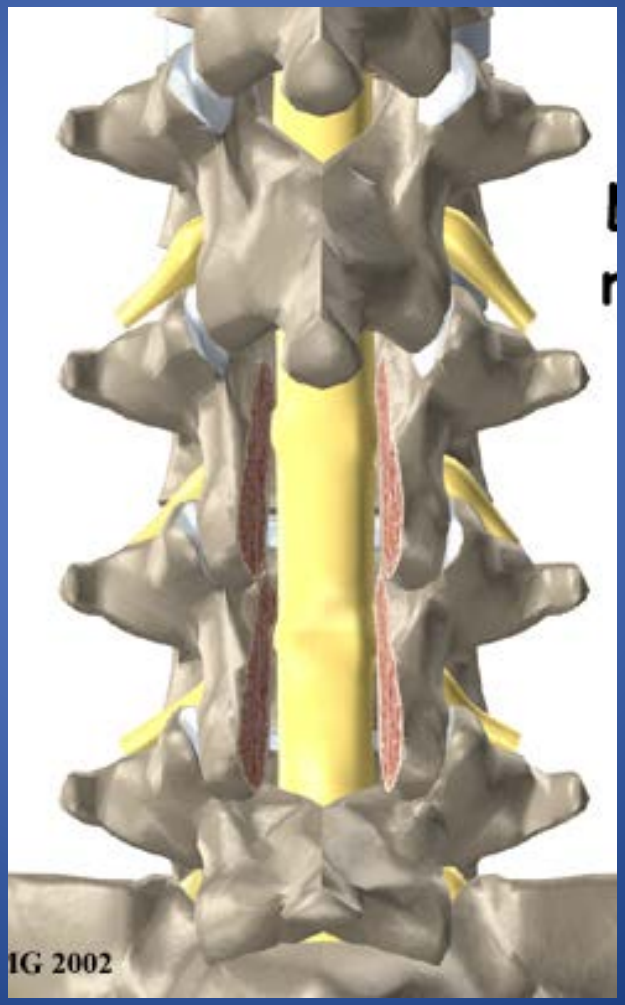


Variable Results!

63% of patients improved (29% non-op)
75% would do it again
(Fritzell 2001)

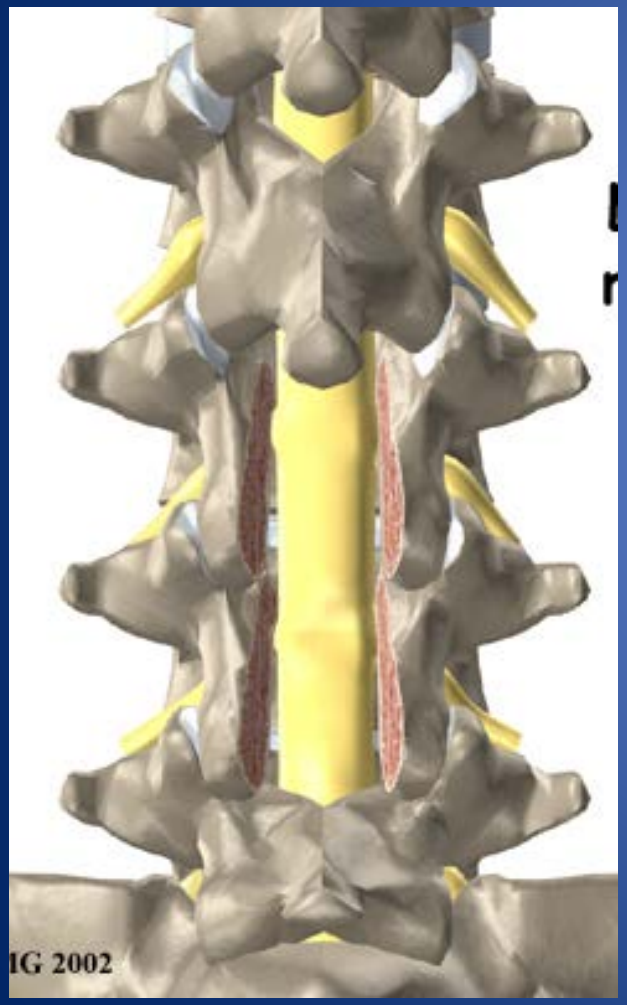
Surgical Treatment
Spinal Stenosis

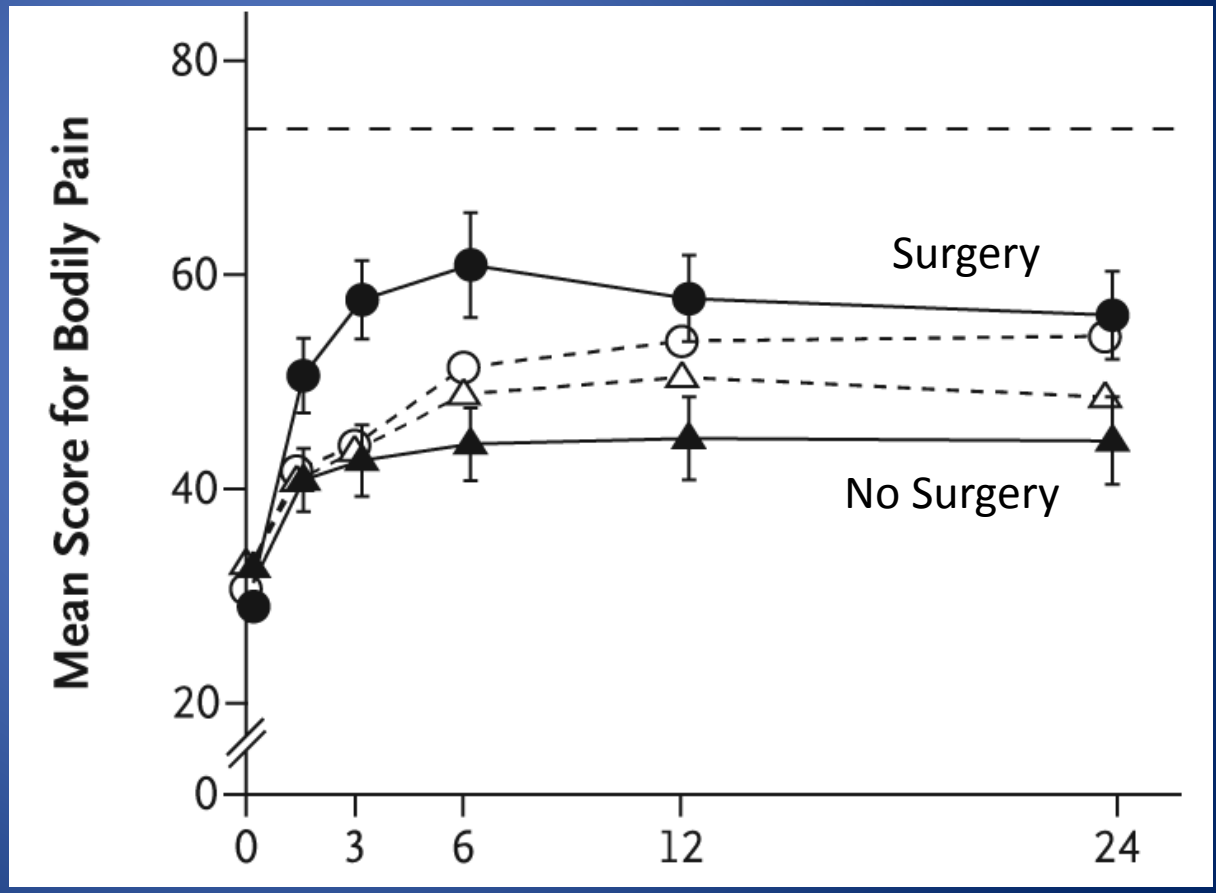




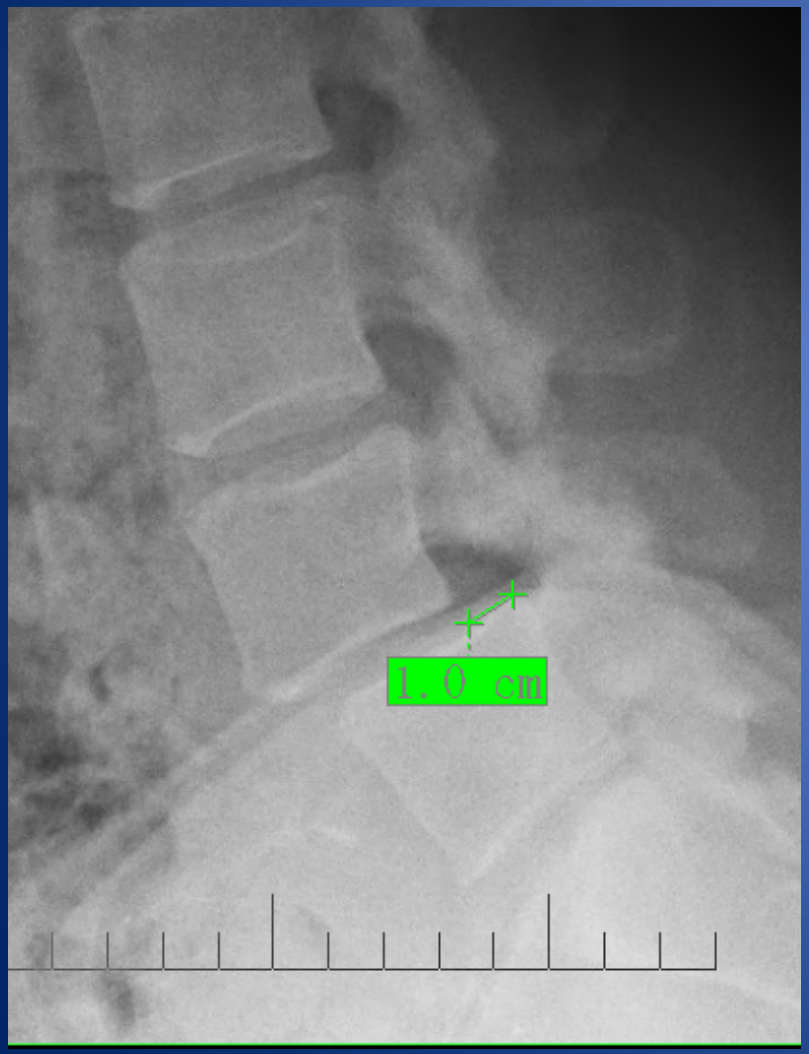
- Laminectomy
- Minimally invasive vs Open

Spinal Stenosis
SPORT Trial Results

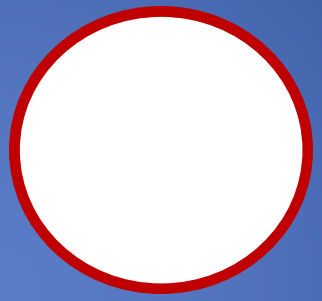




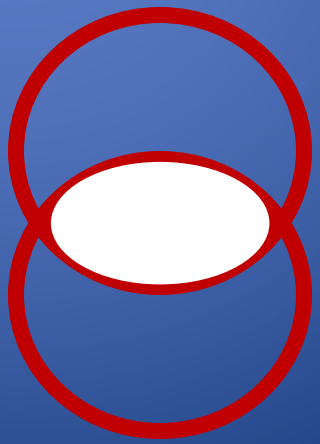
Surgical Treatment
Degenerative Spondylolisthesis

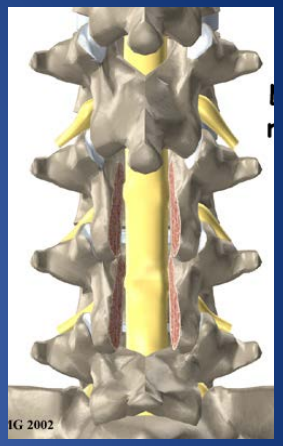


NORMAL



SPONDYLOLISTHESIS





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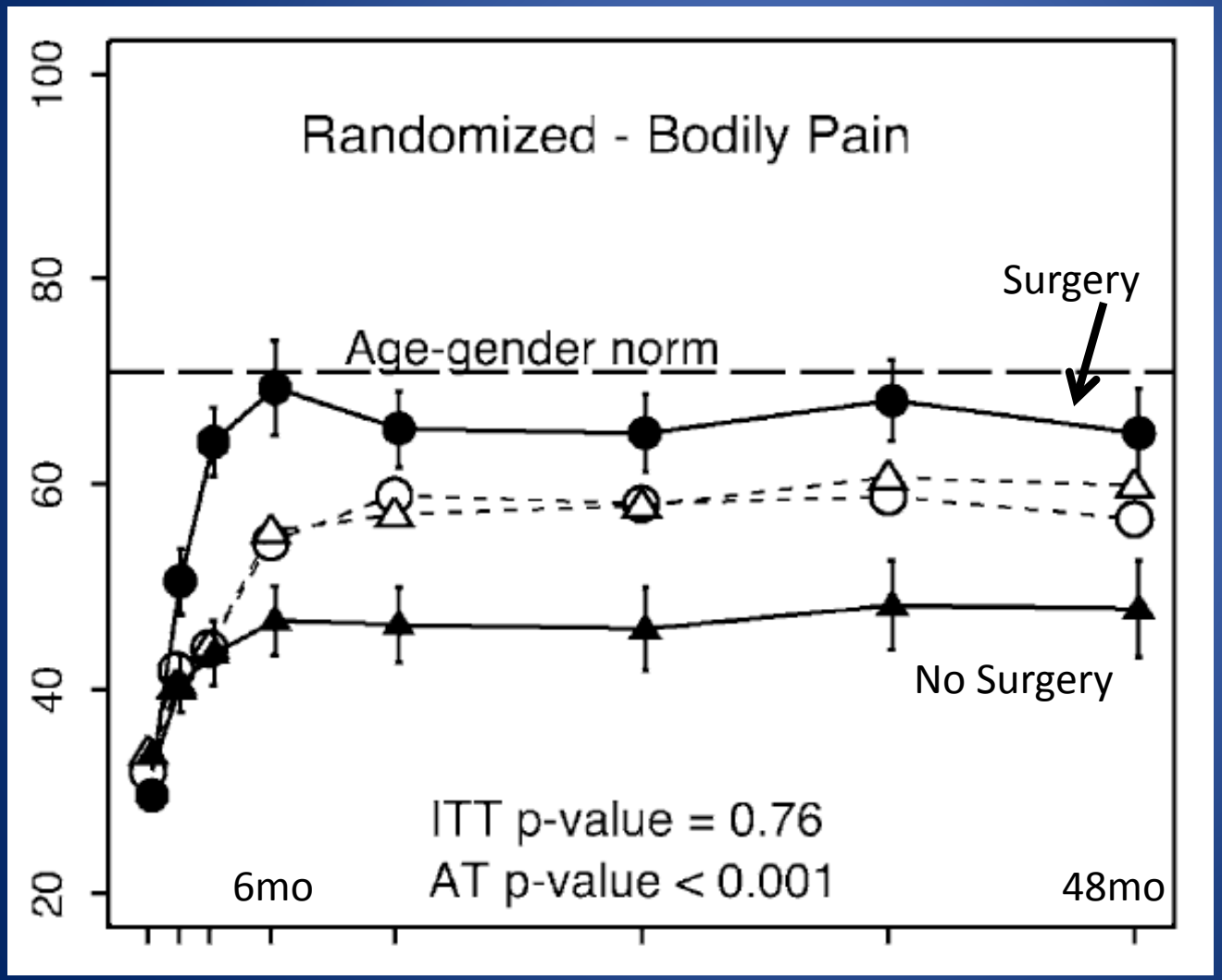
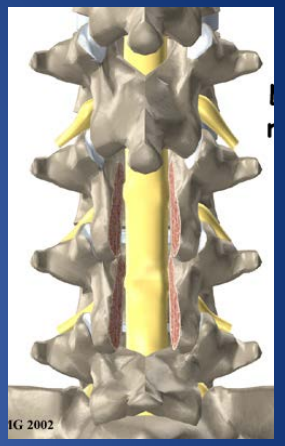
Degenerative Spondylolisthesis 4 year SPORT Trial Results





ELSEVIER

The Spine Journal 8 (2007) 296–304

THE SPINE JOURNAL

2007 Outstanding Paper Award: Surgical Science

Assessment of health-related quality of life after surgical treatment of focal symptomatic spinal stenosis compared with osteoarthritis of the hip or knee

Y. Raja Rampersaud, MD[a,b,*], Bheesma Ravi, HBSc[c], Stephen J. Lewis, MD[a,b], Venessa Stas, MD[c], Ronald Barron[c], Roderick Davey, MD[c], Nizar Mahomed, MD, MPH[c]

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Received 12 February 2007; accepted 2 May 2007

- **No difference in SF36 scores in decompression or decomp + fusion vs THA and TKA**

Table 2
SF-36 PCS and MCS scores for the entire cohort

SF-36 component summary	Time interval (years)	FLSS (n_0=90; n_1=80; n_2=80)	H-OA (n_0=90; n_1=80; n_2=80)	K-OA (n_0=90; n_1=80; n_2=78)
PCS	0	32.0	30.2	31.3
	1	39.6[a,1]	44.5[c,1]	38.5[1]
	2	38.6[a,2]	43.2[c,2]	37.1[2]
MCS	0	43.5	45.0	46.2
	1	47.1	45.5	47.8
	2	50.3[b,2]	50.9[c,2,3]	44.8

The Spine Journal 2007. 8:296-304

Adjacent Segment Disease

- Gillet 2003
  - 78 pts with instrumented posterolateral fusion
  - Minimum follow up 5 years
  - 32/78 (41%) evidence for adjacent segment changes
    - 47% had second operation
  - 1 segment fusions: ASMA: 12 (32%), Reop: 4 (11%)
- Ghiselli et al. 2004
  - 215 patients PSF
  - 27.4% (59/215) re-operation for adjacent segment
  - **Kaplan-Meier predicted adjacent disease warranting decompression or fusion in 16.5% at 5 years and 36.1% at 10 years**
- Biomechanics
  - Adjacent segments have increased motion and 45% increase in intradiscal pressure

BUT

DDD
Normal
Fused
Fused
1951 Dec 14 M 93412686
Acc: 4807379
2010 Aug 25
Img Tm: 15:10:48.593000
DFOV: 27.5 x 27.5cm
NOT TO SCALE
t2_tse_axial 3mm
Se: 6/6
Im: 30/14
Ax: 56.5
320 x 320
Mag: 2.7x
(7.8:1)
ET: 11
TR: 4100.0
TE: 109.0
3.0thk/1.0sp
Lin
W:1039 L:458
1951 Dec 14 M 9
Acc:
2010
Img Tm: 15:27:21
DFOV: 22.0 x
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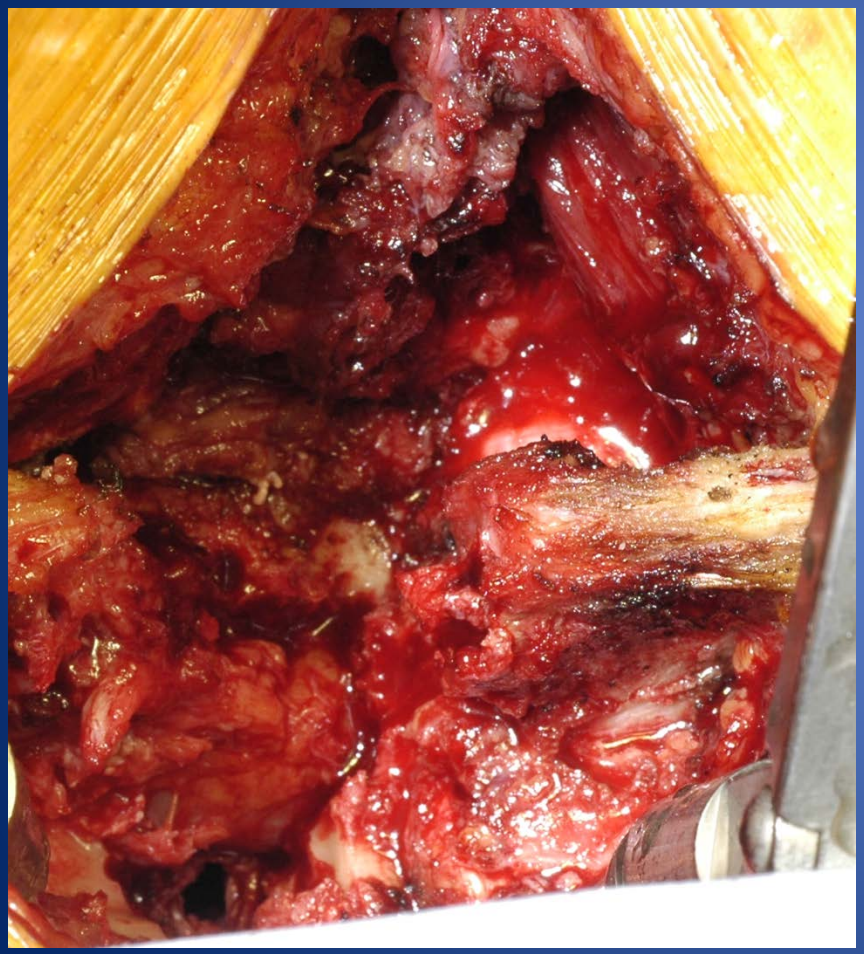
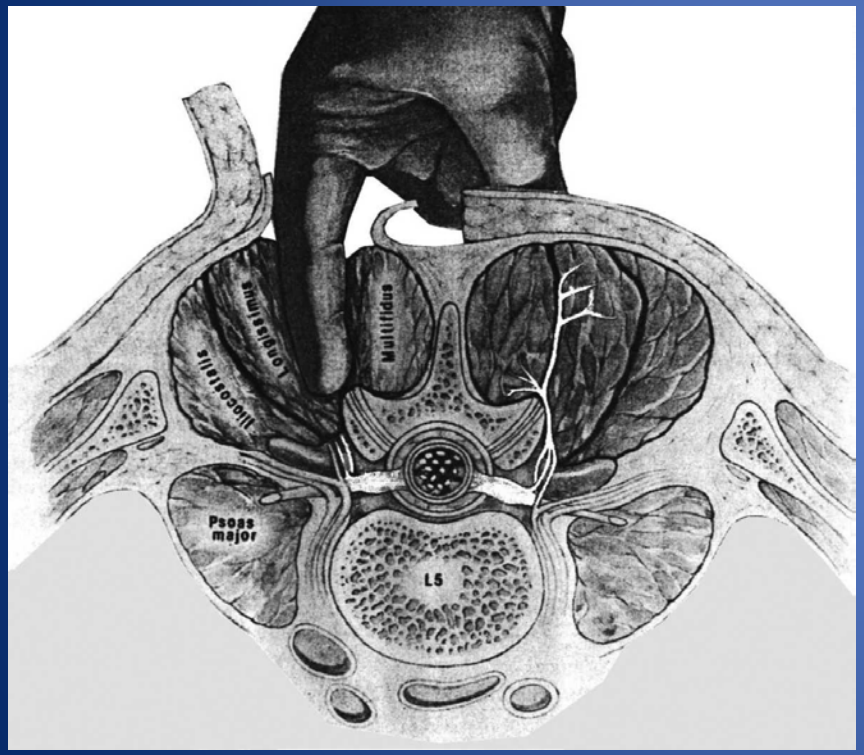
What is Minimally Invasive Spine Surgery?

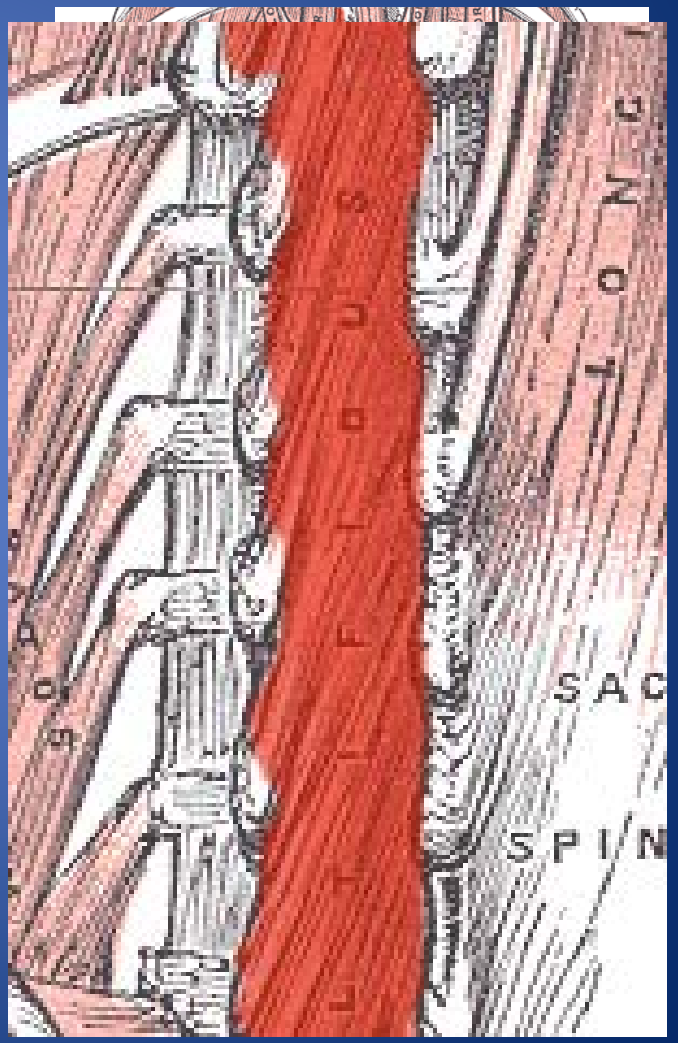
Problems with Open Spinal Surgery



- Paraspinal muscle damage
- Blood loss
- Prolonged Recovery
- Adjacent Segment Degeneration
- Failed back syndrome

Problems with Open Surgery Multifidis and Longissimus





Multifidis Atrophy

SPINE Volume 30, Number 1, pp 123–129
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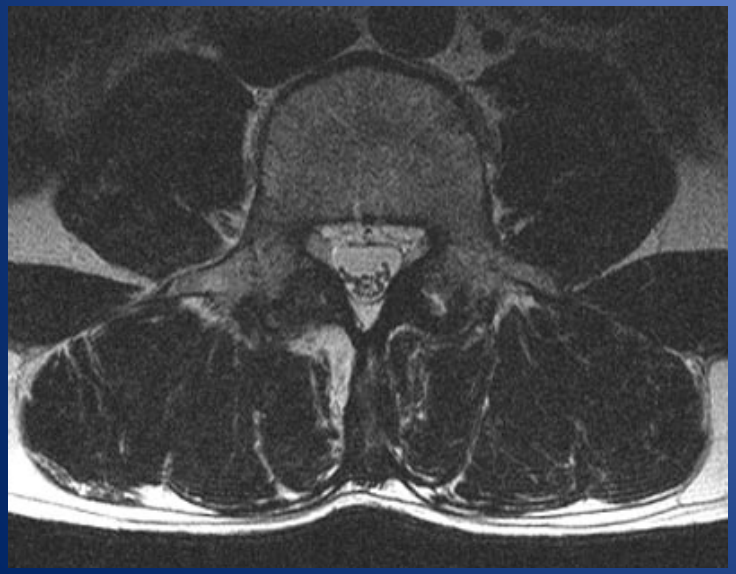
Comparison of Multifidus Muscle Atrophy and Trunk Extension Muscle Strength

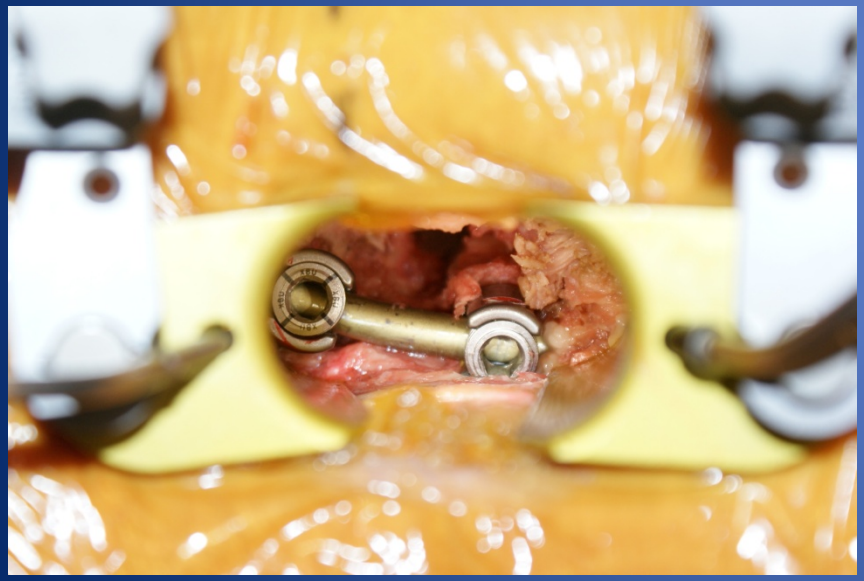
Percutaneous *Versus* Open Pedicle Screw Fixation

Dong-Yun Kim, MD,* Sang-Ho Lee, MD, PhD,* Sang Ki Chung, MD,†
Ho-Yeon Lee, MD, PhD*

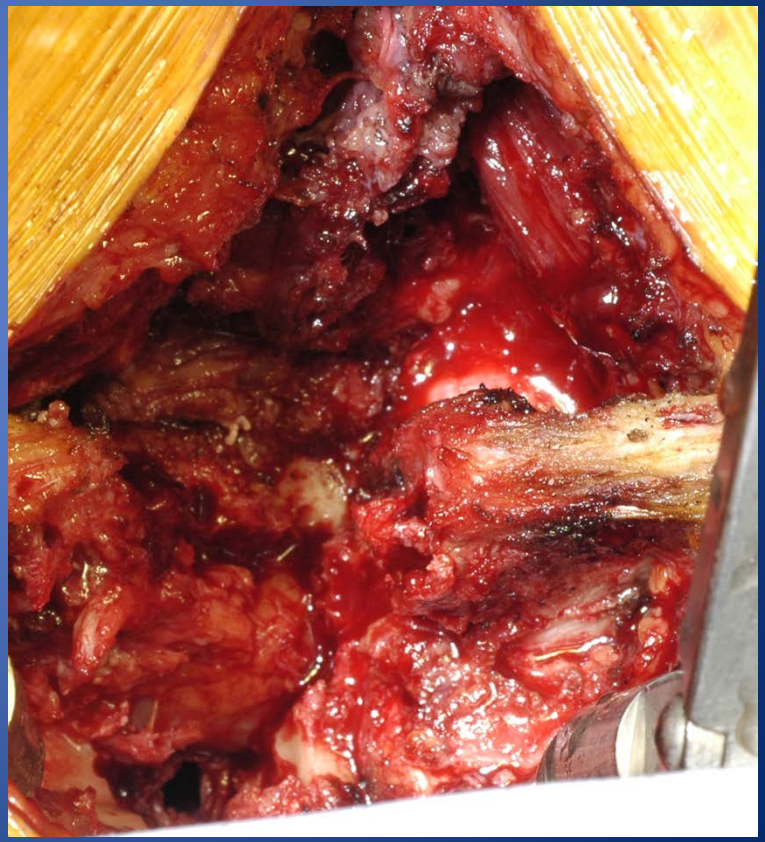


Exposure

MIS

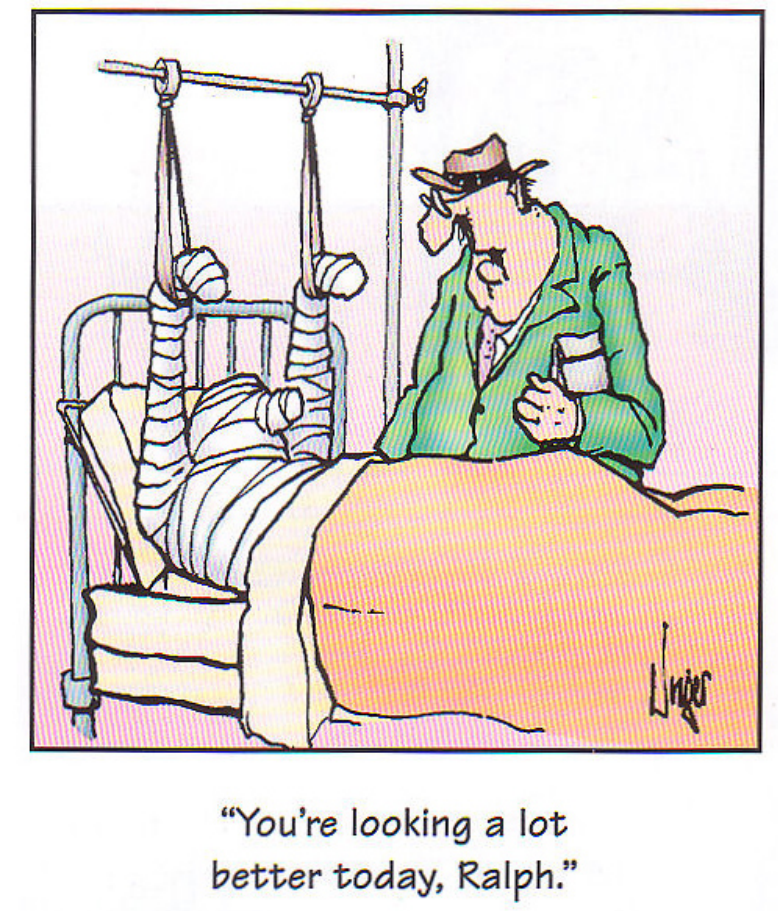


Open



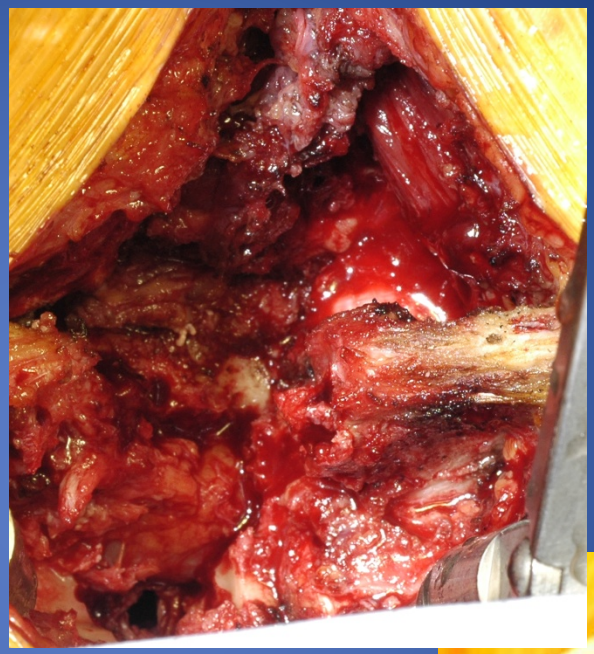
Reported Advantages

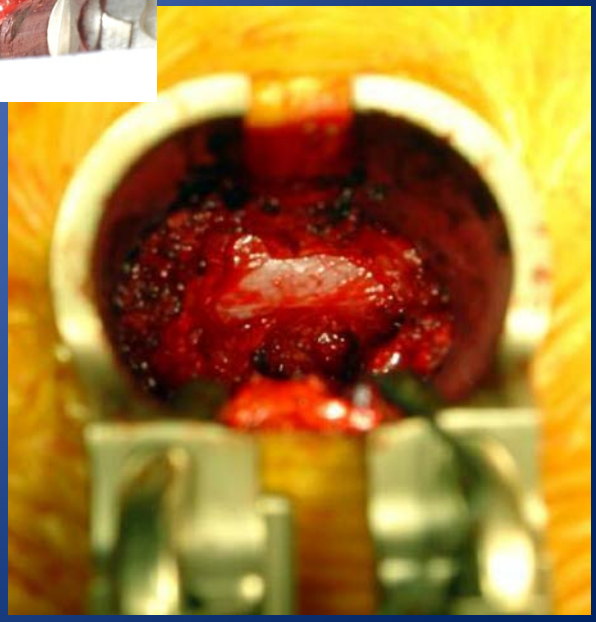
- Less soft tissue damage
- Less blood loss
- Shorter hospital stay
- Lower infection rate



Proposed Advantages

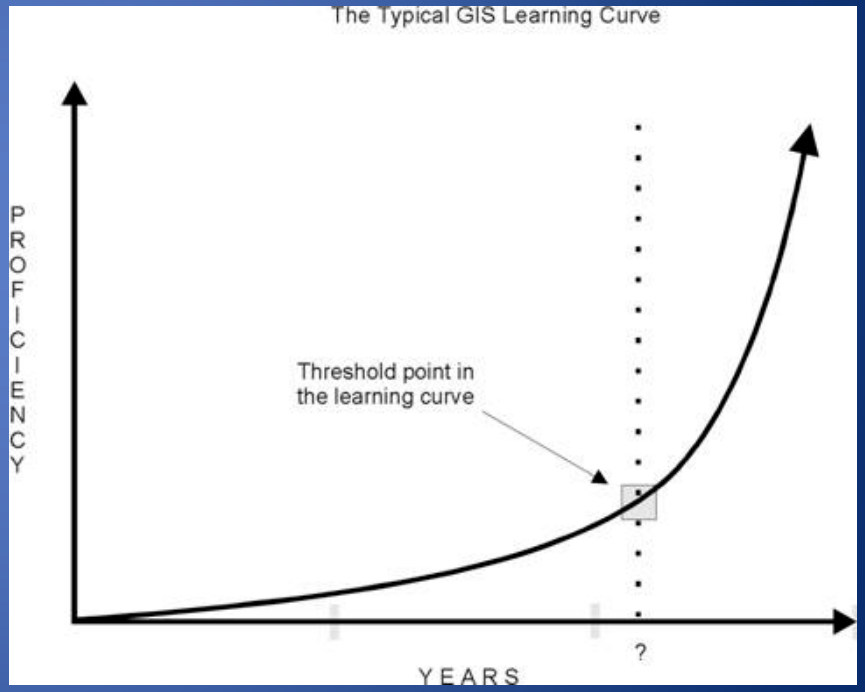
- Faster initial recovery
- Less adjacent segment disease
- Maintained paraspinal muscle function
- Improved overall patient outcomes





Disadvantages

- Increased O.R. Time
- Increased use of fluoroscopy
- Steep learning curve
- Long term outcome data missing
  - Fusion Rates?
  - Outcomes?
  - Technical complications?

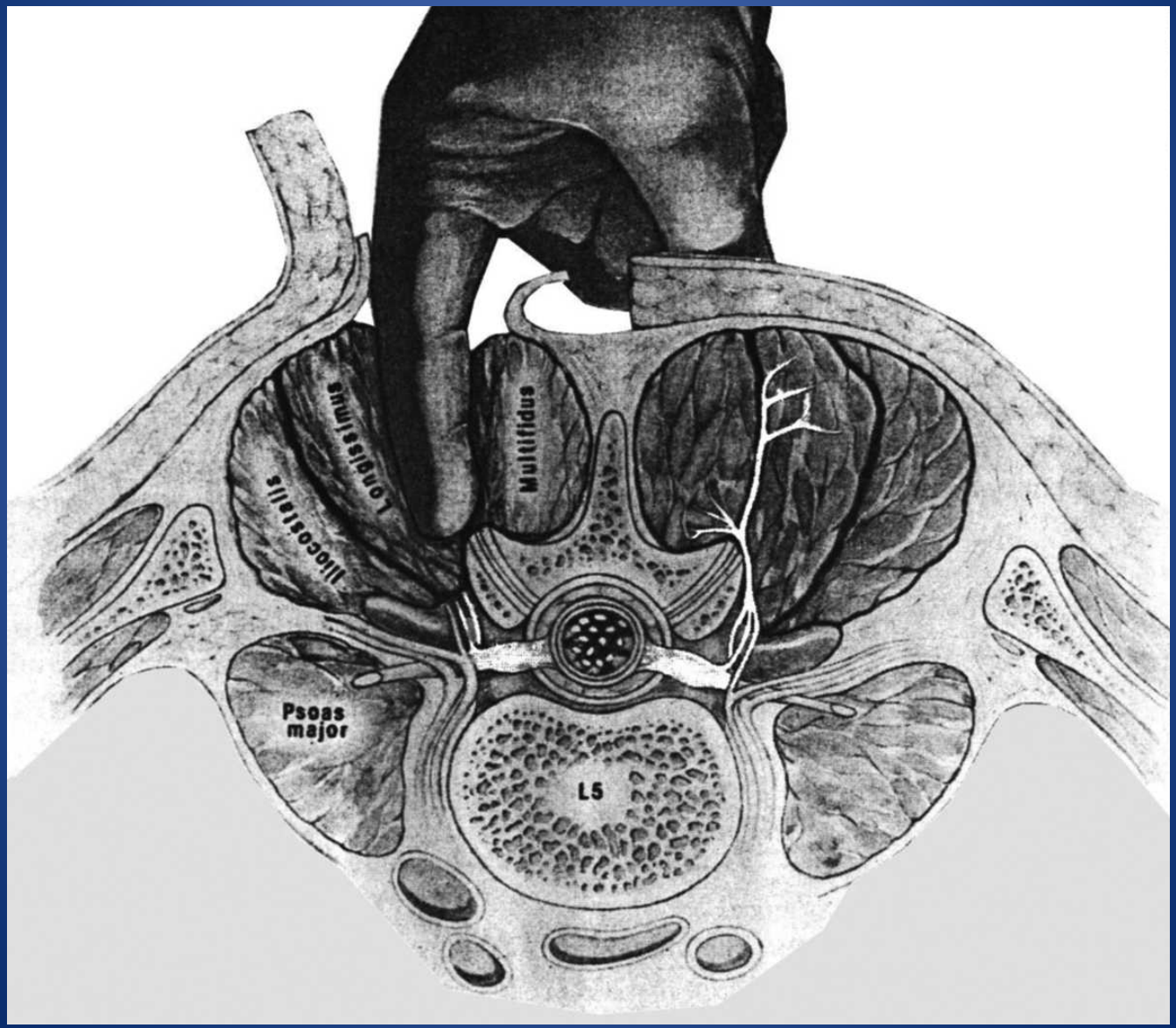


Minimally Invasive Spine Surgery

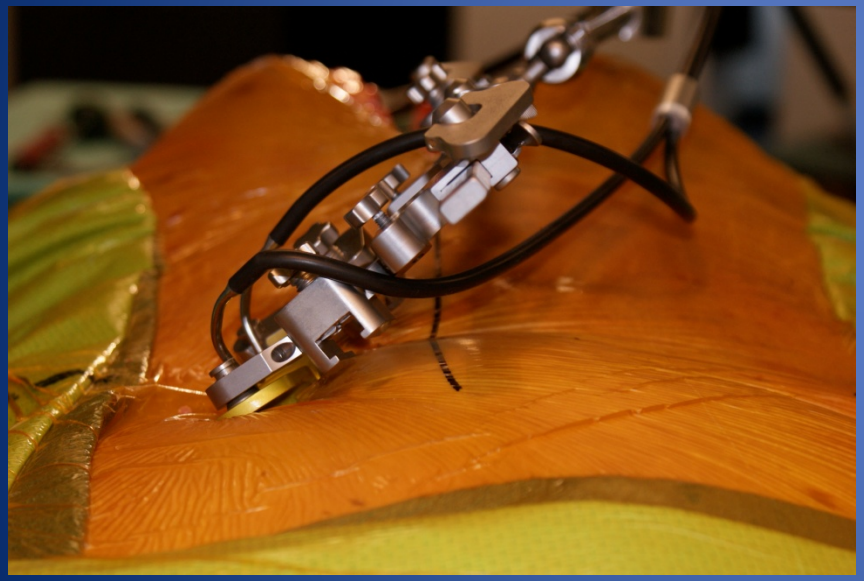
The MIS Mantra

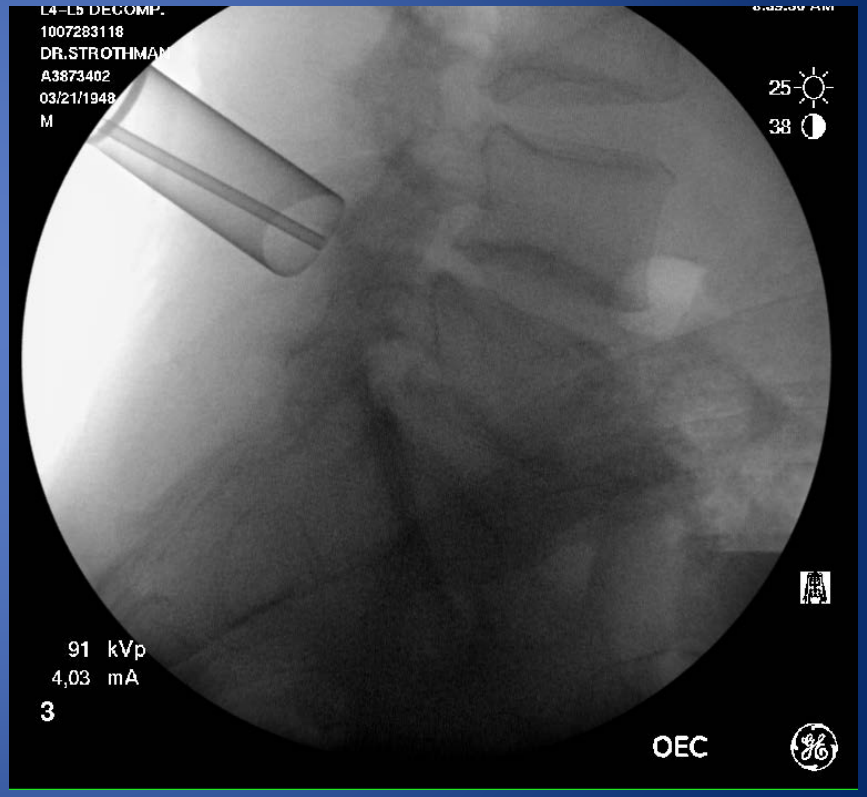
- Peform the same surgery as you would perform open!
  - Nerve Root compression = Decompress the nerve root
  - Instability / DDD = Achieve a solid fusion

SURGICAL CORRIDOR

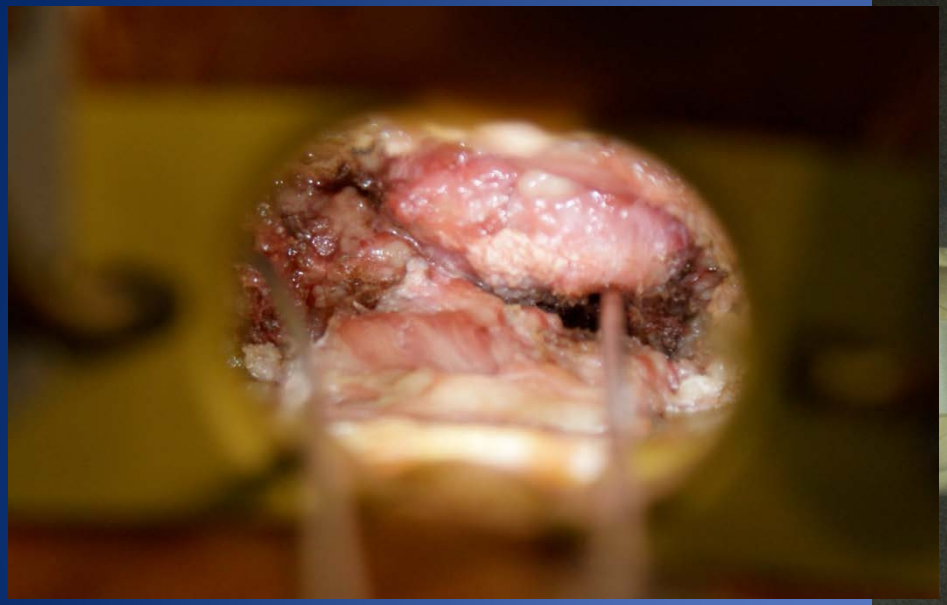


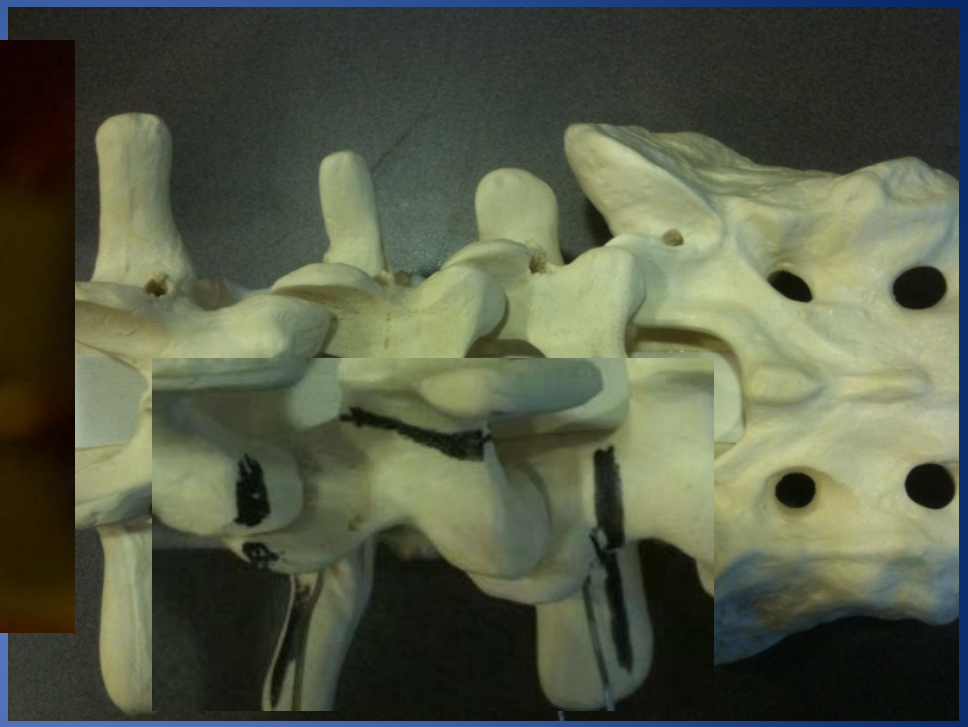
Tubular Retractors





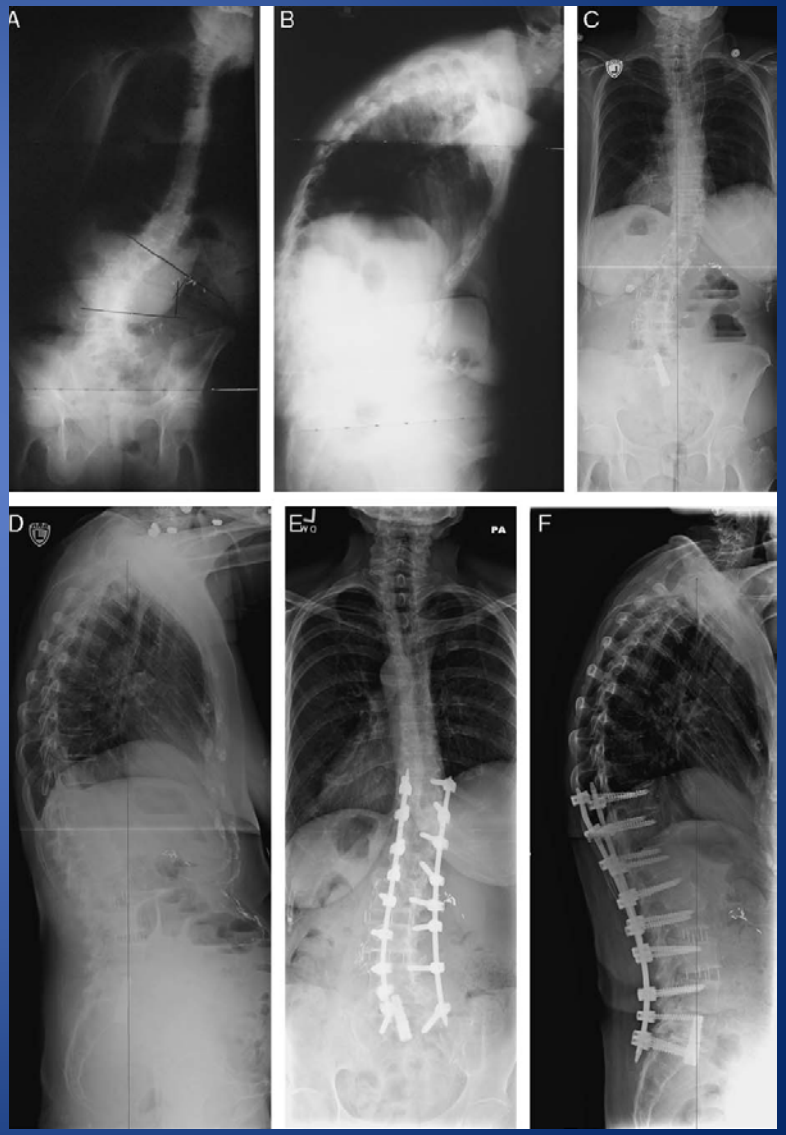
Tubular Retractor Expansion





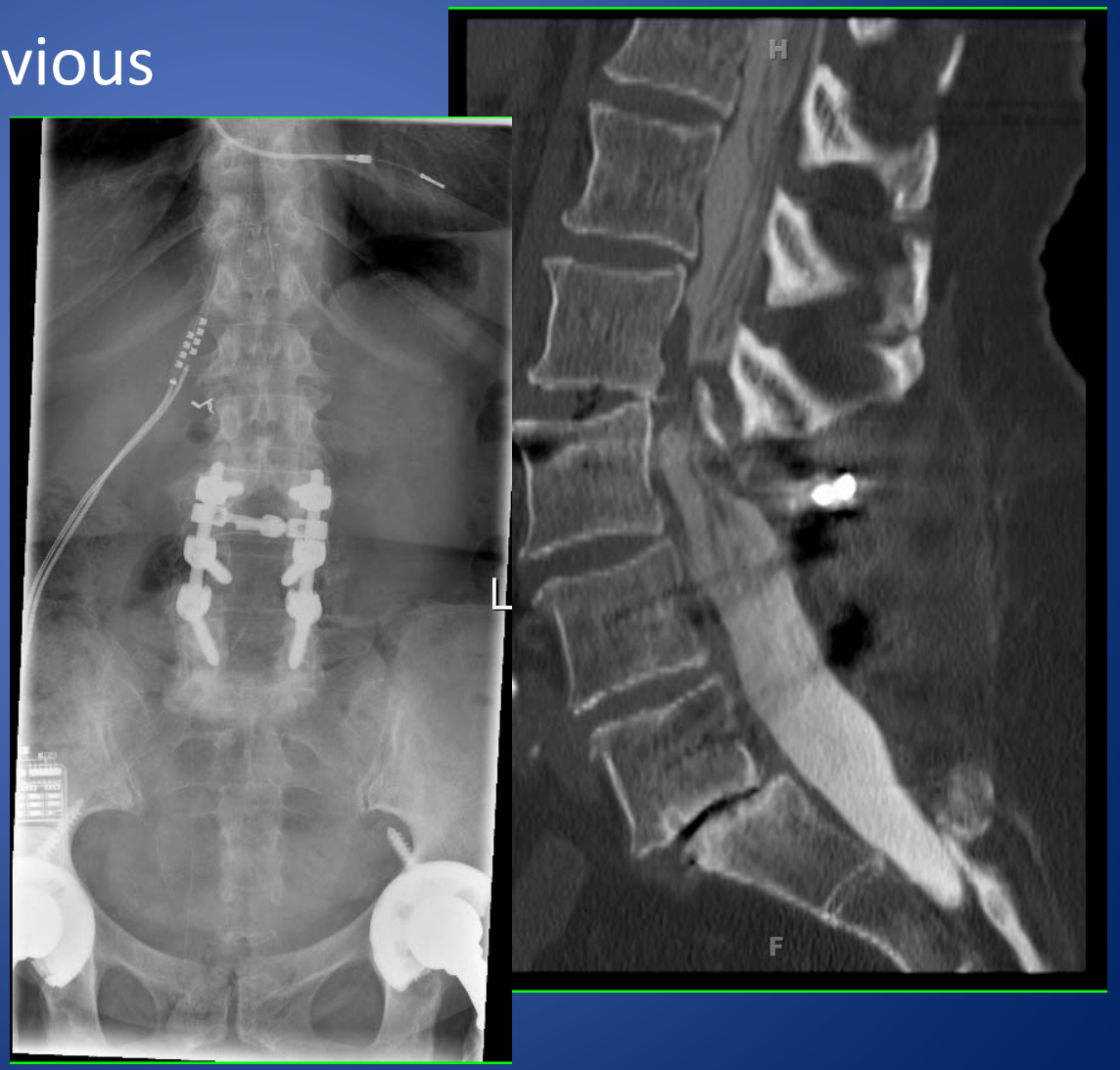
Indications

- Spinal Stenosis
- Herniated Disc
- Degenerative Spondylolysthesis
- Isthmic Spondylolysthesis
- Degenerative Disc Disease
- Trauma
- Scoliosis?



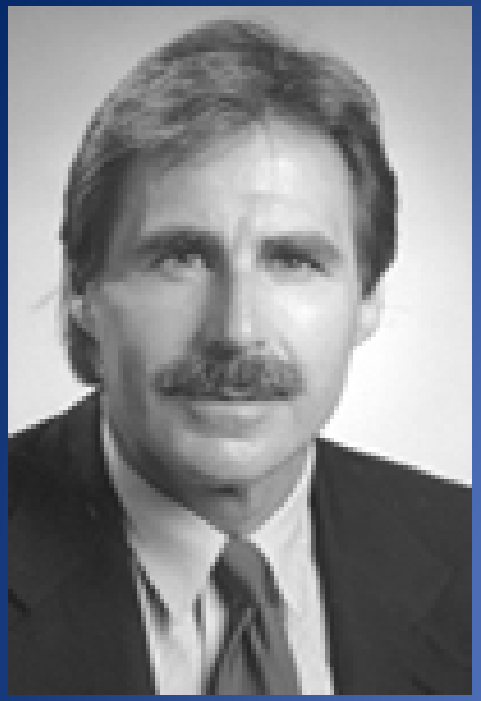
Contraindications

- Extension of previous instrumentation
- Morbid obesity



INDICATIONS

Degenerative Spondylolysthesis
The Role for Minimally Invasive Decompression



The Gold Standard?

DECOMPRESSION AND FUSION FOR DEGENERATIVE SPONDYLOLYSTHESIS

Degenerative Lumbar Spondylolisthesis with Spinal Stenosis

A Prospective Study Comparing Decompression with Decompression and Intertransverse Process Arthrodesis*†

By Harry N. Herkowitz, M.D.‡, and Lawrence T. Kurz, M.D.‡, Royal Oak, Michigan

From the Section of Spine Surgery, Department of Orthopaedic Surgery, William Beaumont Hospital, Royal Oak

TABLE I

Data on the Fifty Patients

	Arthrodesis (N = 25)		No Arthrodesis (N = 25)	
	Preop.	Postop.	Preop.	Postop.
Result				
Excellent	96%	11 (44%)	44%	2 (8%)
Good		13 (52%)		9 (36%)
Fair		1 (4%)		12 (48%)
Poor		0 (0%)		2 (8%)
Mean scores for pain *(points)*				
Back	3.3	1.3	2.9*	2.5†
Lower limbs	4.3	1.0	4.0*	1.7
Mean height of disc space *(mm)*	6.8	5.7	7.4	5.8
Mean olisthesis *(mm)*	4.8	5.3	5.3	7.9‡
Mean olisthesis on flexion and extension *(mm)*	2.8	0.1	3.4	5.8
Mean vertebral motion *(degrees)*	9.3	4.2	9.6	12.8‡

* The patients who had not had an arthrodesis had significantly more pain in the low back and lower limbs at the most recent follow-up evaluation.

† $P < 0.01$ (chi-square test).

‡ $P = 0.002$ (Student t test).

- 50 pts assigned alternatively to laminectomy and laminectomy + intertransverse process arthrodesis
- Mean f/u 3 years (2.4-4 yrs)

Pseudarthrosis = 36%

- All with good or excellent result

JBJS 1991

Spine:Volume 22(24)15 December 1997pp 2807-2812

1997 Volvo Award Winner in Clinical Studies: Degenerative Lumbar Spondylolisthesis With Spinal Stenosis: A Prospective, Randomized Study Comparing Decompressive Laminectomy and Arthrodesis With and Without Spinal Instrumentation

[Clinical Studies]

Fischgrund, Jeffrey S. MD*; Mackay, Michael MD*; Herkowitz, Harry N. MD*; Brower, Richard MD; Montgomery, David M. MD*; Kurz, Lawrence T. MD*

- PRCT, 68 pts
- Instrumented vs noninstrumented fusion
- Mean f/u: 28mo (2-3 yrs)

	Successful Arthrodesis	Pseudarthrosis
Instrumentation	29 (83%)	6 (18%)
No instrumentation	15 (45%)	18 (55%)

	Instrumentation (N = 35)		No Instrumentation (N = 33)	
	Preoperative	Postoperative	Preoperative	Postoperative
Result				
Excellent		20 (57%)		16 (49%)
Good		7 (21%)		12 (36%)
Fair		4 (12%)		1 (3%)
Poor		4 (12%)		4 (12%)
Mean scores for pain (points)				
Back	4	1	4	2
Lower limbs	4	1	4	1
Mean olisthesis (mm)	8	6	7	7
Mean sagittal motion on flexion and extension (mm)	3	1	3	2
Mean angulation (°)	9	1	9	5

Degenerative Lumbar Spondylolisthesis With Spinal Stenosis

A Prospective Long-Term Study Comparing Fusion and Pseudarthrosis

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

SPINE Volume 29, Number 7, pp 726–734
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Fusion (22pts)

- Excellent/Good: **86%**
- Back pain (5 pt scale)
  - Preop 3.7 to 1.4 postop
- Leg pain (5pt scale)
  - Preop 4.5 to 0.5 postop

Pseudarthrosis (25 pts)

- Excellent/Good: 56%
- Back pain (5 pt scale)
  - Preop 3.5 to 2.6 postop
- Leg pain (5pt scale)
  - Preop 4.2 to 2.1 postop

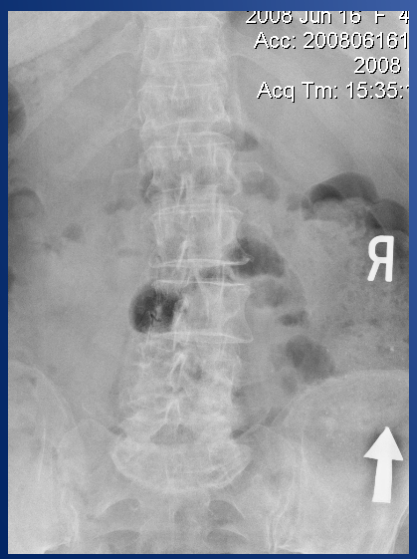
Mean Follow up: 7yrs 8months (5-14 yrs)

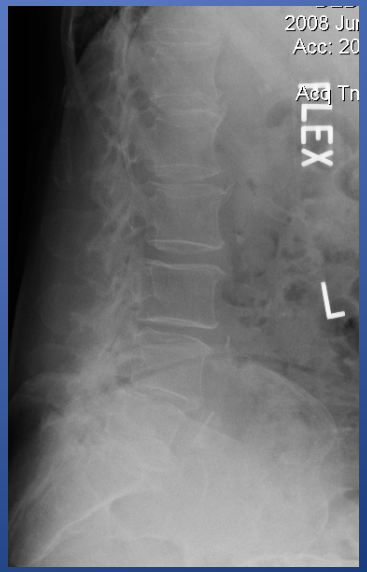
Spondylolysthesis

STABLE VS UNSTABLE

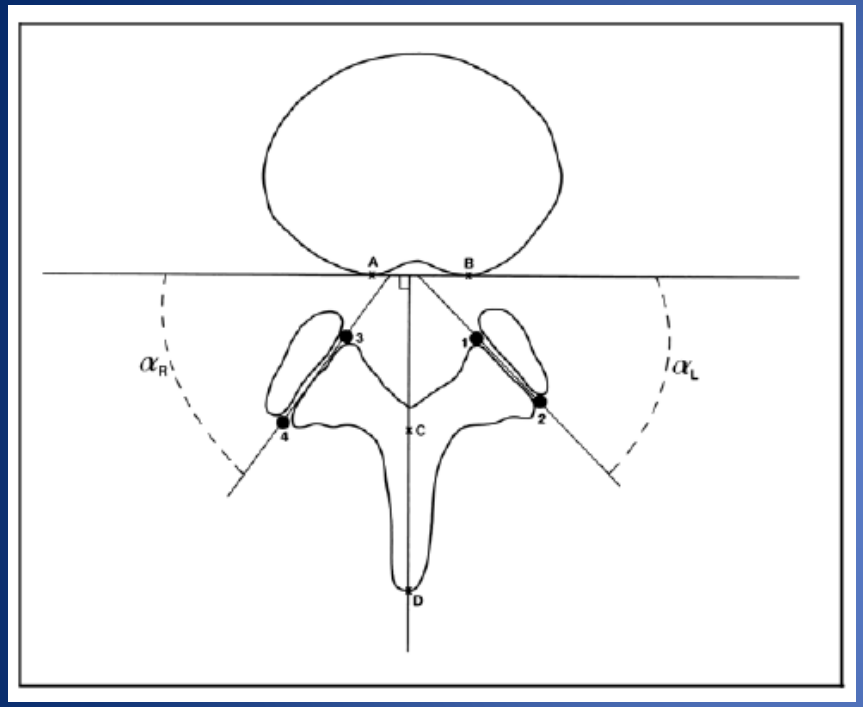
Stable vs Unstable

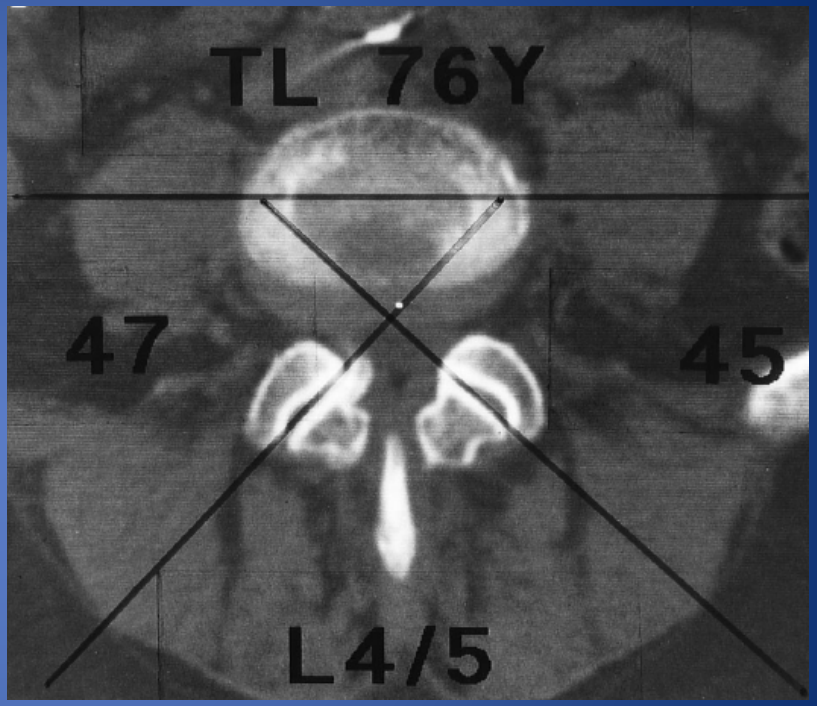
- Stable Degnerative Spondylolisthetic Segment:
  - Flex/Ext slip change <4mm (Ha et al. JSDT 2008)
  - Slip angle <10deg (Ha et al. JSDT 2008)
- Unstable Degenerative Spondylolisthetic Segment:
  - Flex/Ext slip change >4mm (Ha et al. JSDT 2008)
  - Slip angle > 10 deg (Ha et al. JSDT 2008)





Facet Orientation



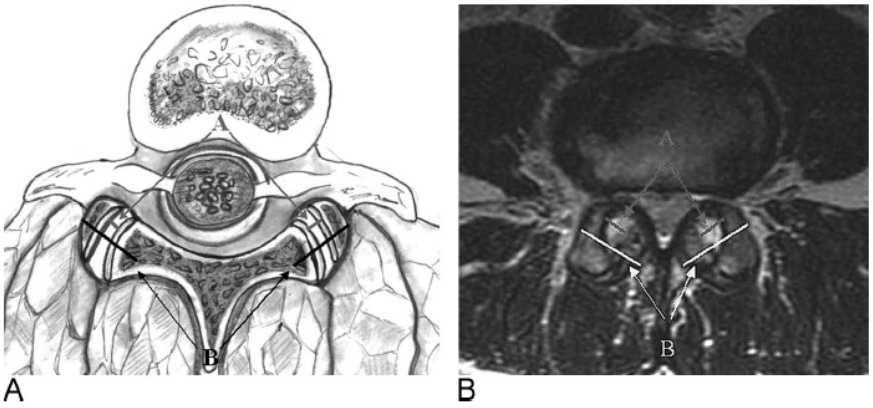


If facet angle >45 deg bilaterally then 25x more likely to have Degnerative Spondylolisthesis

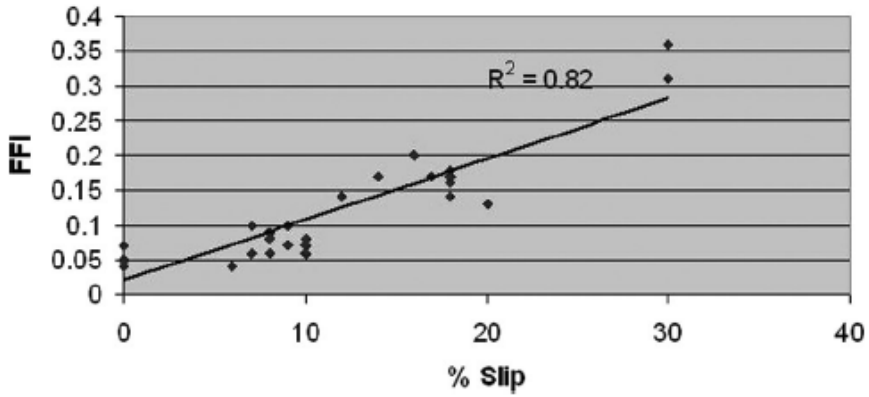
Boden et al. JBJS 1996

Does Lumbar Facet Fluid Detected on Magnetic Resonance Imaging Correlate With Radiographic Instability in Patients With Degenerative Lumbar Disease?

Jeffrey A. Rihn, MD,* Joon Y. Lee, MD,* Mustafa Khan, MD,* James A. Ulibarri, MD,* Chadi Tannoury, MD,† William F. Donaldson, III, MD,* and James D. Kang, MD*



0.12% and 11.1%, respectively. There was a positive linear association between these values (Pearson correlation coefficient of 0.90, $P < 0.001$). The positive predictive value of L4–L5 facet fluid on MRI as an indicator of radiographic instability was 82%.



Conclusions. There is a close linear association between the facet fluid index and the amount of radiographic instability at L4–L5. Facet fluid on MRI should raise high suspicion of lumbar instability.

Risk Factors for Instability

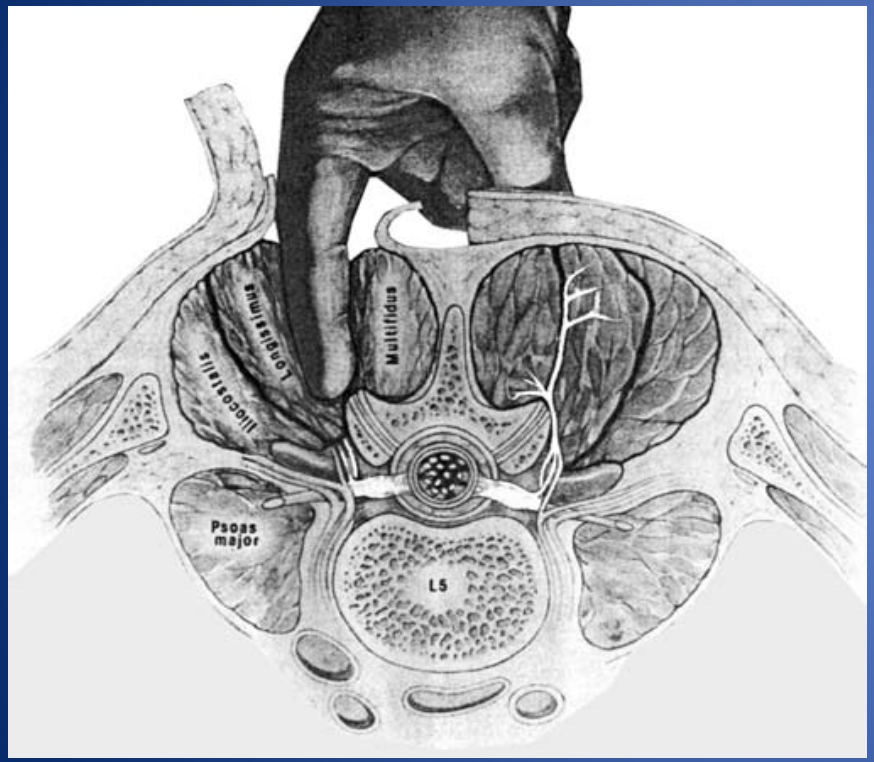
Likely Unstable

- Disc space narrowing < 50%, No osteophytes (Tall Space)
- Bilateral facet angle >45 deg
- Positive facet synovitis
  - >1mm
- Preoperative instability on flexion and extension xrays

Current Debate

ADVANTAGE MINIMALLY INVASIVE DECOMPRESSION

Minimally Invasive Lumbar Decompression



Advantages

- Less muscle damage
- Less blood loss
- Shorter hospital stay

- Possible
  - Less adjacent tissue damage

SPINE Volume 34, Number 1, pp 17–23
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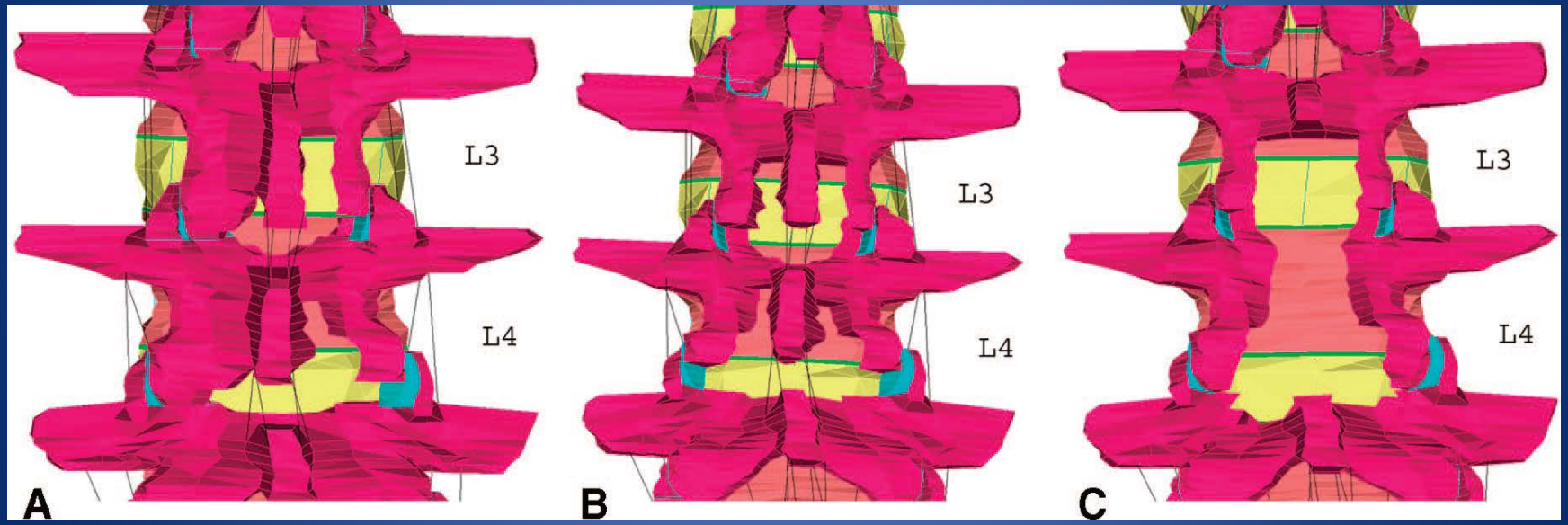
A Biomechanical Evaluation of Graded Posterior Element Removal for Treatment of Lumbar Stenosis

Comparison of a Minimally Invasive Approach With Two Standard Laminectomy Techniques

Lacey Bresnahan, MSE,*† Alfred T. Ogden, MD,* Raghu N. Natarajan, PhD,† and Richard G. Fessler, MD, PhD*



Microendoscopic decompression | Bilateral laminotomies | Open Laminectomy

4x ↑ Flex / Ext motion

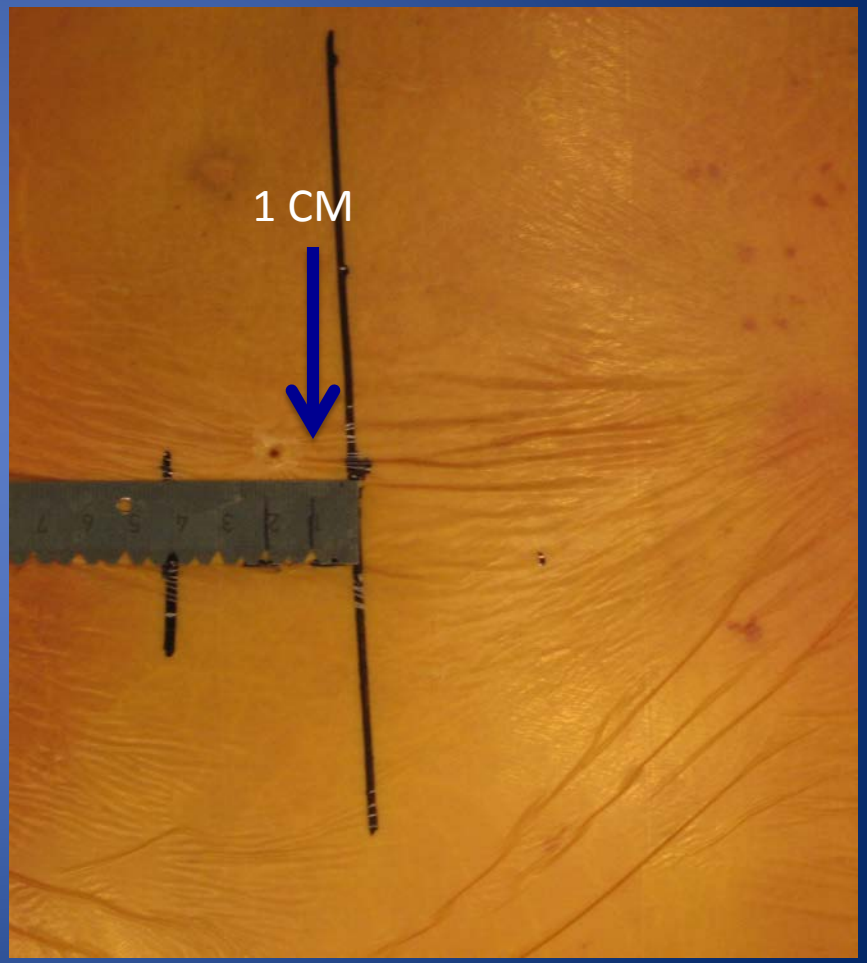
Degenerative Spondylolysthesis Summary

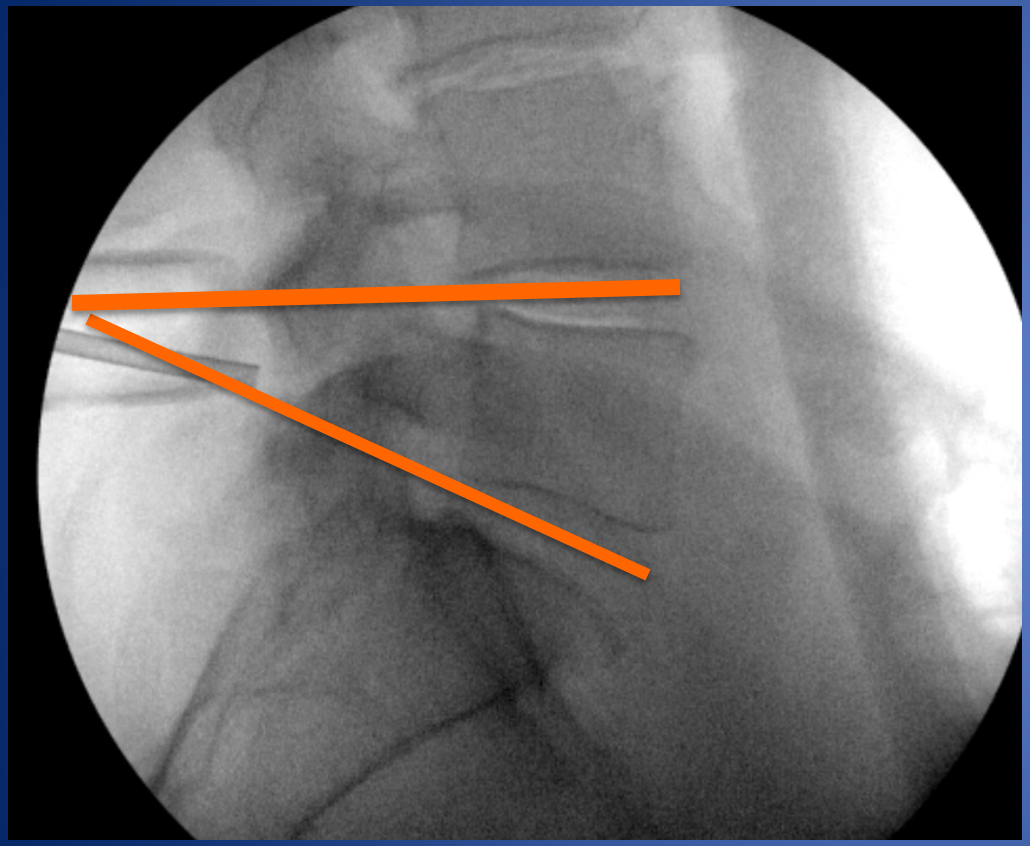
- Current Gold Standard
  - Decompression and Fusion
- Risk Factors for Instability
  - Tall disc without osteophytes
  - Facets parallel (>45 deg)
  - Facet fluid (>1mm)
  - Instability on preop flexion / extension xrays
- Stable Spondylolysthesis without risk factors
  - MIS Decompression is reasonable

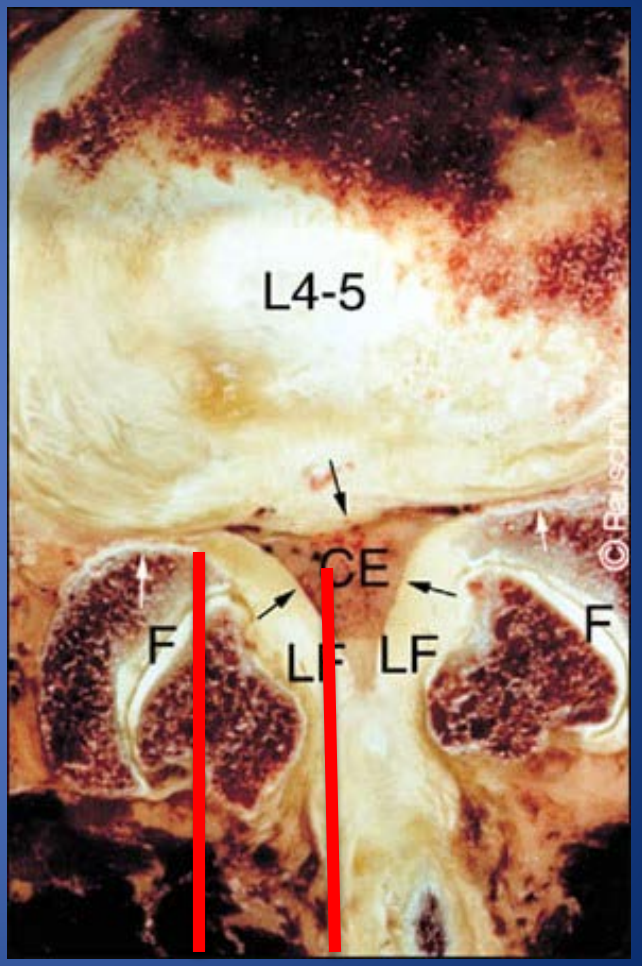
HOW TO: THE NUTS AND BOLTS

Minimally Invasive Discectomy

- Starting point 1cm lateral to midline
- Dock retractor on posterior lamina in line with the disc space
- Standard laminotomy and discectomy
- Bayonetted dural retractors are helpful
- Know where to expect the herniation by looking at the preop MRI

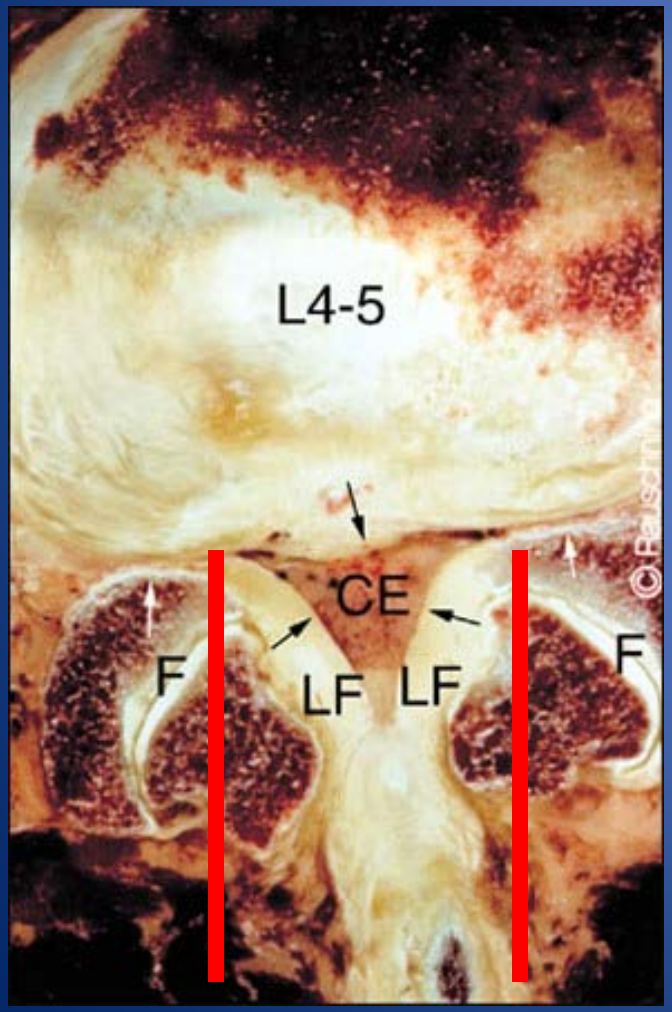




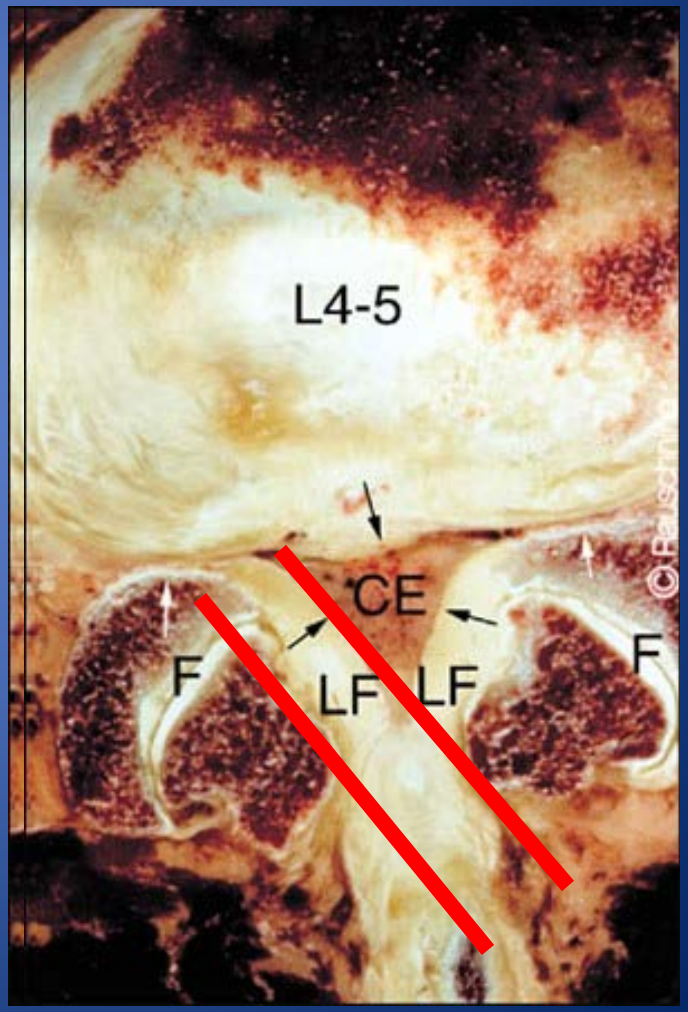

L4-5
CE
F
LF
LF
F

Surgical Decompression

OPEN

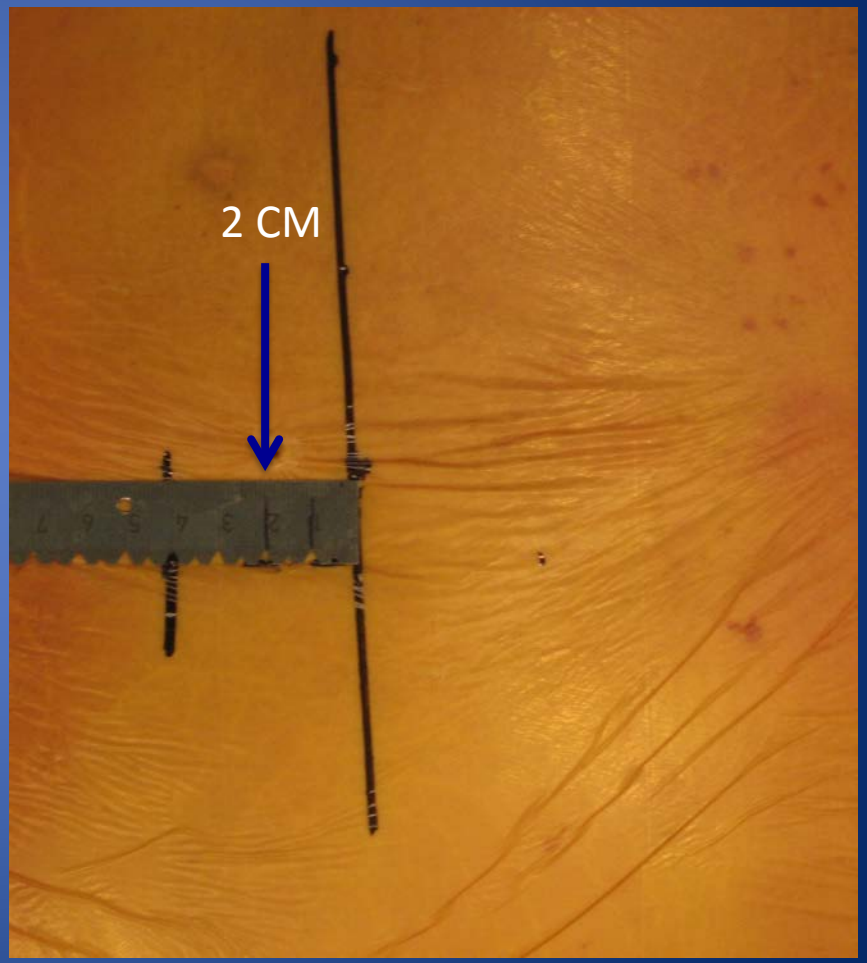


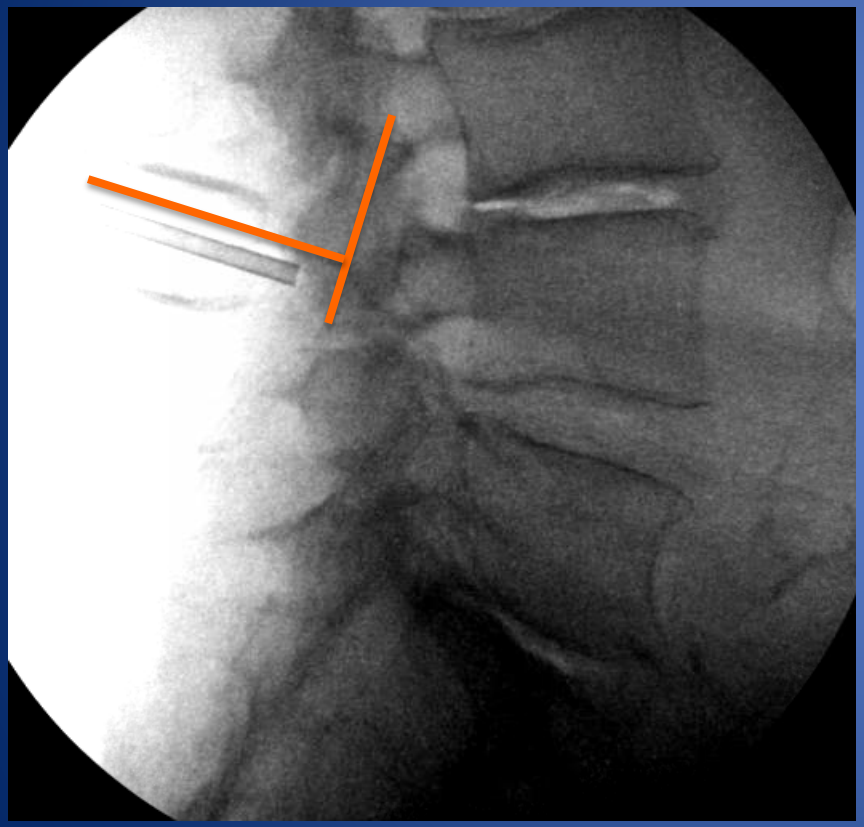
MIS

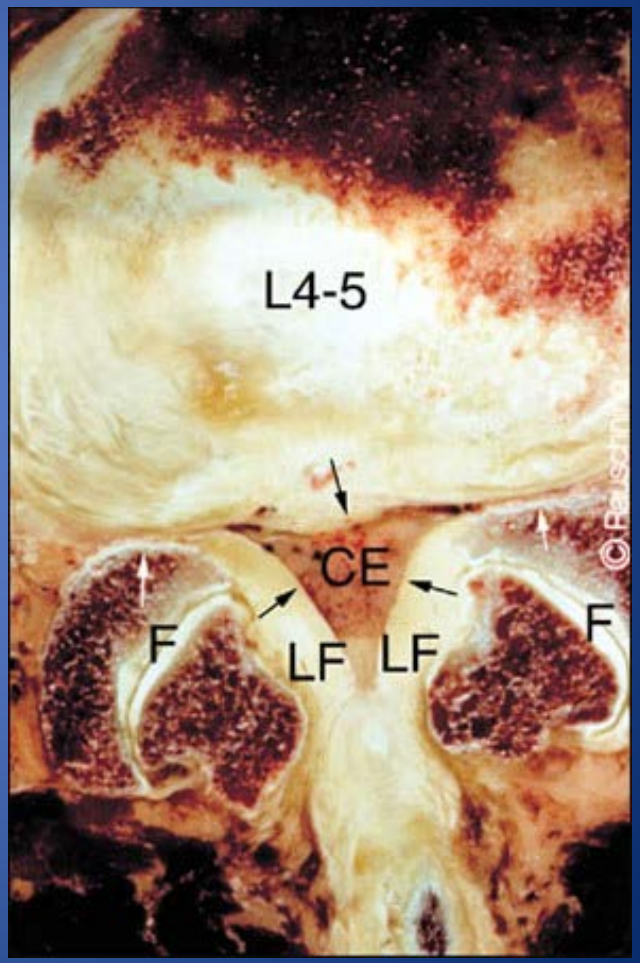


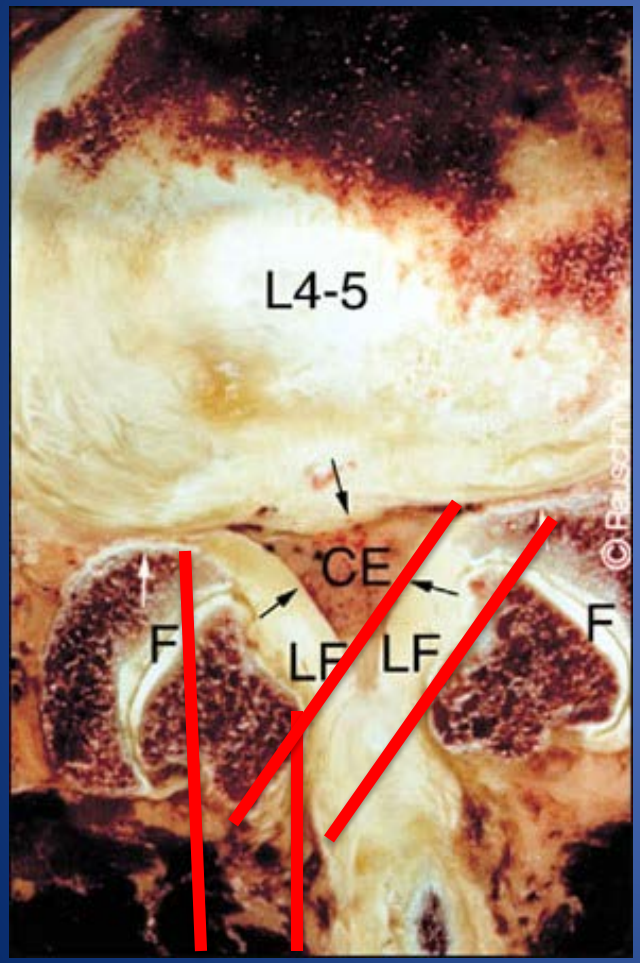
Minimally Invasive Decompression

- Start 2cm lateral to midline
- Split lumbodorsal fascia in line with incision
- Split muscle fascia slightly medial
- Dock on posterior edge of lamina perpendicular to lamina

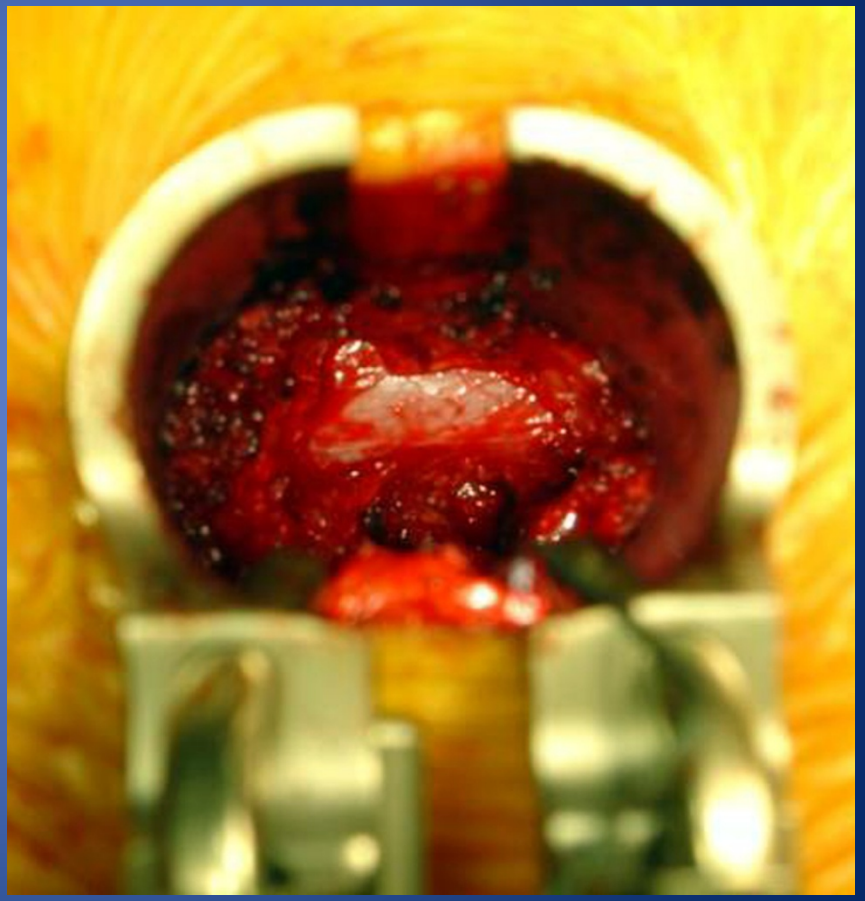





L4-5
CE
F
LF
LF
F

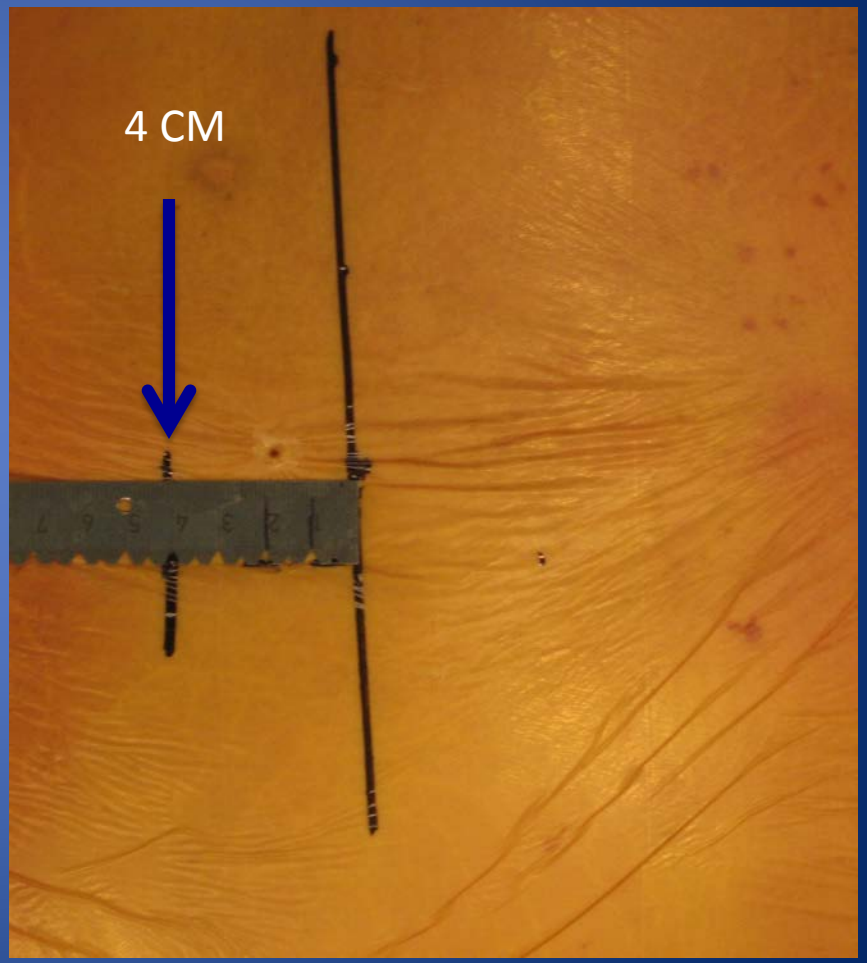

L4-5
CE
F
LF
LF
F

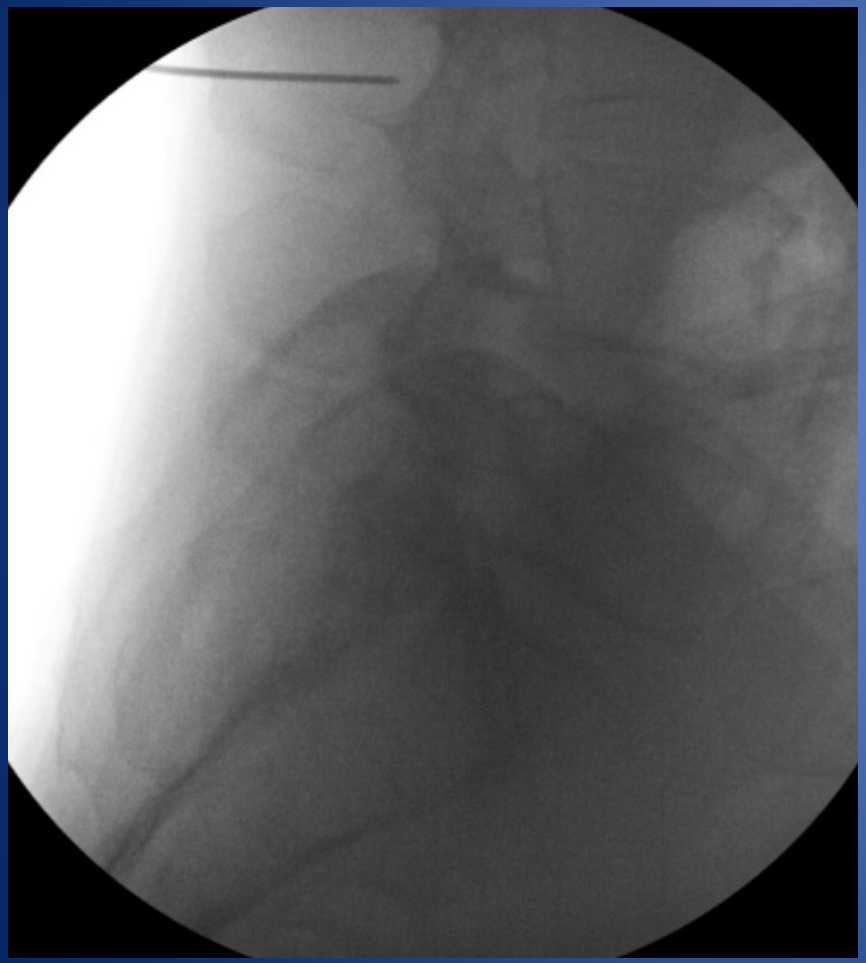
MIS Decompression

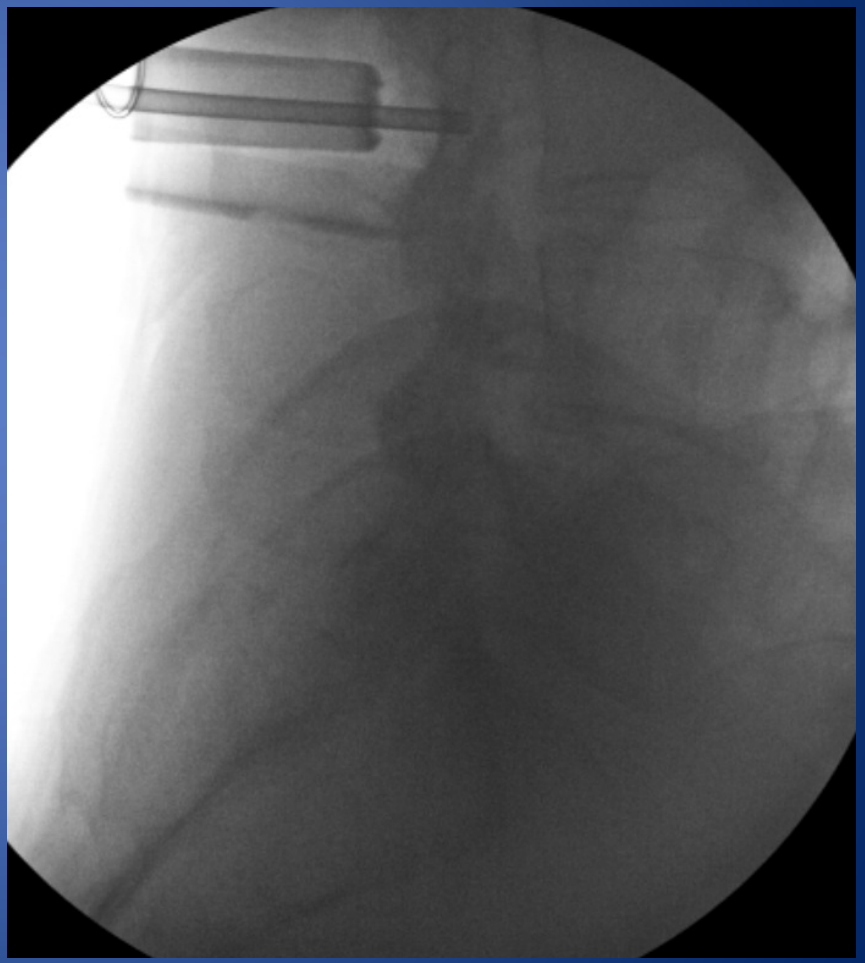


Minimally Invasive Far Lateral Discectomy

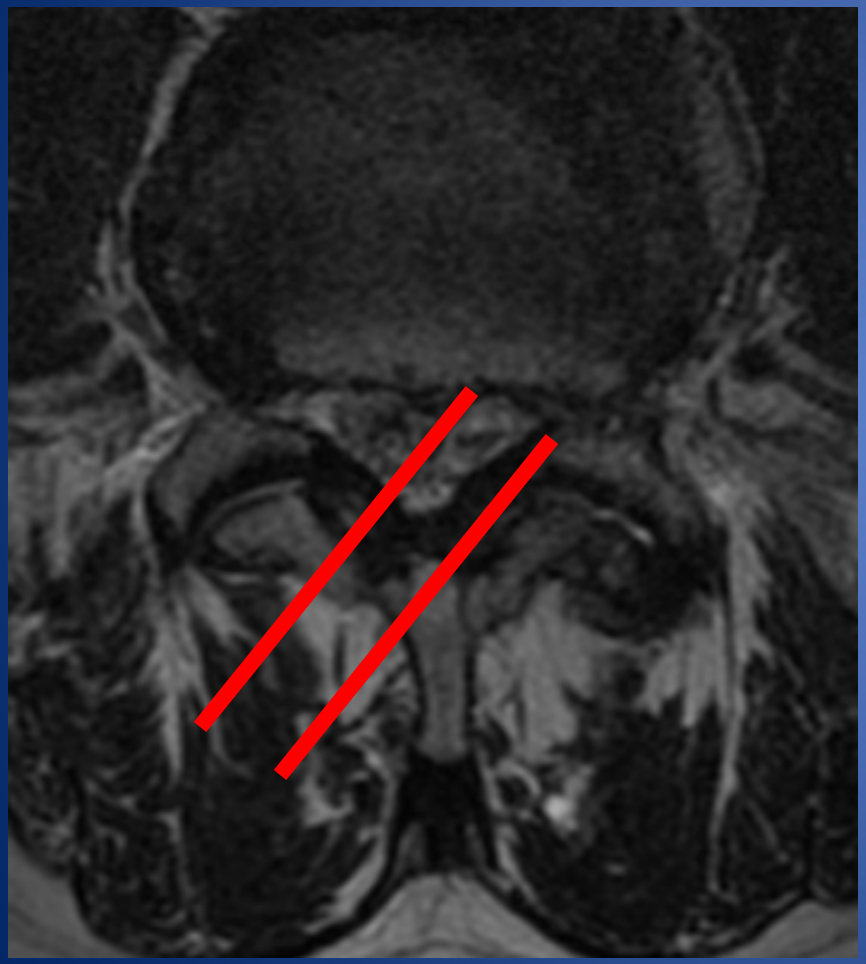
- Skin incision 4cm lateral to midline
- Offset fascial incisions
- Dock on lateral pars
- Expose pars and cephalad TP

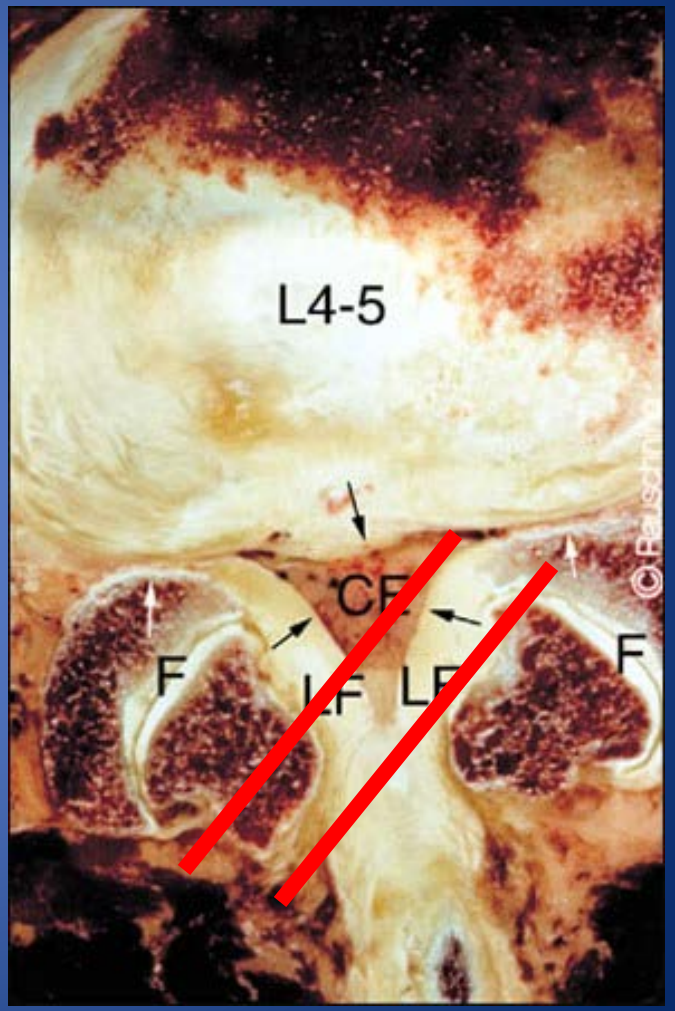






MIS Decompression: Synovial Cyst



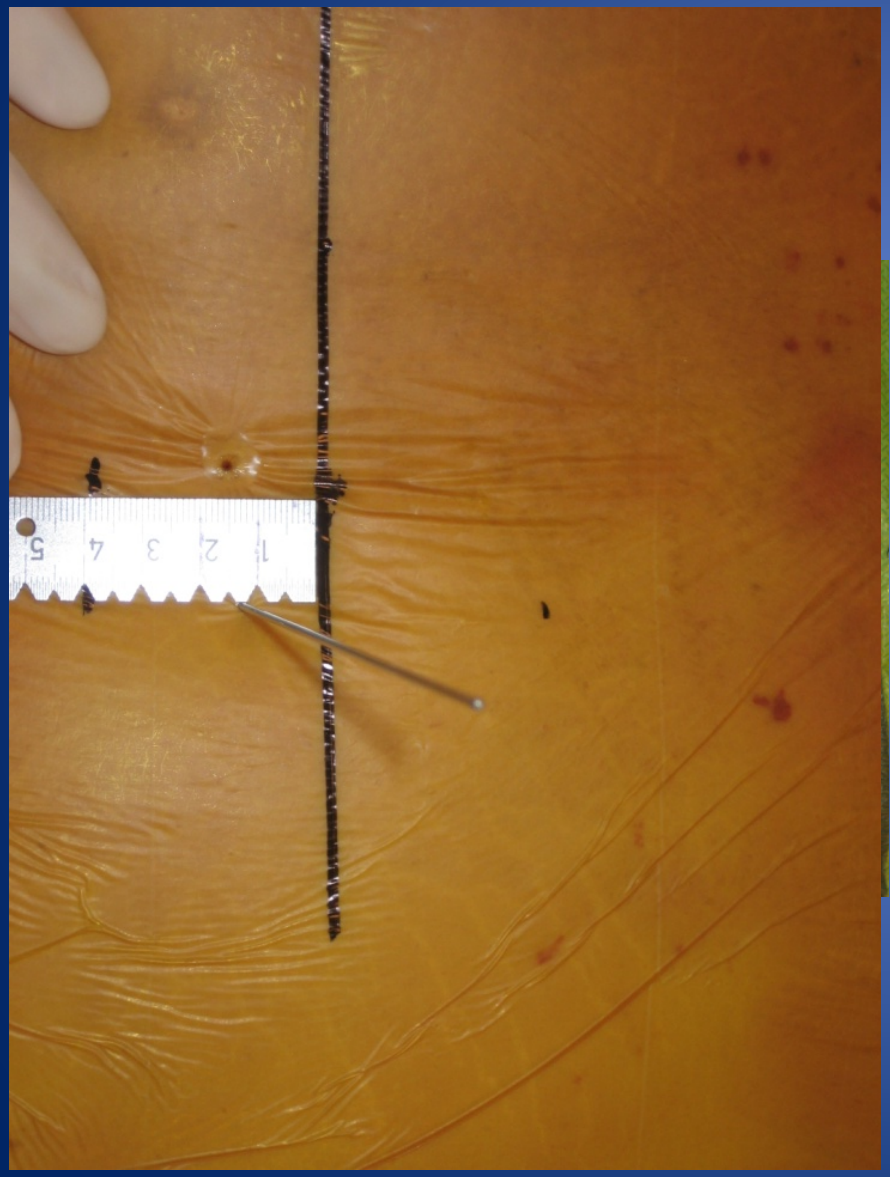


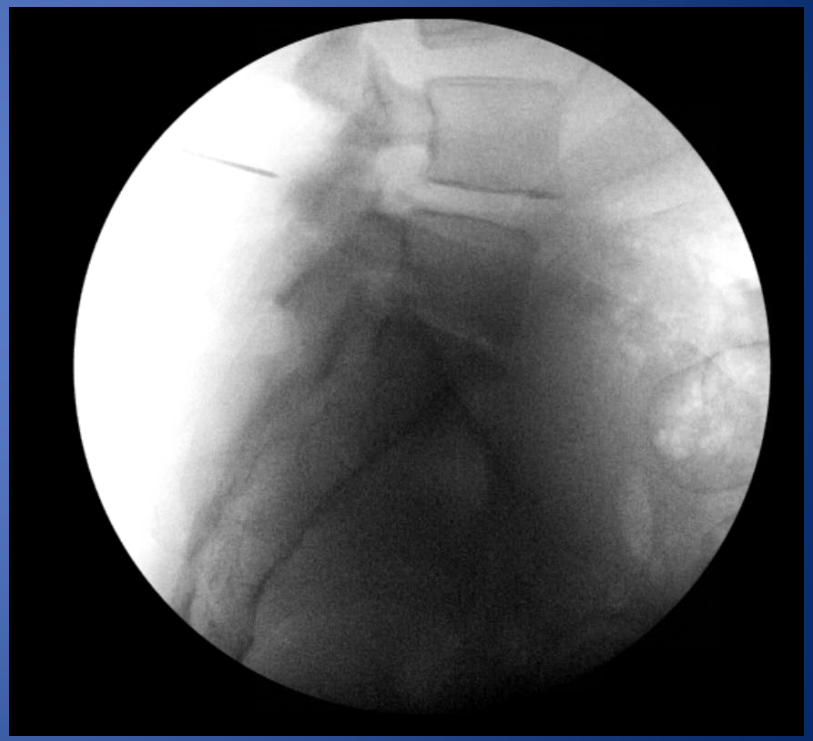
MIS TLIF

Positioning

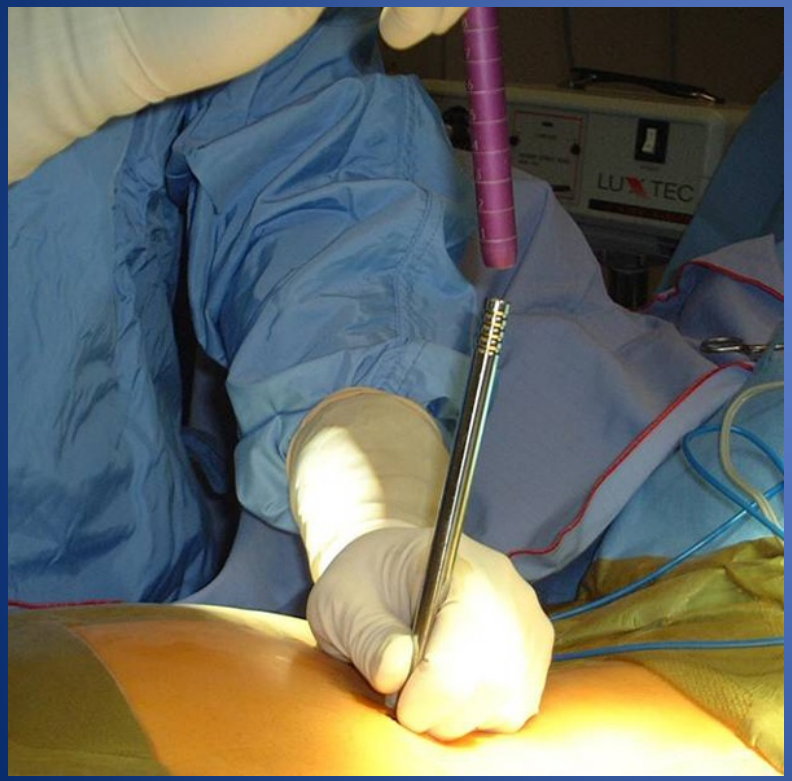
- Axis Table or Wilson Frame
- 25 deg kyphosis
- Reverse Trend (L5-S1)

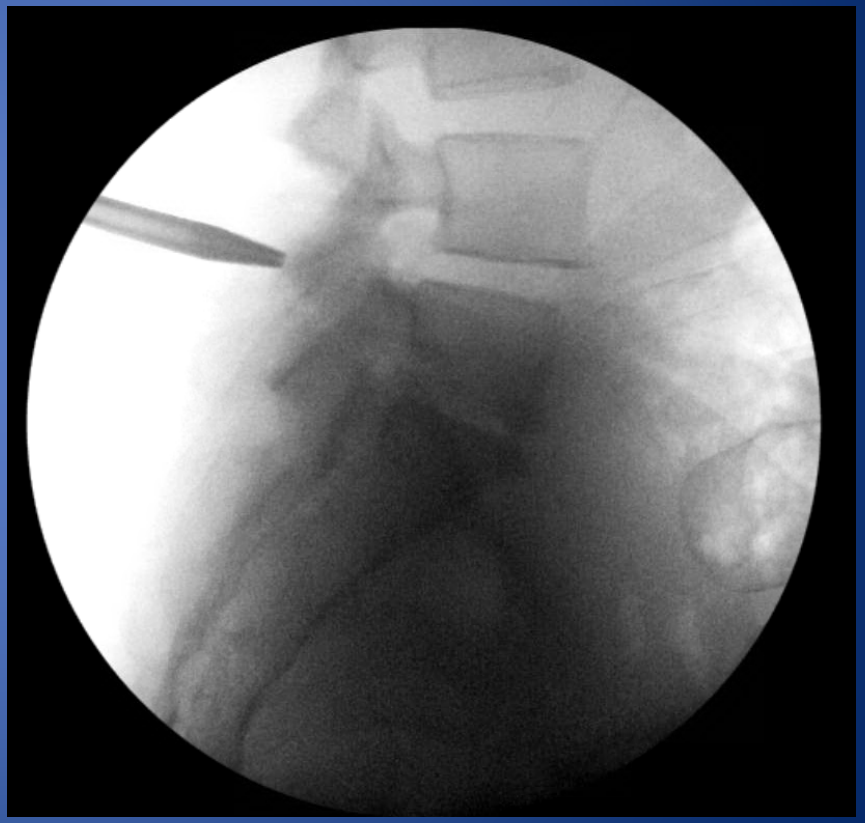
Localization





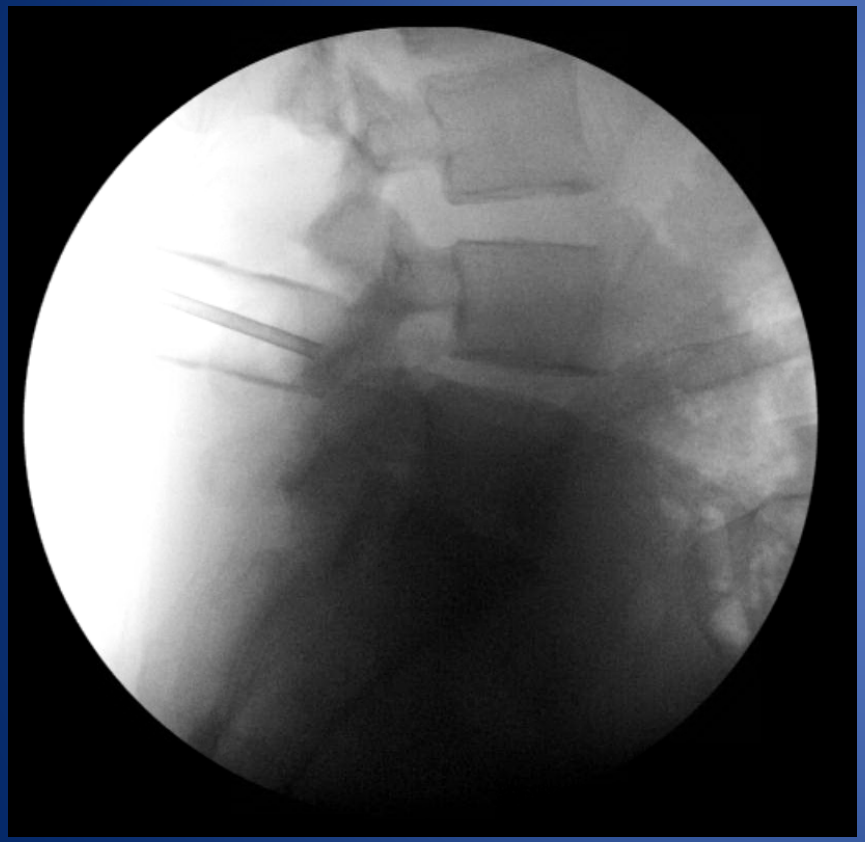
Initial Dilation



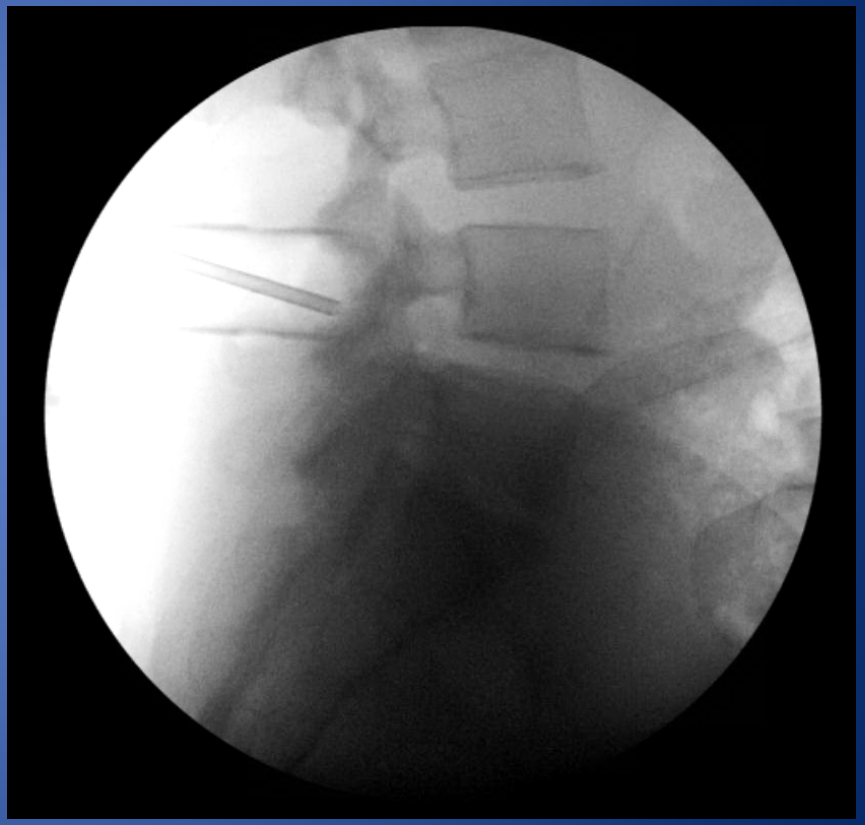


Fix retractor

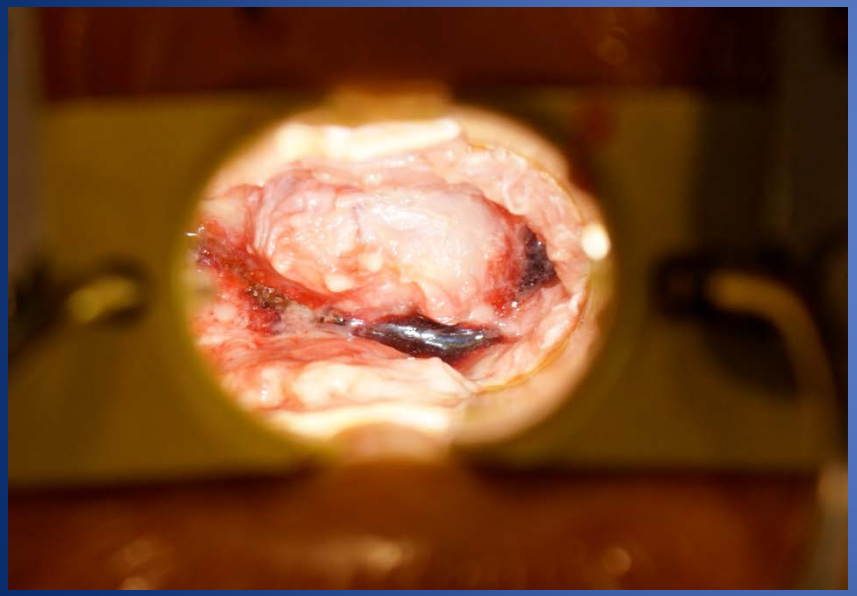
Correct



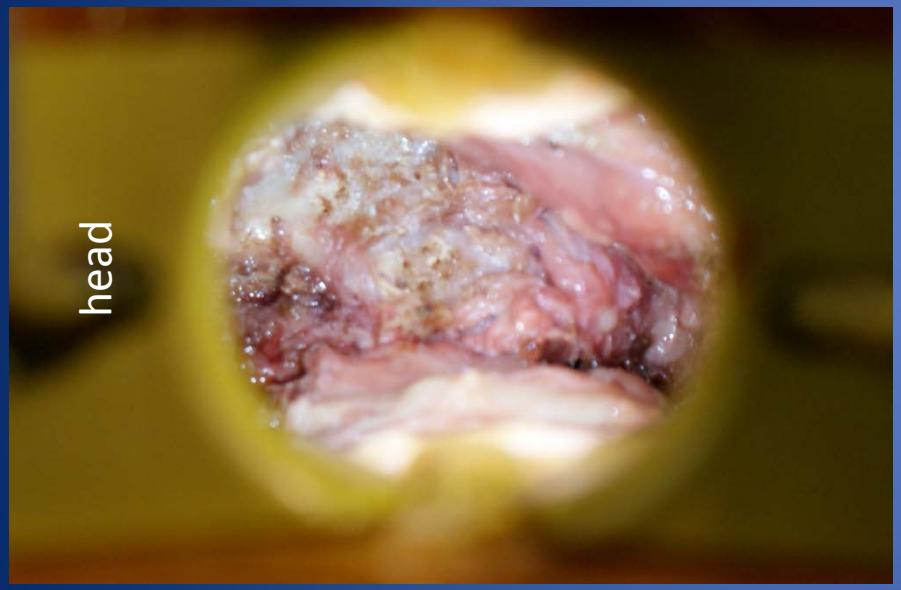
Incorrect



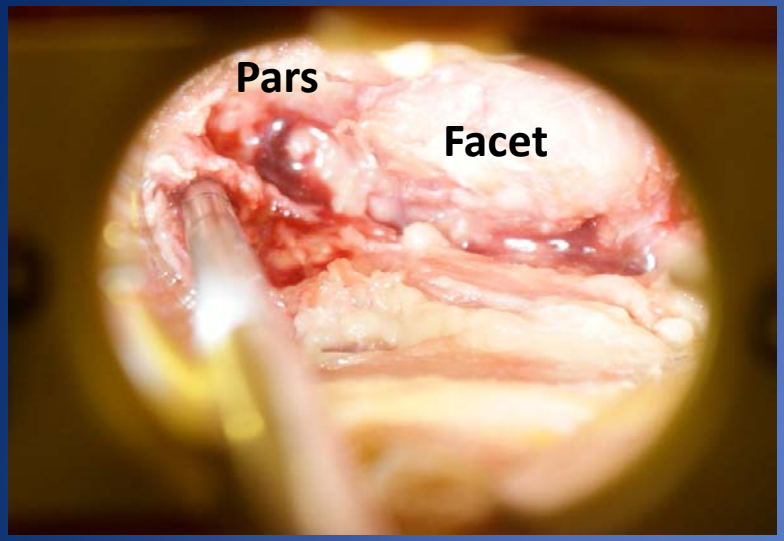
Initial view

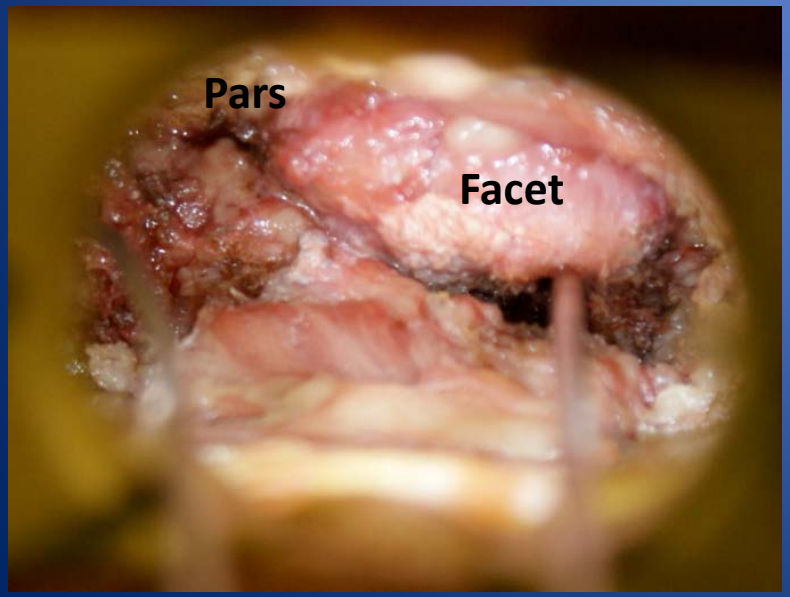


Exposure of Lamina



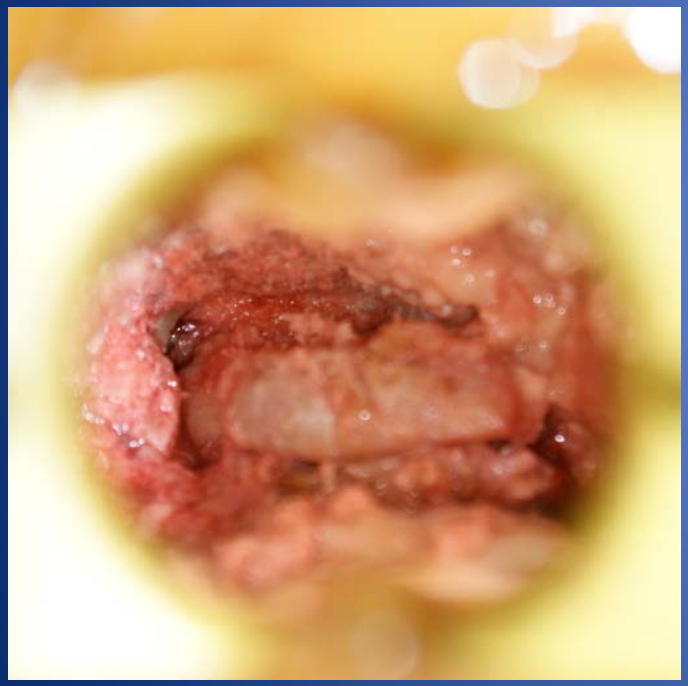
Pedicle Screw Preparation

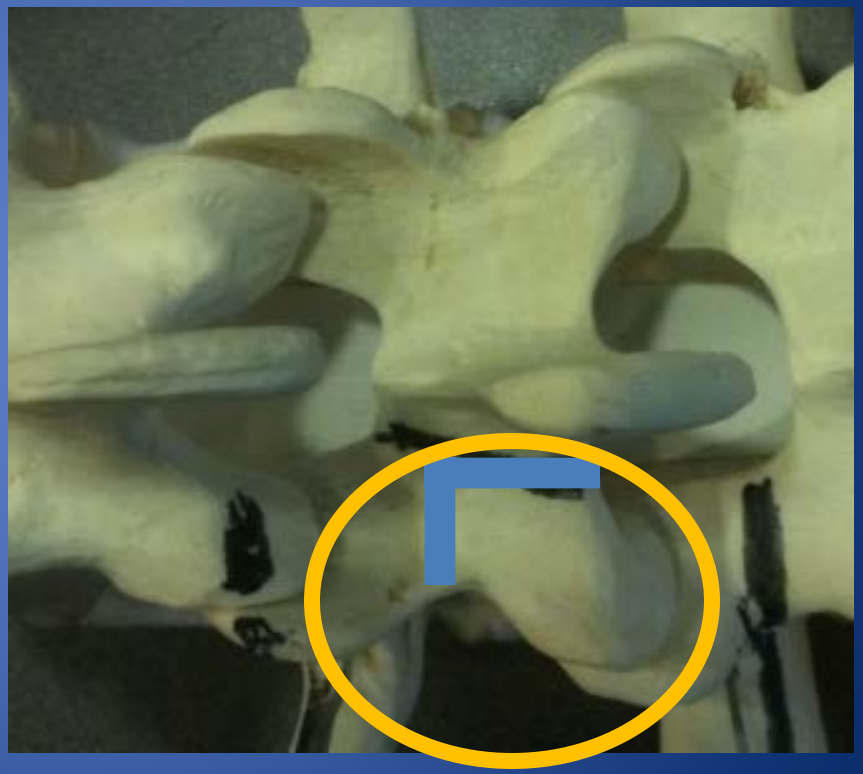




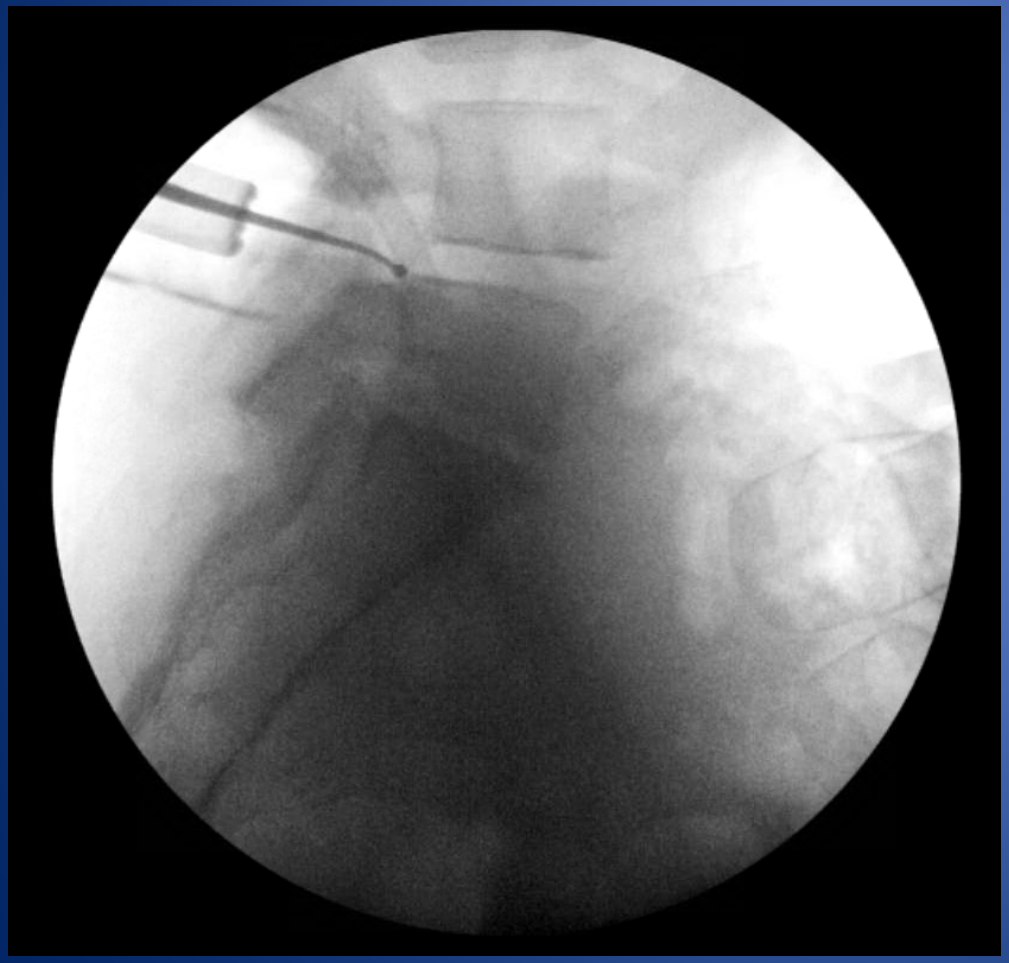
Facetectomy: Descending Articular Process

head

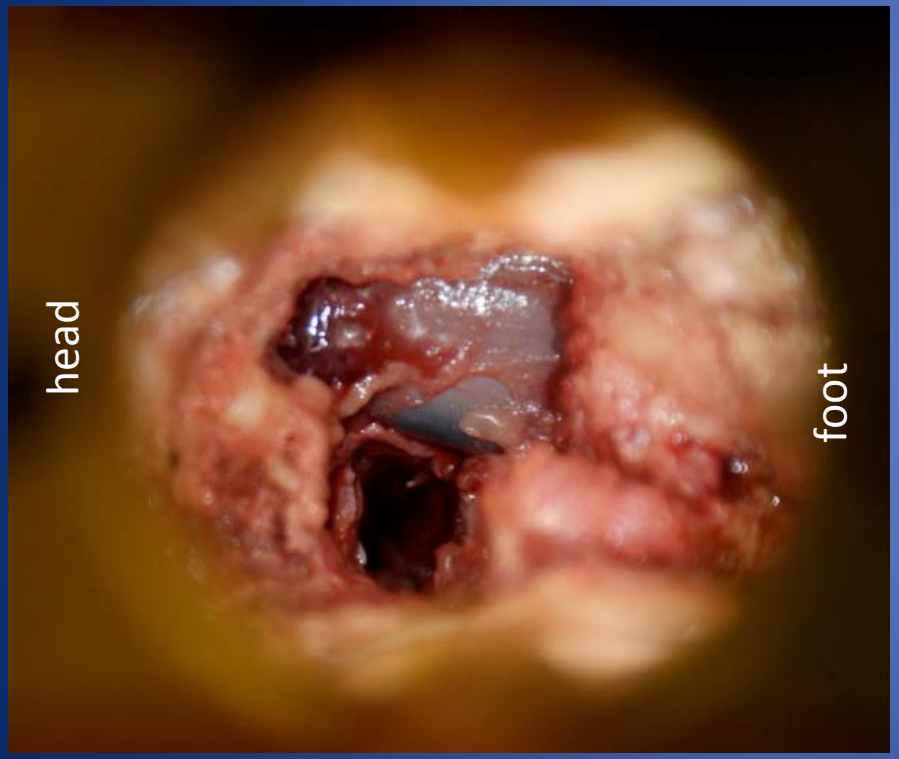


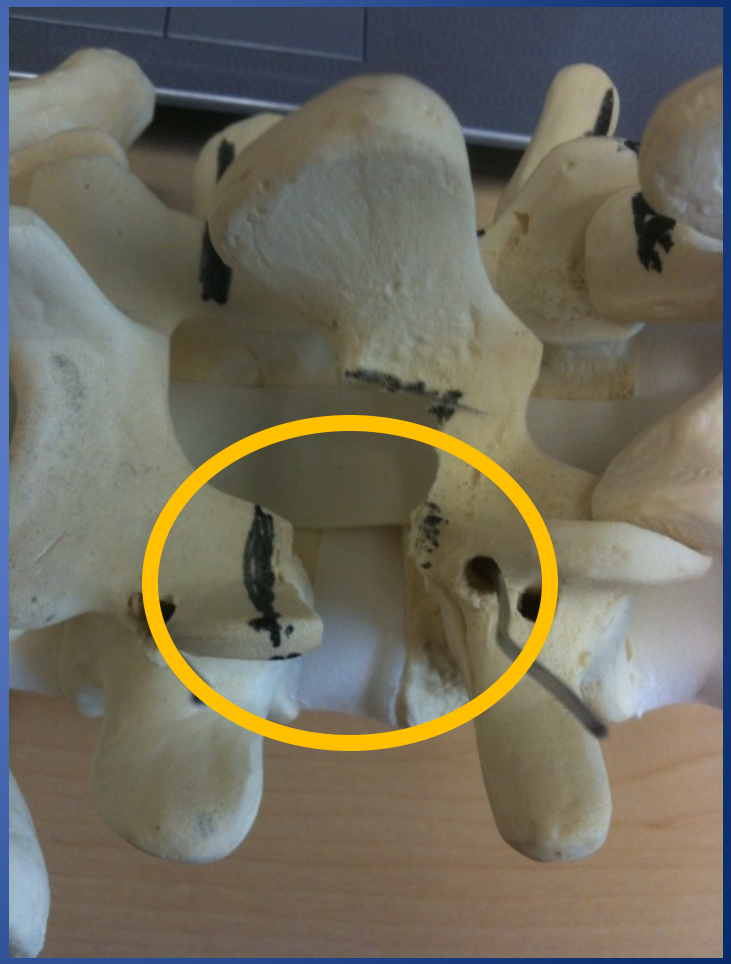


Facetectomy: Ascending Articular Process / Subarticular Decompression

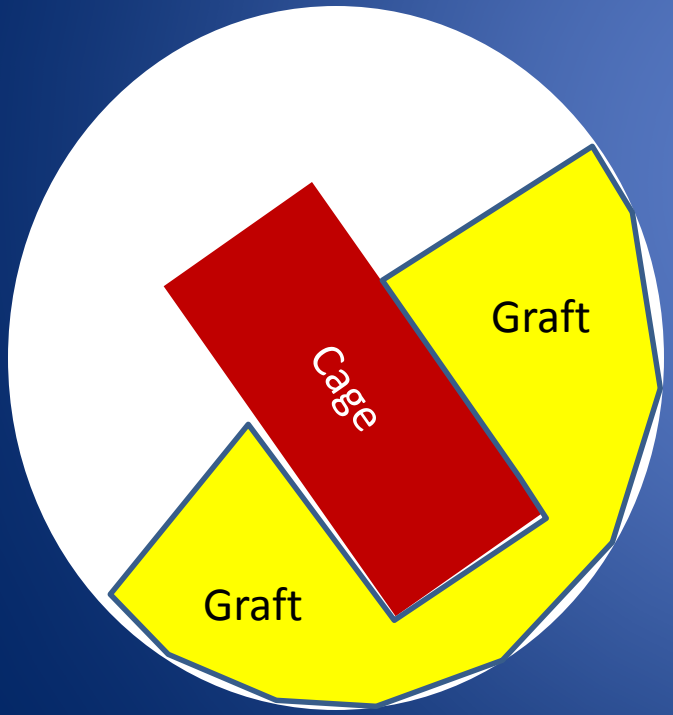


Discectomy

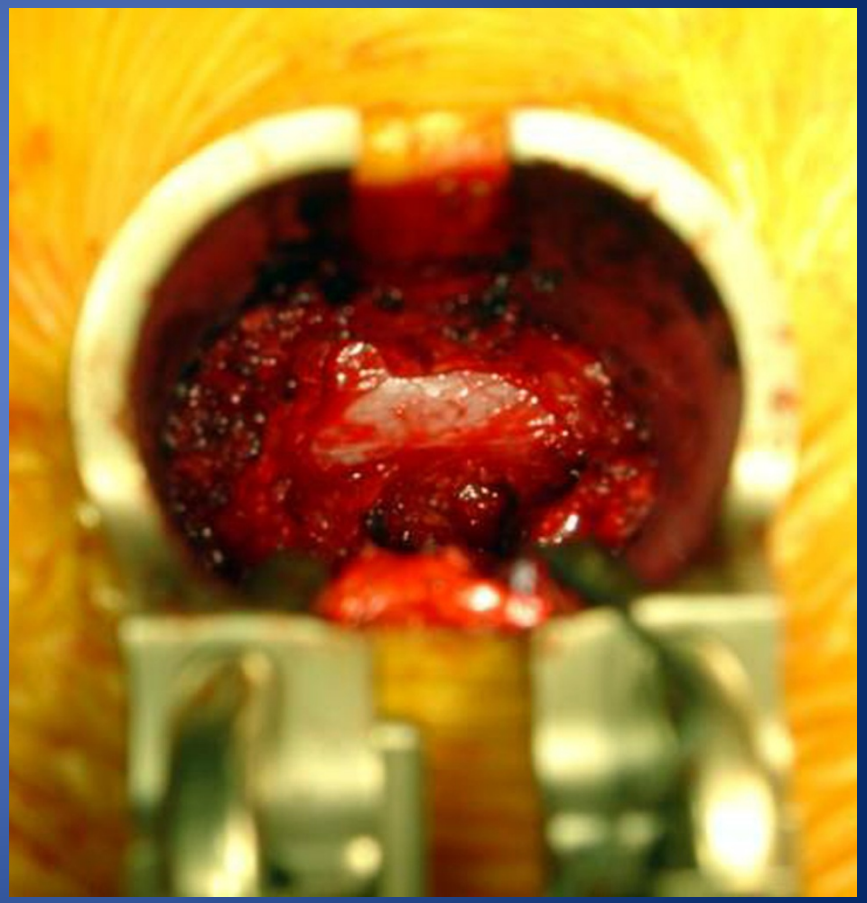




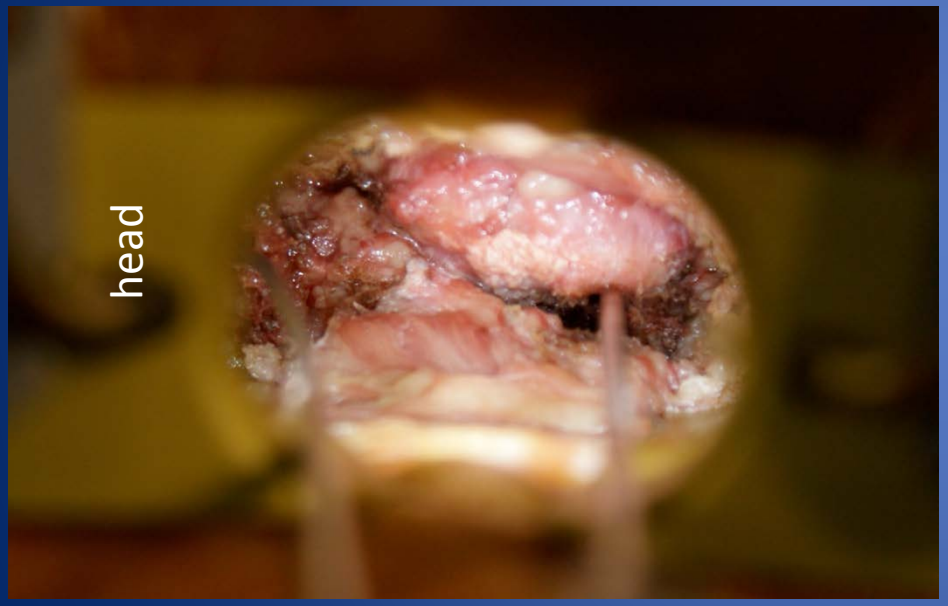
Placement of Graft / Interbody Cage



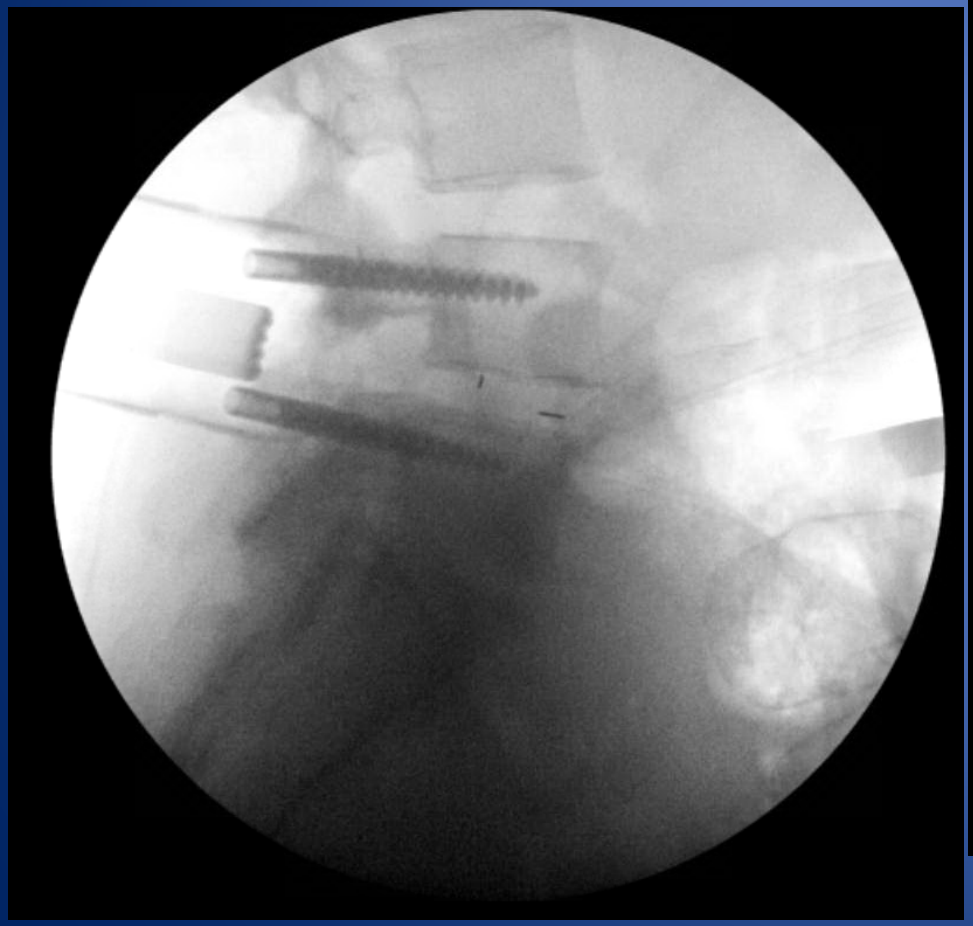
Decompression



Free Hand Pedicle Screw Placement

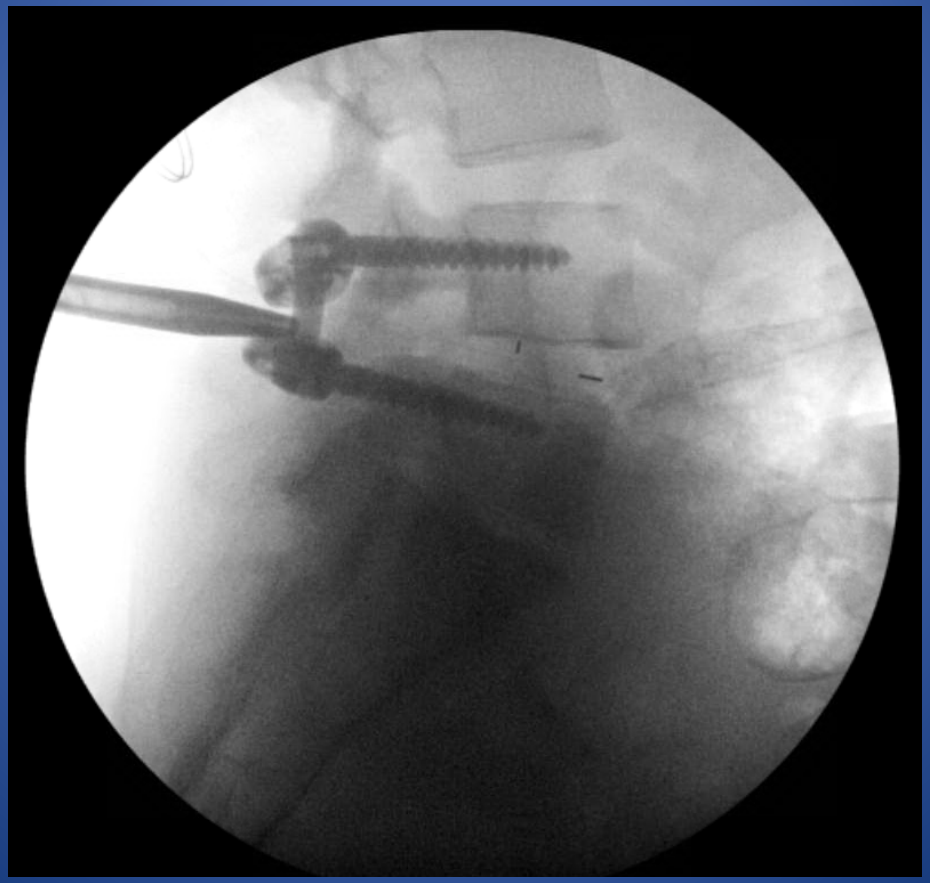


Place rods and compress
Take table out of kyphosis!

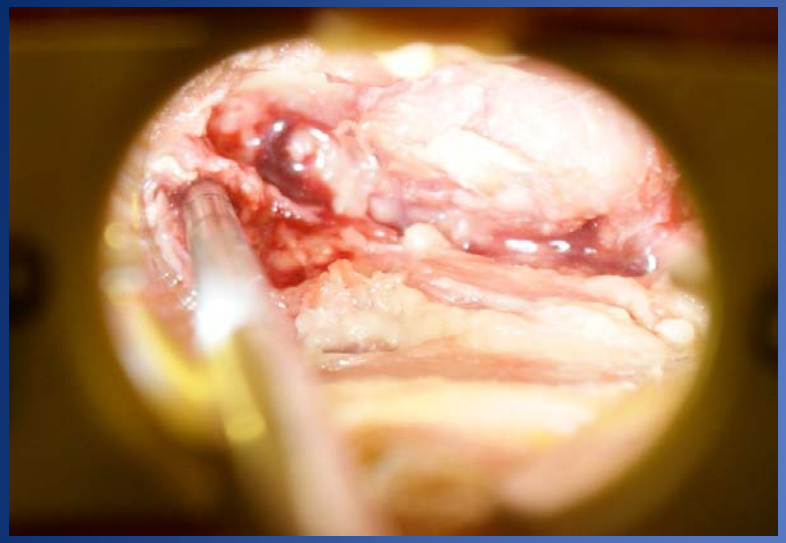


Compression

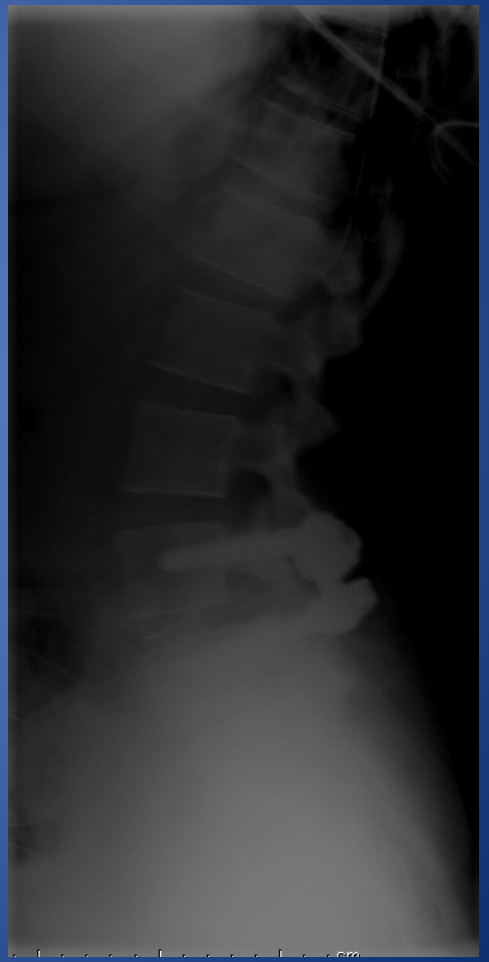
Dilate and secure retractor on contralateral side



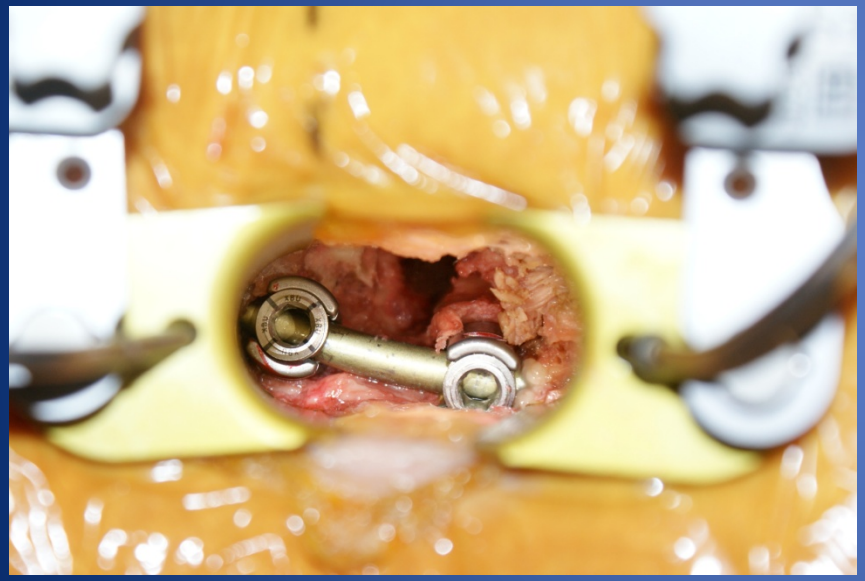
Contralateral Pedicle Screw Placement and Facet Fusion



Final Xrays



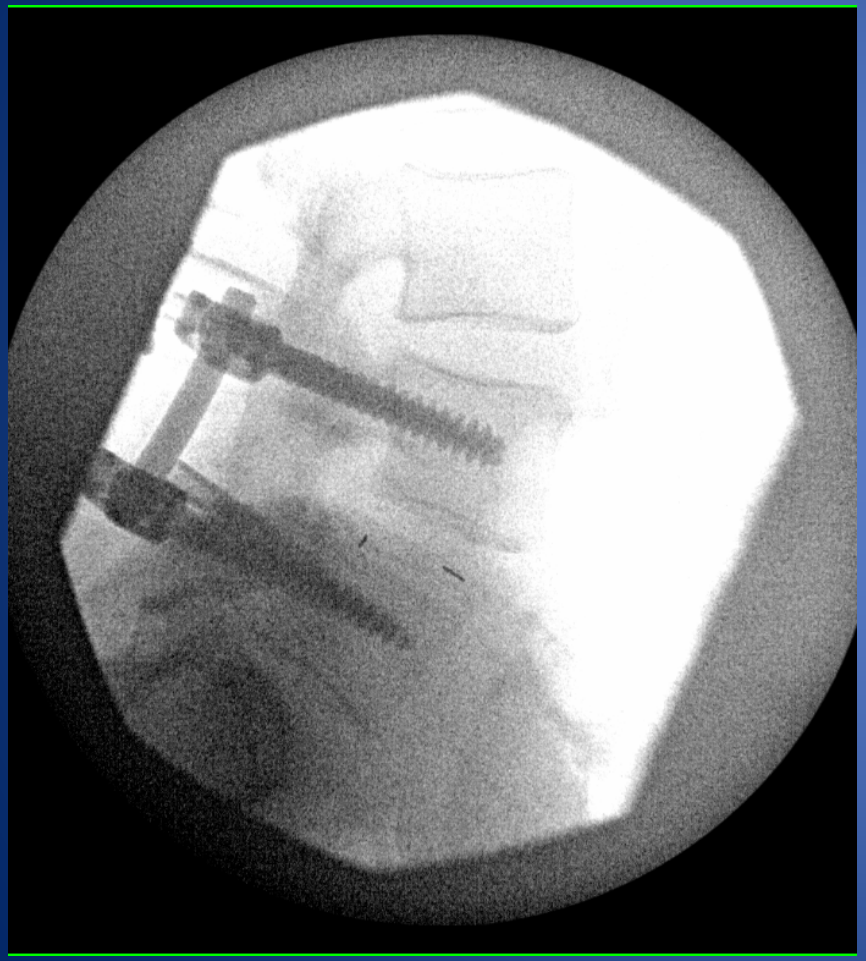
Final



Morbid Obesity

- Need extended tubes (100mm and greater)
- Axis Jackson Table
- Long Kerrisons
- Trajectory is very important
- Start a little more lateral
- Consider adding a posterolateral fusion
- Small movements at top of tube = large movements at bottom

Percutaneous vs Open screws



Author(s) (Year)	Procedure N	EBL (mL)	OR Time (min)	Hospitals Stay (days)
Schwender et al. 2005	MIS TLIF – PS n= 49	<140	240	1.9
Park and Ha 2007	MIS PLIF – PS n=32 Open PLIF n=29	433 738	192 149	5.3 10.8
Schizas et al. 2008	MIS TLIF – PS n=18 Open TLIF n=18	456 961	NR	6.1 8.2
Peng et al. 2009	MIS TLIF – PS n=29 Open TLIF n=29	150 681	216 171	4 6.7
Dhall et al. 2008	MIS TLIF – MO n=21 Open TLIF n=21	194 505	199 237	3 5.5

MIS TLIF Results

EBL: MIS << Open

OR Time: MIS > Open

Hospital Stay MIS < Open by about 2 days.

Table 2: MIS Decompression

Author (s) (Year)	Procedure # of patients	Diagnosis	EBL (mL)	OR Time (minutes)	Hospital Stay (days)	Clinical results
Sasai et al. 2008	MIS Decompression	Spondylolysthesis N=23 patients Stenosis N=25 patients	97 65	186 191	NR NR	ODI Δ: 12 ODI Δ: 17
Podichetty et al. 2006	MIS Decompression	Stenosis Spondylolystehsis (31%)	92	91	1.2 days 88% <24 hours	NR
Weinstein et al. 2008	Laminectomy Randomized: 280 Observational: 365	Stenosis without Spondylolysthesis	314	120	3.0	As Treated Analysis ODI Δ Surgery: 21 ODI Δ No Surgery: 9

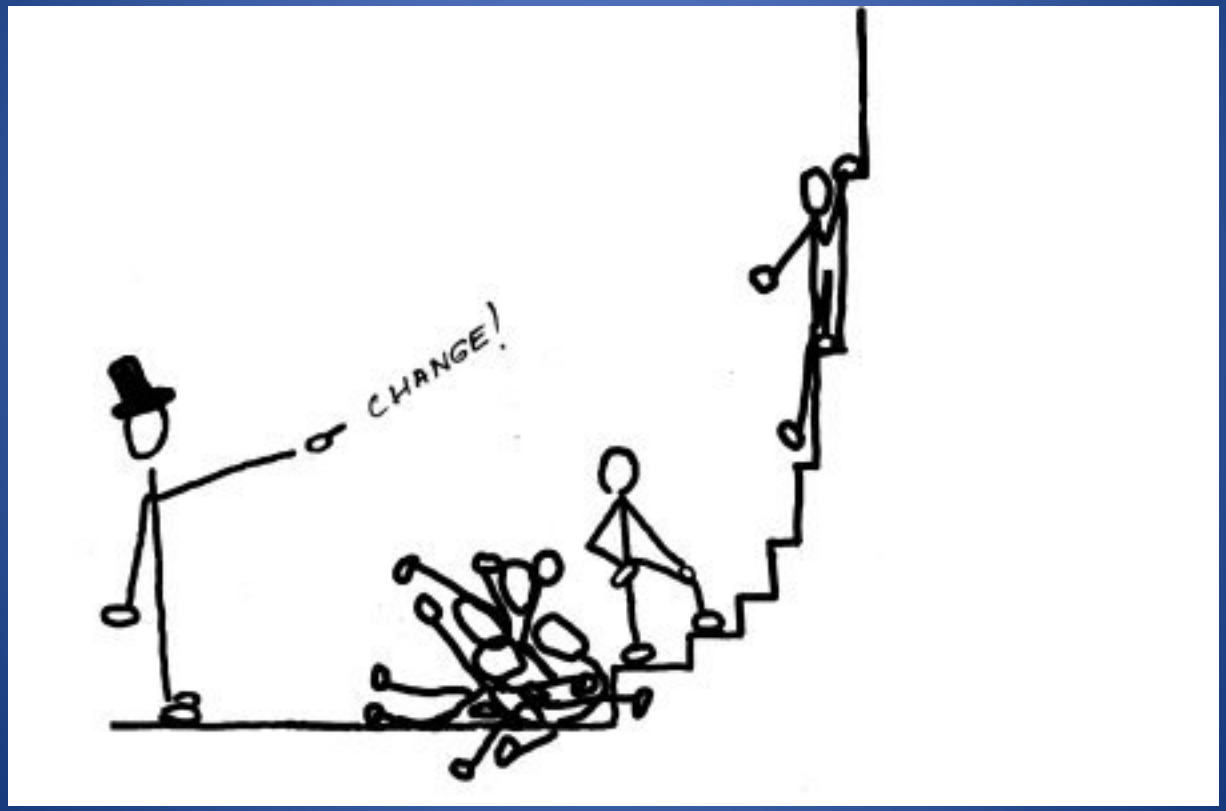
MIS Decompression Results

EBL: MIS < Open

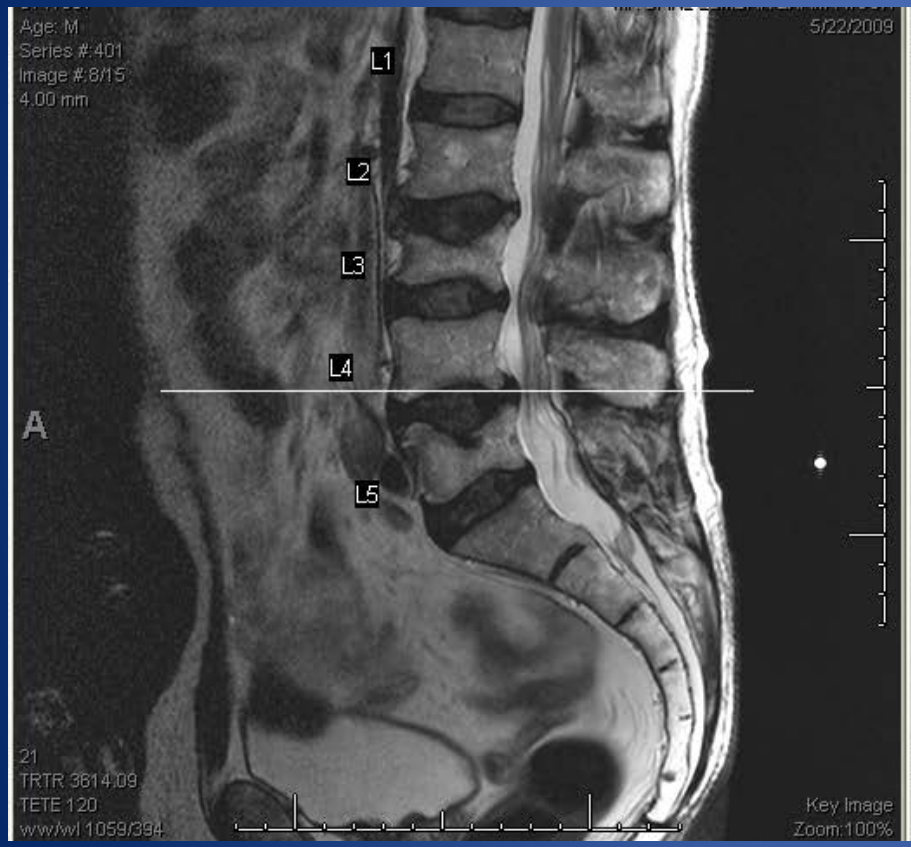
OR Time: MIS = Open

Hospital Stay: MIS < Open (2 days)

Why doesn’t everyone do this?



Case MF


Age: M
Series #:401
Image #:8/15
4.00 mm
5/22/2009
L1
L2
L3
L4
L5
A
21
TRTR 3614.09
TETE 120
ww/wl 1059/394
Key Image
Zoom:100%

Age: M
Series #:701
Image #:11/26
4.00 mm
R
98
TRTR 4425
TETE 120
ww/wl 1951/1051
Zoom:200%

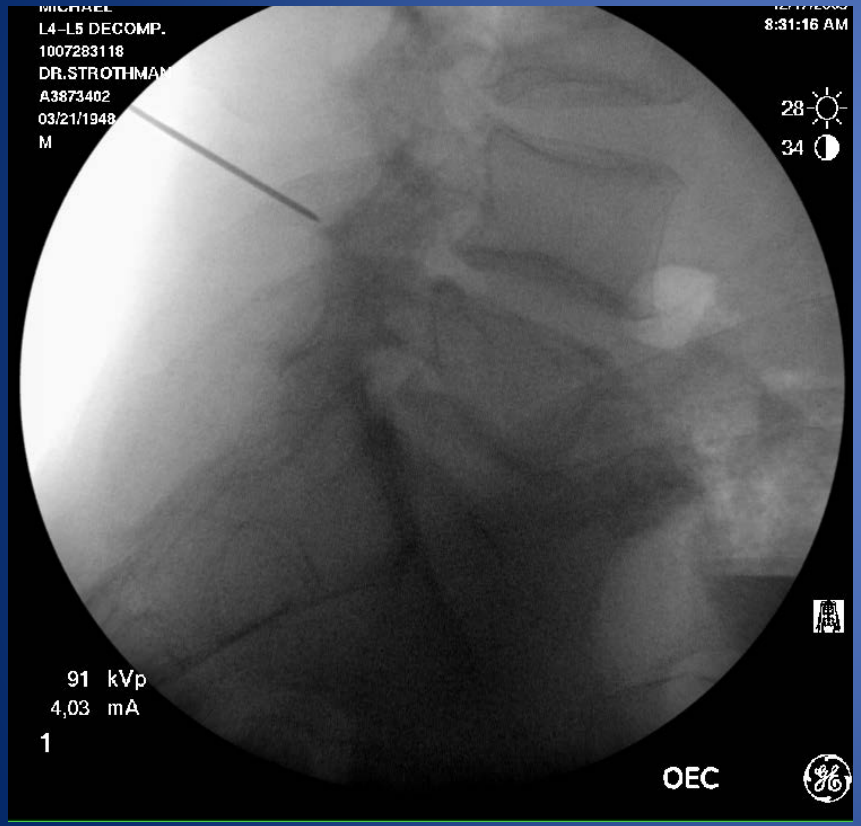
R
DR

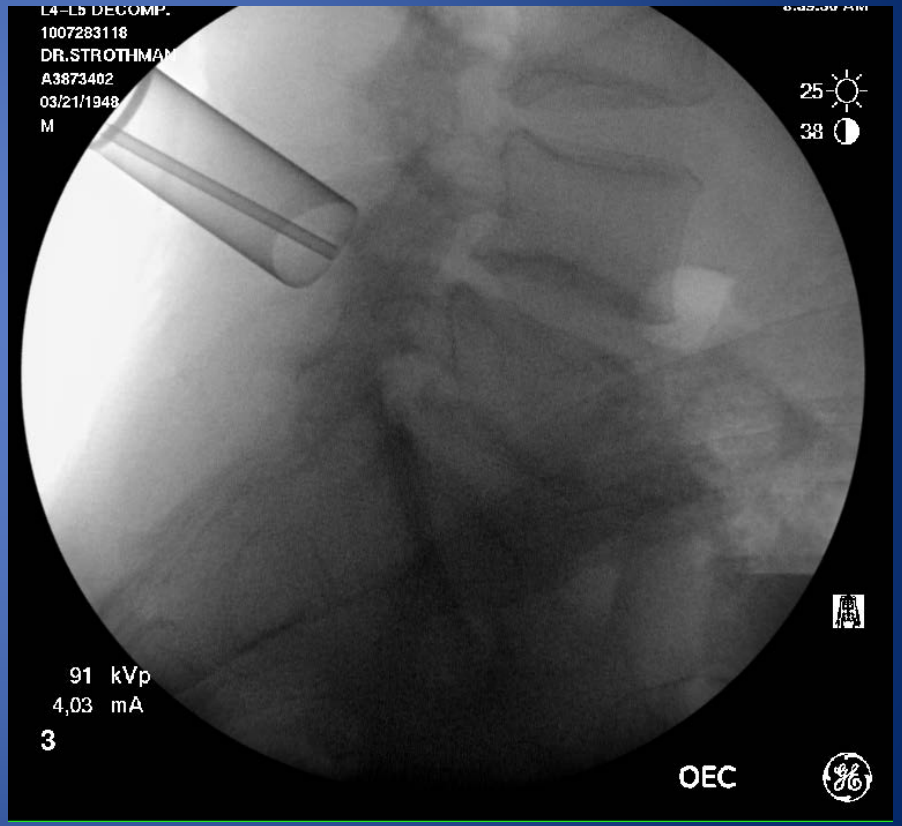
L
BJA

FLEX

L
EXTENSION

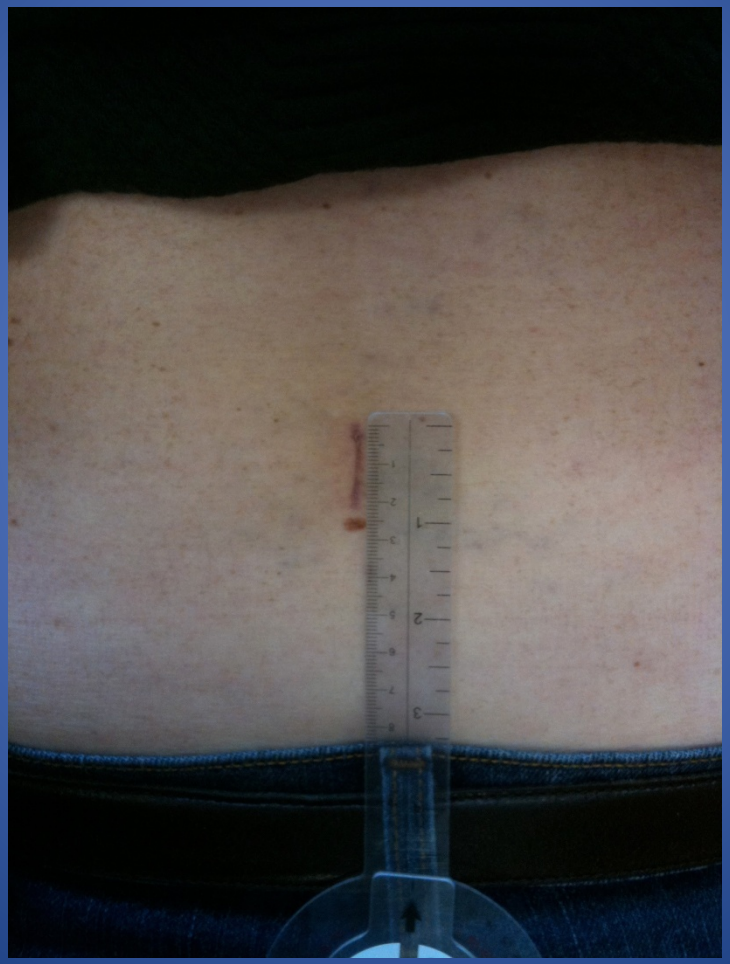
Case MF
MAST Decompression L4-5





Patient eating at McDonalds POD#0

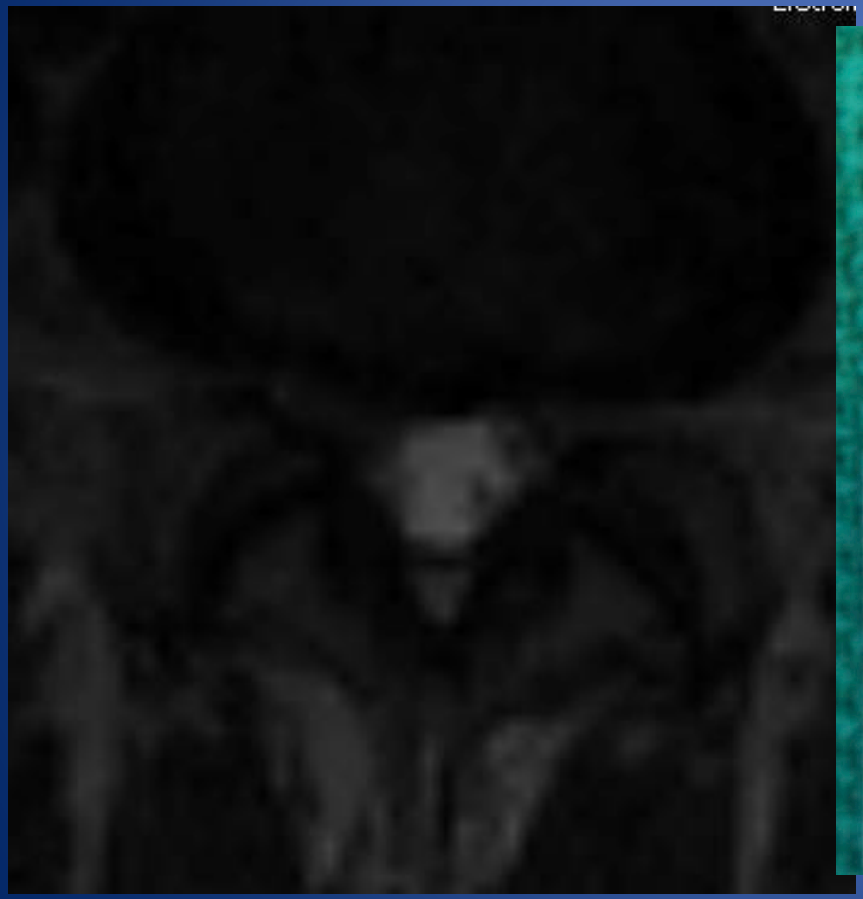
Incision MIS Decompression



IDEAL CASE

RIGHT L4-5 HERNIATED DISC

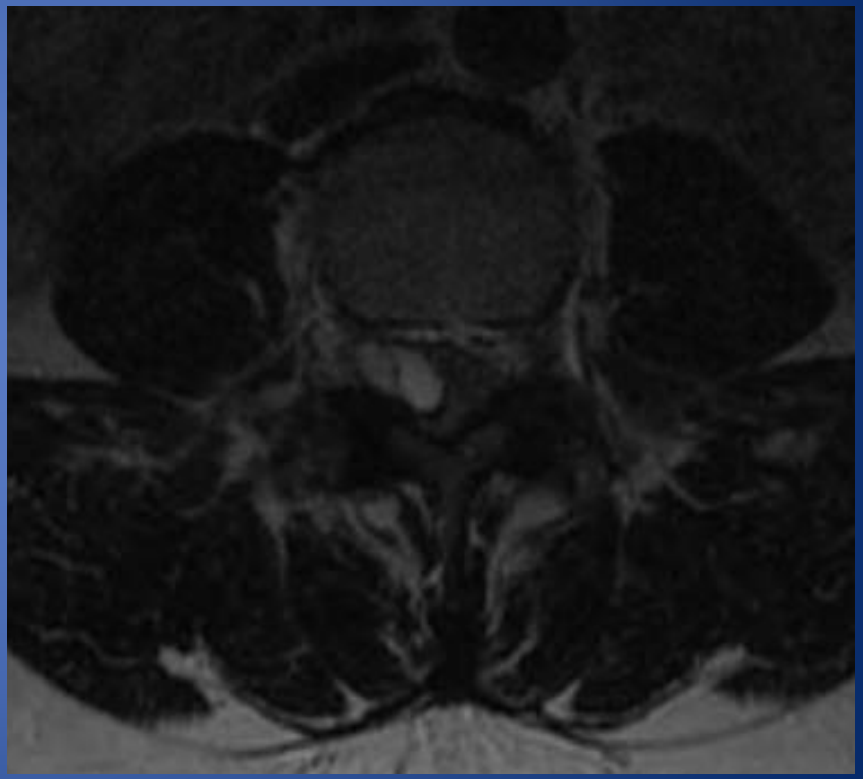
MIS Discectomy



Ideal Case

SYNOVIAL CYST

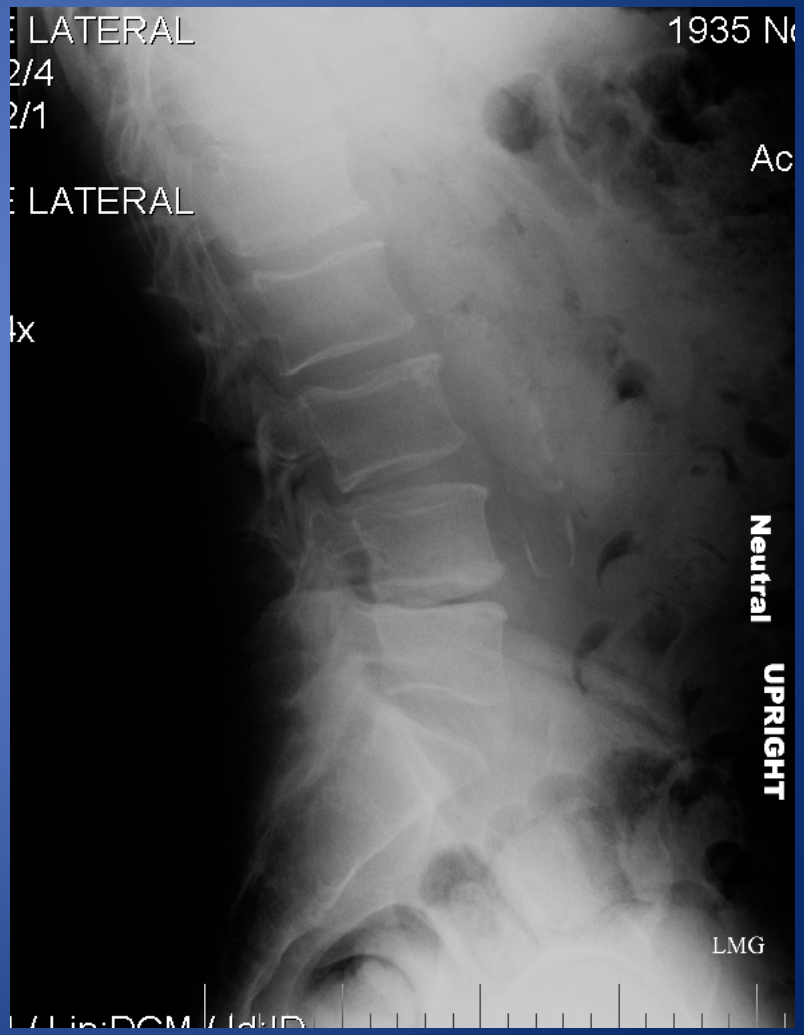
Minimally invasive decompress / excision of synovial cyst



Ideal Case

SEVERE FORAMINAL STENOSIS

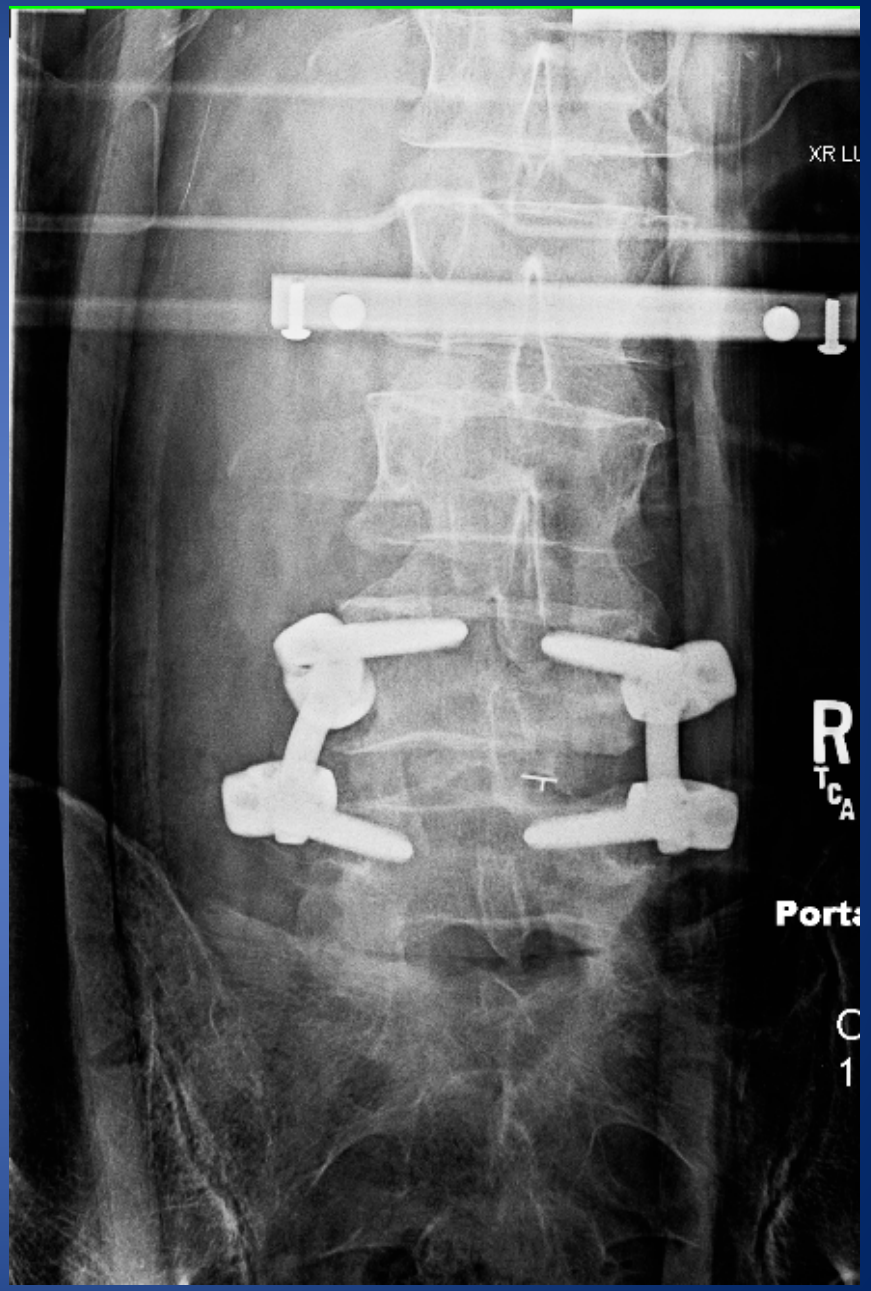
74 yo Male with Right Leg Pain



Hp
CDI_MN_
LARSON
1935 Nov 13 M
Acq Tm: 10:18

MIS TLIF, Decompression, PSF L4-5

A


XR LL
R

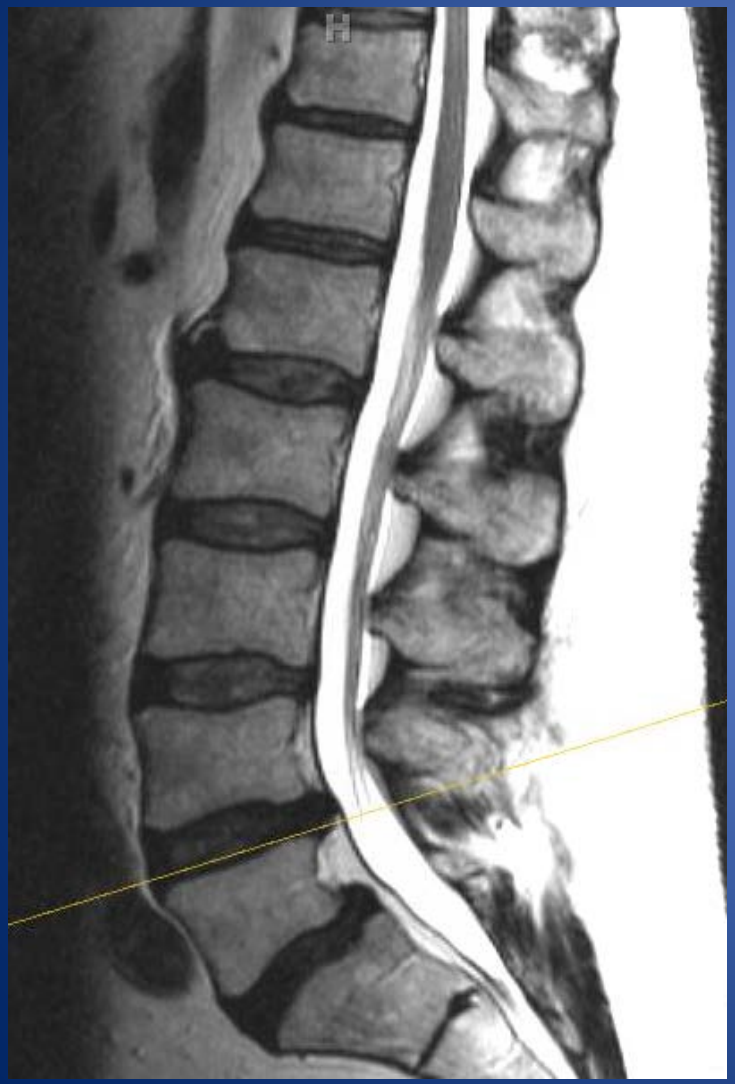
Ideal Candidate

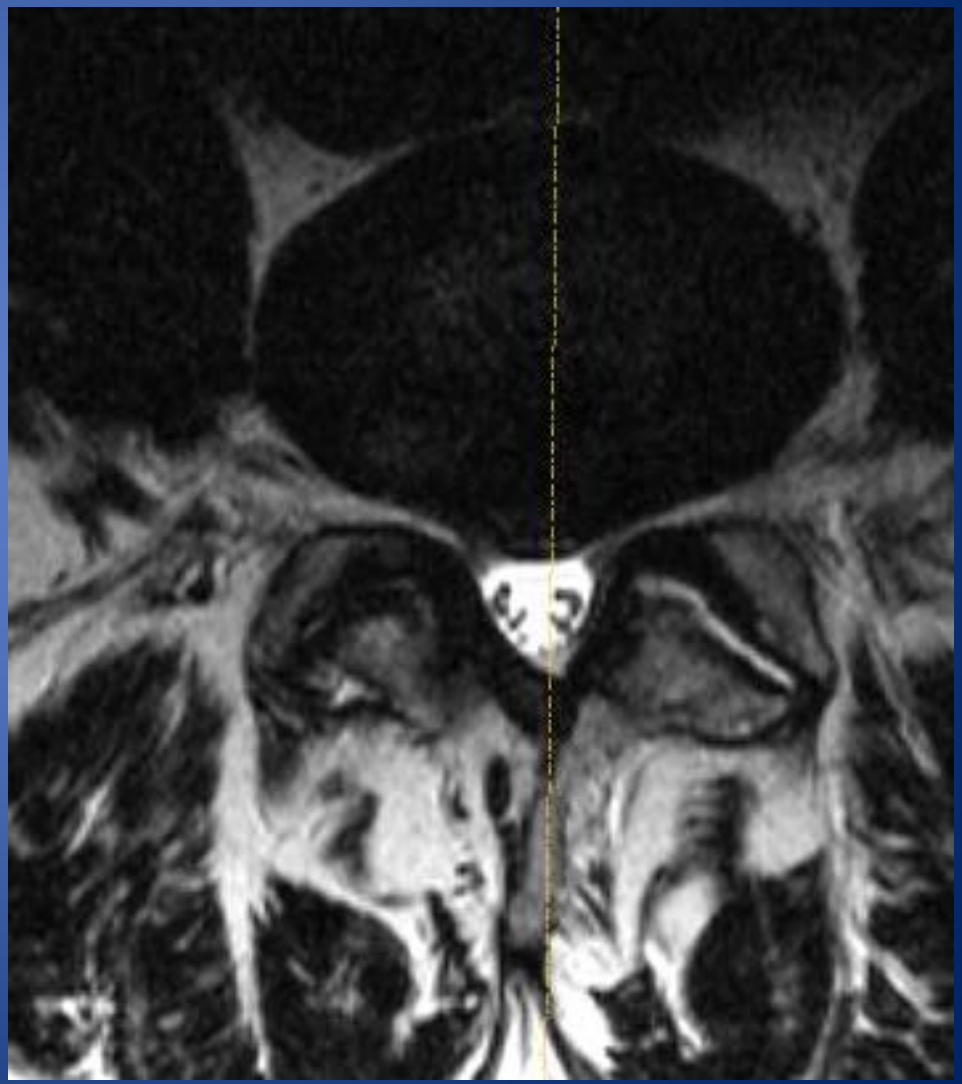
ISTHMIC SPONDYLOLISTHESIS

CASE JH

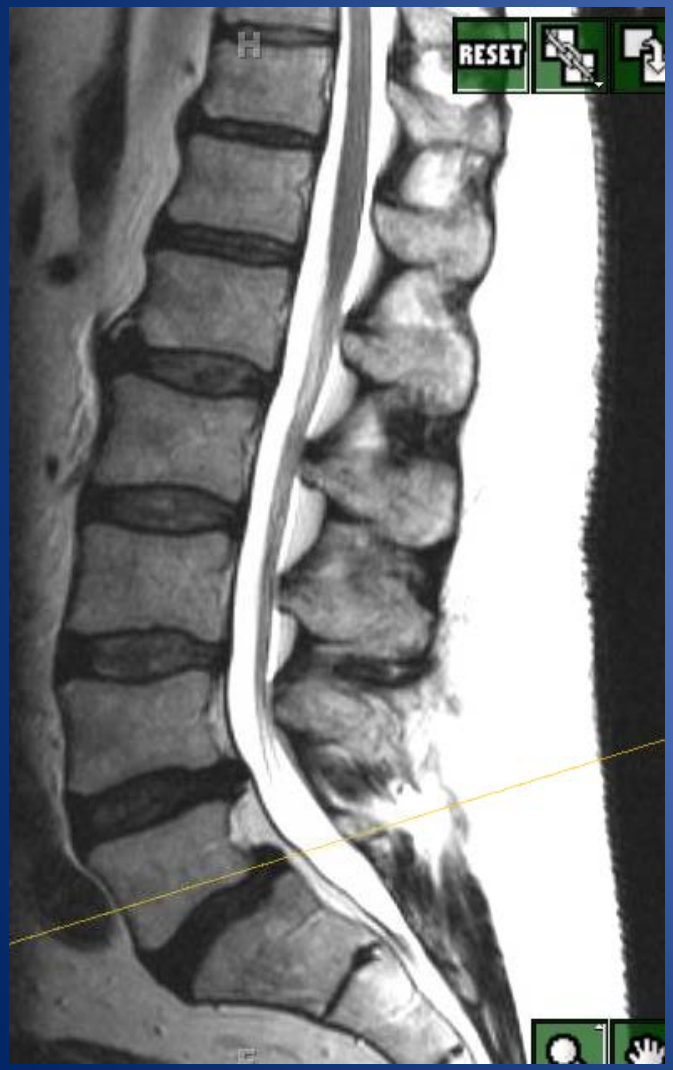
- CC: 80% LBP, 20% Left Leg Pain
- HISTORY: Long history for low back pain, but pain has been severe x 5 months. Walk 1-2 blocks. Stand 5 minutes. Sit for hours. Relief of pain with bending forward and sitting.
- Left L5 NRI: 80% relief for 3 hours, No long term relief.
- Has failed non surgical care (PT, Chiro, etc.)
- EXAM: 5/5 BLE and WNL

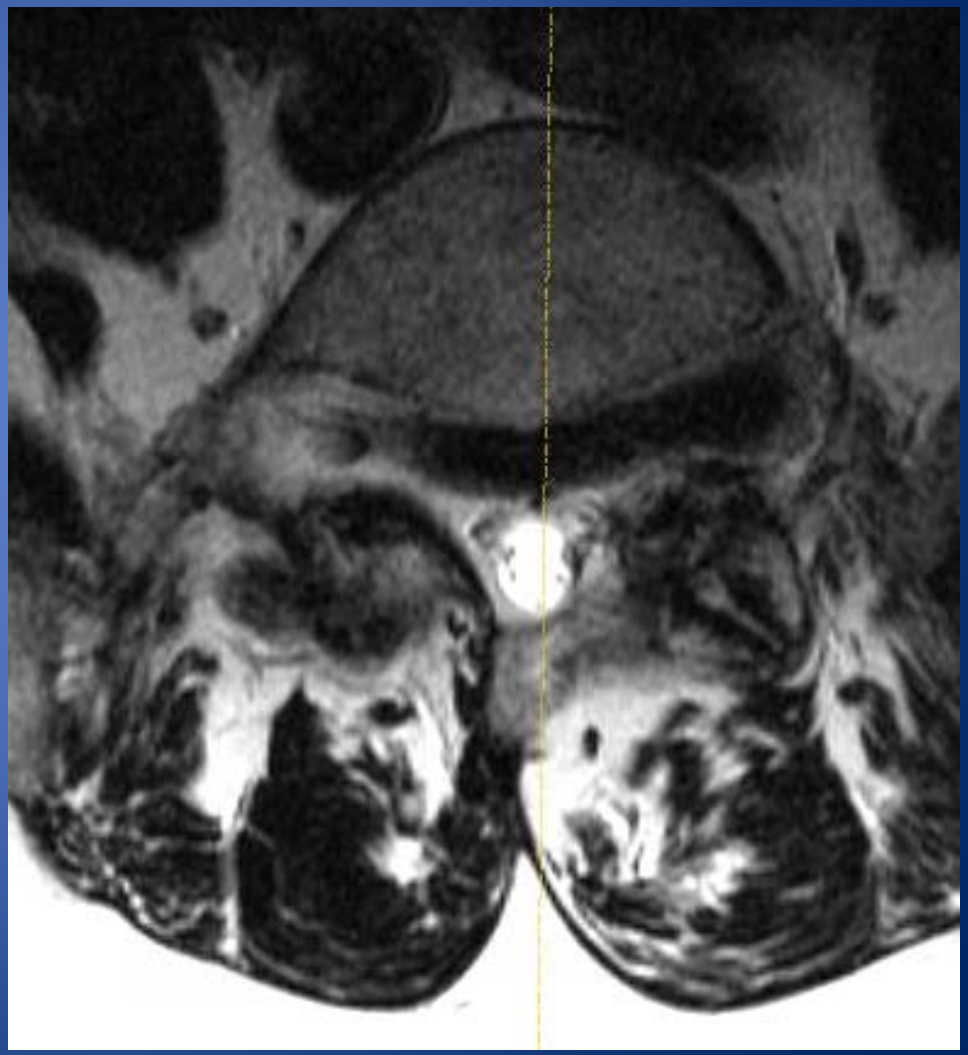
L4-5



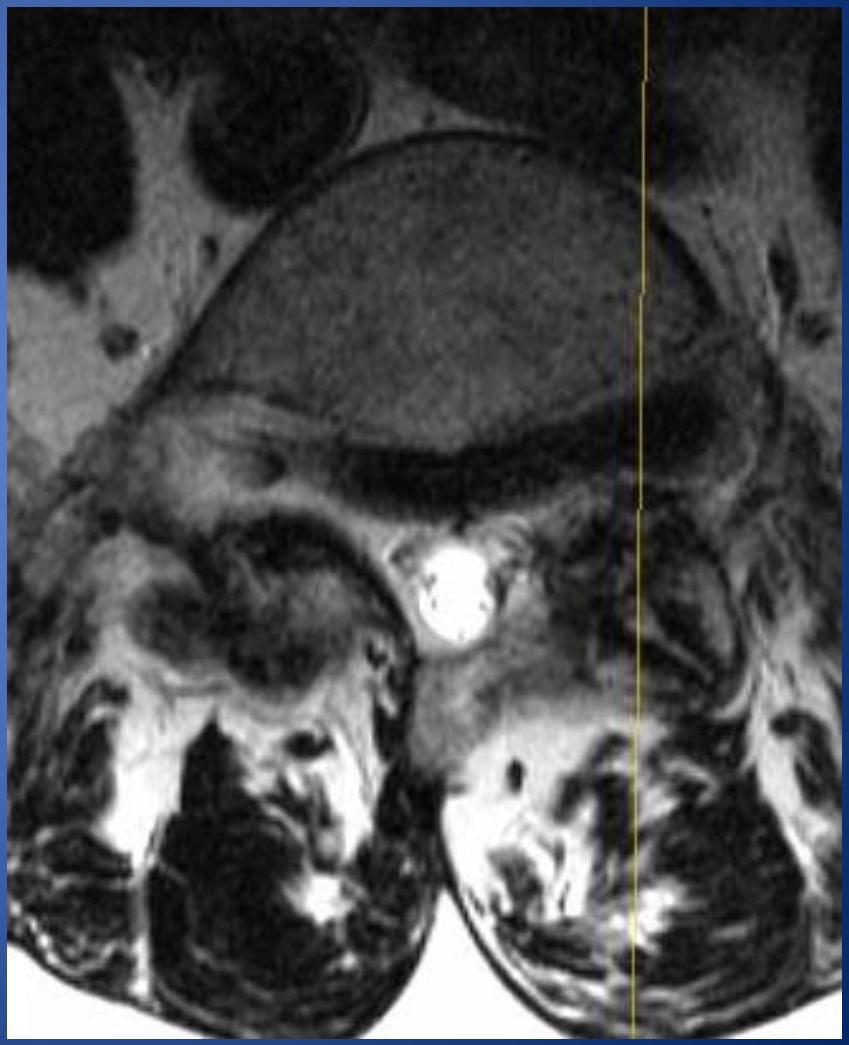


L5-S1

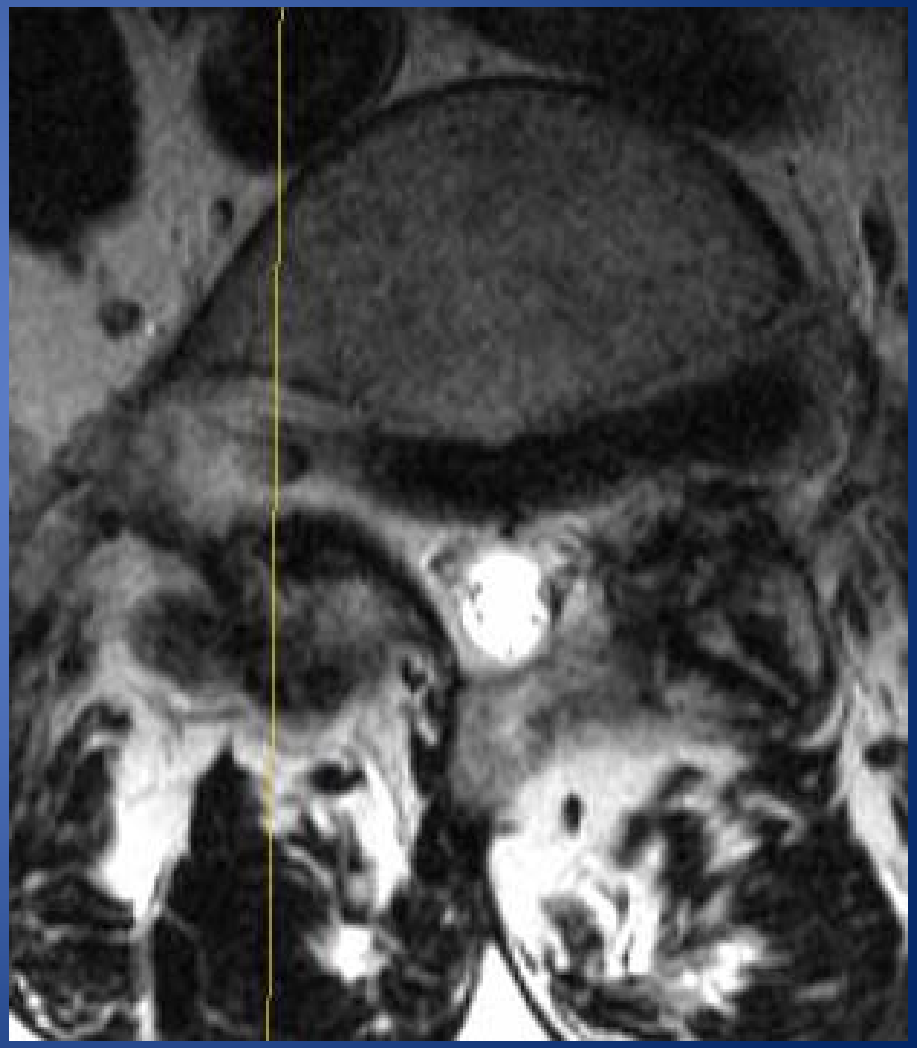




Left



Right



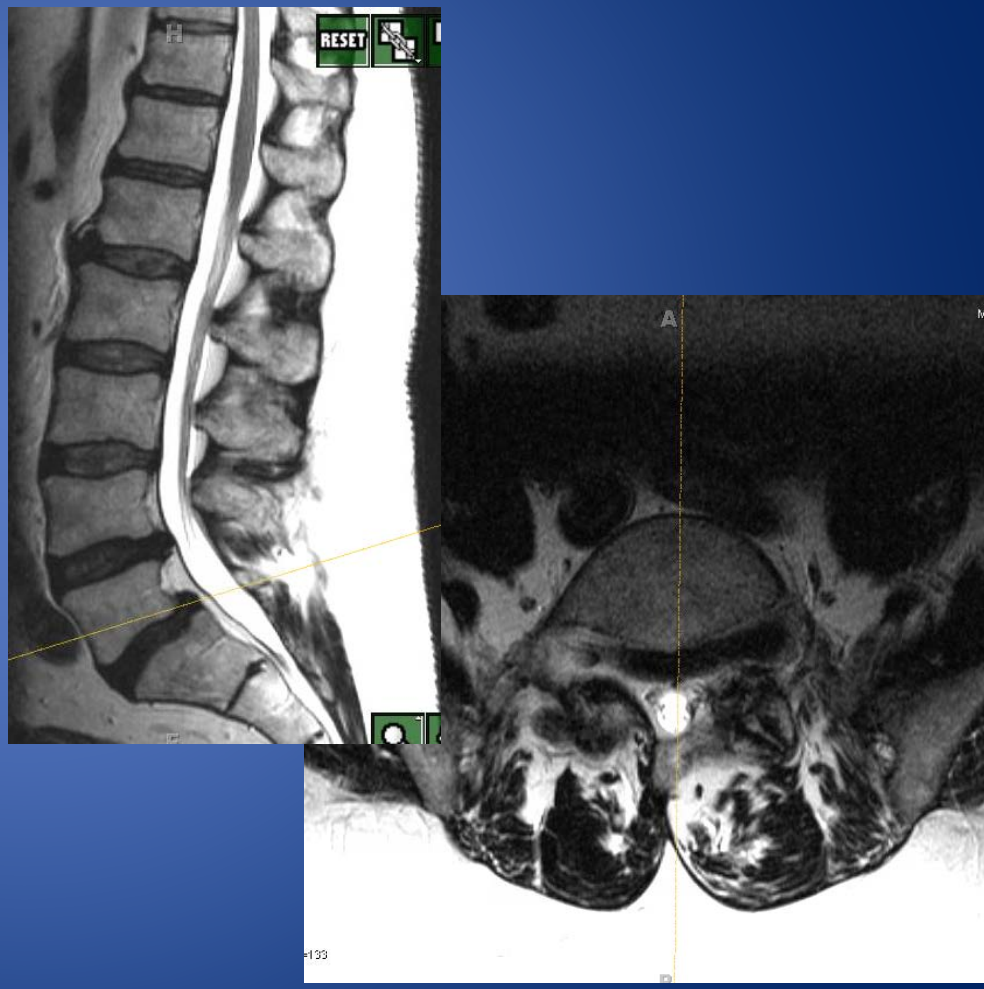
UPRIGHT

L
ATH

RESET

Diagnosis

1. Left L5-S1 foraminal stenosis
2. Left L5-S1 foraminal HNP
3. Isthmic spondylolisthesis L5-S1
4. DDD L4-5

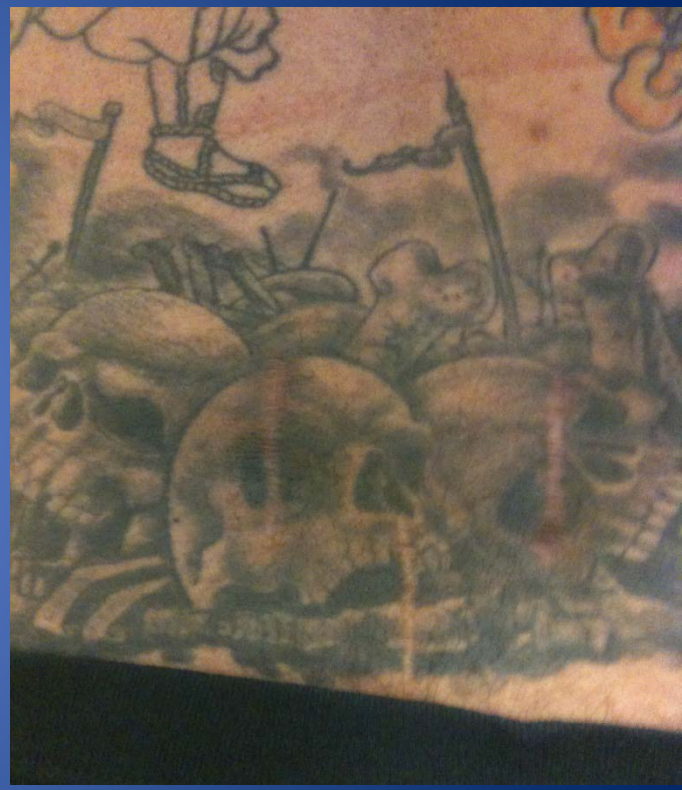


MIS Decompression L4-5
MIS Left L5-S1 Transpedicular Decompression
MIS TLIF/PSF L5-S1

Case Example

2 LEVELS

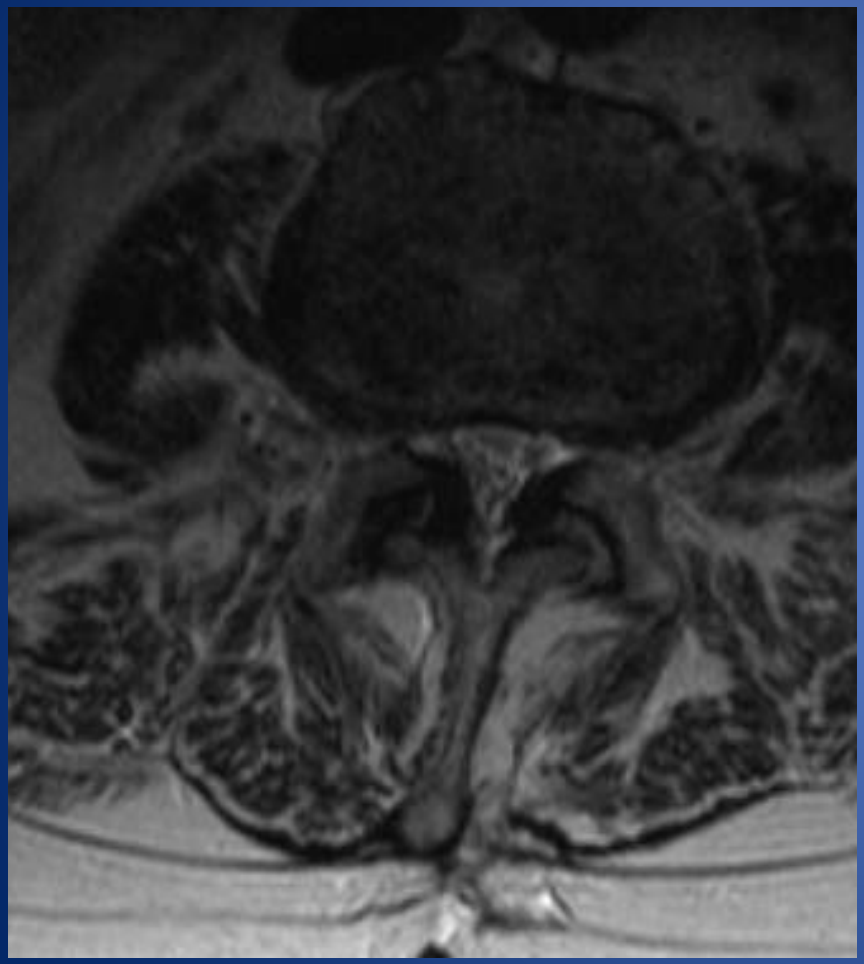
2 levels



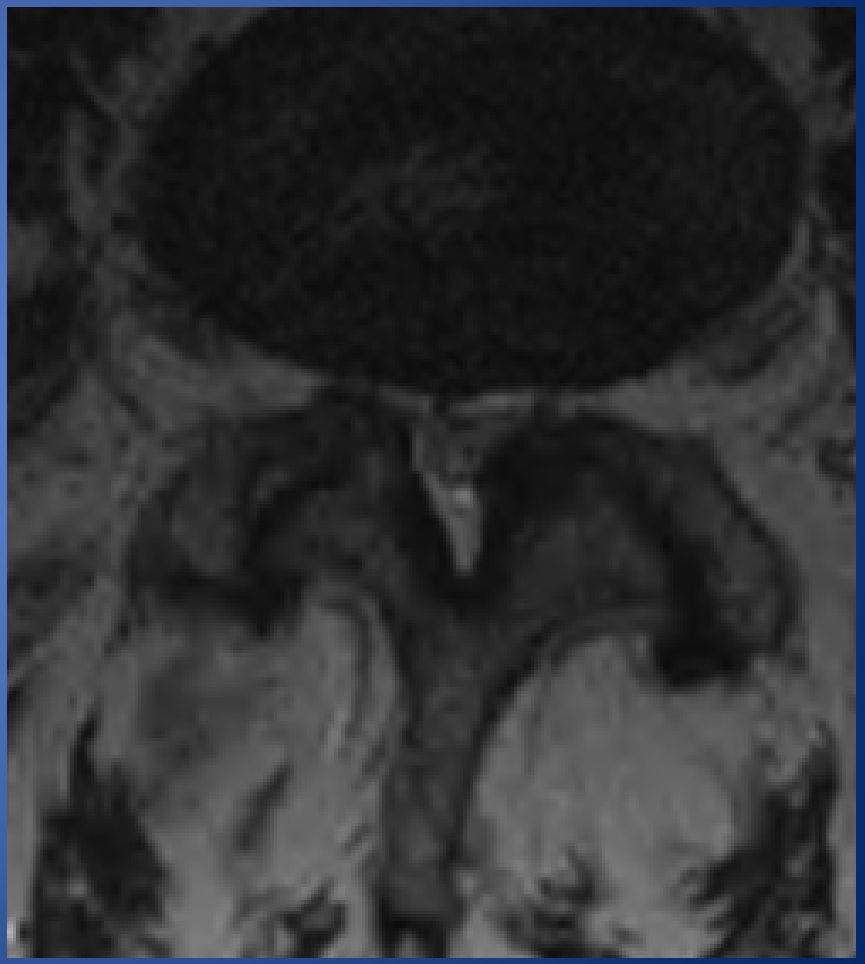
MIS Decompression

GOOD CANDIDATE

Patient MB



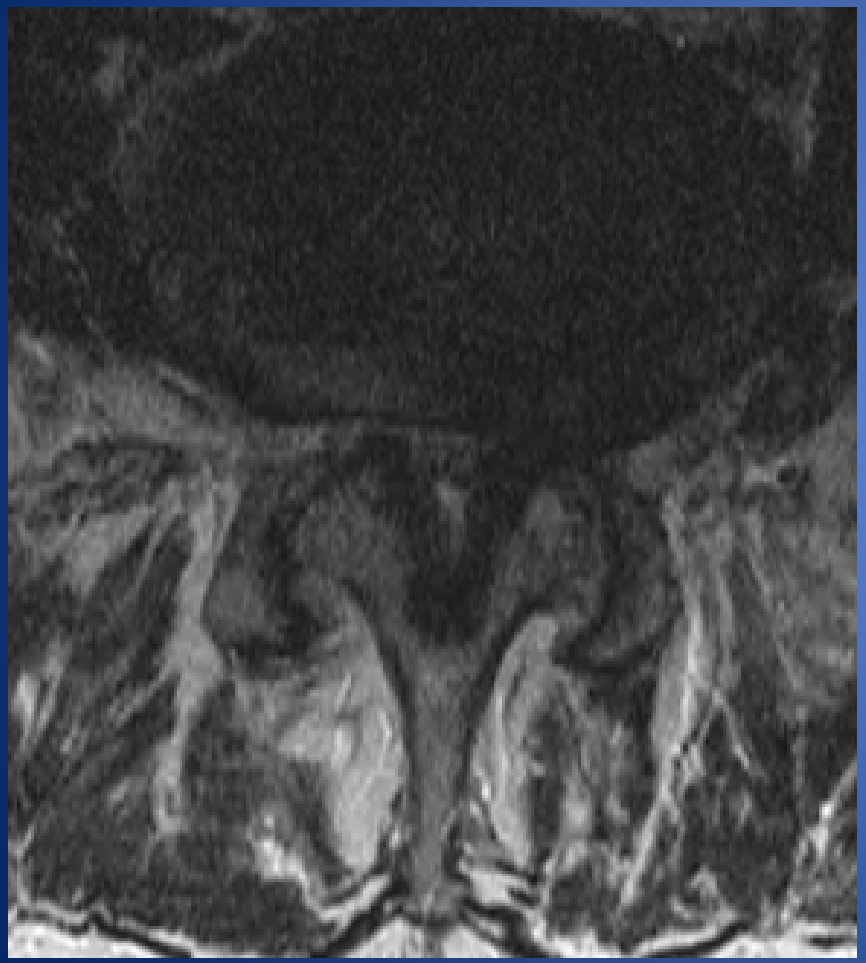
Patient DG



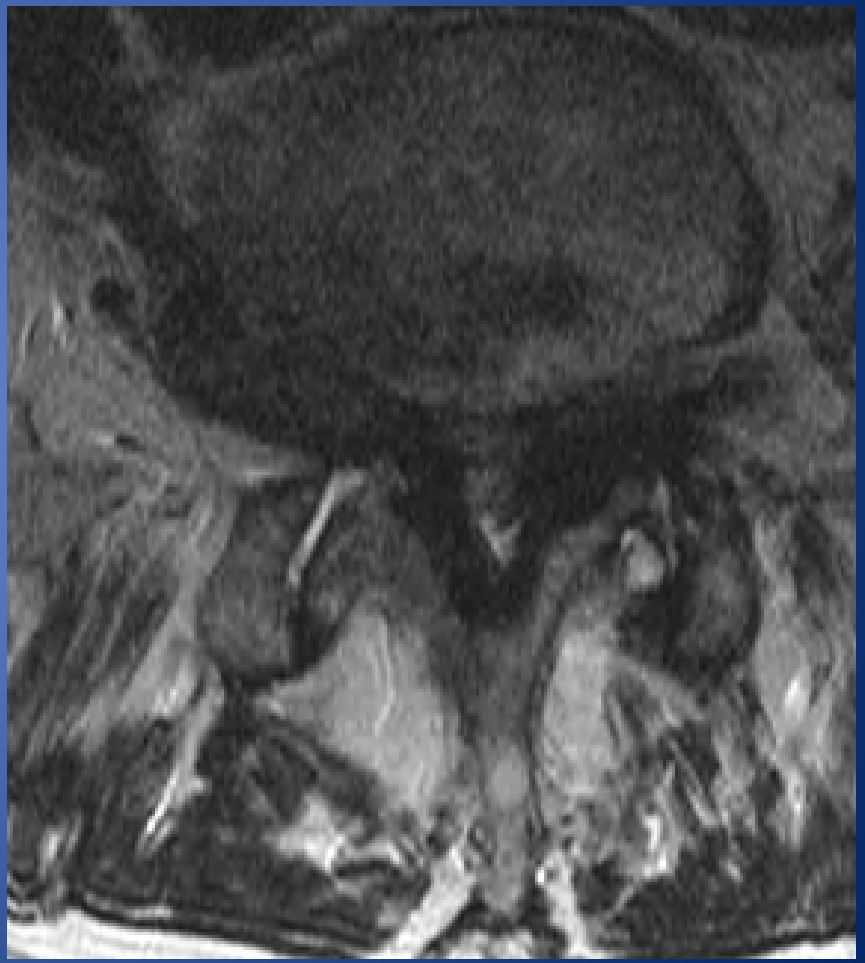
MIS Decompression

POOR CANDIDATE

L3-4



L4-5



OUTPATIENT: Spine Surgery

ILBNC EXPERIENCE

ILBNC Surgery Center Plymouth, MN

- Surgical Cases done to date
  - Discectomies
  - One level decompressions
  - Two level decompressions
  - Synovial cyst resection
  - Lumbar hardware removals
  - Anterior cervical decompression and fusion
  - Lumbar fusions

Overnight Stay Available

- Quiet and Comfortable
- Concierge level care
- Private ILBNC RN

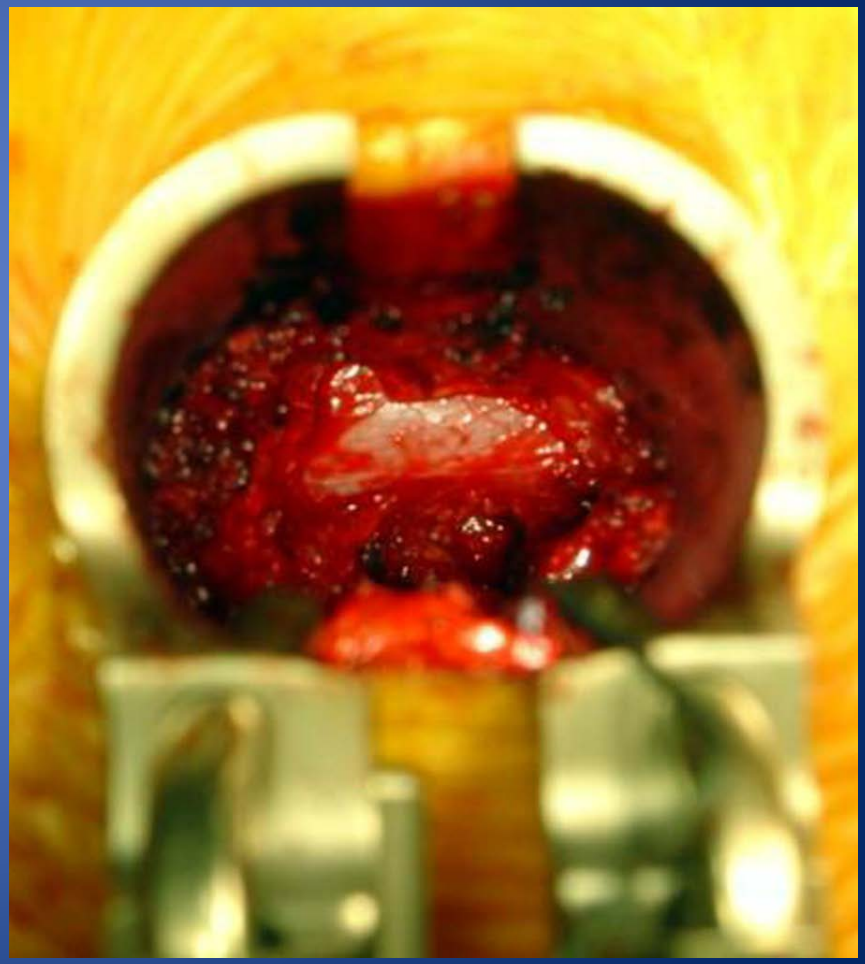
THE ILBNC OUTPATIENT ADVANTAGE

- Better patient experience
- Better Outcomes
- Lower Cost

Patient Satisfaction: 100% Good or Excellent quarter 1, 2015

PATIENT SERVICE / EXCELLENCE!

Questions

David H Strothman, MD
Orthopaedic Surgeon
Medical Director
952-814-6600

Institute for Low Back and Neck Care
Decades of Integrated Spine Care