

# Spinal Alignment

## *Alignment in Lumbar Degenerative Pathology*



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# Overview

- Lumbar degenerative pathology is common and is associated with loss of lordosis
- Alignment of the spine should be considered at the segmental, regional and global levels.
- Adjacent segment degeneration is common in patients with degenerative pathology inadequate restoration of lumbosacral parameters
- Recognition and treatment of segmental malalignment in degenerative pathology is important to avoid creation of global malalignment

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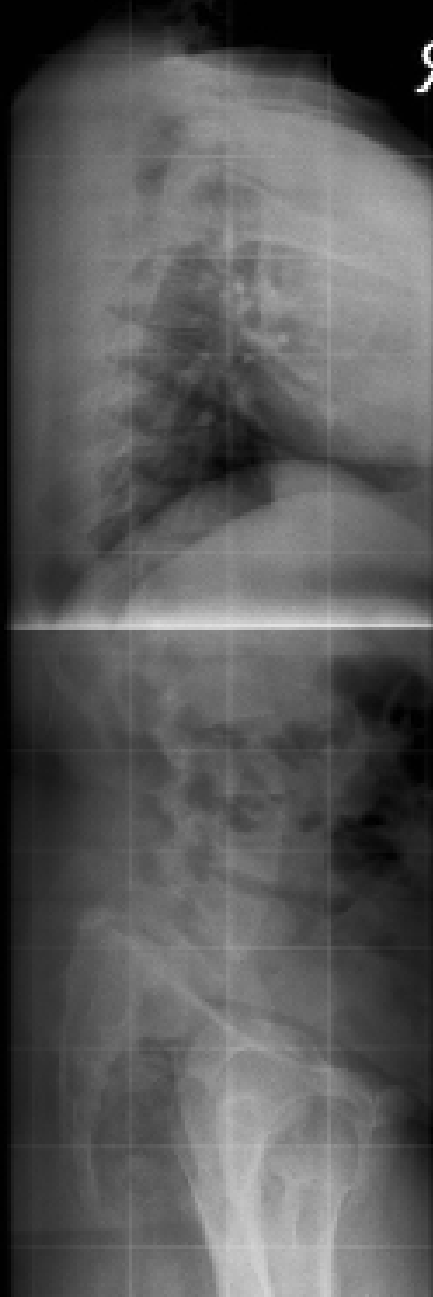
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# Surgical Options

- Posterior Decompression Alone
- Posterior Decompression and Fusion
- Circumferential Fusion
  - Anterior and Posterior
  - Posterior-based fusion

# Approaches to Lumbar Degenerative Pathology

- Characterized by significant variability



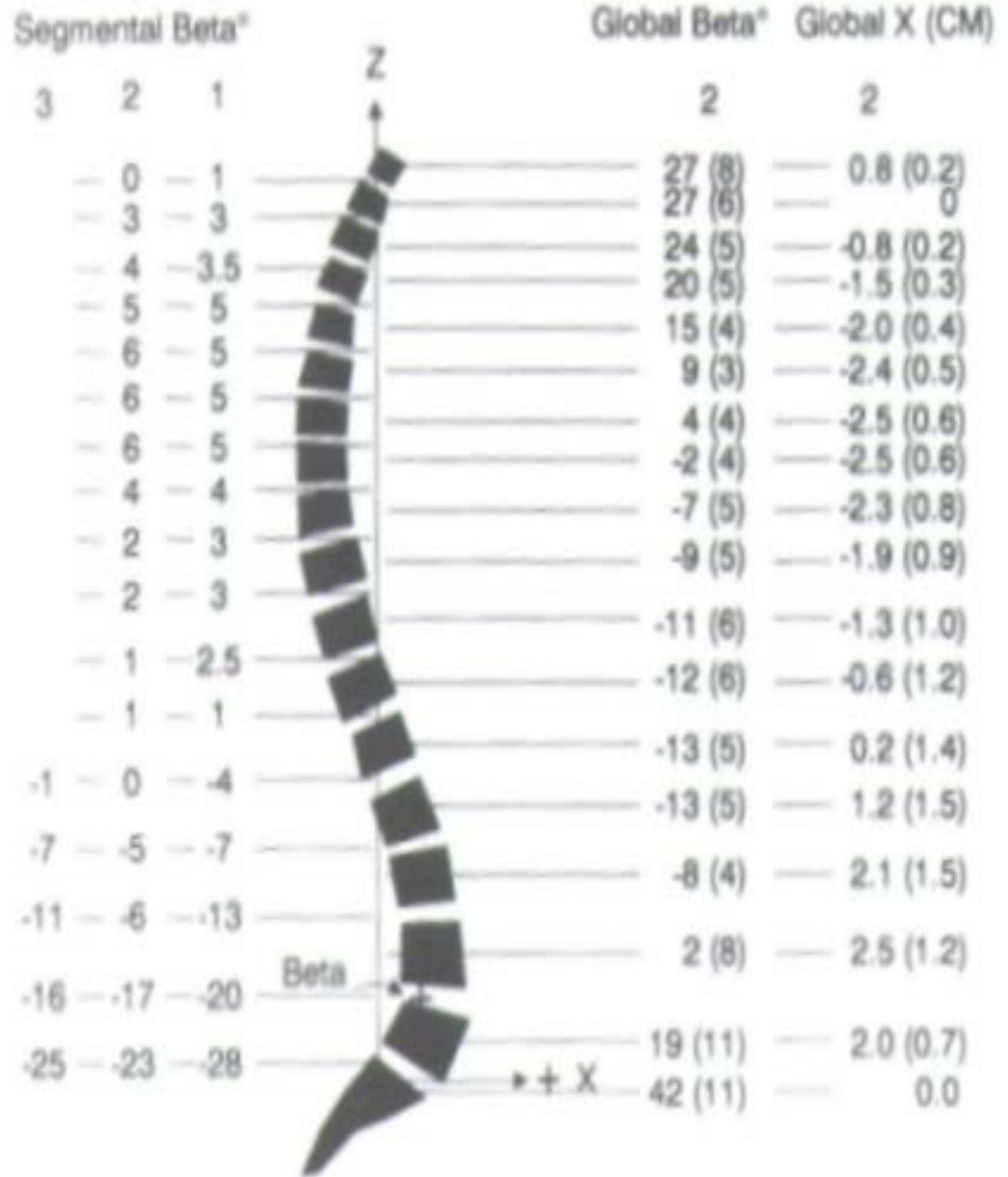
# Improvement of Lordosis with Surgical Approaches



- Restoration of segmental lordosis is an important goal of lumbar degenerative deformity
- Prevention of a degenerative case becoming a deformity case



# Normal Sagittal Plane Alignment in Stance



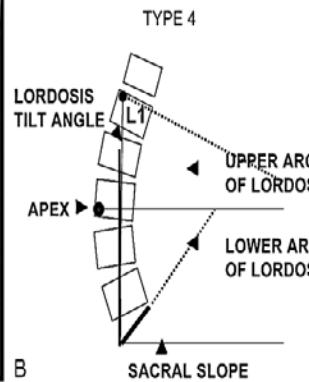
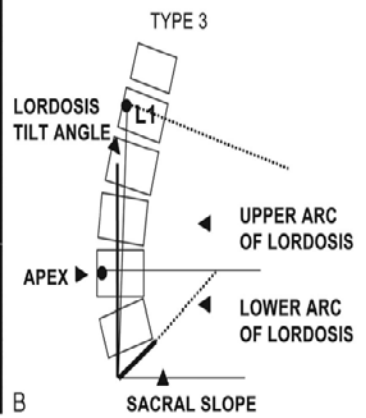
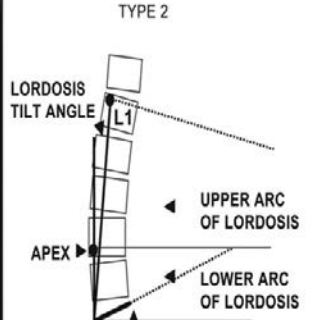
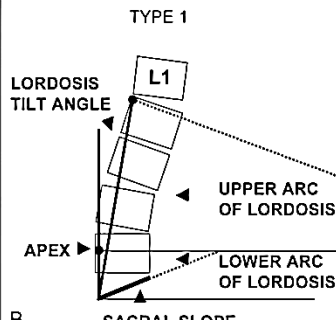
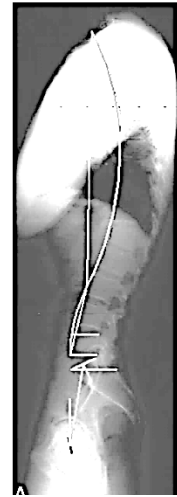
# Classification of the Normal Variation in the Sagittal Alignment of the Human Lumbar Spine and Pelvis in the Standing Position

Roussouly, Pierre MD\*; Gollogly, Sohrab MD\*; Berthonnaud, Eric PhD†; Dimnet, Johannes PhD†

Spine: February 1st, 2005 - Volume 30 - Issue 3 - p 346-353

doi:10.1097/BRS.0b11353e81814111

- Patterns of Normal Lordosis defined by sacral slope, arc of lordosis, and apex of lordosis



# MORPHOLOGY OF LORDOSIS

**Table 3. The Characteristics of the Lumbar Lordosis as a Function of the Type of Sagittal Morphology**

Sacral Slope	No.	Incidence [mean (range)] (°)	Apex	Lordosis Tilt Angle [mean (range)] (°)	Global Lordosis [mean (range)] (°)	No. of Lordotic Vertebrae [mean (range)] (°)	Upper Arc [mean (range)] (°)
<35° (mean, 30°; range, 21°–35°)	34	41 (34–54)	Middle L5	-1 (-3--15)	52 (41–64)	4 (1.5–6)	22 (13–29)
<35° (mean, 32°; range, 28°–35°)	18	44 (38–51)	Base L4	-5 (-1--9)	52 (44–58)	5 (4–7.5)	19 (11–26)
35° < PS < 45° (mean, 39°)	60	51 (36–65)	Middle L4	6.5 (10--16)	61 (43–76)	4.5 (3–6.5)	22 (7–35)
PS > 45° (mean, 50°; range, 45°–66°)	48	63 (43–83)	Base L3	-2.5 (6--12)	71 (61–82)	5 (3.5–6)	21.5 (13–32)

2/3 lordosis ~ L4-S1

Roussouly, P., S. Gollogly, E. Berthonnaud and J. Dimnet (2005). "Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position." *Spine (Phila Pa 1976)* **30(3): 346-353.**

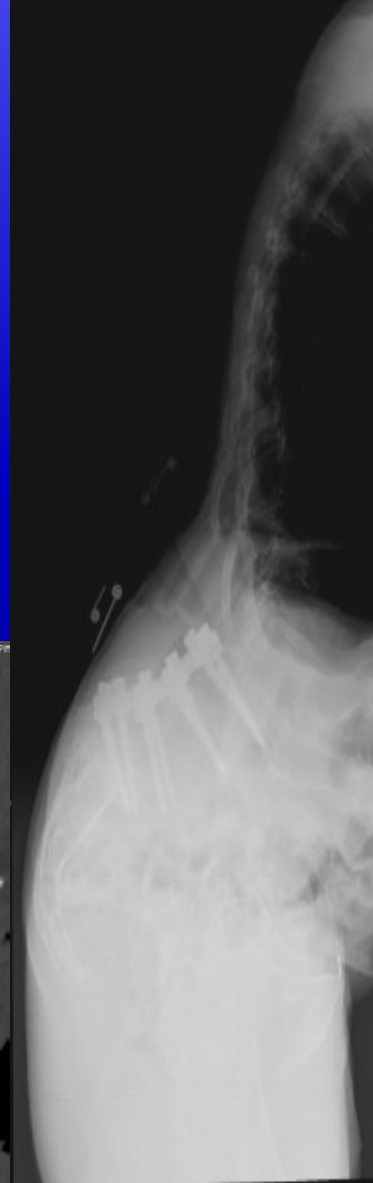
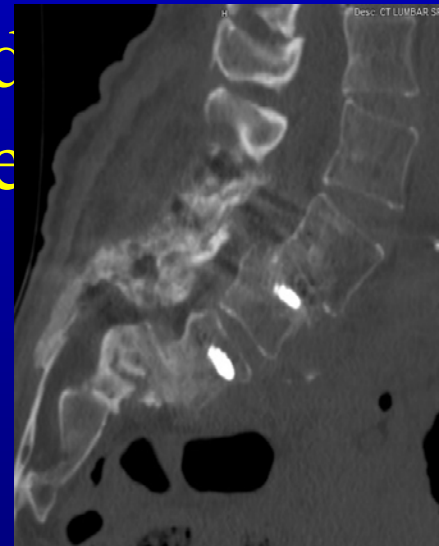




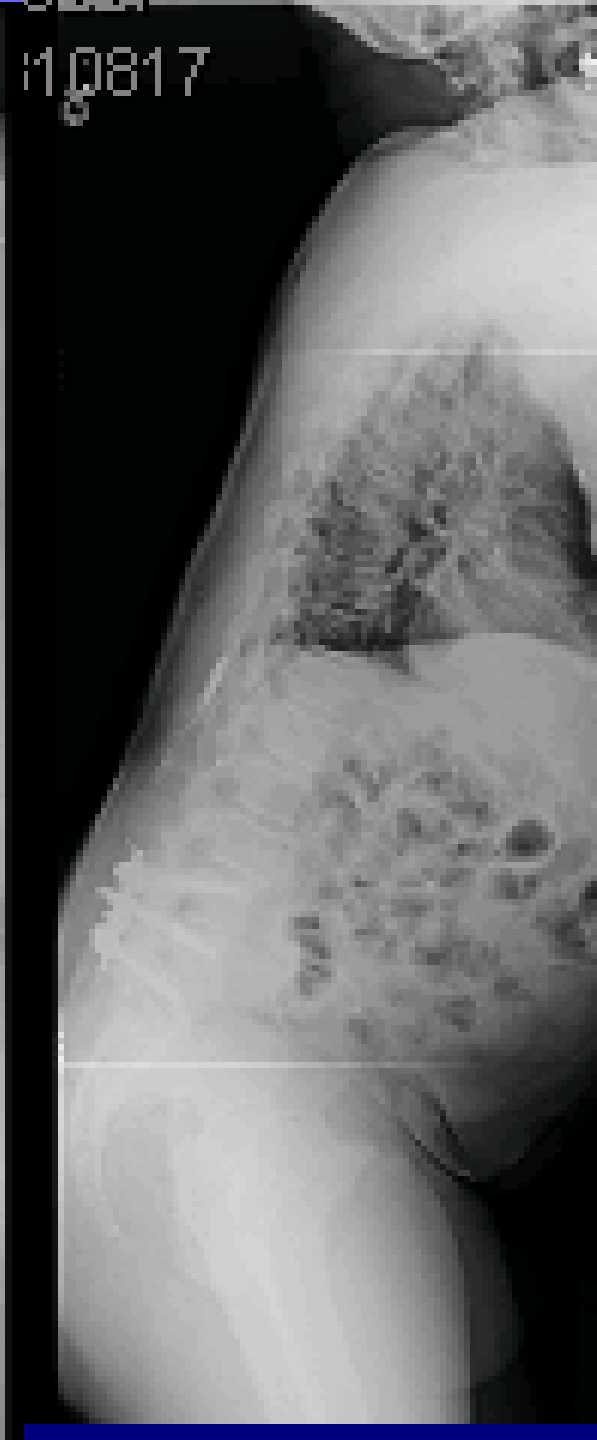
# Why Is Lumbosacral Lordosis Important

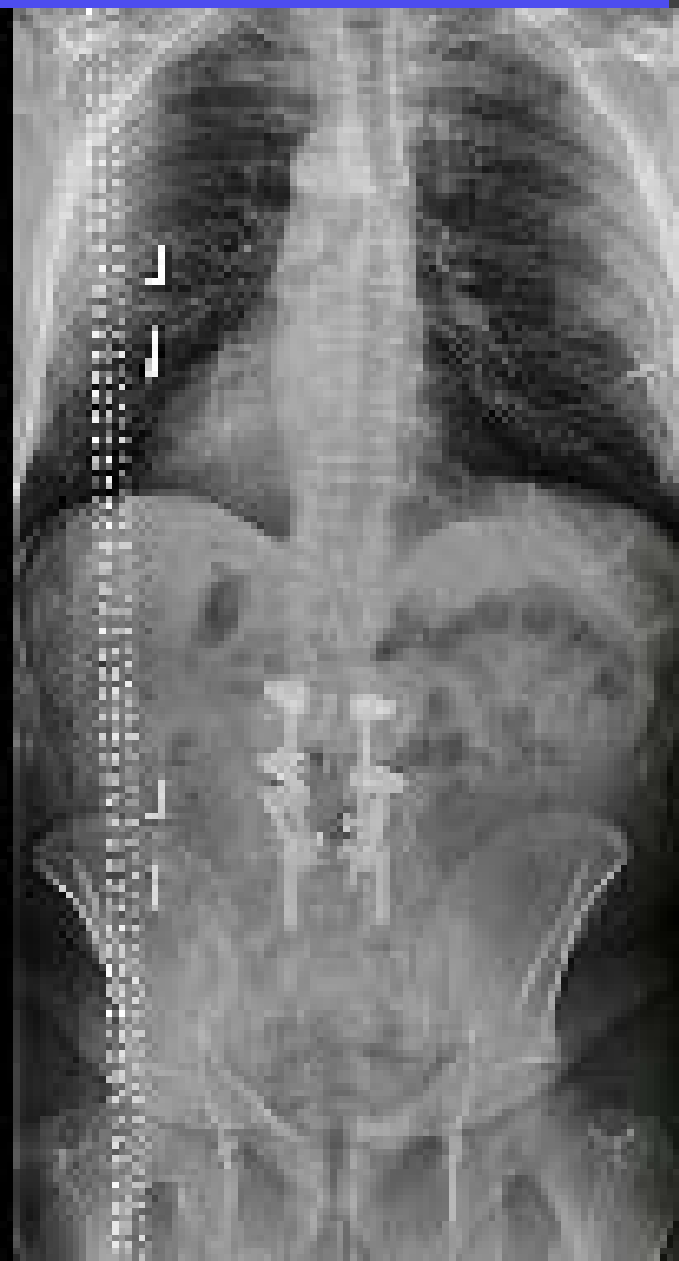
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- Correlation of sagittal balance with Health Status
- Correlation with adjacent segment degeneration
- Correlation with malpositioned discs with junctional kyphosis above











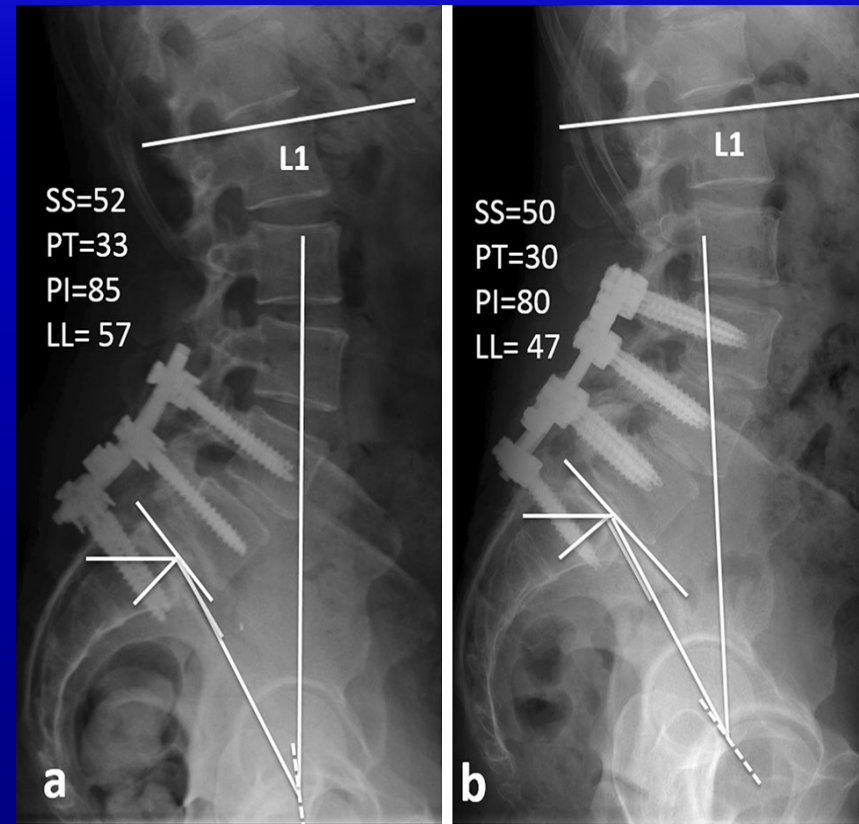


# Estimating the risk for symptomatic adjacent segment degeneration after lumbar fusion: analysis from a cohort of patients undergoing revision surgery

Eur Spine J (2014) 23 (Suppl 6):S693–S698

Alberto Di Martino • Carlo Cosimo Quattrocchi •  
Laura Scarciolla • Nicola Papapietro •  
Bruno Beomonte Zobel • Vincenzo Denaro

- Case-control study design to determine the risk of adjacent segment degeneration in lumbar degenerative pathology
- High pelvic tilt and kyphotic lumbopelvic parameters predict adjacent level

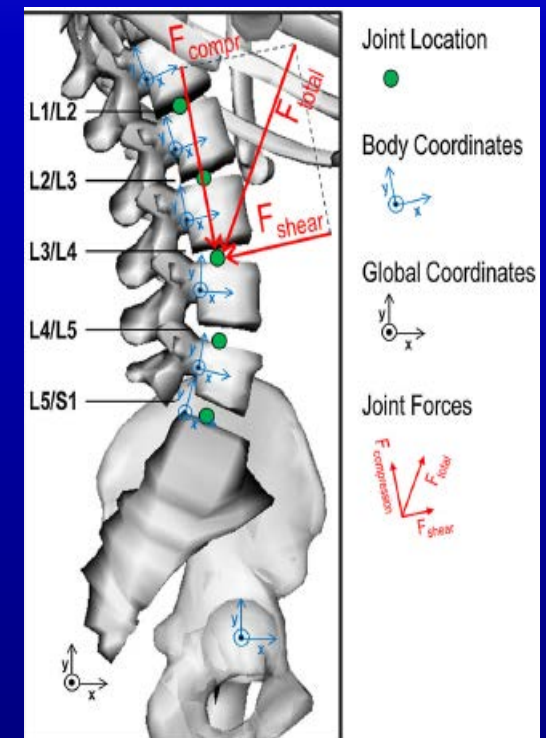
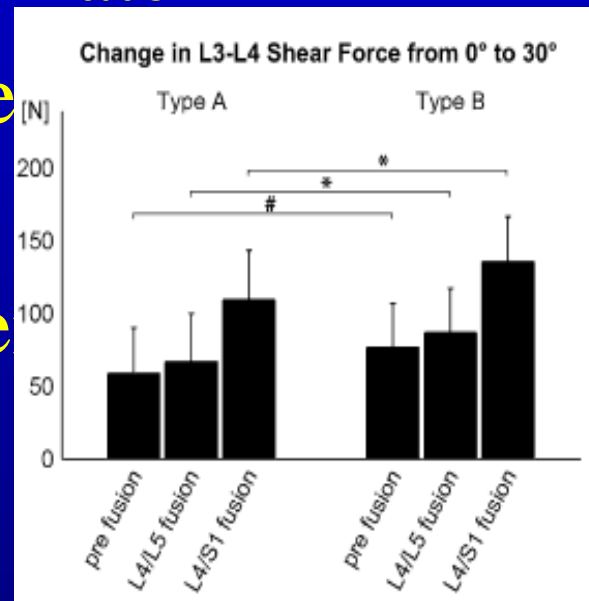


# Pelvic incidence–lumbar lordosis mismatch results in increased segmental joint loads in the unfused and fused lumbar spine

Marco Senteler • Bernhard Weisse •  
Jess G. Snedeker • Dominique A. Rothenfluh

Eur Spine J (2014) 23:1384–1393

- Biomechanical study demonstrating higher shear forces in patients fused with lumbopelvic mismatch
- Type A Alignment
  - PI-LL < 15°
- Type B Alignment
  - PI-LL > 15°

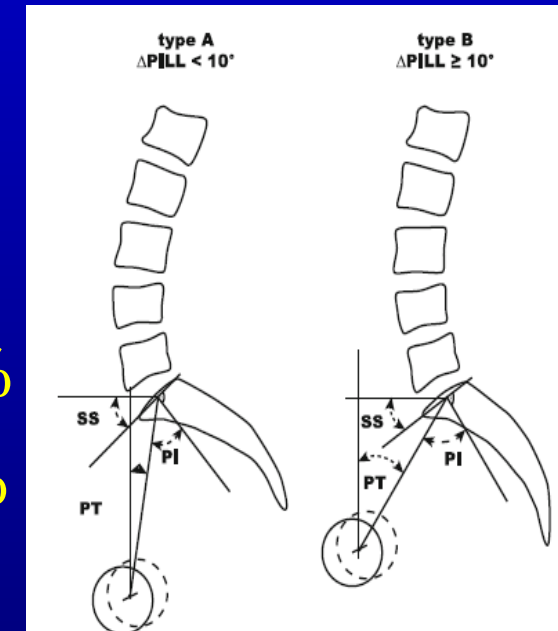


# Pelvic incidence-lumbar lordosis mismatch predisposes to adjacent segment disease after lumbar spinal fusion

Dominique A. Rothenfluh • Daniel A. Mueller •  
Esin Rothenfluh • Kan Min

Eur Spine J. 2014 Jul 14.

- Spinopelvic alignment is a significant predictor of risk for revision surgery in patients undergoing fusion of 1 to 3 segments for lumbar degenerative pathology
- Risk of revision surgery:
  - Type A spino-pelvic alignment: 25.5%
  - Type B spino-pelvic alignment: 78.3%



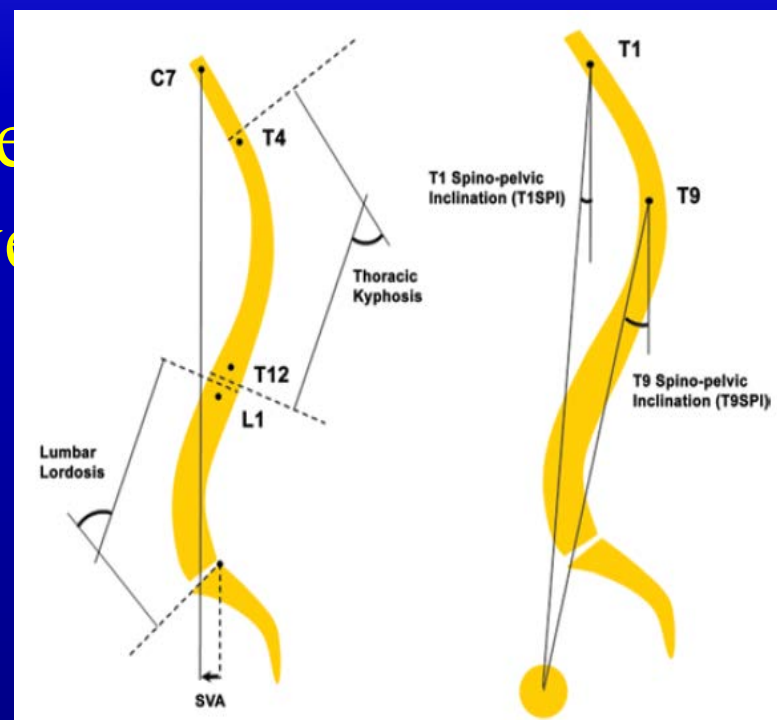
# Does vertebral level of pedicle subtraction osteotomy correlate with degree of spinopelvic parameter correction?

Clinical article

J Neurosurg Spine 14:184–191, 2011

VIRGINIE LAFAGE, PH.D.,<sup>1</sup> FRANK SCHWAB, M.D.,<sup>1</sup> SHALEEN VIRI, B.S.,<sup>1</sup>  
ROBERT HART, M.D.,<sup>2</sup> DOUGLAS BURTON, M.D.,<sup>3</sup> JUSTIN S. SMITH, M.D., PH.D.,<sup>4</sup>  
OHENEBA BOACHIE-ADJEI, M.D.,<sup>5</sup> ALEXIS SHELOKOV, M.D.,<sup>6</sup> RICHARD HOSTIN, M.D.,<sup>6</sup>  
CHRISTOPHER I. SHAFFREY, M.D.,<sup>4</sup> MUNISH GUPTA, M.D.,<sup>7</sup> BEHROOZ A. AKBARNIA, M.D.,<sup>8</sup>  
SHAY BESS, M.D.,<sup>8</sup> AND JEAN-PIERRE FARCY, M.D.<sup>1</sup>

- Restoration of lordosis at lower lumbar levels is more effective in improving pelvic tilt
- Possible benefit in reducing junctional kyphosis



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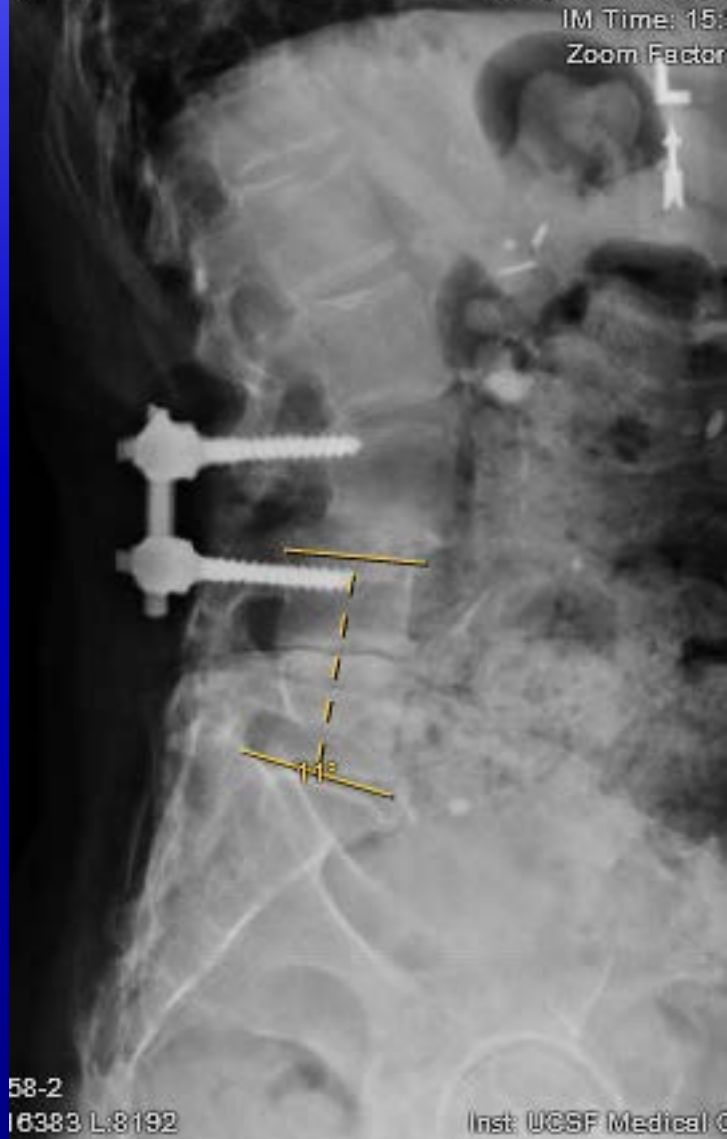
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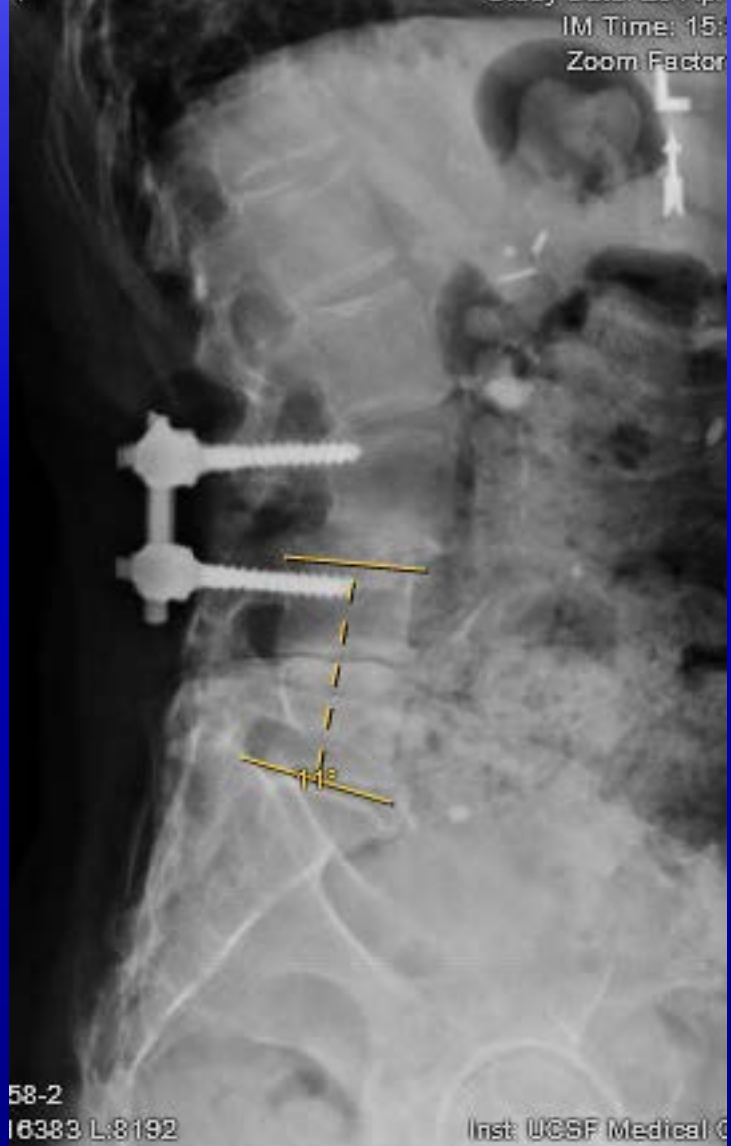
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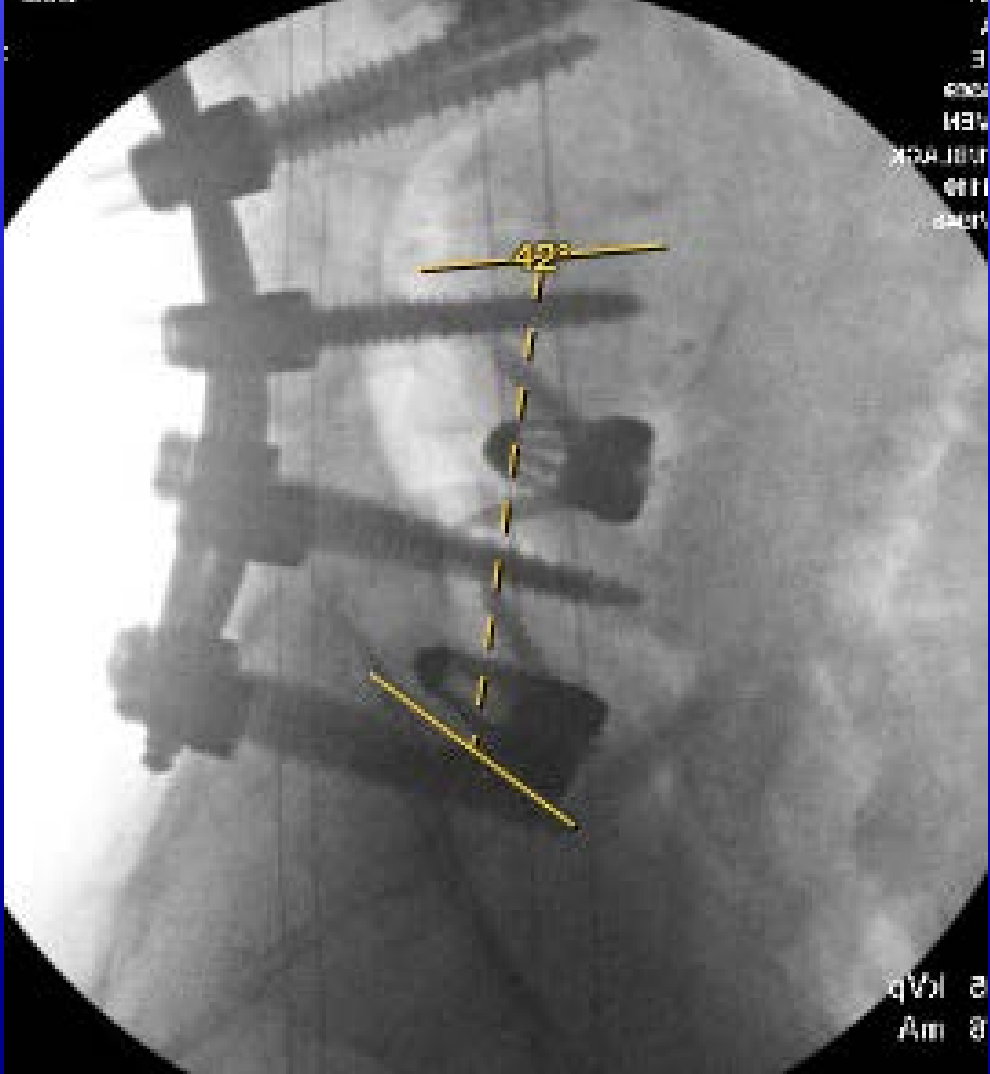
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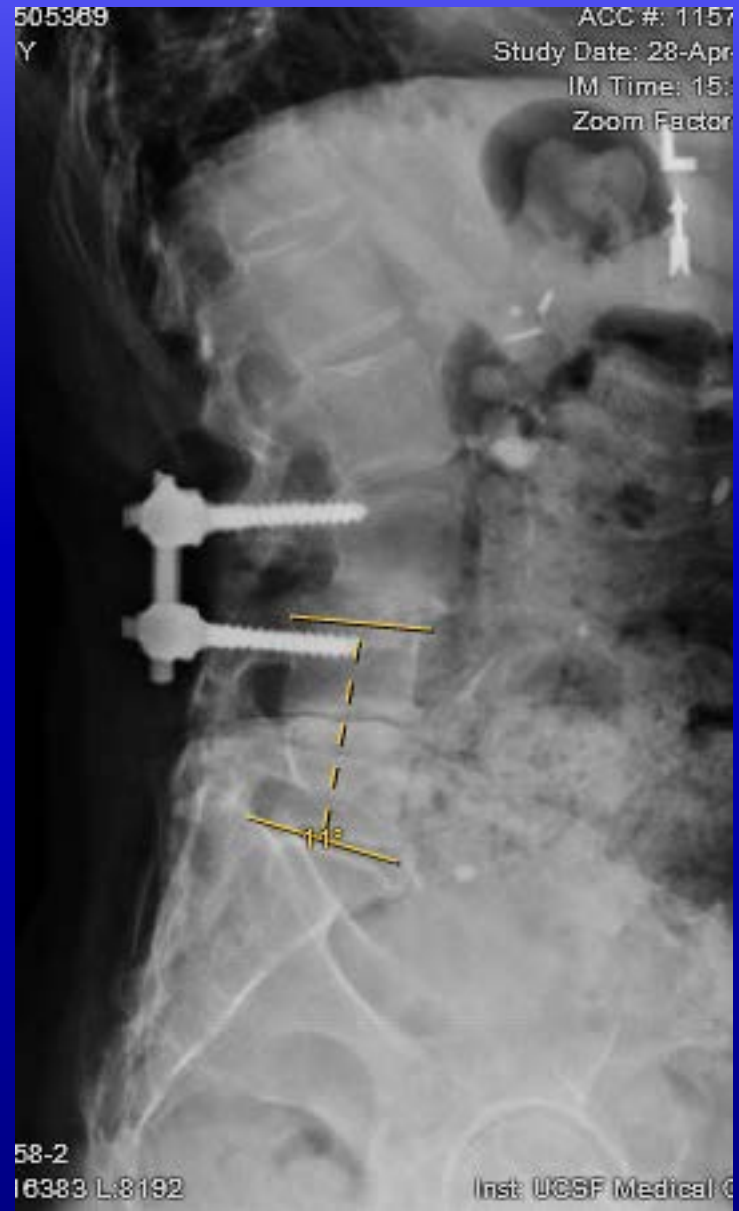
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# Creating Lumbosacral Lordosis in Lumbar Degenerative Pathology

- Circumferential Arthrodesis
  - Anterior and Posterior
  - Transpsoas
  - TLIF/PLIF
- Reduction of Slip Angle in Spondylolisthesis
- Posterior-based 3 column osteotomies

LT. ERECT



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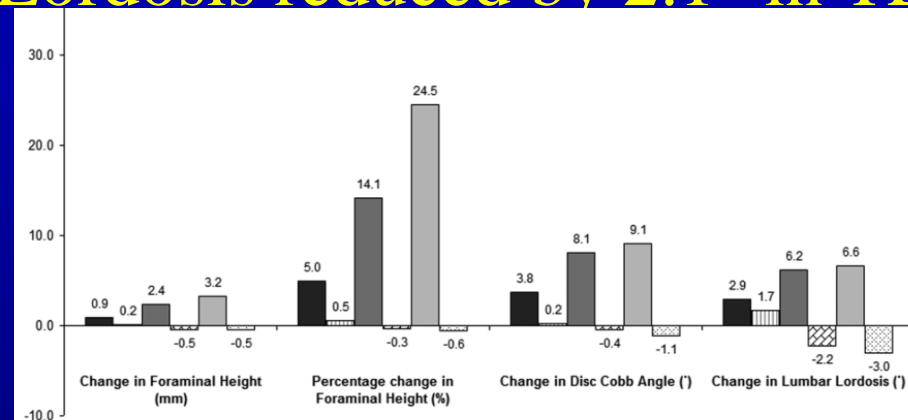
# Anterior lumbar interbody fusion in comparison with transforaminal lumbar interbody fusion: implications for the restoration of foraminal height, local disc angle, lumbar lordosis, and sagittal balance

Patrick C. Hsieh, M.D., Tyler R. Koski, M.D., Brian A. O'Shaughnessy, M.D., Patrick Sugrue, M.D., Sean Salehi, M.D., Stephen Ondra, M.D., and John C. Liu, M.D.

**Journal of Neurosurgery: Spine**

October 2007 / Vol. 7 / No. 4 / Pages 379-386

- Retrospective study of 32 pts with ALIF and 20 with TLIF
- ALIF is superior to TLIF:
  - Increased foraminal height by 18.5% vs -0.4%
  - Segmental Lordosis increased by 6.2° in ALIF
  - Segmental Lordosis reduced by 2.1° in TLIF.



■ ALIF L3-4 □ TLIF L3-4 ■ ALIF L4-5 ▨ TLIF L4-5 ■ ALIF L5-S1 ▨ TLIF L5-S1

# Comparison of outcomes of anterior-, posterior- and transforaminal lumbar interbody fusion surgery at a single lumbar level with degenerative spinal disease

Nam Lee, MD, Keung Nyun Kim, MD, PhD, Seong Yi, MD, PhD, Yoon Ha, MD, PhD, Dong Ah Shin, MD, PhD, Do Heum Yoon, MD, PhD, Keun Su Kim, MD, PhD

World Neurosurgery

Available online 9 February 2017

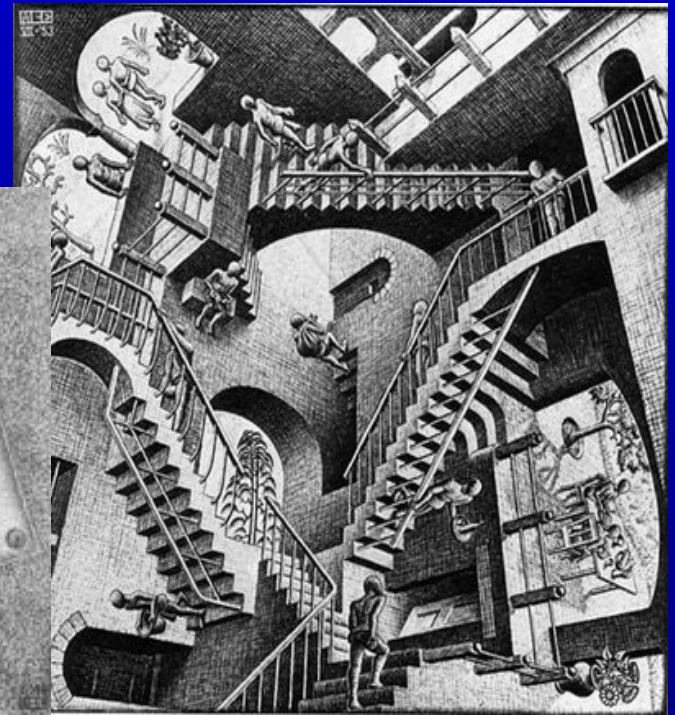
- 77 patients with lumbar degenerative pathology including spondylolisthesis
  - ALIF- 26 patients
  - TLIF- 21 patients
  - PLIF- 30 patients
- Improvement in Segmental Lordosis best with ALIF
  - 4degrees vs 0 degrees
- Fusion rates similar
- Improvement in VAS best with TLIF
- Equipoise regarding overall outcomes

# TLIF Paradox

- Anterior Placement of Cage to Optimize Segmental Lordosis
  - Cantilever Technique
- Maintenance of Foraminal Volume
- Safety of Neural Elements during cage insertion



"Everything's a tradeoff — now that I can walk upright, I can't wiggle my ears any more."



# Limitations of TLIF

- Neural Complications
  - Direct injury
  - Implant migration
- Limited restoration of lordosis
- Technique Matters



# Radiographic Analysis of Transforaminal Lumbar Interbody Fusion for the Treatment of Adult Isthmic Spondylolisthesis

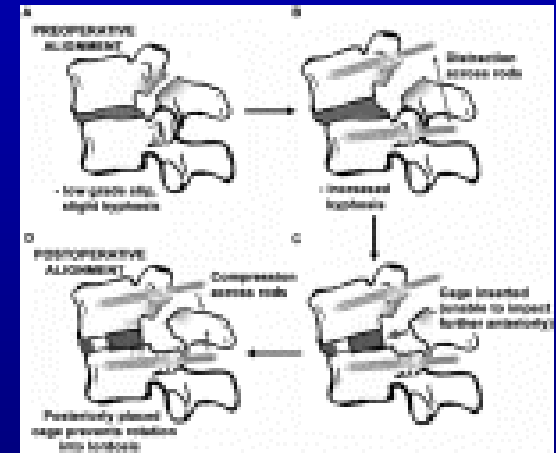
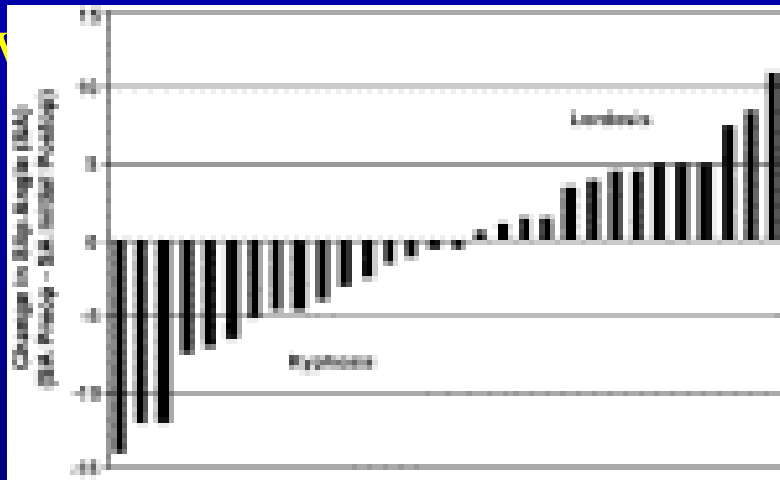
Kwon, Brian K.\*‡; Berta, Scott\*; Daffner, Scott D.\*; Vaccaro, Alexander R.\*†; Hilibrand, Alan S.\*; Grauer, Jonathan N.\*; Beiner, John\*; Albert, Todd J.\*

October 2003 - Volume 16 - Issue 5 - pp 469-476



## Journal of Spinal Disorders & Techniques

- Retrospective Study Design
- 35 Consecutive patients with Isthmic Spondylolisthesis
- Limited Improvement of sagittal alignment or slip angle









# Transforaminal Anterior Release for the Treatment of Fixed Sagittal Imbalance and Segmental Kyphosis, Minimum 2-Year Follow-Up Study

Fred A. Sweet, MD<sup>a,\*</sup>, Andrea Sweet, BS<sup>b</sup>

<sup>a</sup>Rockford Spine Center, 2902 McFarland Rd, Suite 300, Rockford, IL 61107, USA

<sup>b</sup>University of Missouri, Columbia, MO 65211, USA

Spine Deformity 3 (2015) 502–511

- 47 Consecutive patients treated with TFAR for management of Sagittal Plane Deformity
  - Transforaminal Anterior Release
- 13-32 degree improvement in segmental lordosis
- 36 degree increase in regional lordosis
- 8% Nonunion

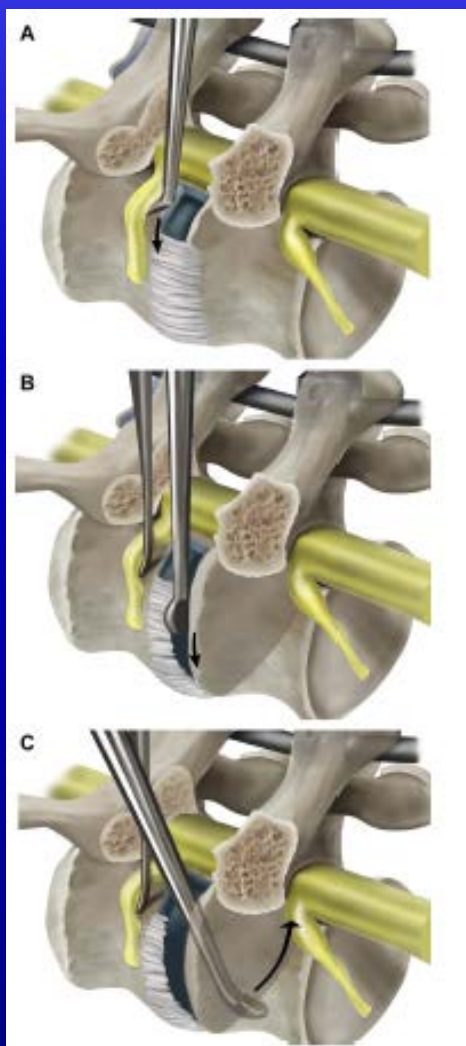
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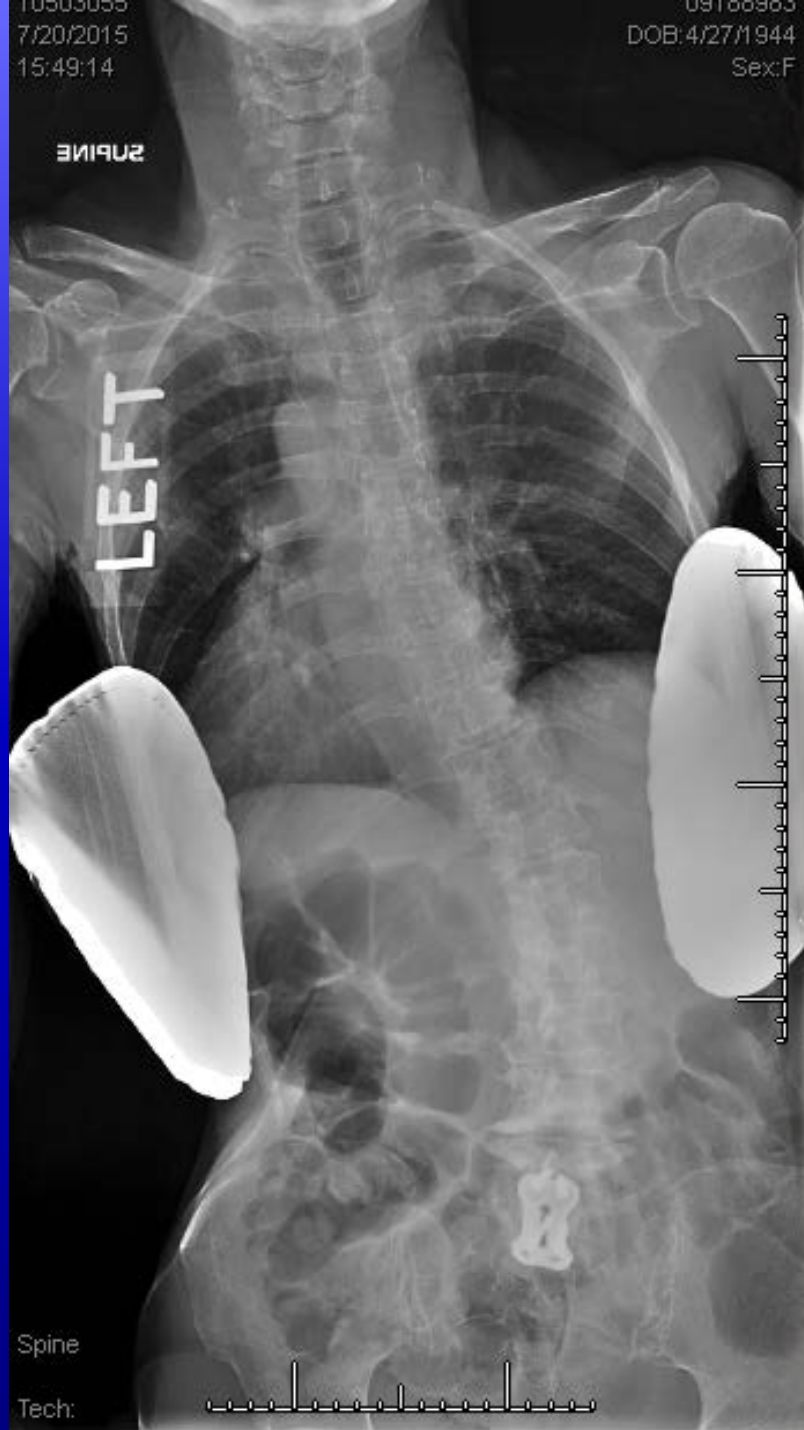


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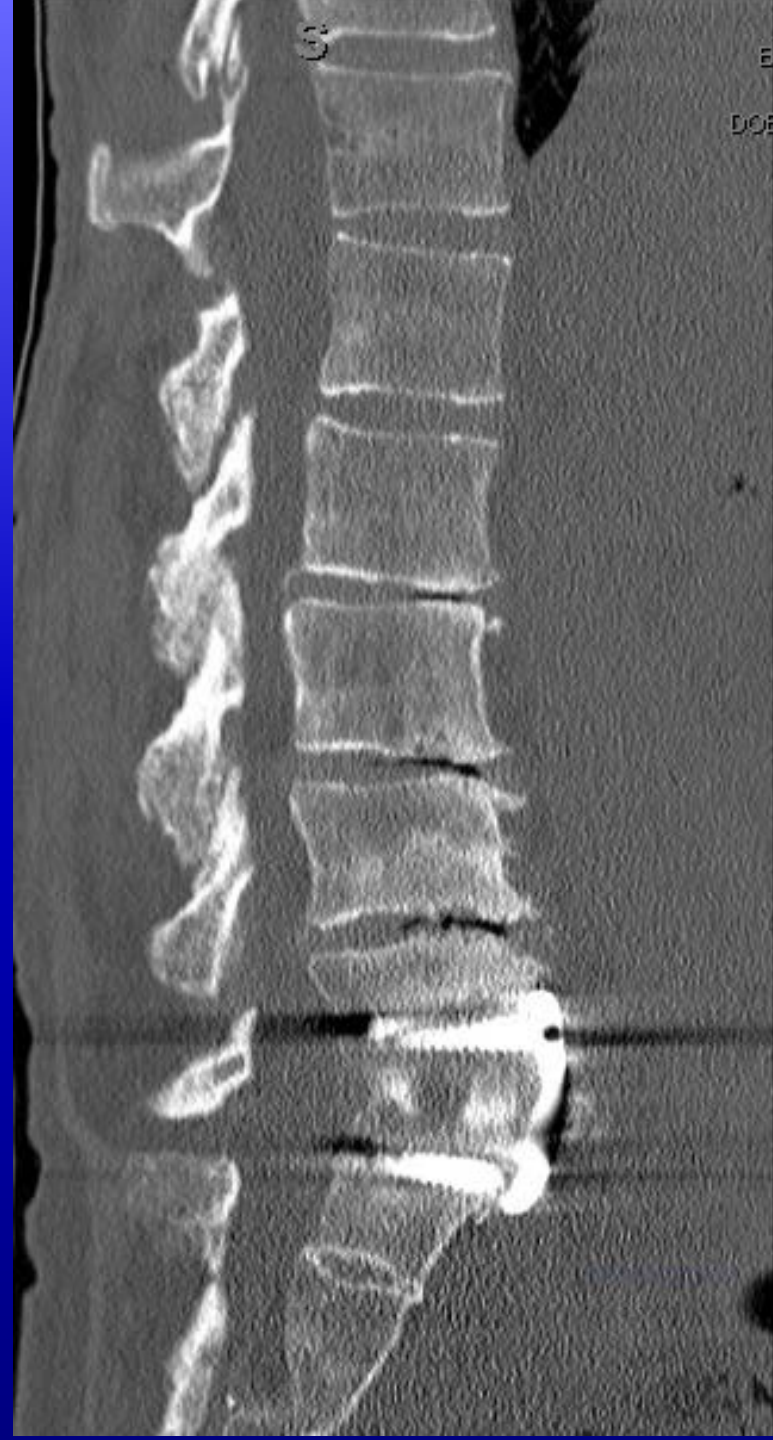


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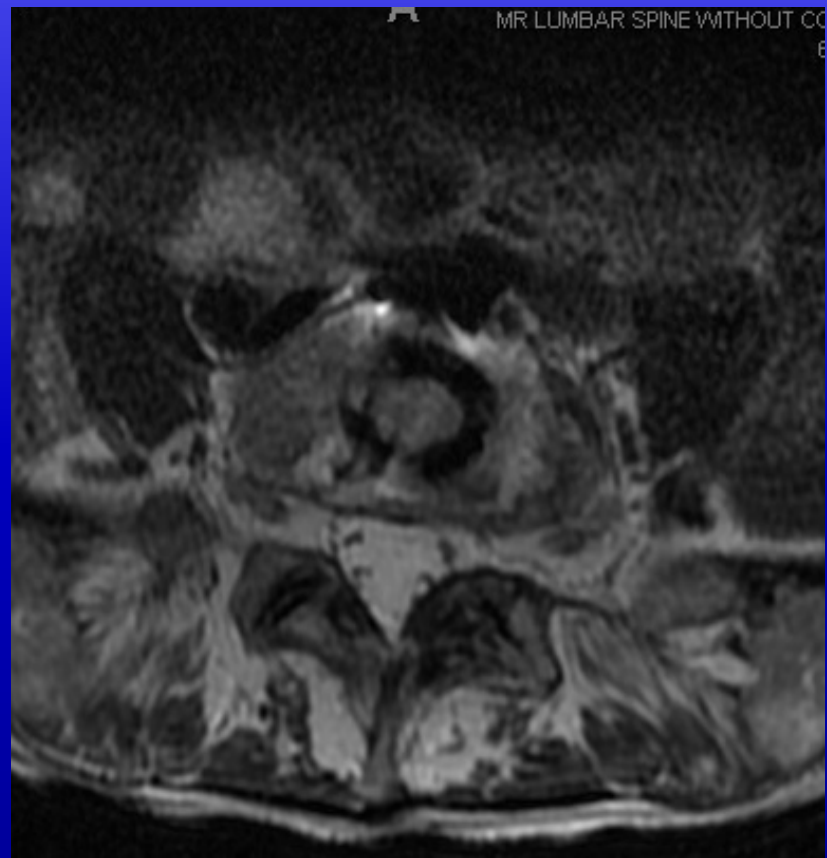
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fingers on clavicles  
knees, hips fully extended









# Intraoperative xray after facetectomies

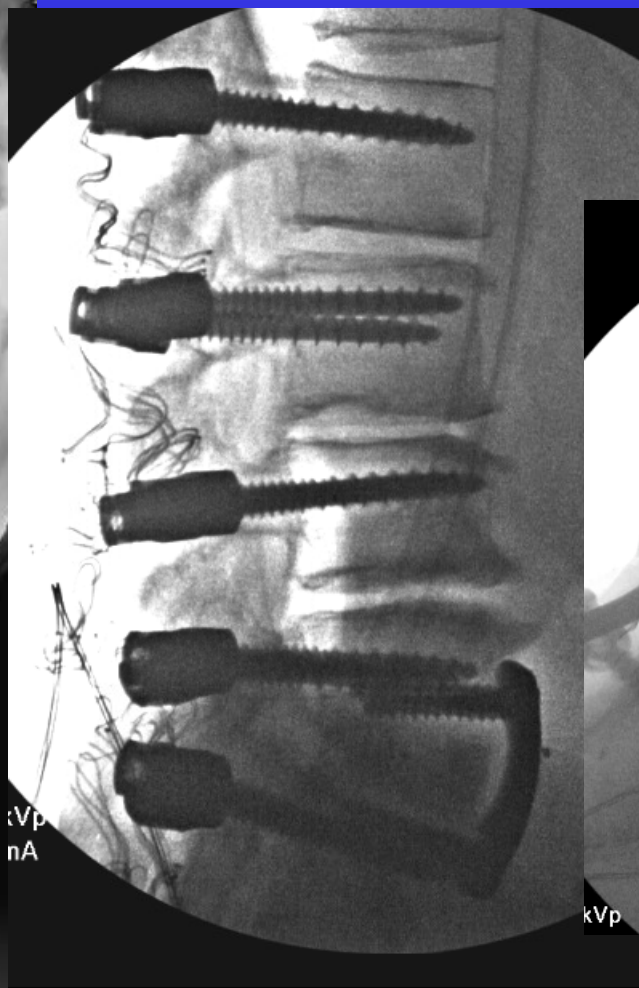


*After TLIF at L4-5*

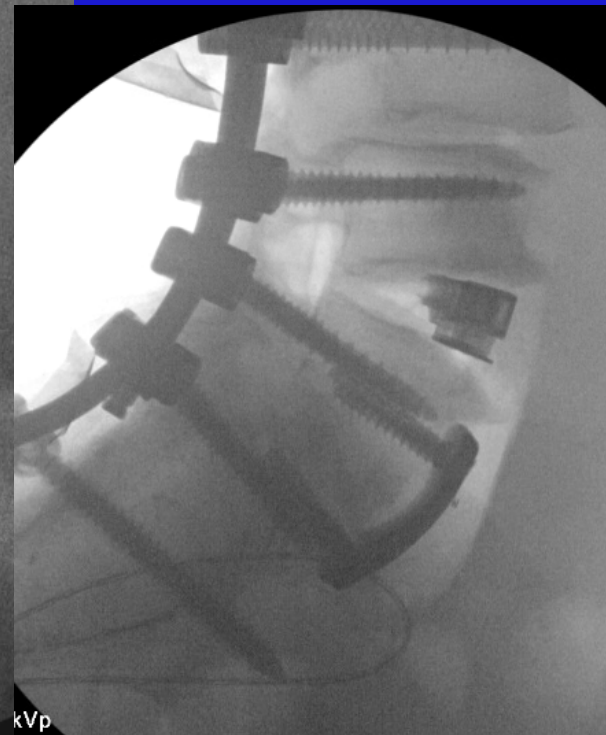
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fingers on clavicles  
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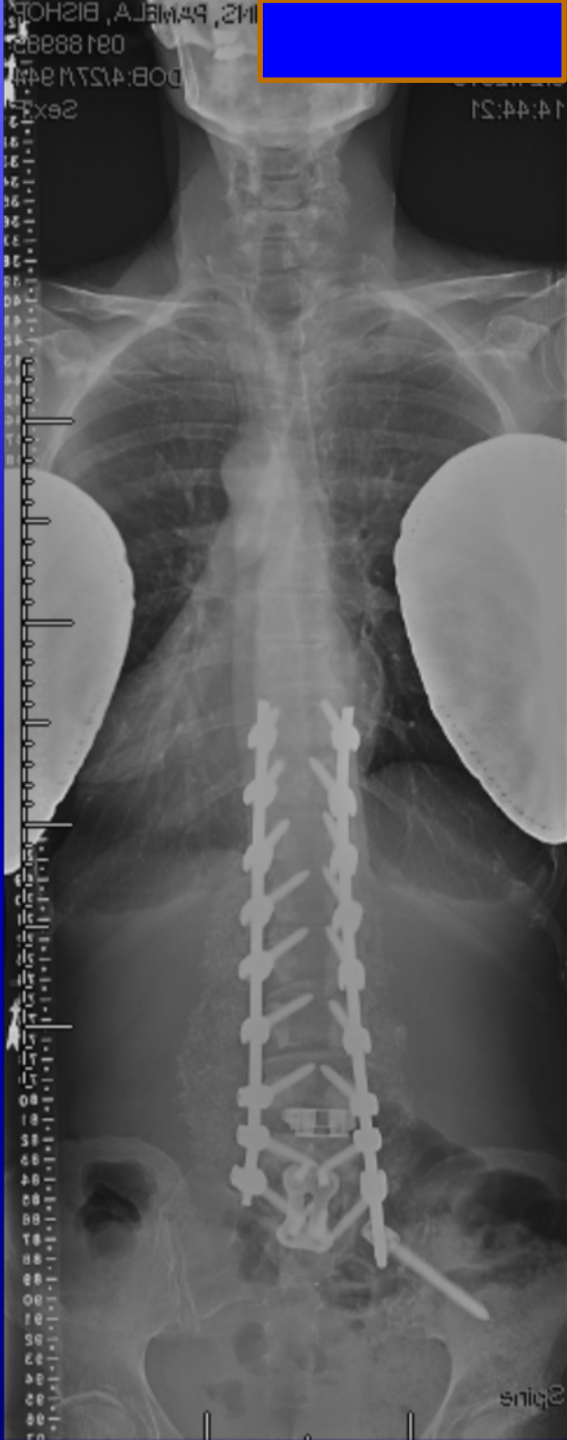


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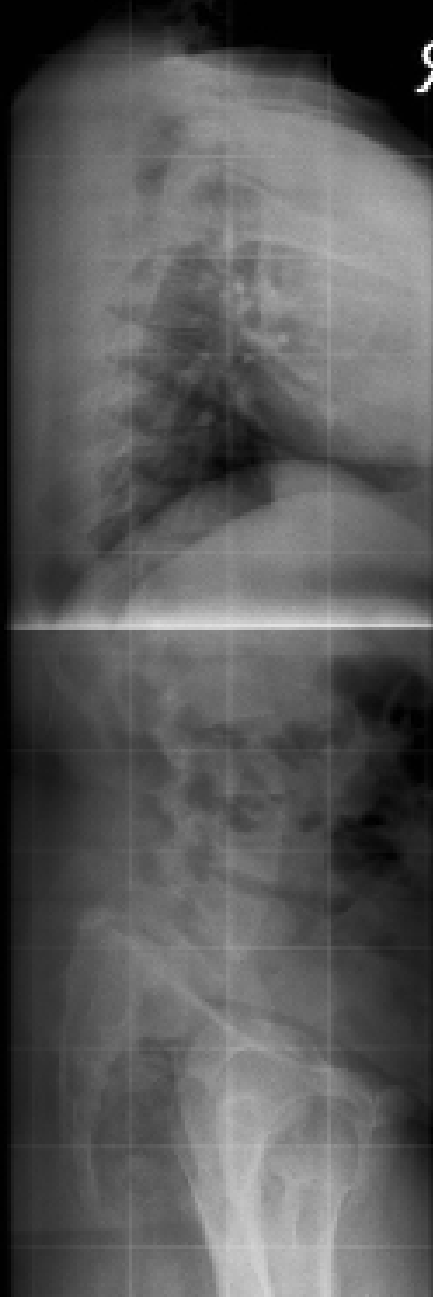


# Creating Lumbosacral Lordosis

- Reduction of Slip Angle in Spondylolisthesis
- Circumferential Arthrodesis
  - Anterior and Posterior
  - Transpsoas/Antepsoas
  - TLIF/PLIF
- Posterior-based 3 column osteotomies

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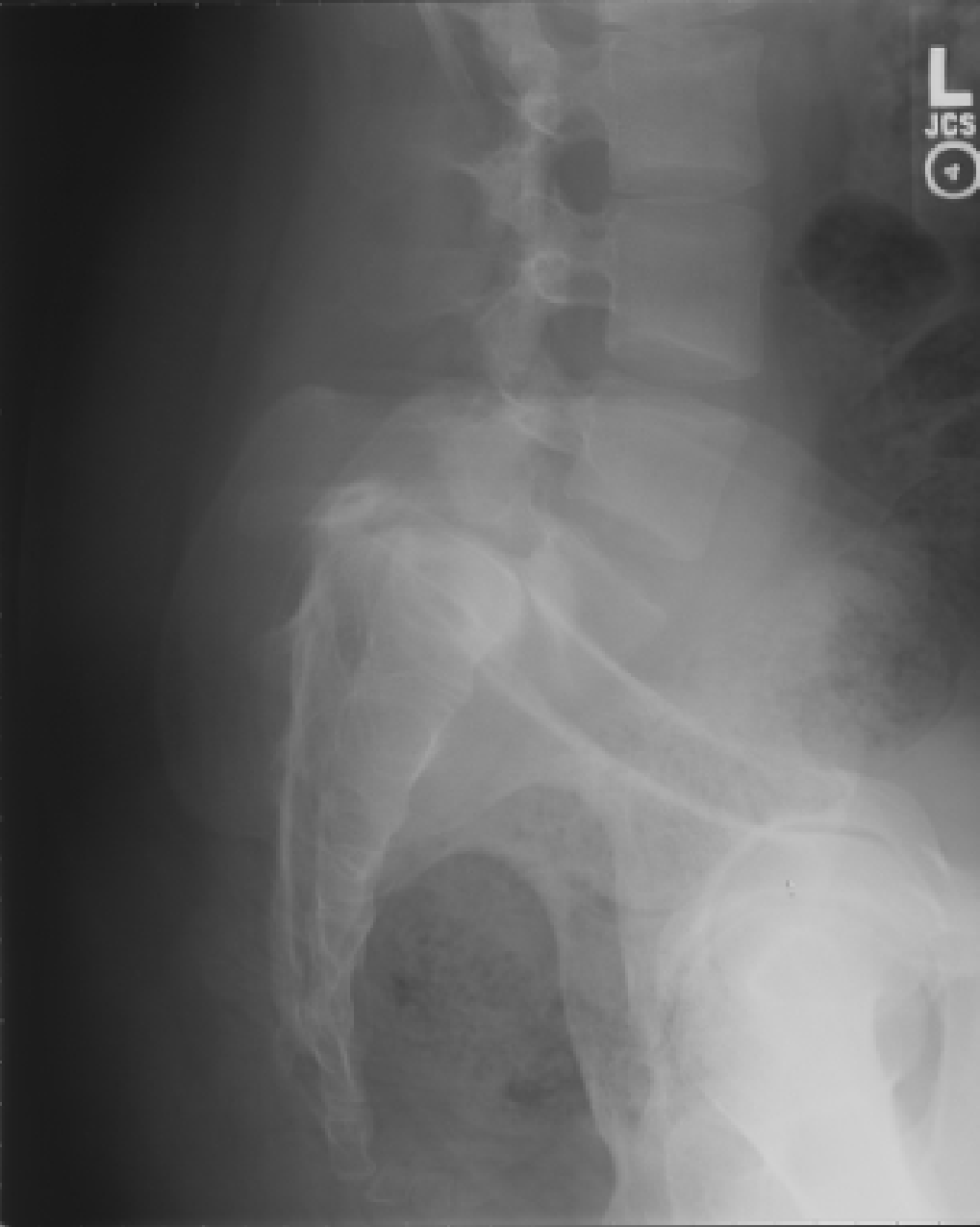
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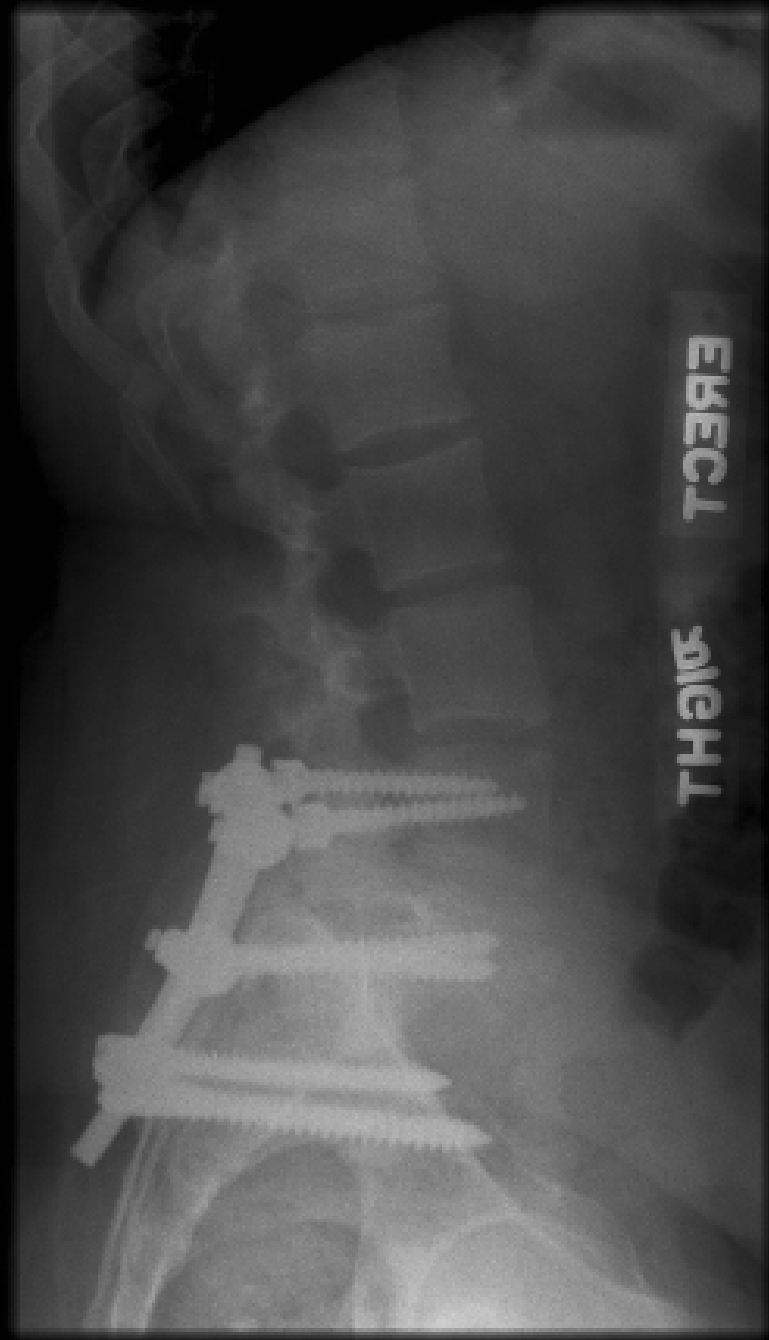
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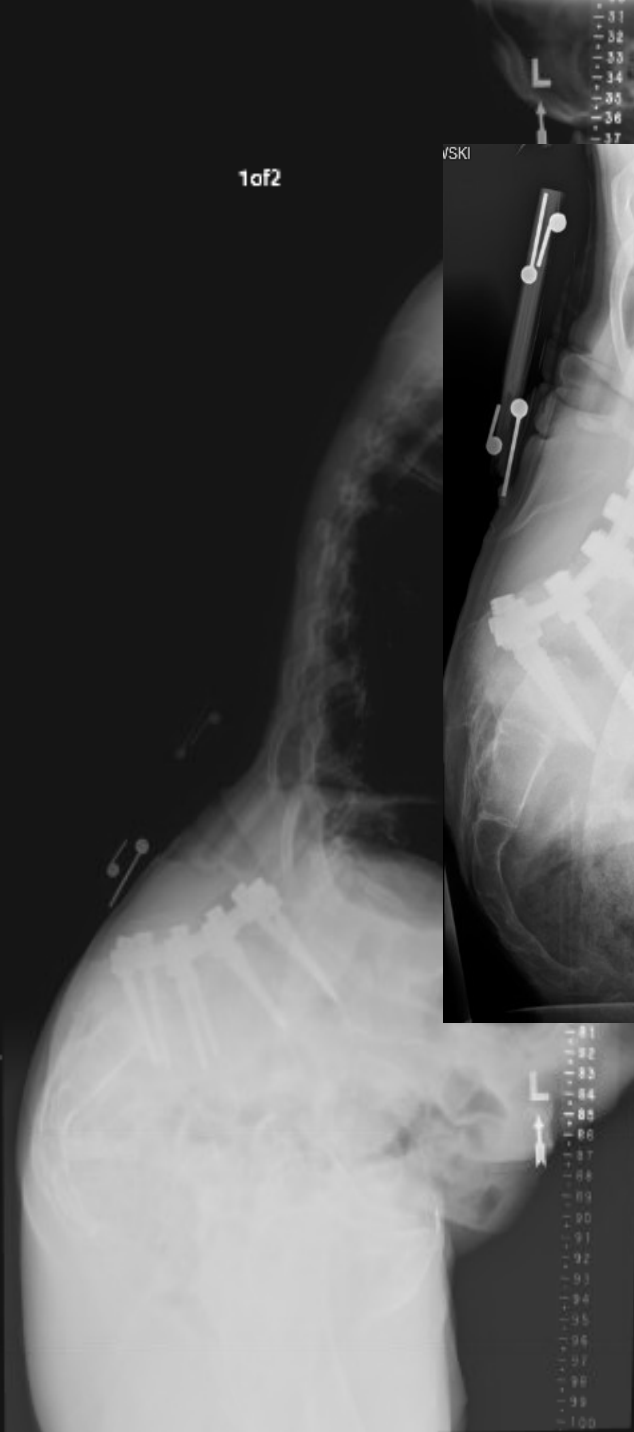
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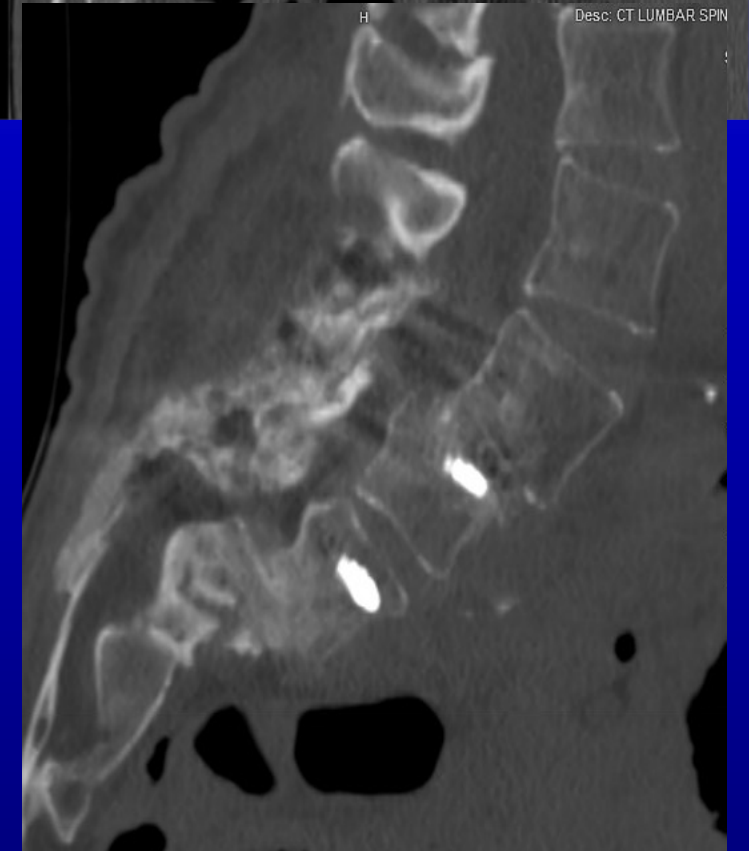
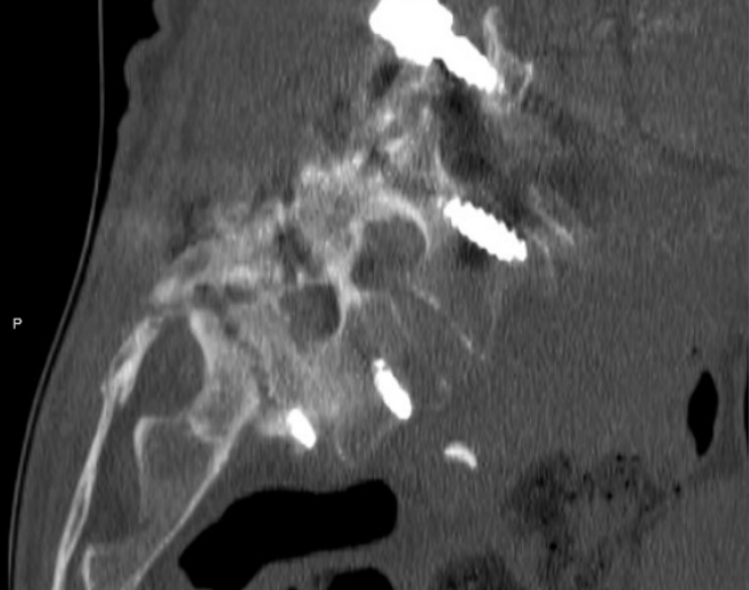


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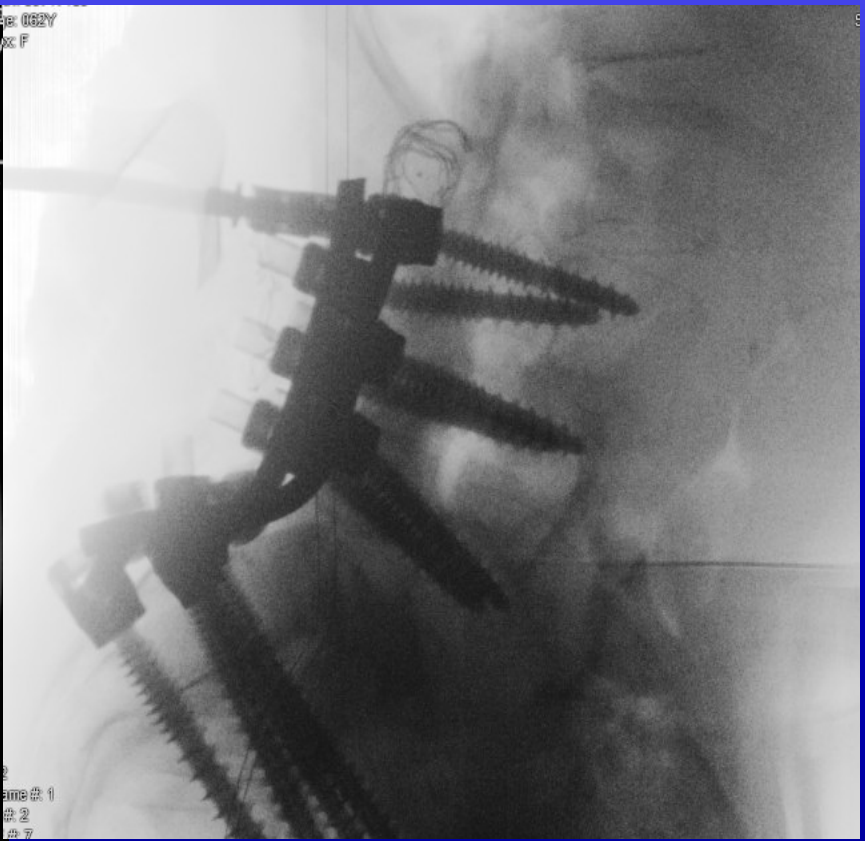
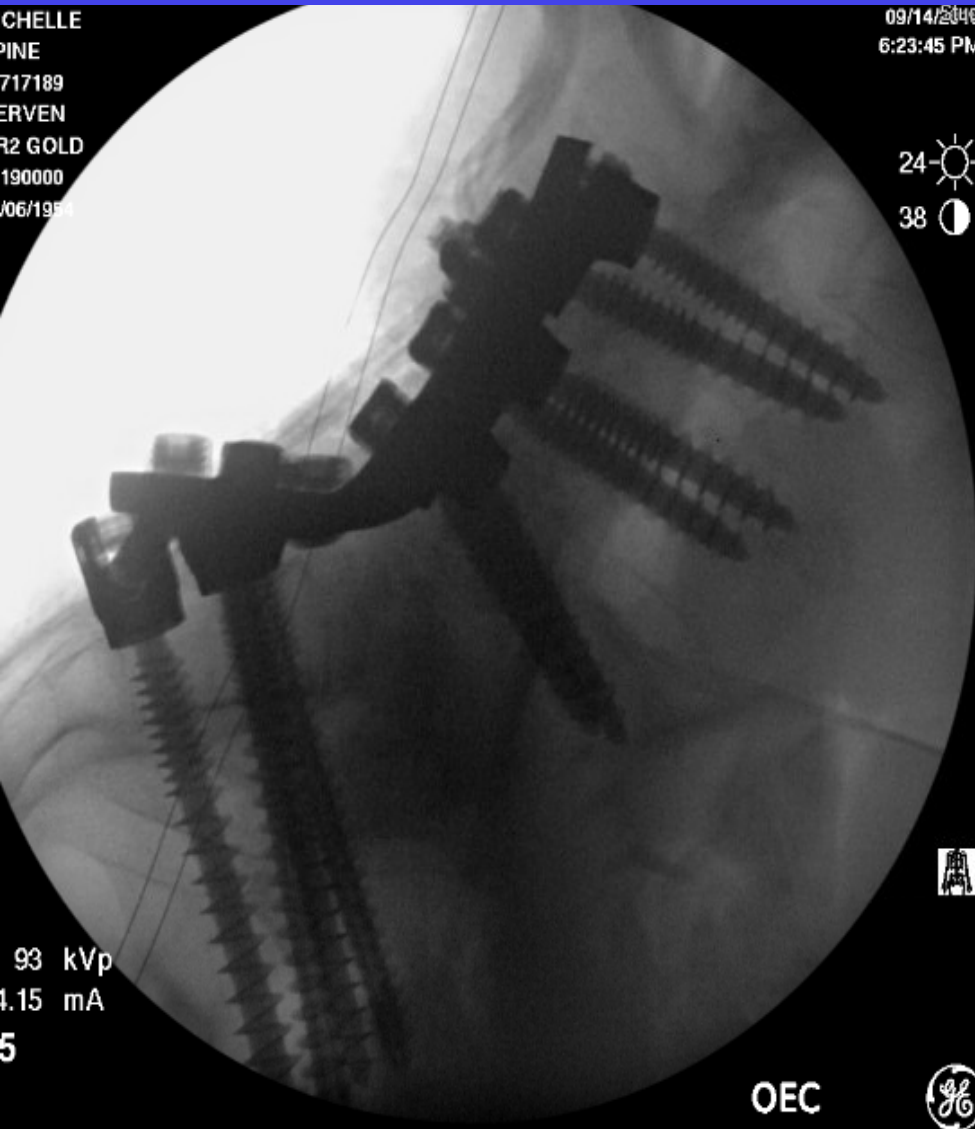


- SVA= 24cm
- LL= 68degrees
- PI= 90degrees
- L5 incidence 84 degrees

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93 kVp  
1.15 mA  
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# Conclusions

- Lumbar degenerative pathologies are associated with significant loss of lordosis at L4-S1
- Recognition and correction of deformity at the segmental level in degenerative pathology is important to avoid the creation of more severe global deformity
- Techniques to create and restore lumbosacral lordosis are important in optimal management of lumbar degenerative disorders



UCSF Center for Outcomes Research