



# Strategies For Sagittal Alignment

9<sup>th</sup> Annual Spine Symposium

Deer Valley

Jeremy Smith, MD

Orthopaedic Spine Surgery

Orthopaedic Specialty Institute

Director, Hoag Orthopaedic Institute Spine Fellowship

- Research/Institutional support:
  - Nuvasive
- Consultancies/Scientific Advisory:
  - Nuvasive, Spineart
- Royalties:
  - Nuvasive, Spineart

# Why Alignment Matters

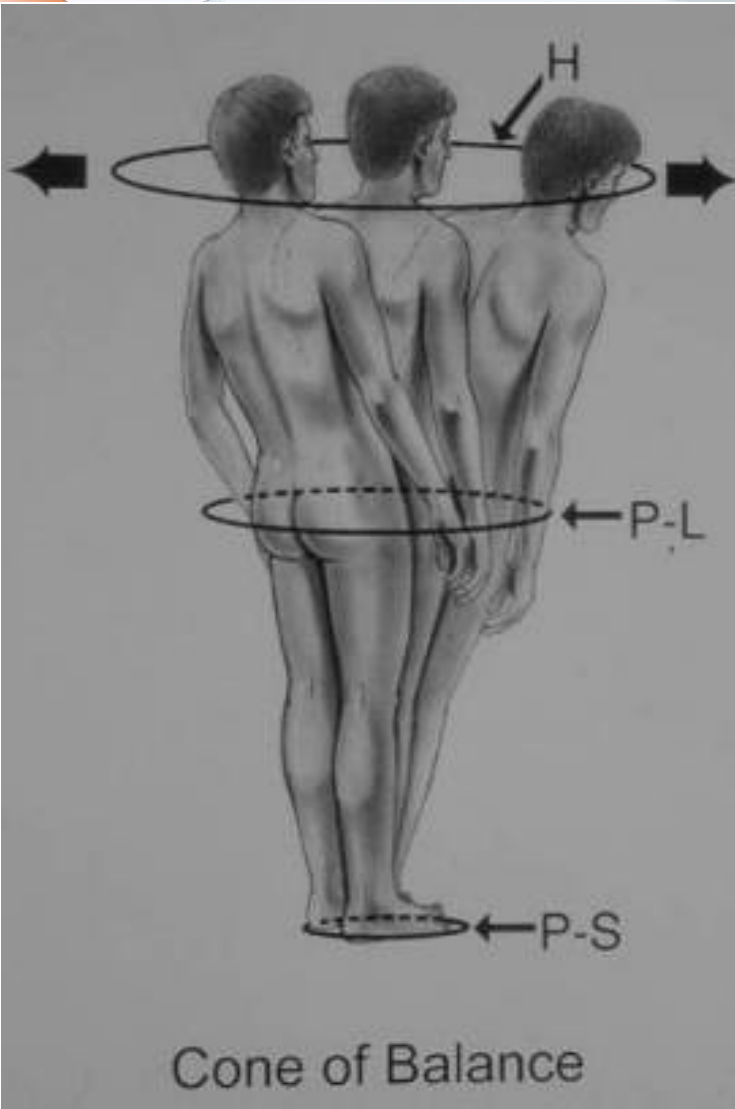
## Goals of Spinal Surgery:

- Decompress, relieve symptoms
- Stabilize, when unstable
- *Preserve or restore alignment*



COMPENSATED  
ALIGNMENT

# Why is Alignment Important



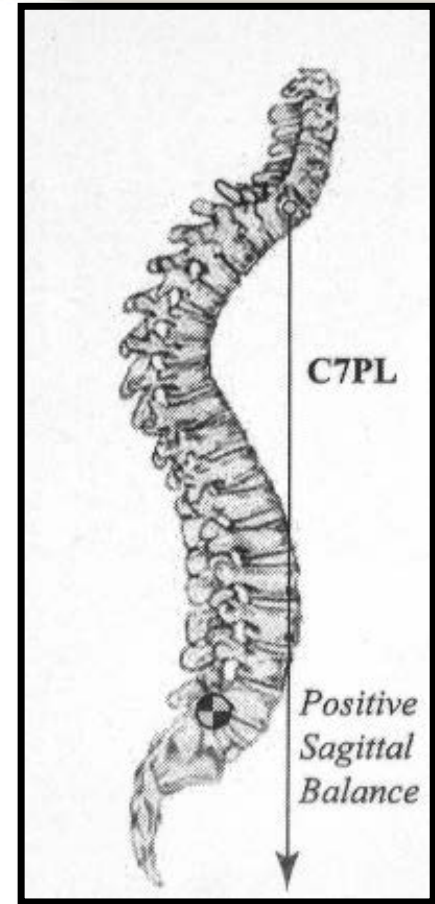
- A stable zone in which standing requires limited energy expenditure
- Poor alignment = disability
- Must compensate for anatomic deformation

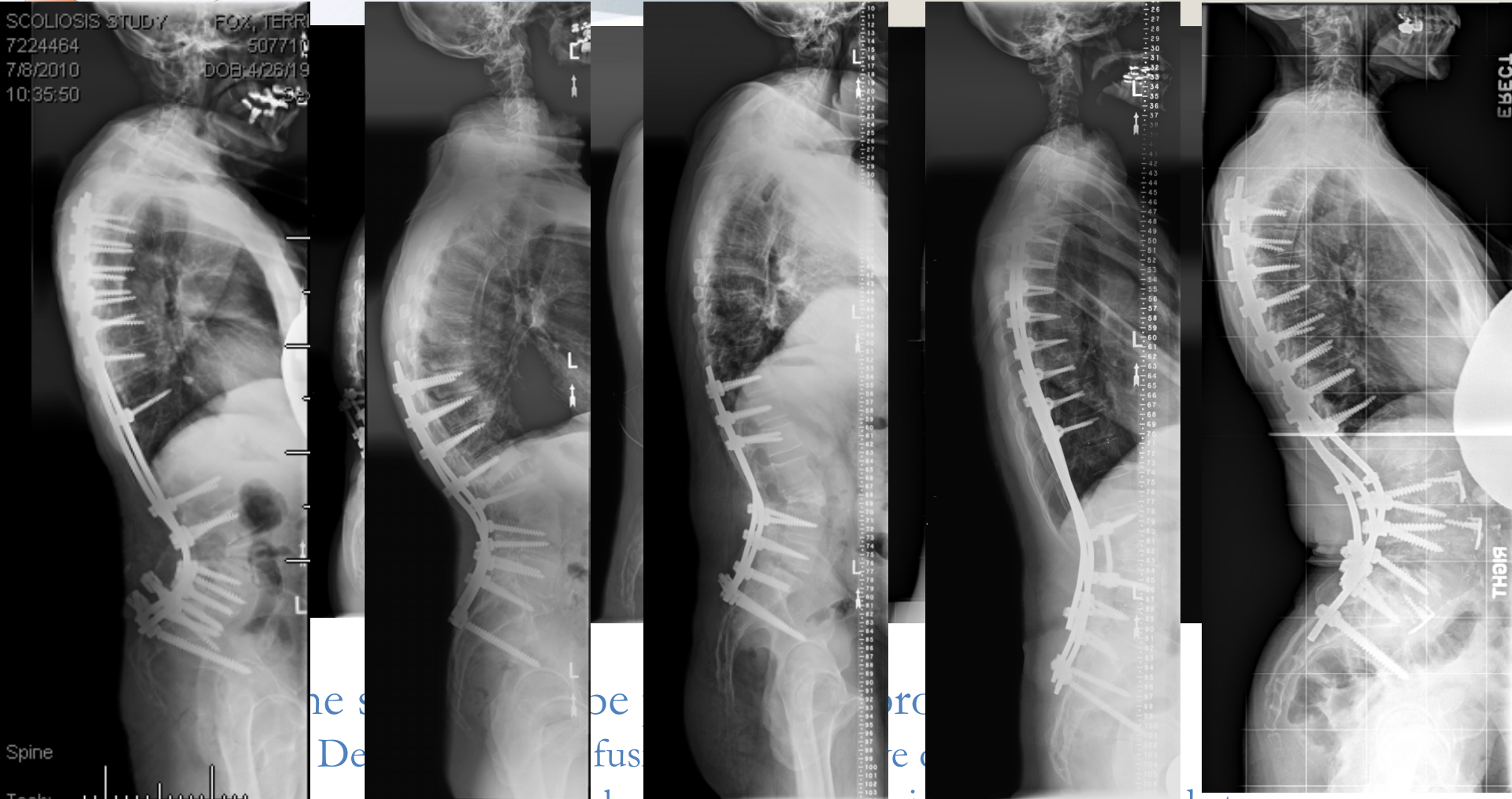
Deviation from stable zone = Increase  
Muscular / energy use

## Plumbline Shift Anteriorly



- Increasing disability
  - SF-12, SRS-29, ODI ( $p < 0.001$ )
- Lumbar kyphosis marked disability
  - SRS-29, ODI ( $p < 0.05$ )

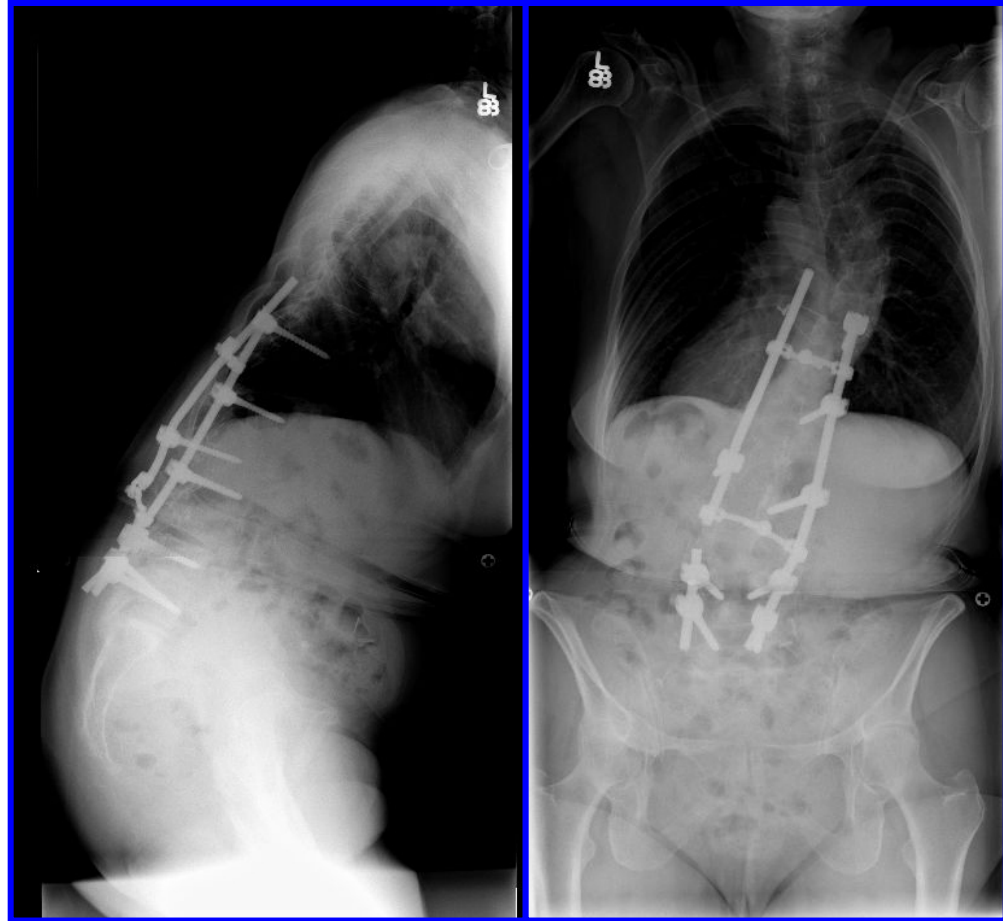




Failure to consider global balance as well as regional balance leads to poor outcomes

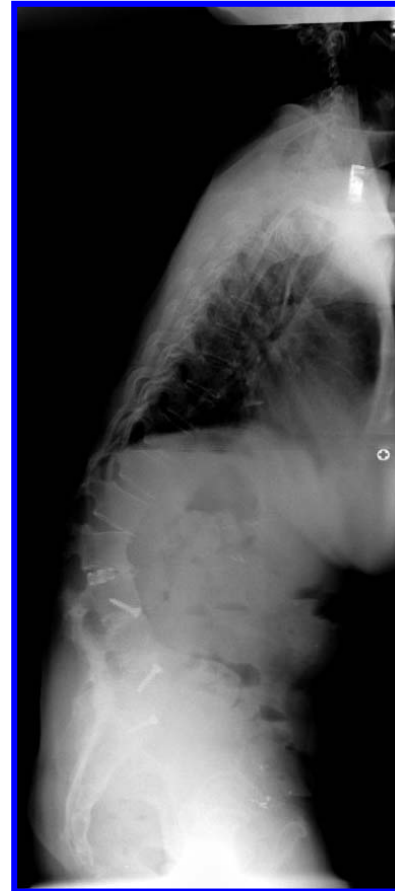
# Sagittal Balance

- Surgery that corrects neural impingement or spinal instability but causes poor sagittal or coronal balance = bad result



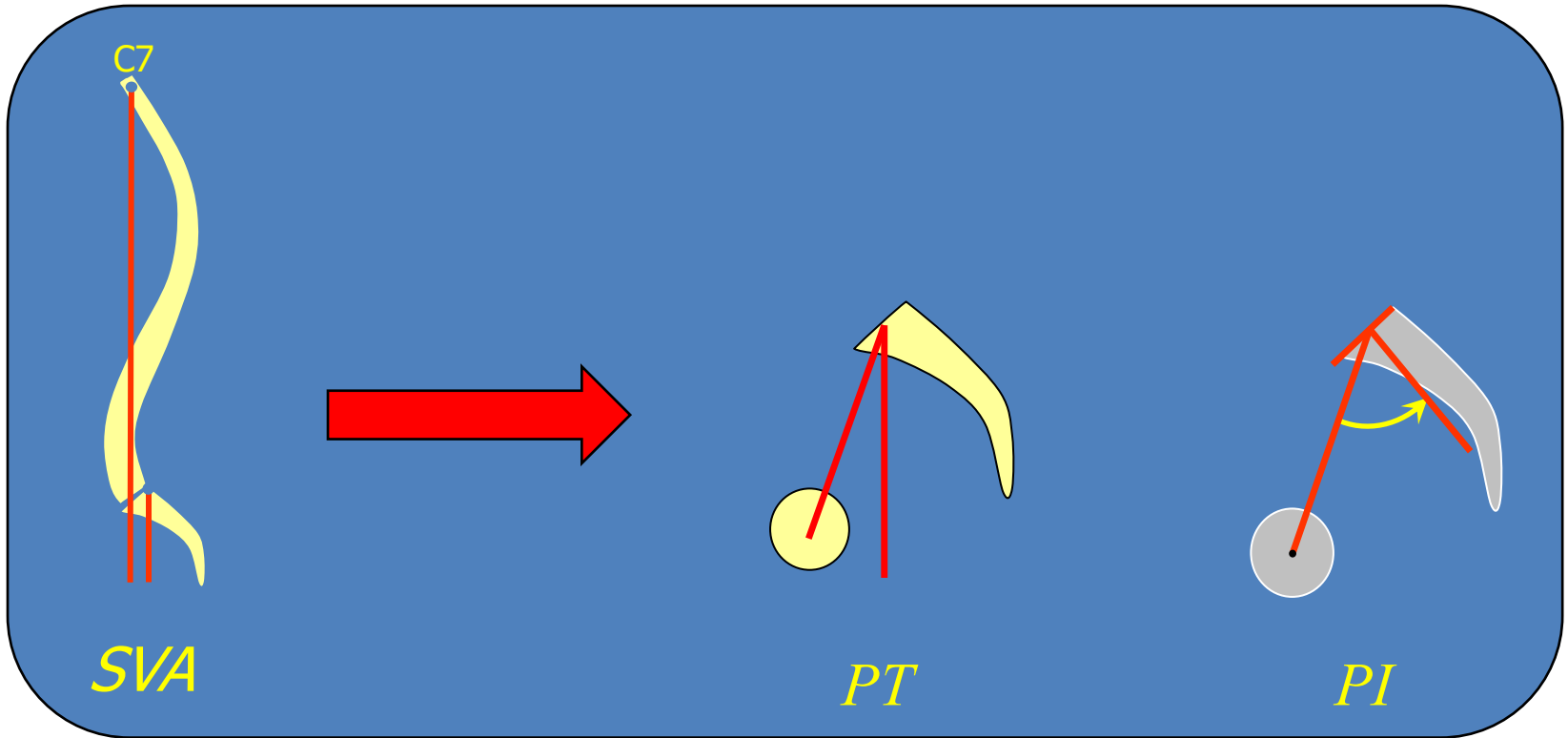
# Prevention

- With attempted correction of sagittal imbalance, 47% of patients have residual sagittal deformity
- Complication rates for revision spinal fusion are as high as 60%
- Treatment of iatrogenic flat-back should begin with prevention





# Parameters of Sagittal Alignment



*SVA*

*PT*

*PI*

< 5cm

< 25°

Proportional:  
 $LL = PI \pm 9^\circ$

# Degenerative Surgical Candidates



**ALIGNED**  
**PI-LL= <10°**



**COMPENSATED**  
**PI-LL= 10 to 20°**



**DECOMPENSATED**  
**PI-LL= >20°**

- Sagittal Plane
  - Pelvic retroversion
  - Knees bent
  - Thoracic hypokyphosis
  - Cervical or Occipital Cervical hyperlordosis



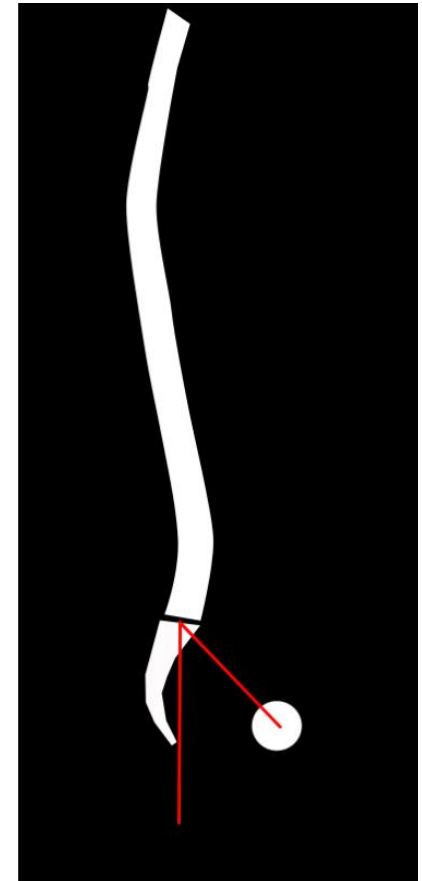
# Assessment of Spinal Alignment

## Pelvic Tilt ... a compensatory mechanism

When the SVA increases, it is expected to have an increase in Pelvic Tilt, unless the patient is unable to compensate.

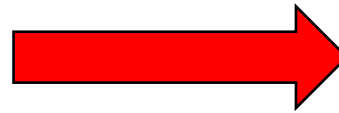
➤ *Aging*

➤ *Hip Disease*



# Assessment of Spinal Alignment

Pelvic Tilt ... a compensatory mechanism



Add knee flexion



# Considerations

- Age/comorbidities
- Magnitude of correction
- Available disk space
- Supine radiographs (passive correction)
- Correction at lower lumbar levels?

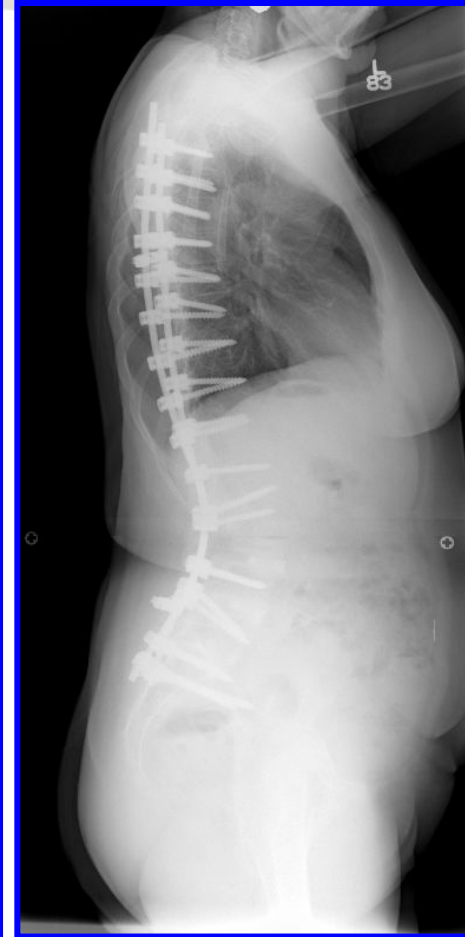
- Posterior
  - PLIF/TLIF
    - Minimal correction ability
  - Osteotomy
    - SPO, PSO, VCR
- Anterior
  - ALIF +/- hyperlordotic
  - Lateral +/- hyperlordotic

- Posterior
  - PLIF/TLIF
    - Minimal correction ability
  - Osteotomy
    - SPO, PSO, VCR
- Anterior
  - ALIF +/- hyperlordotic
  - Lateral +/- hyperlordotic



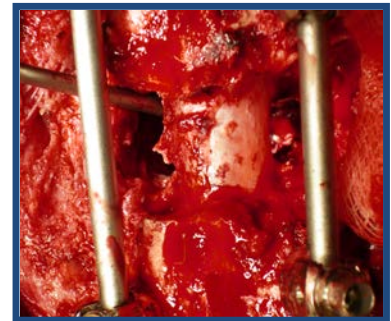
# Osteotomy Options

- Smith-Peterson
- Pedicle Subtraction
- Vertebral Column Resection



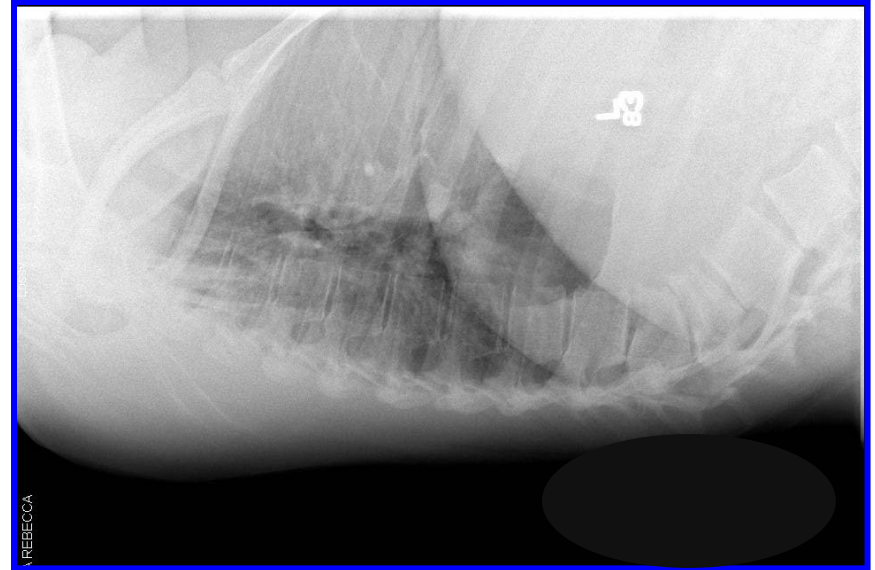
# Osteotomy Choice and Correction

- SPO – 5° to 15° per level
- PSO – 25° to 35° per level
- VCR 40° to 60° per level



# Osteotomy Selection

- Preoperative planning
  - surgimap
- Dynamic radiographs
- Supine/bolster radiographs
- Appearance on intraoperative positioning
- Overcorrection is superior to under

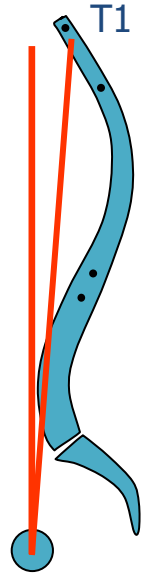


# Alignment objectives



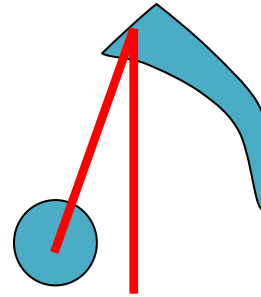
SVA

**<5cm**



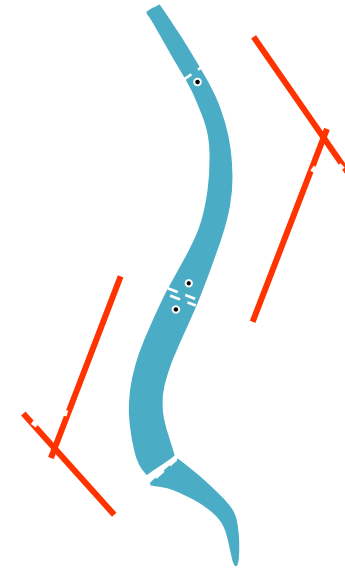
T1 Tilt

**<0°**



PT

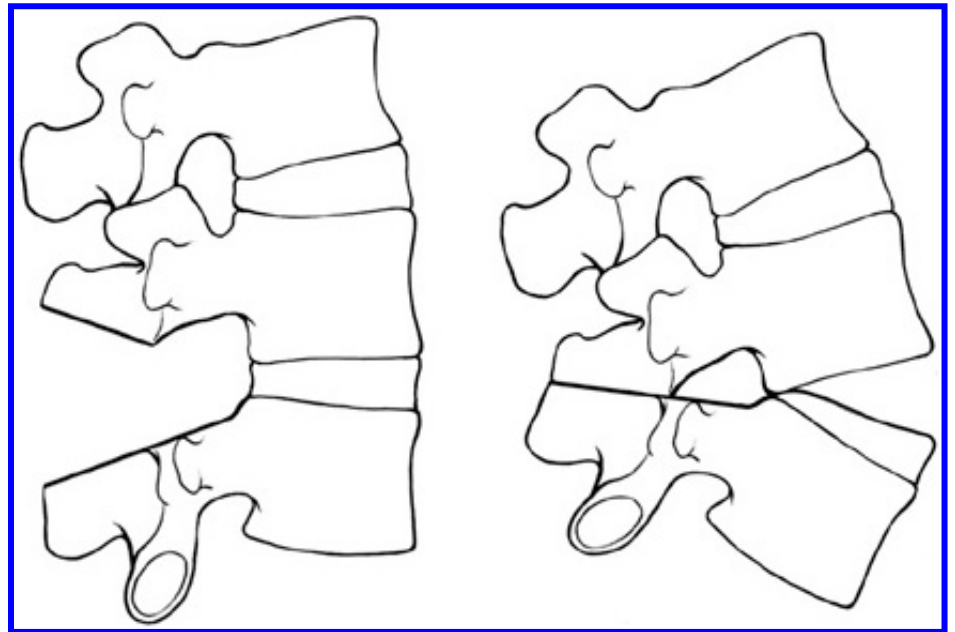
**<25°**

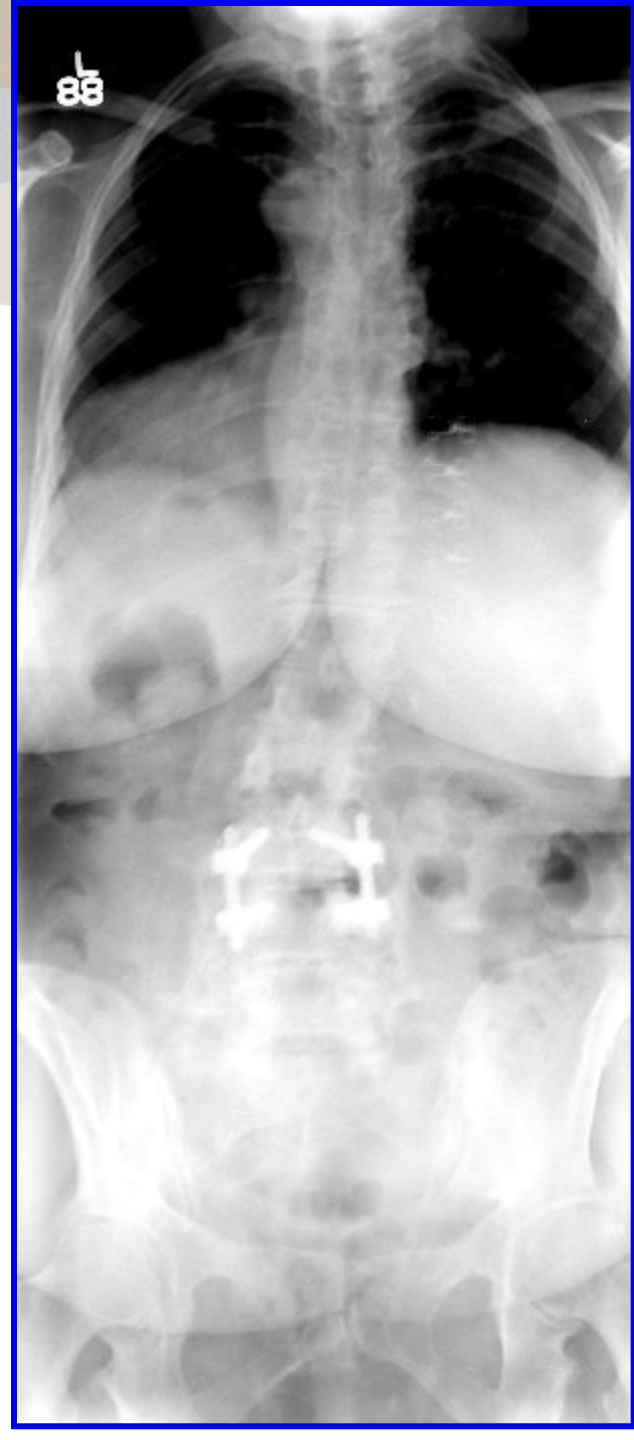
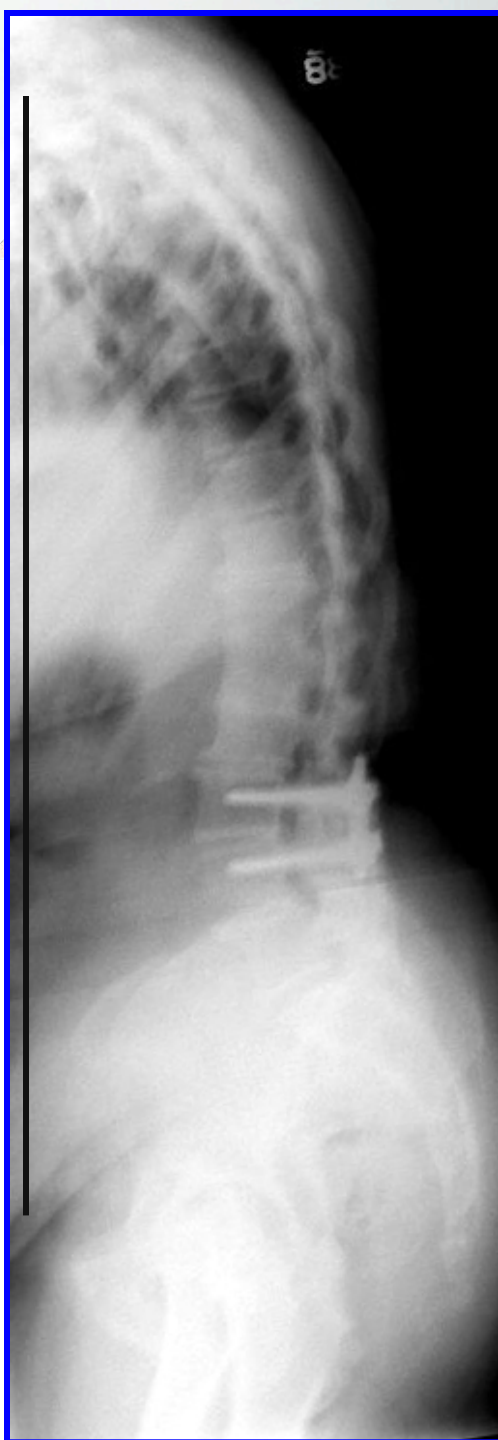


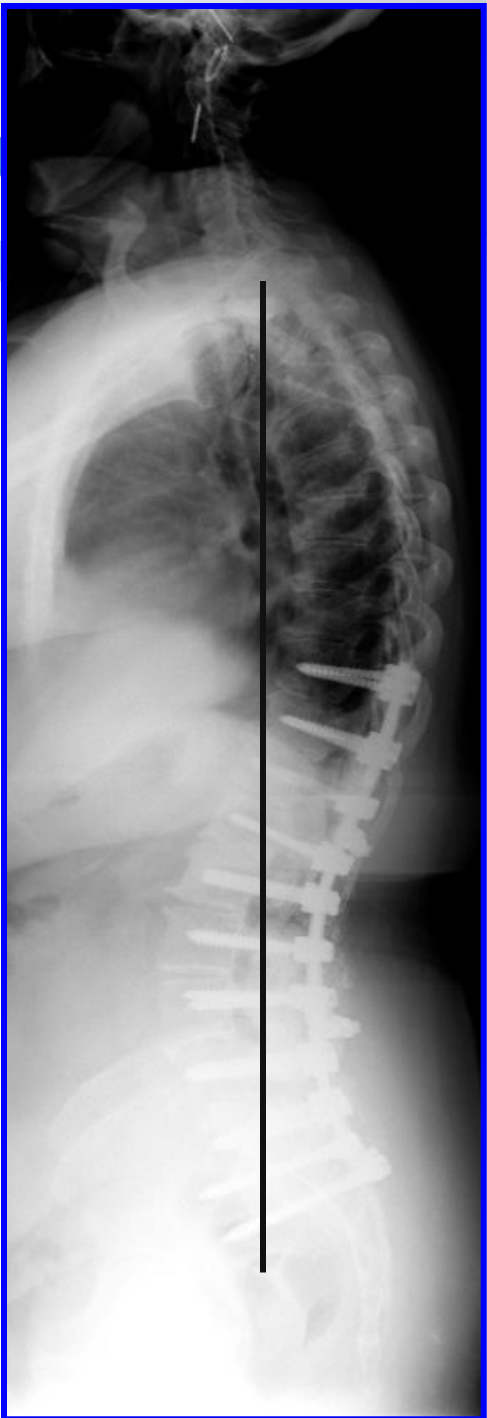
Proportional:  
**LL=PI +/- 90°**

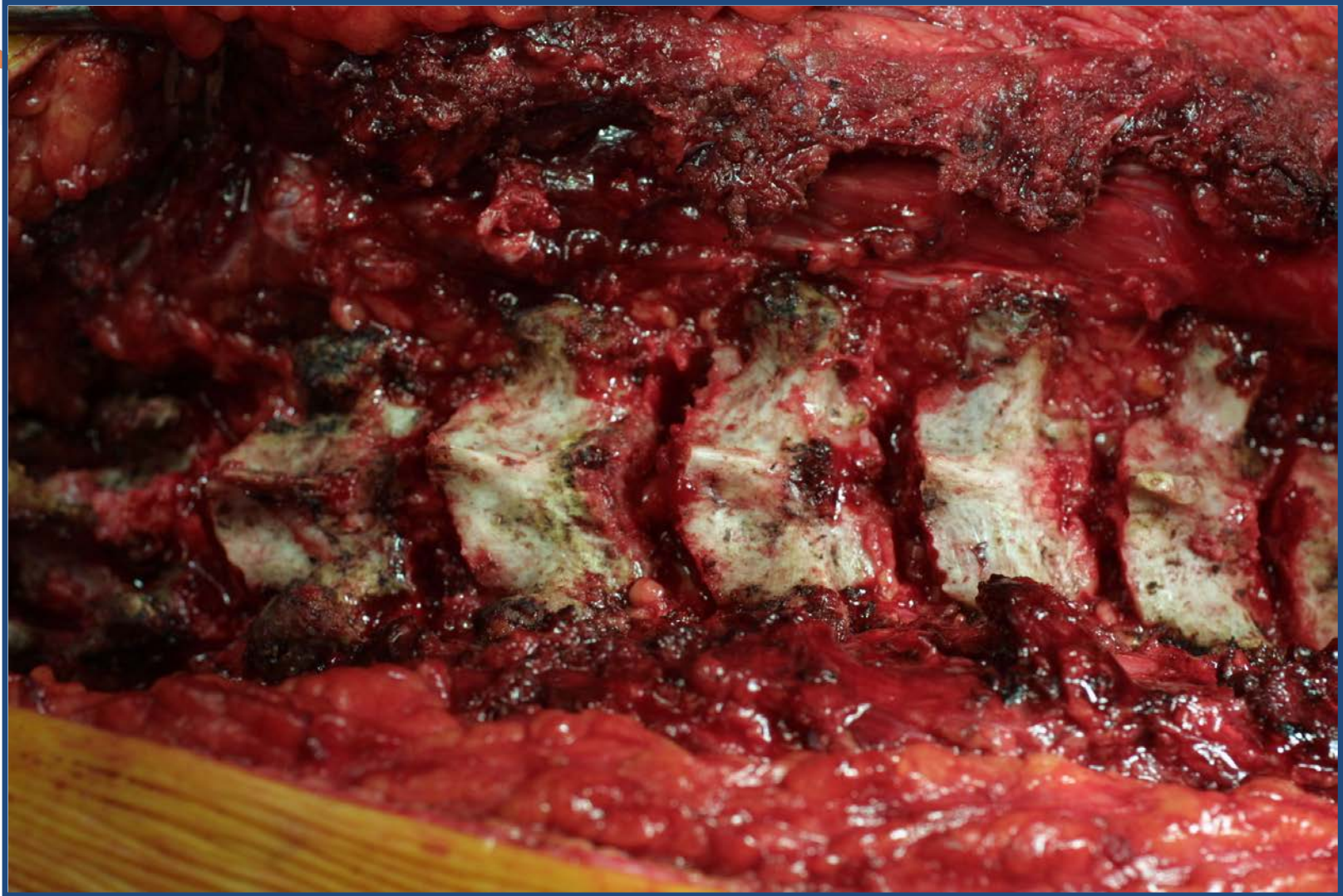
# Osteotomy Options

- Extension (Smith-Peterson) osteotomy
  - Shorten the posterior column and lengthen the anterior column
  - Wide bilateral foraminotomy
  - Opening through disc space and ALL





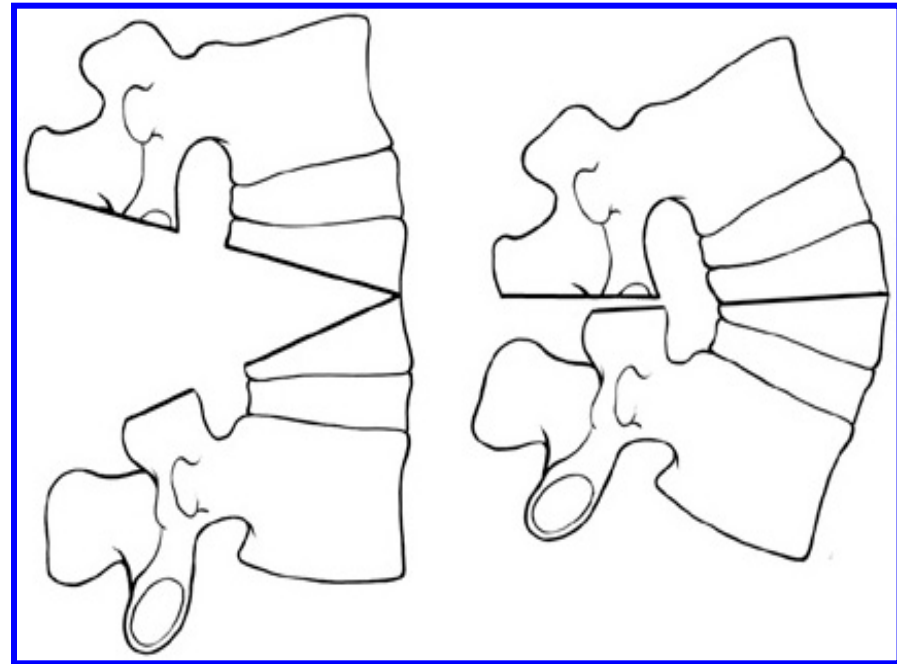




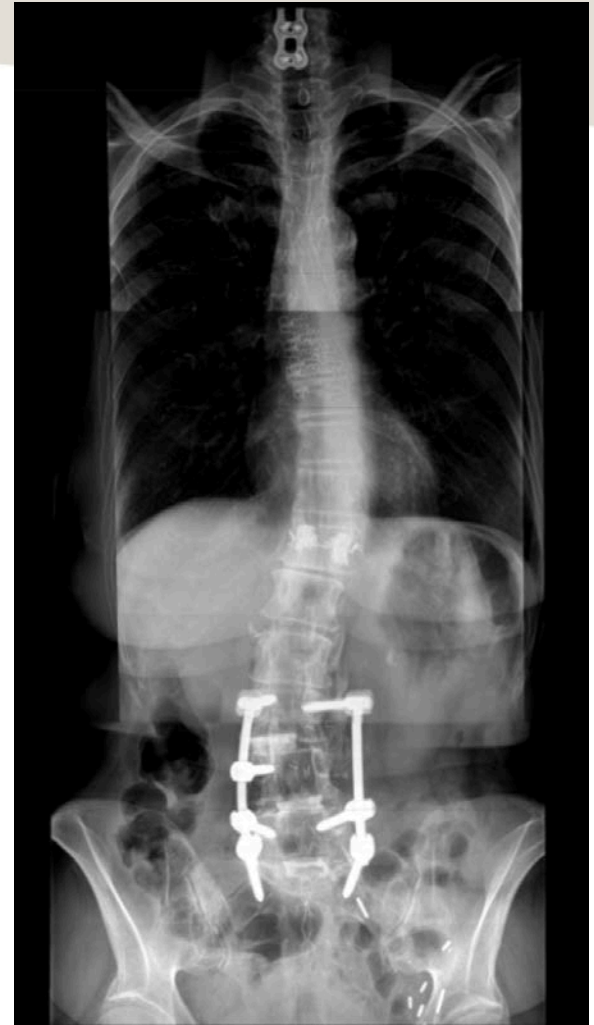


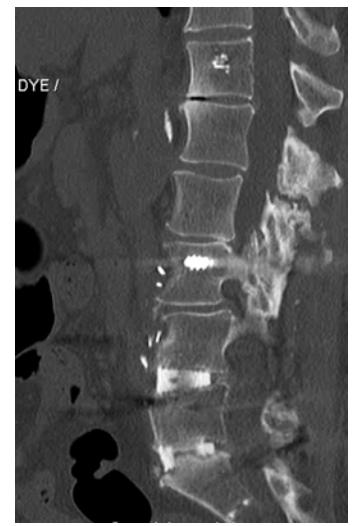
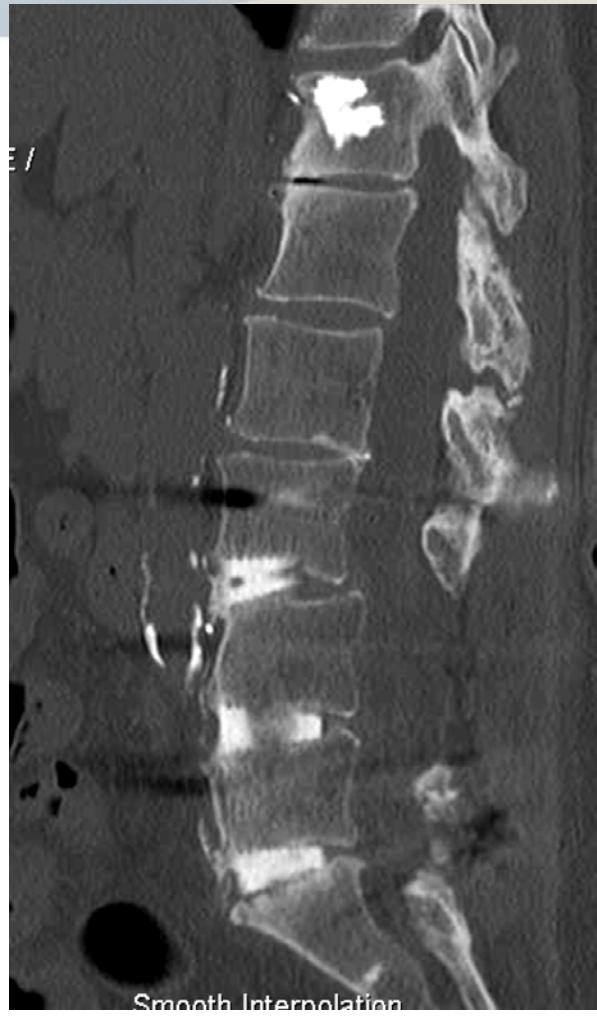
# Surgical Options For Sagittal Imbalance Correction

- Pedicle Subtraction Osteotomy
  - Total resection of posterior elements of involved level with partial of elements above and below
  - Aggressive segmental correction
- Stiff or Fixed Deformity



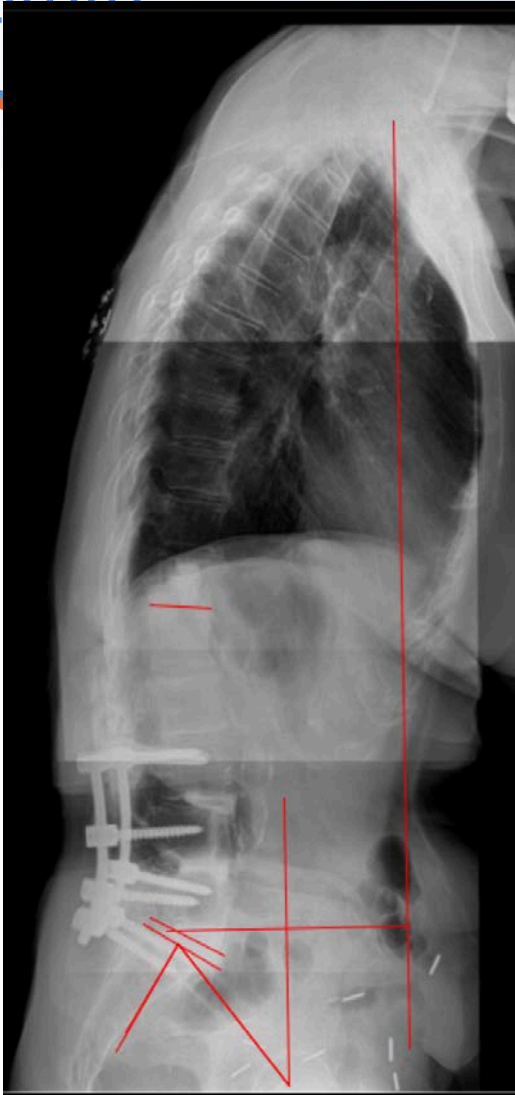
- Sva 14
- Pi 68
- LL 20
- Pt 42
  
- s/p TL fusion, roh
- Ap fusion L3-S1 1 year ago. Now with severe disability





- revision  
T10-pelvis  
with pso L3

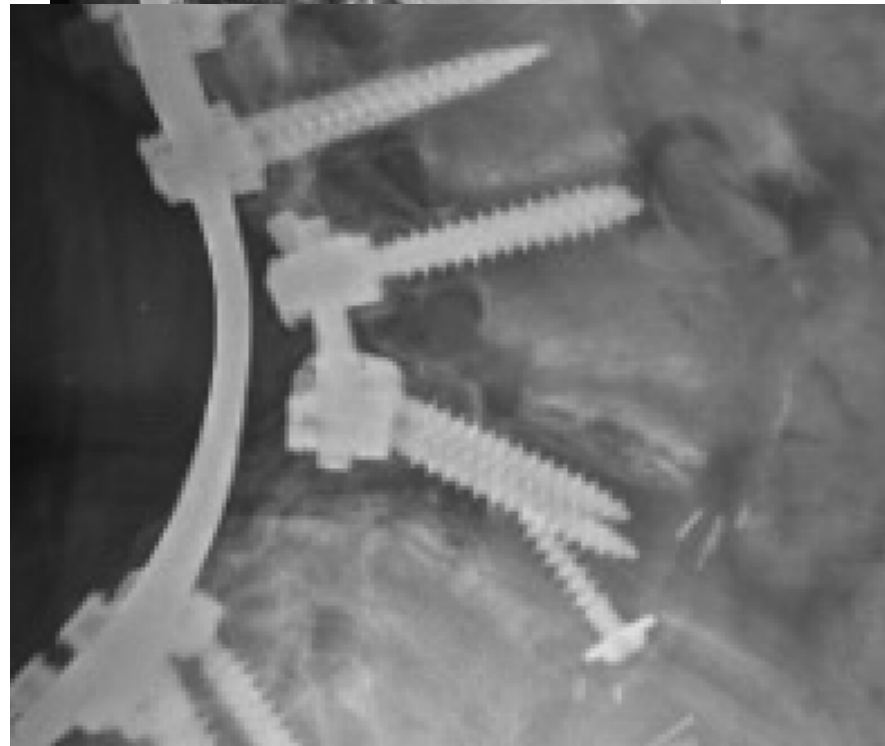
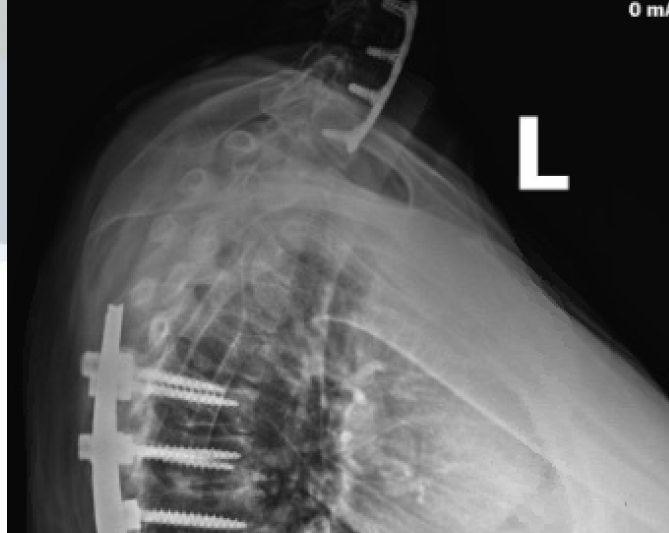




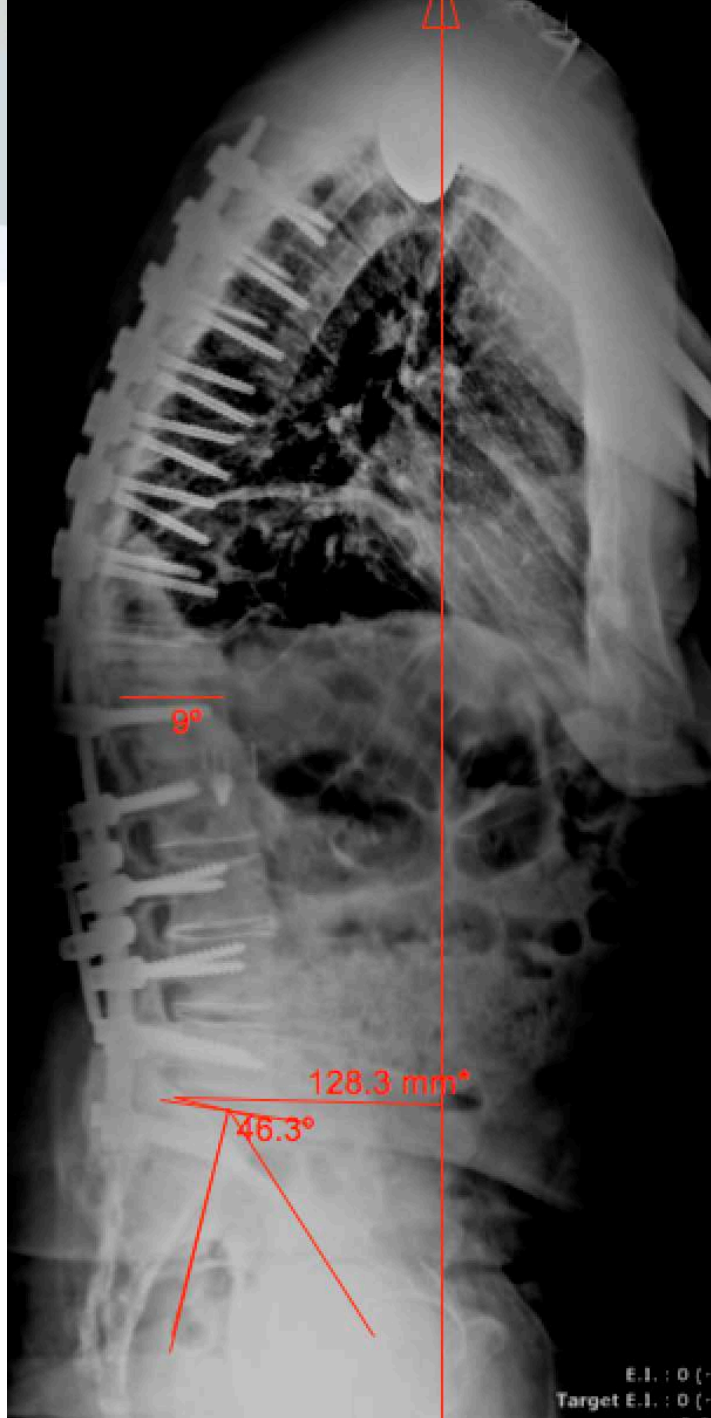
- 60 deg lordosis



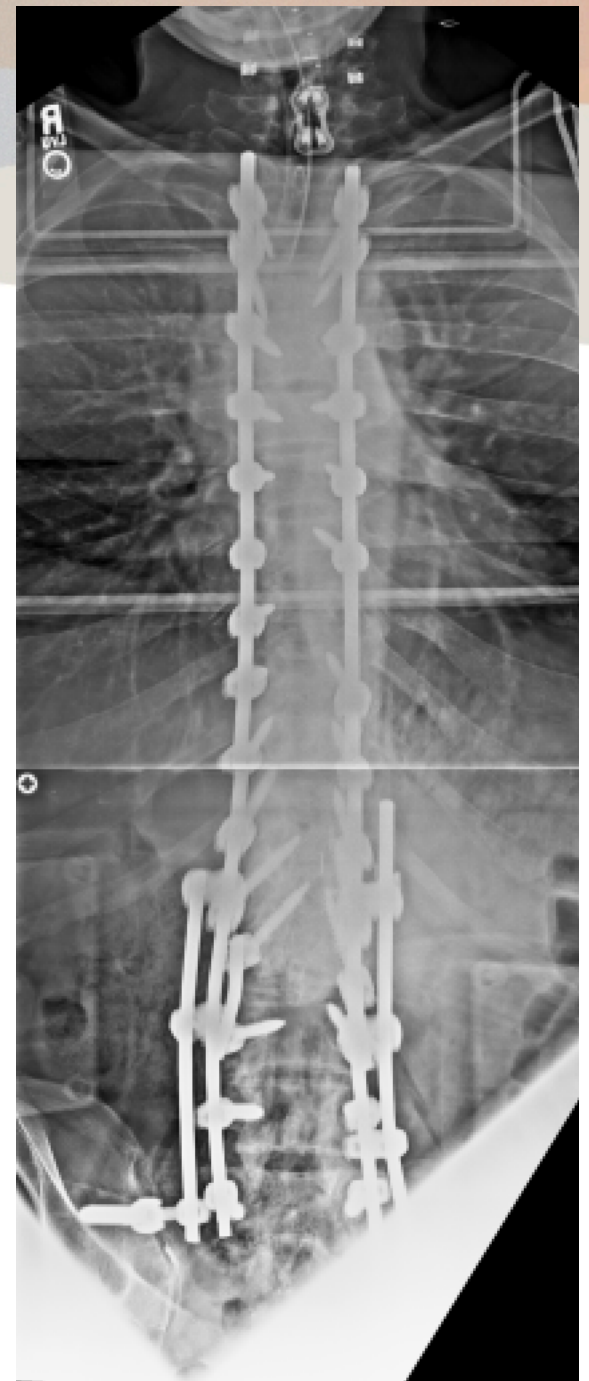
- Dual rod technique



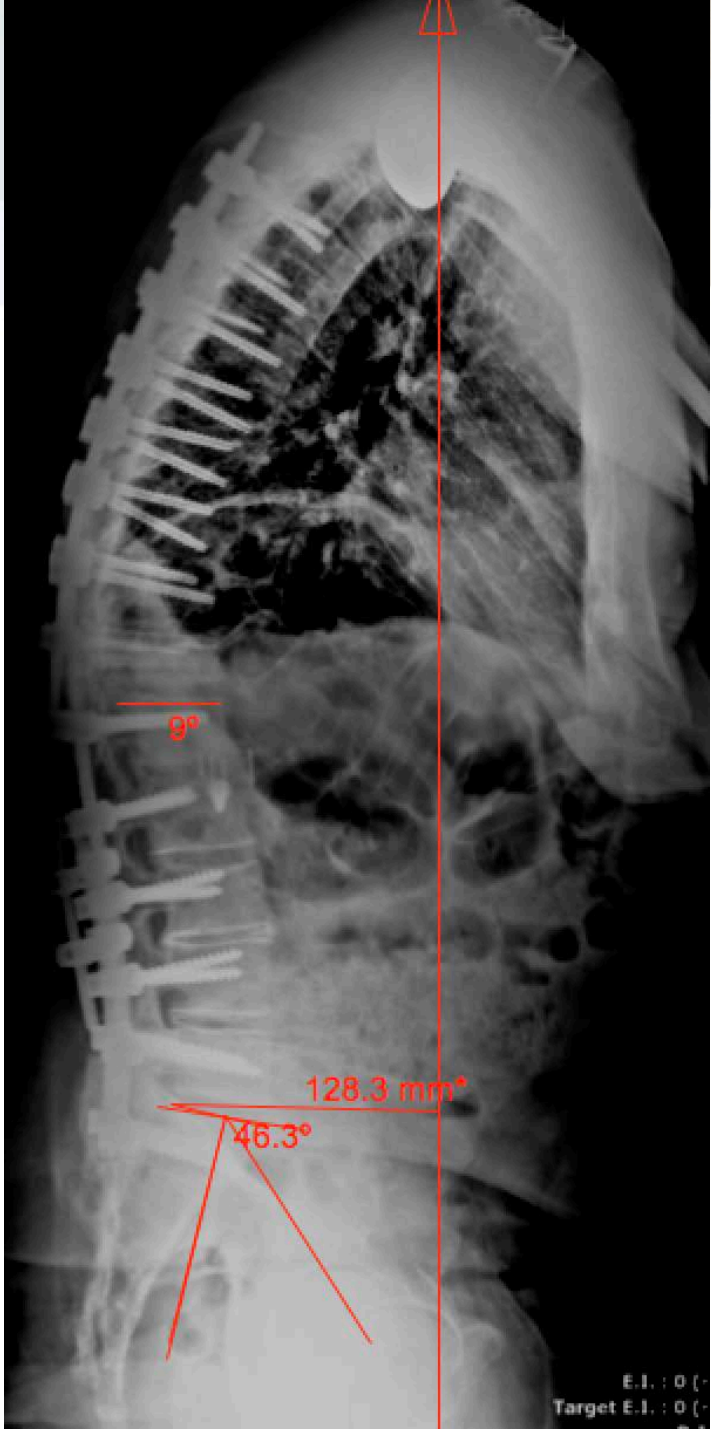
- 58m



- L3PSO



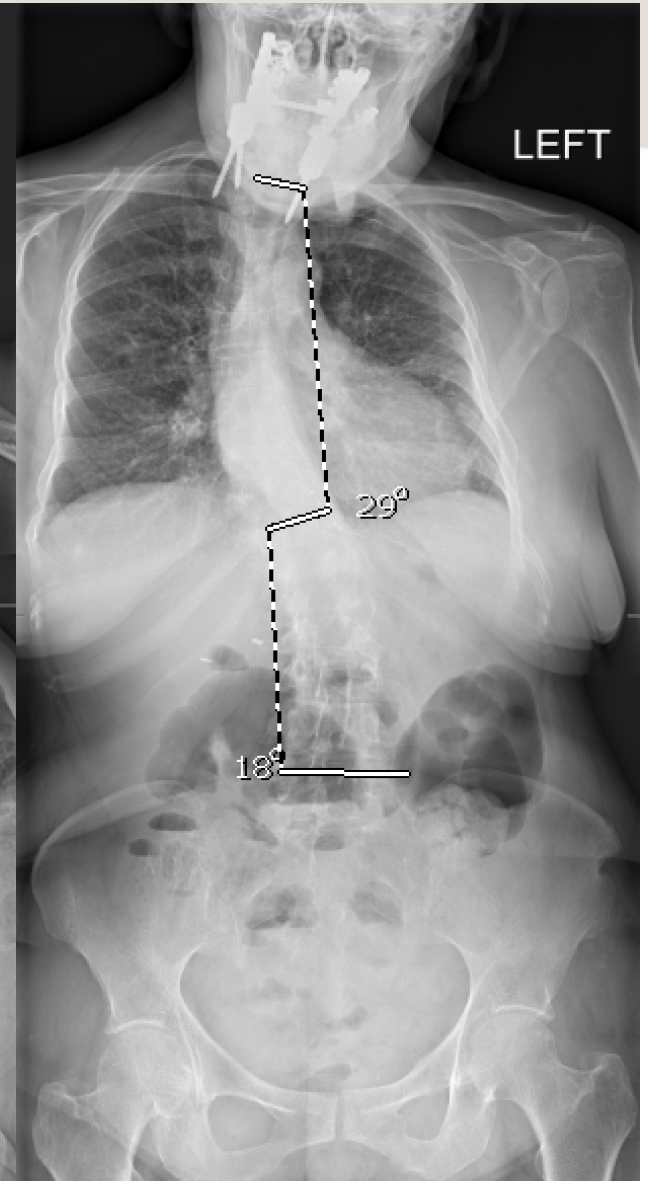


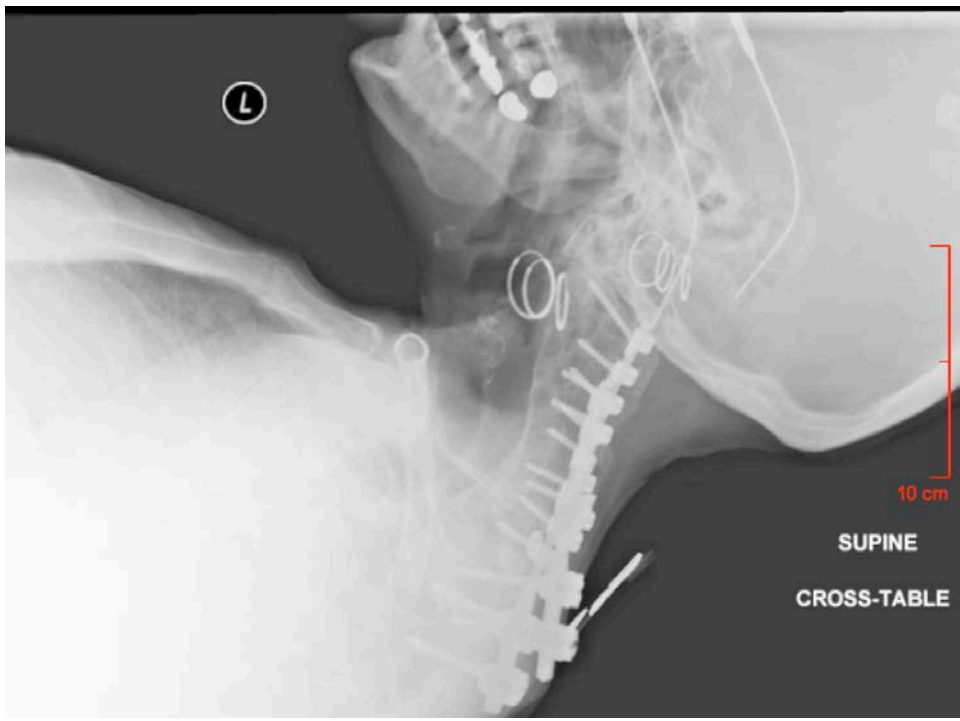


# Vertebral Column Resection



- 63yo F
- Multiple failed surgeries



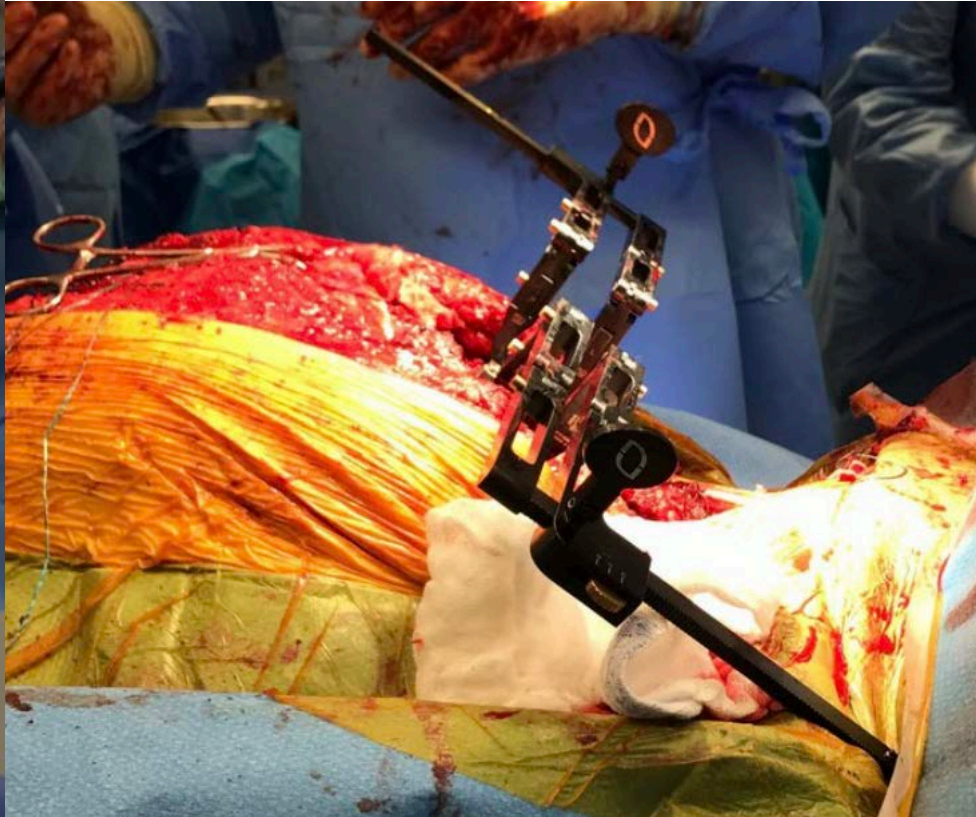
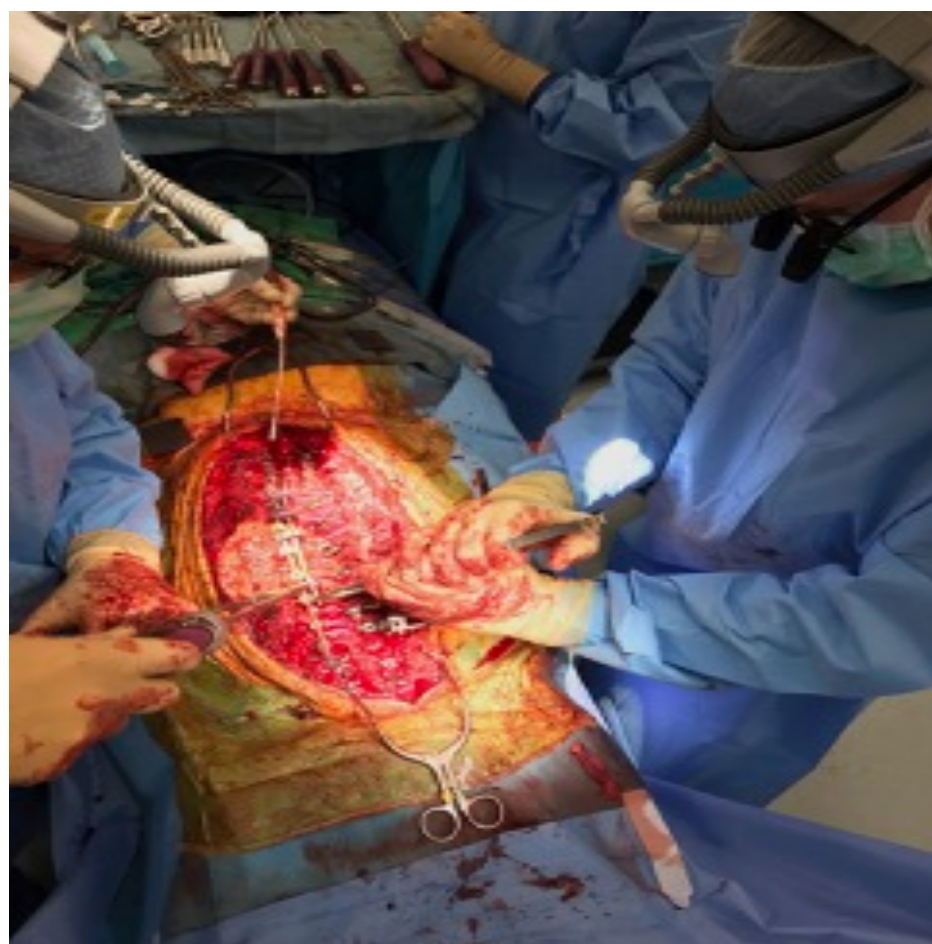


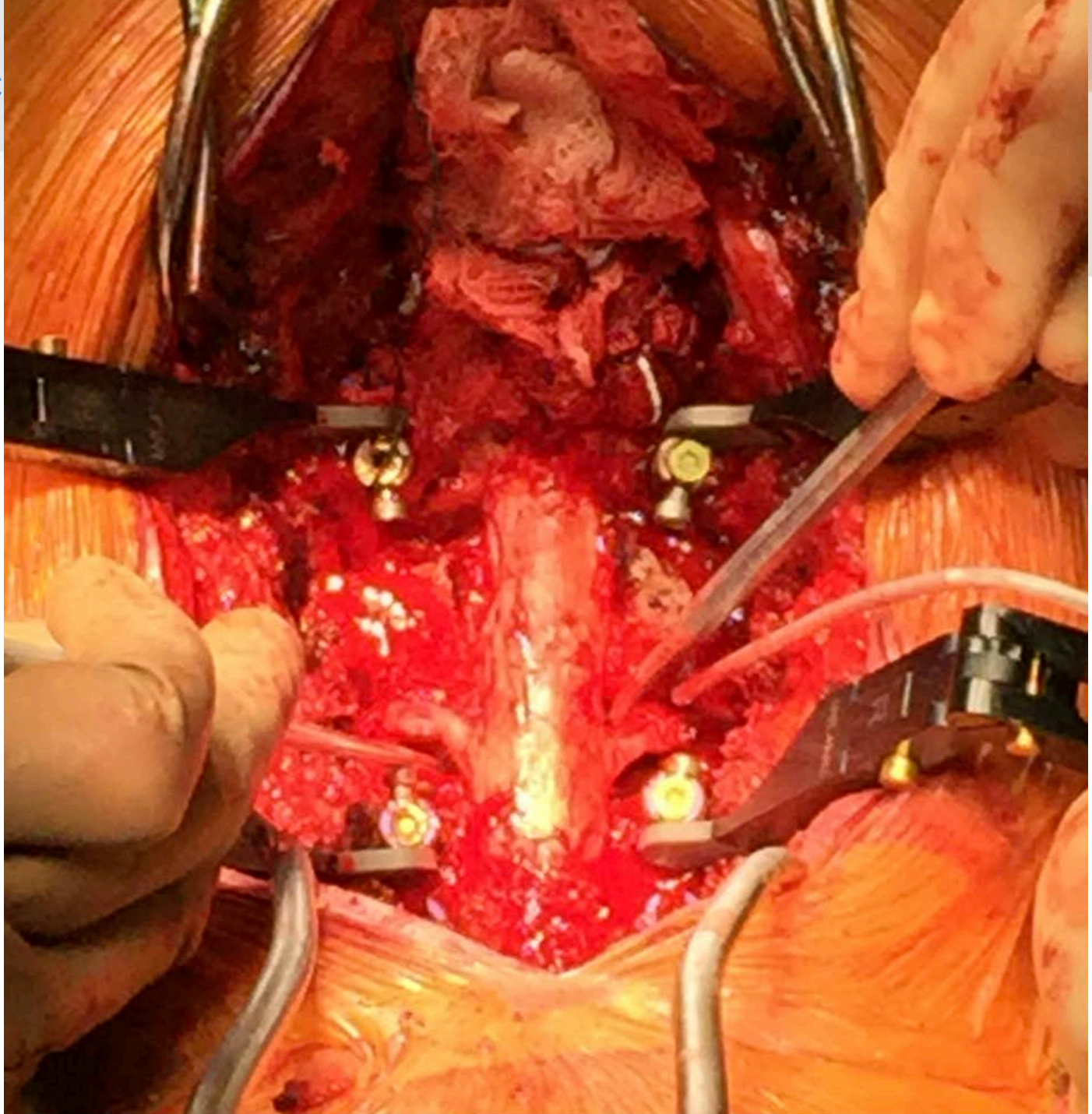




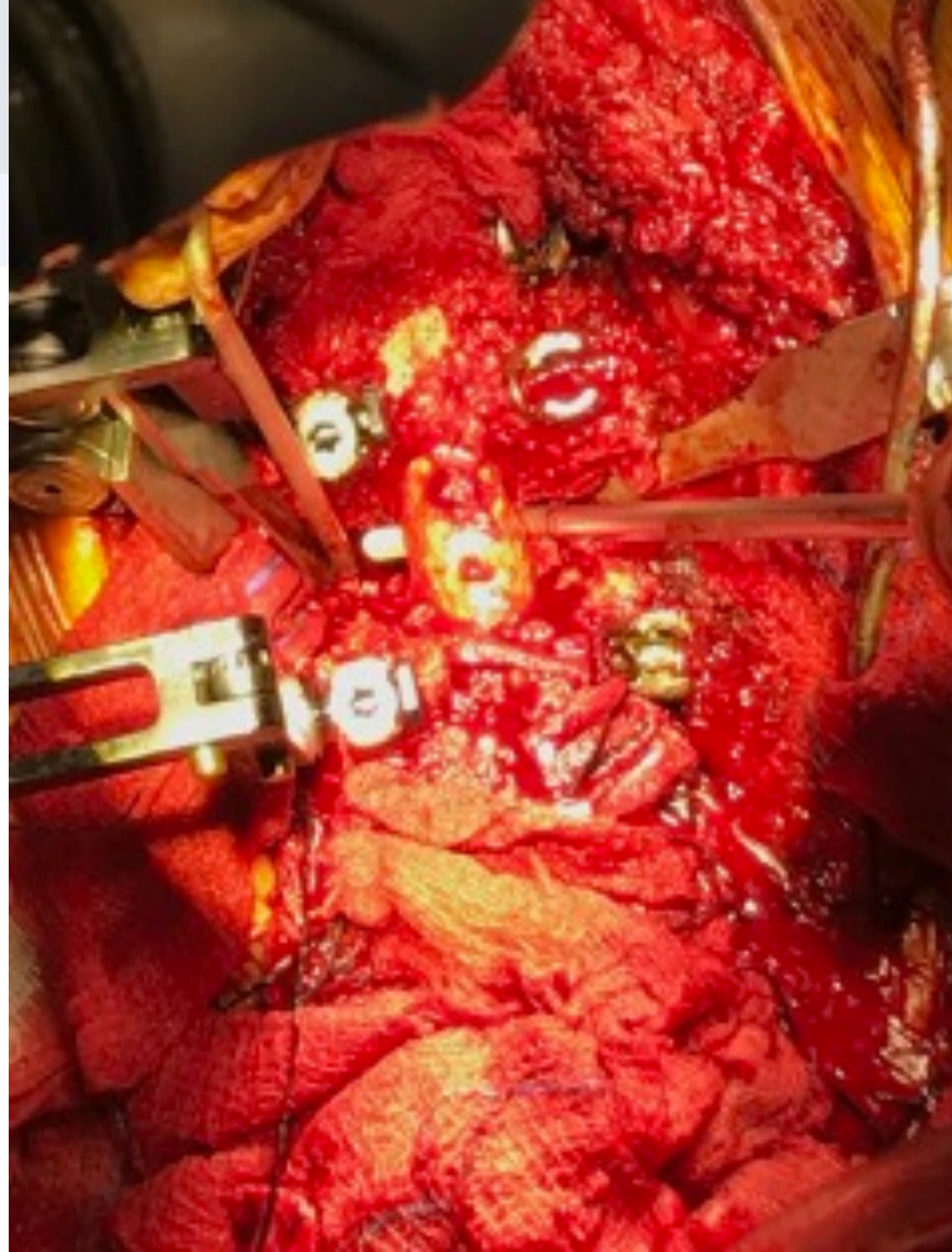
- T2 vcr
- Multiple spo

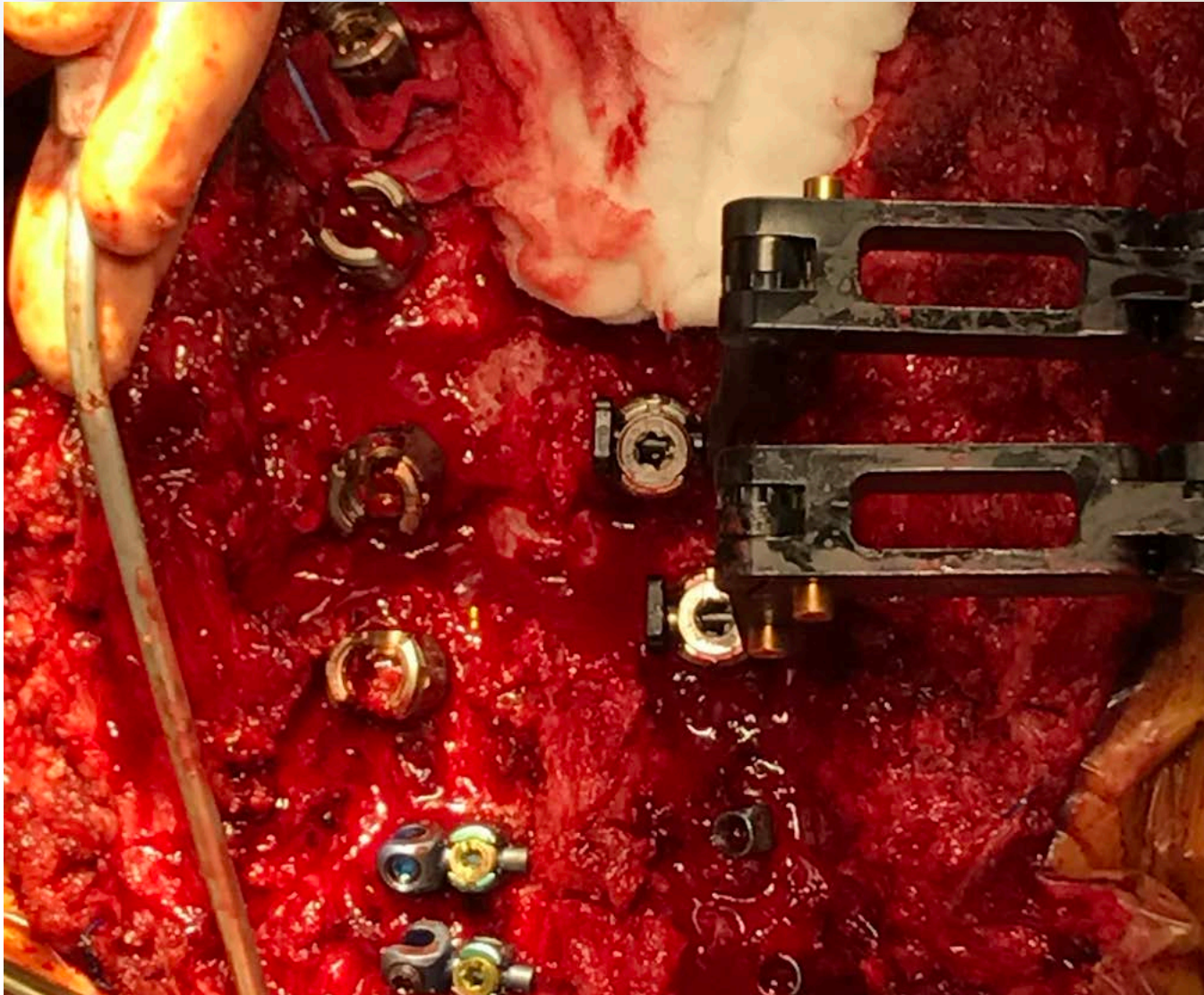




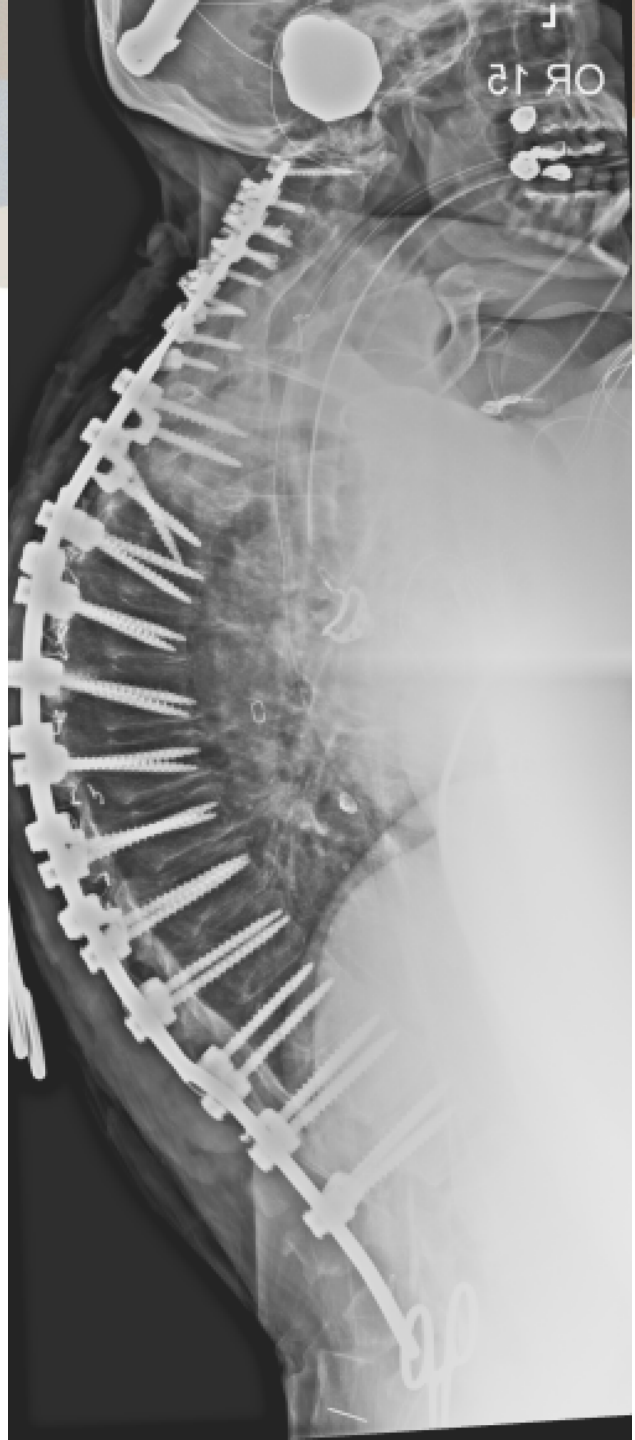








LEFT





3 years



# Osteotomy Complications

- Neurologic deficit
- Dural injury
- Pseudarthrosis
- Blood loss
- Proximal junctional kyphosis
- Inadequate correction

## Complications Increase

- SPO/Polysegmental
- PSO
- Vertebral column resection

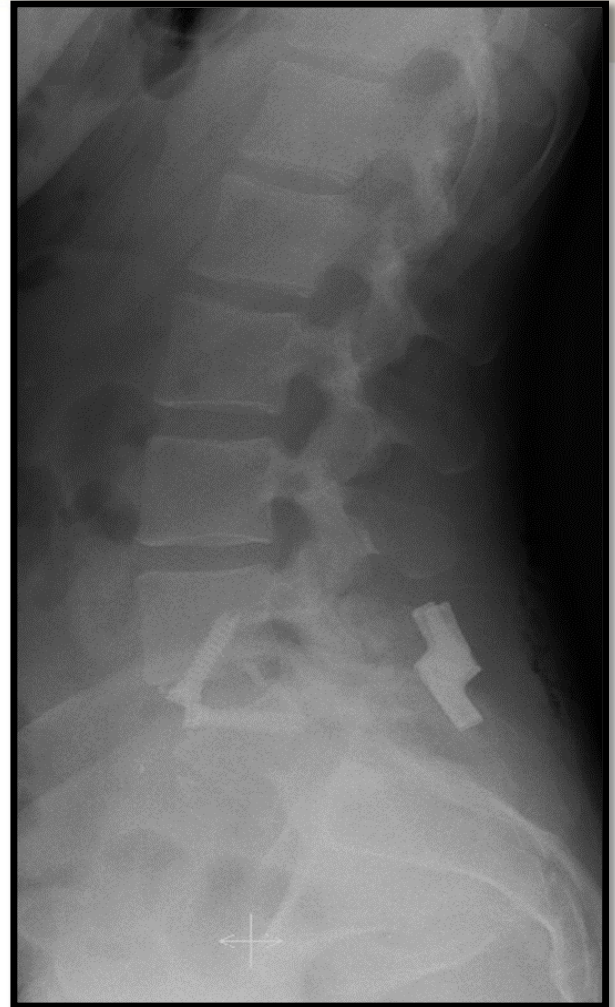


- Posterior
  - PLIF/TLIF
    - Minimal correction ability
  - Osteotomy
    - SPO, PSO, VCR
- Anterior
  - ALIF +/- hyperlordotic
    - Corpectomy +cage
  - Lateral +/- hyperlordotic



# Why ALIF?

- Greater lordosis restoration
- Complete discectomy
- Large interbody spacer
- Greater load sharing
- Height restoration
- Spondylolisthesis reduction
- **Complication reduction**



## Global Sagittal Balance: Indications and Techniques for Anterior Lumbar Interbody Fusion: Part I—Patient Assessment and Operative Technique

David M. Benglis Jr., MD, Laura Prado, MS, NP, and Regis Haid Jr., MD

*“L5-S1 lordosis is the key. It is literally the **foundation** of all the spine levels located above. The ability of ALIF to restore sagittal alignment... is one of its greatest advantages.”*

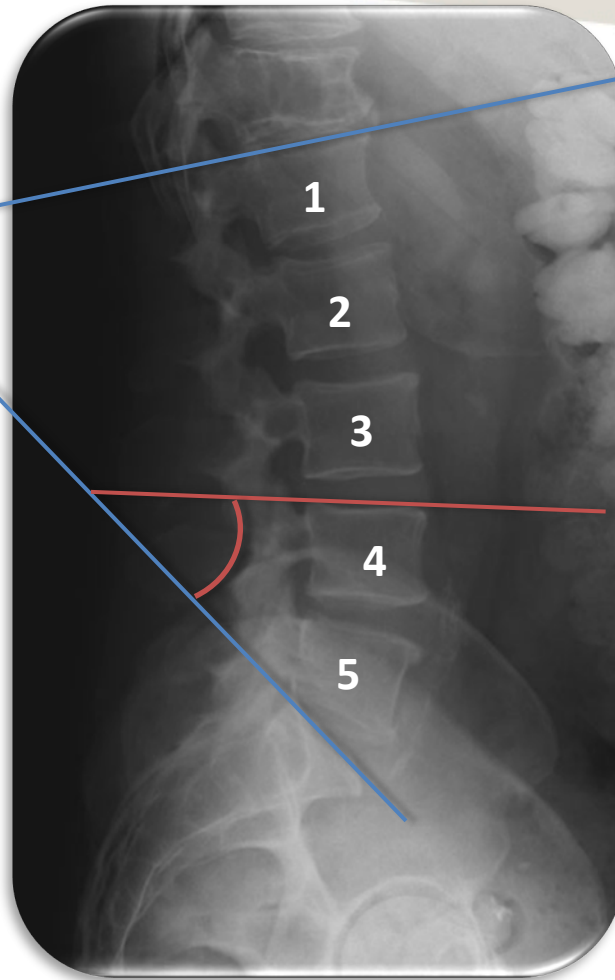
*“...use of lordotic/hyperlordotic cages, and large surface area [ALIF] implants, which have greater load-sharing capabilities compared with transforaminal lumbar interbody fusion (TLIF) and PLIF.”*



# Majority of LL Occurs at L4-S1<sup>1</sup>

L1-S1 =  
55°

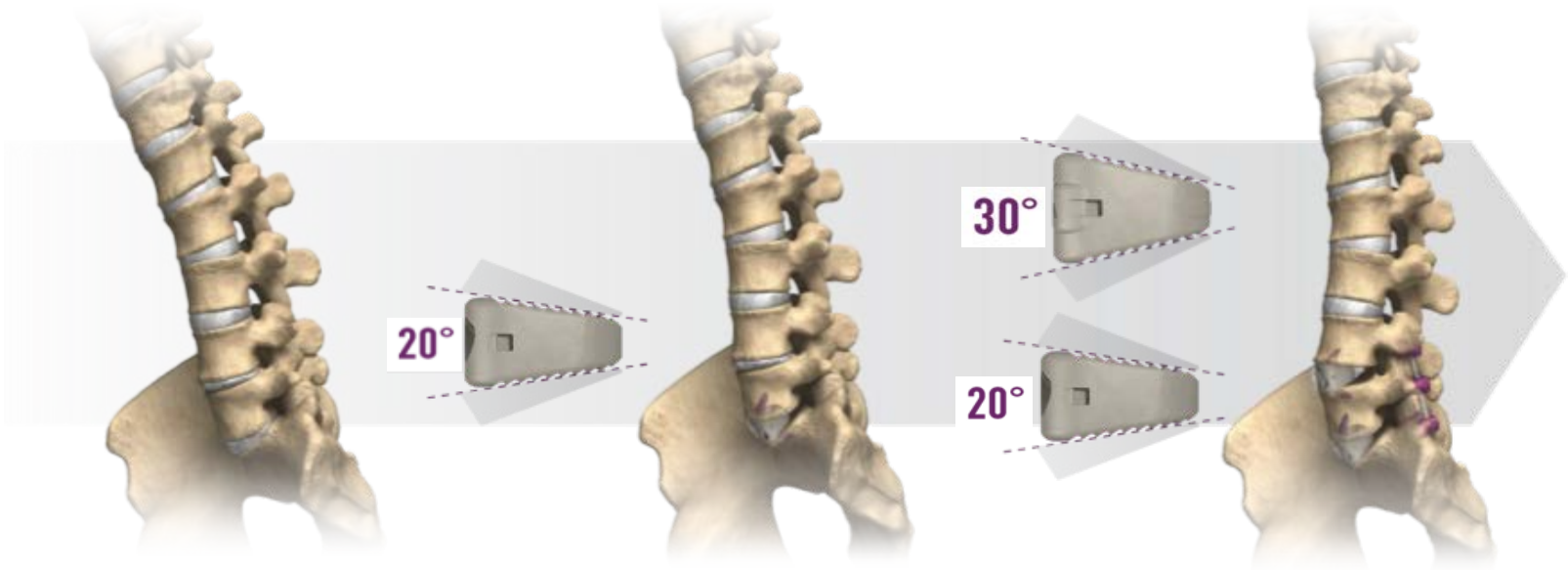
L4-S1 =  
42°



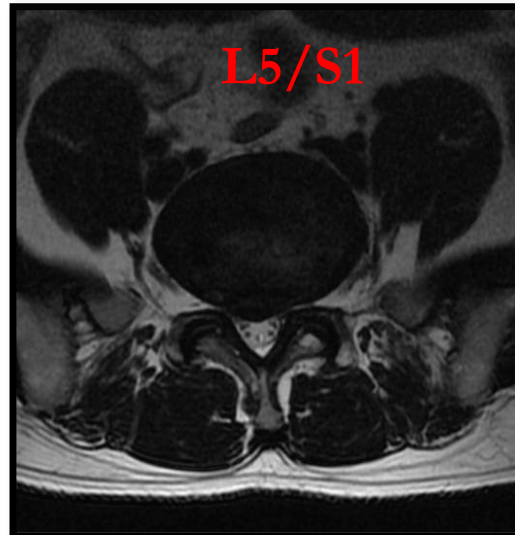
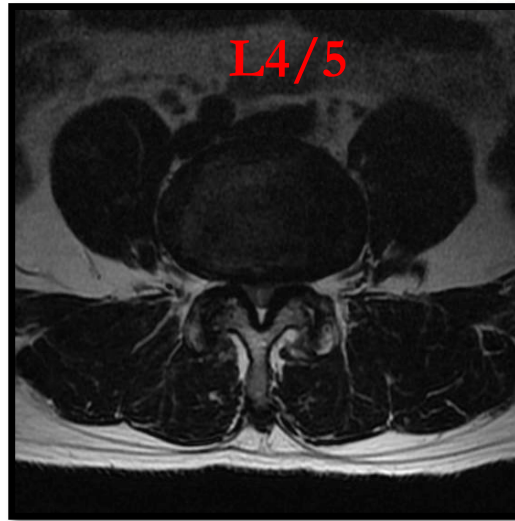
42/55 = 76%

<sup>1</sup>Troyanovich SJ, Cailliet R, Janik TJ, et al. Radiographic Mensuration Characteristics of the Sagittal Lumbar Spine from a Normal Population with a Method to Synthesize Prior Studies of Lordosis. *J of Spinal Disord Tech.* 1997;10(5):380-386.

# Hyperlordotic ALIF Restoring Alignment



- 53M
- Worsening claudication and radicular pain down both legs in L5 distribution
- Had minimally invasive laminectomy
- Recurrent back and leg pain after MIS decompression



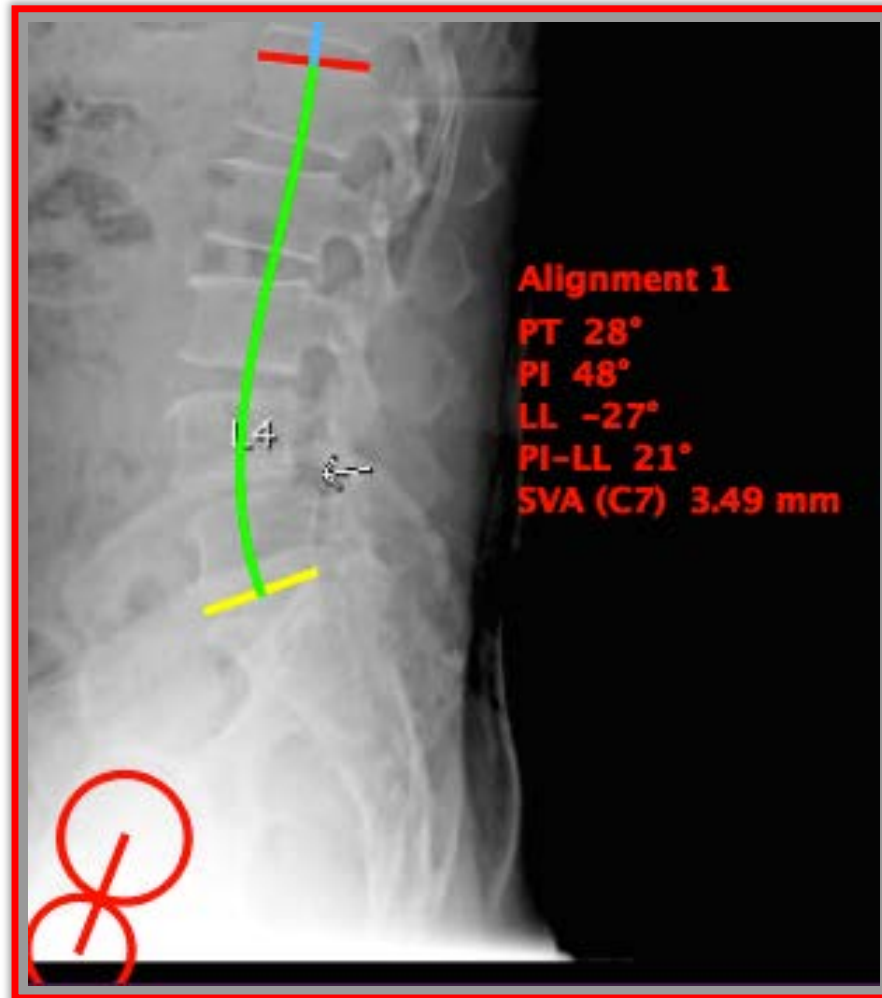


PI = 48°

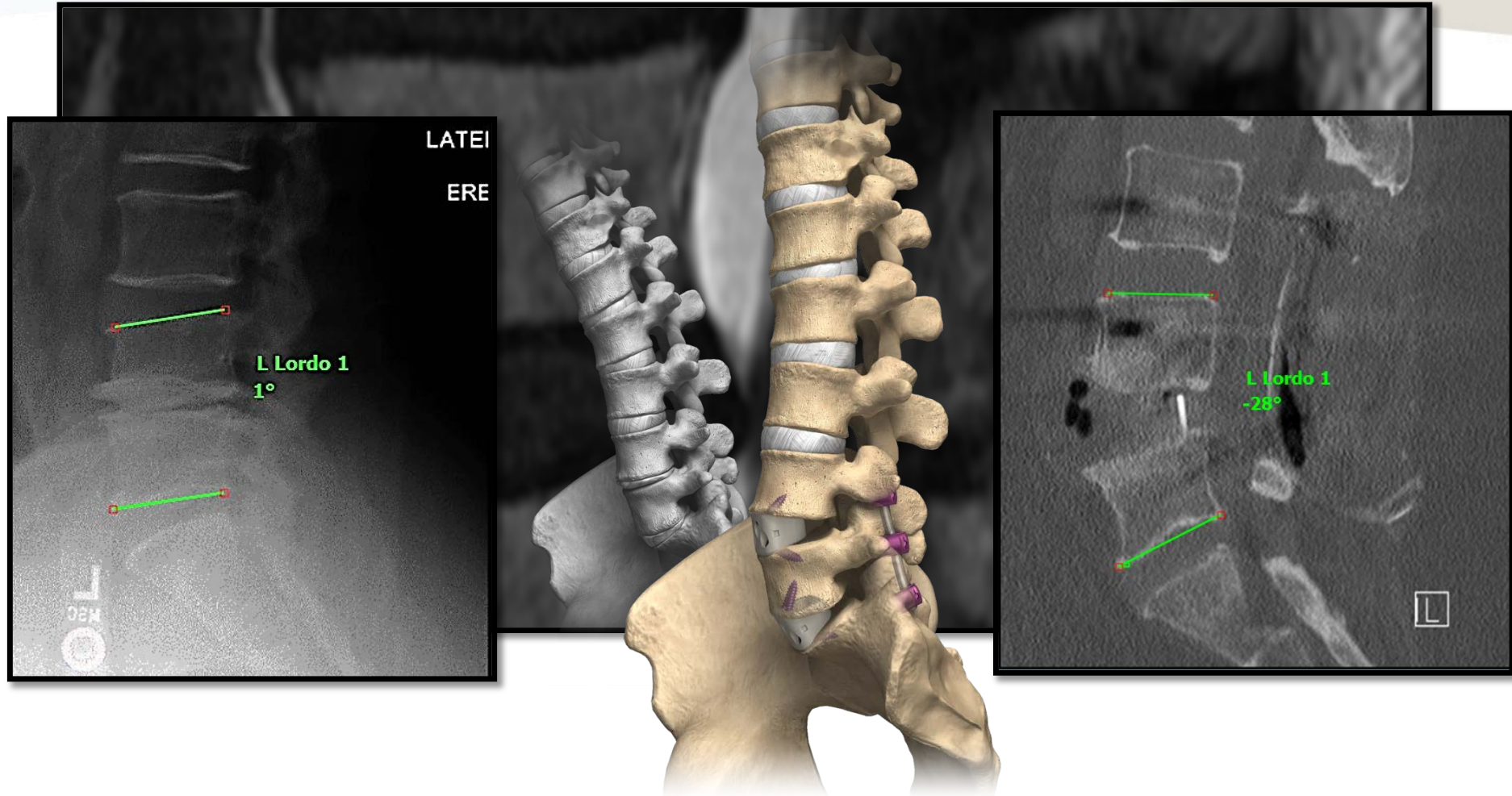
LL = -27°

PI-LL = 21°

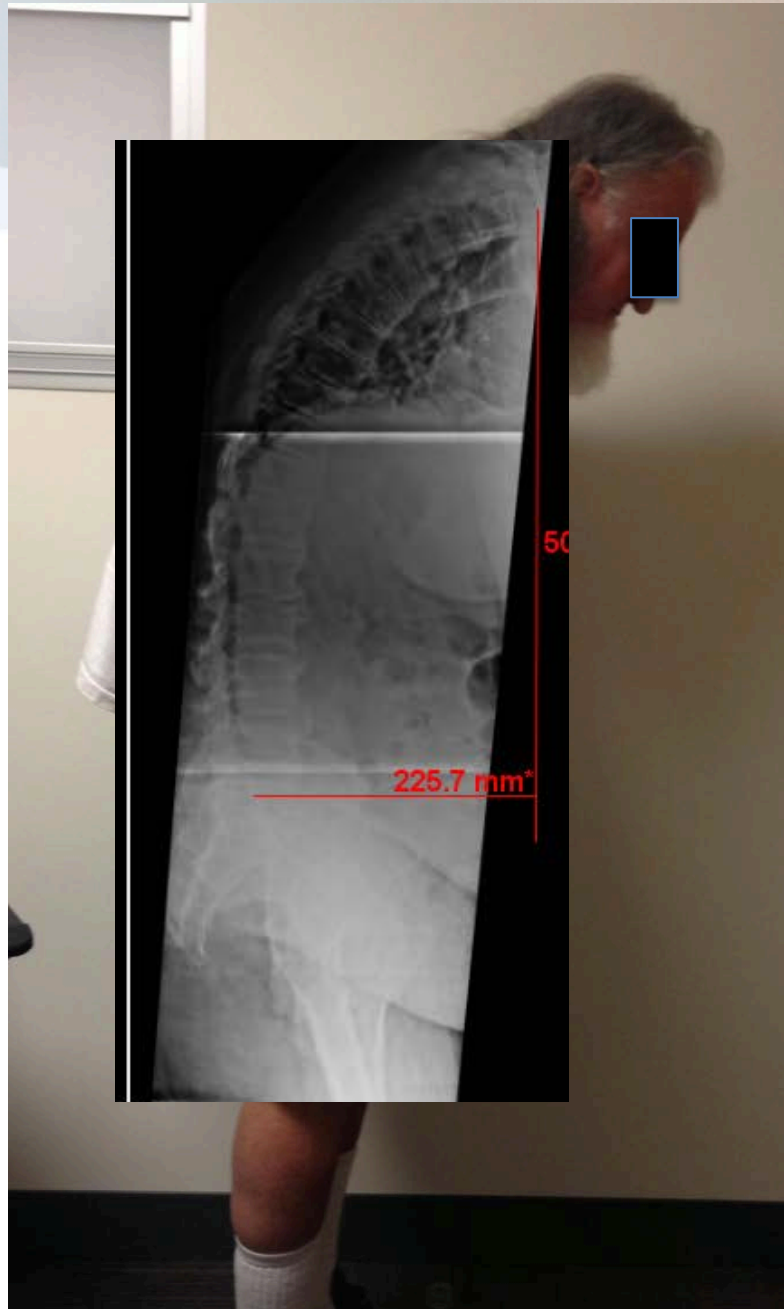
PT = 28°



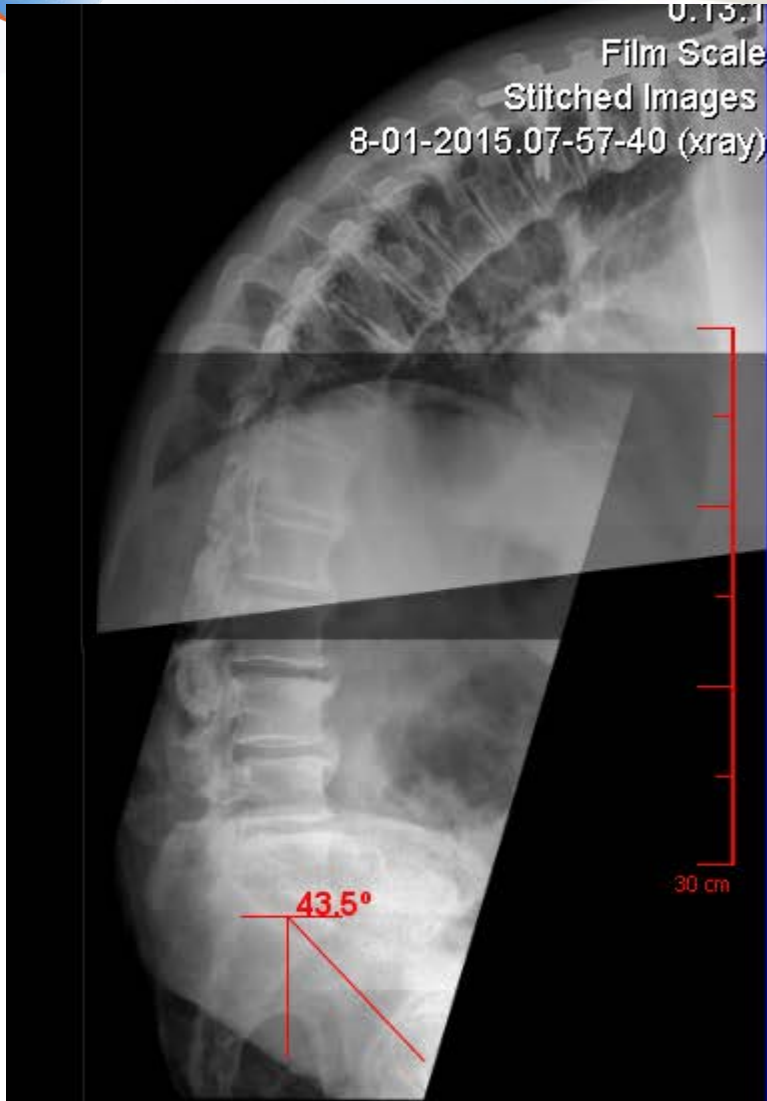
# 20° Hyperlordotic at L4/5







CBVA 30



PI 43  
LL +20 deg



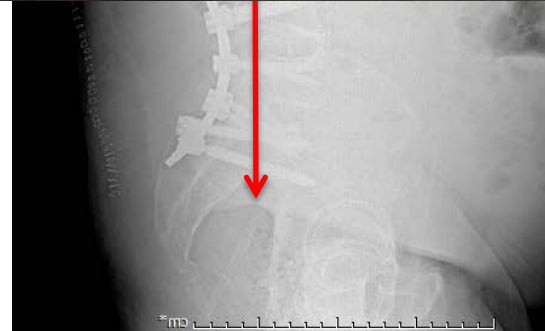
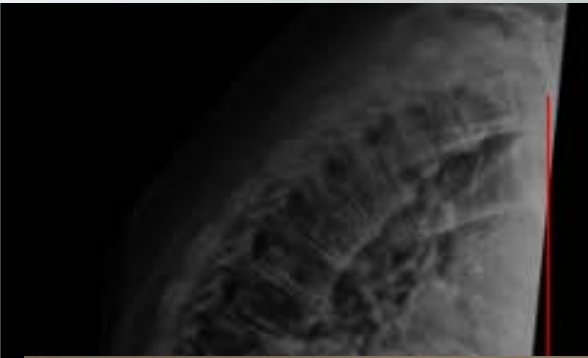


- Stage 1
  - Multilevel segmental lumbar interbody graft
  - Hyperlordotic  $20^{\circ}$  vs  $30^{\circ}$



- Stage 2
  - Posterior instrumentation T10-pelvis with multiple spo's

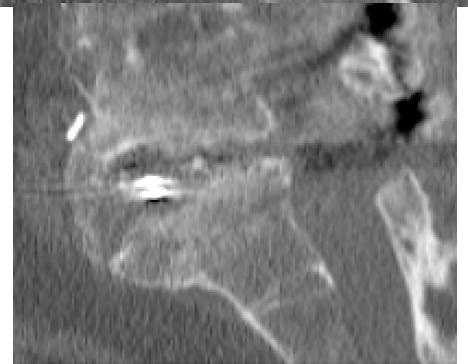
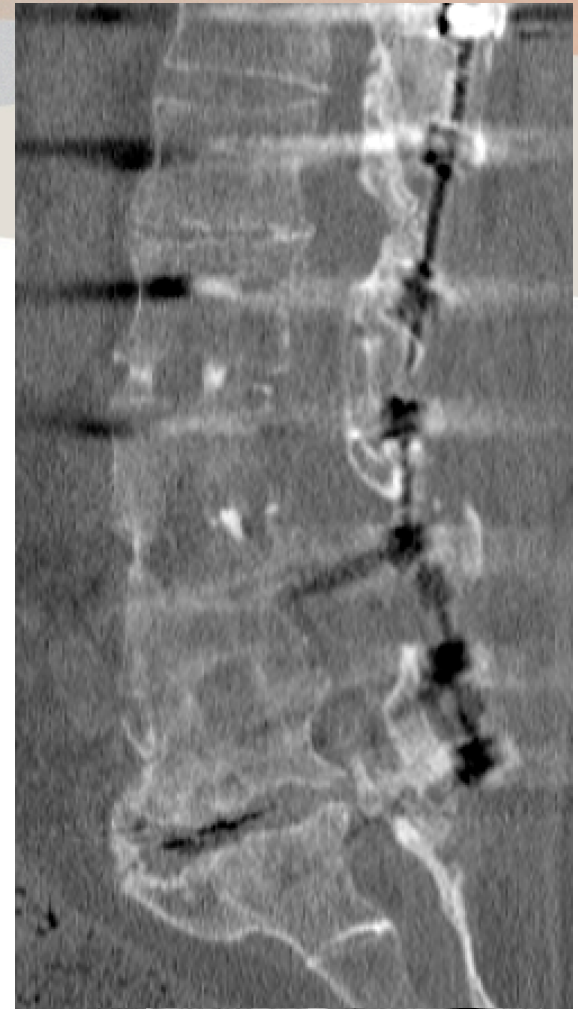
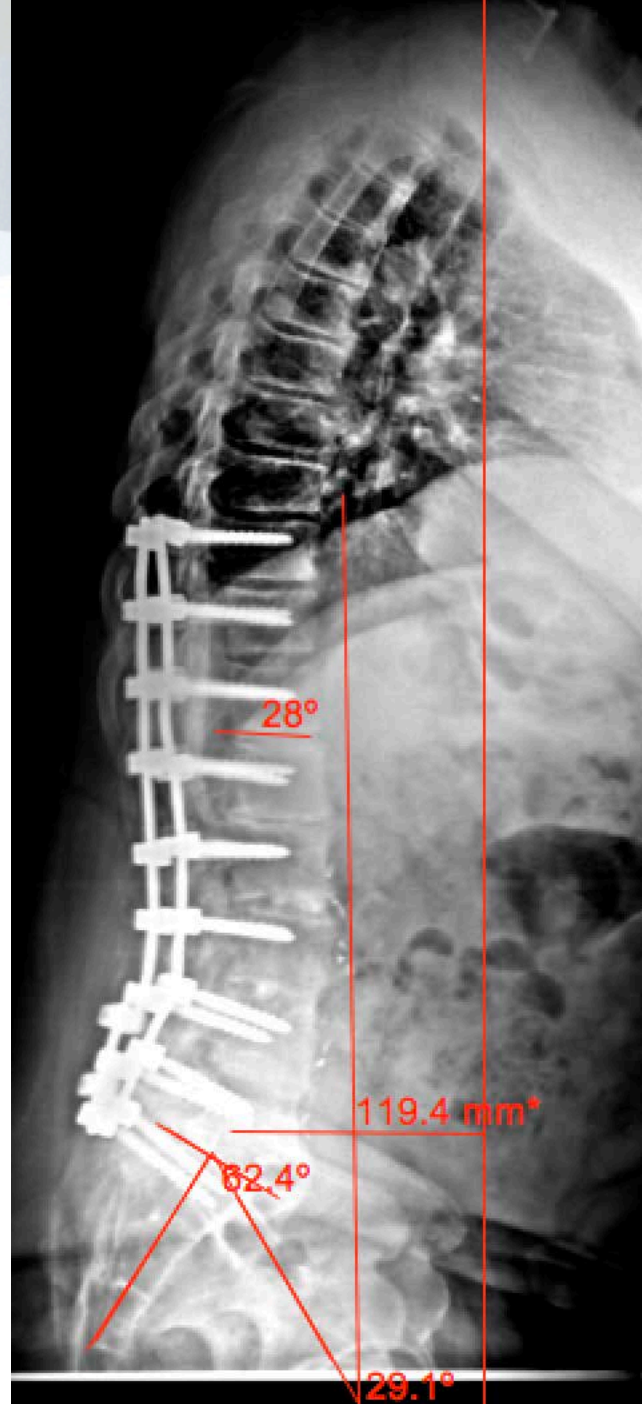




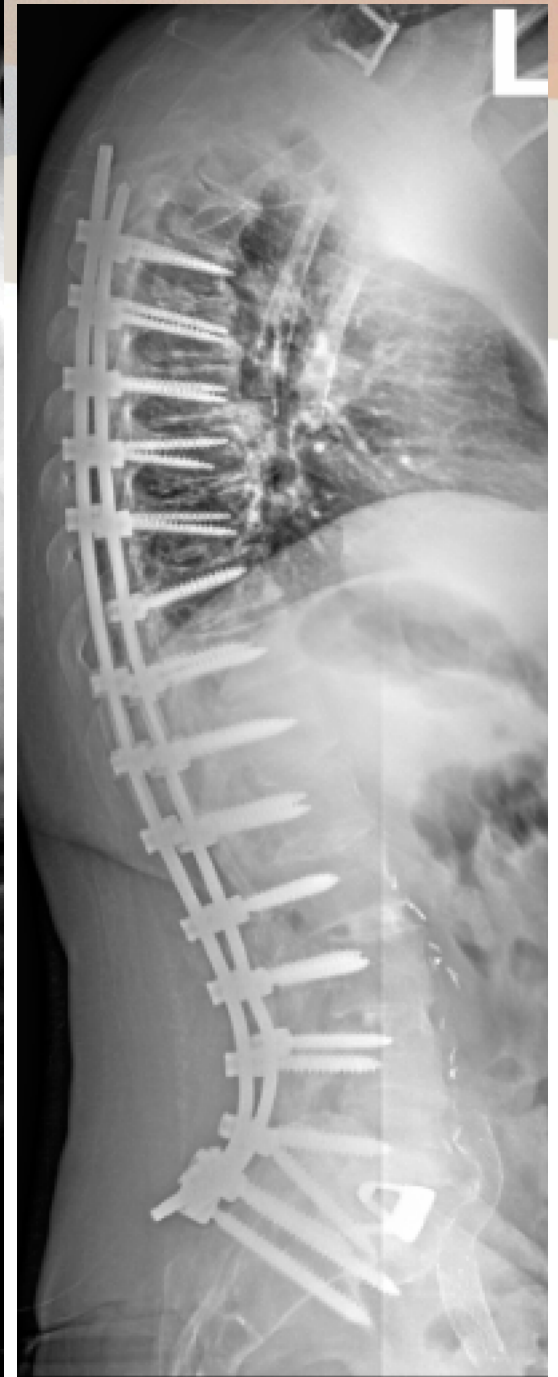
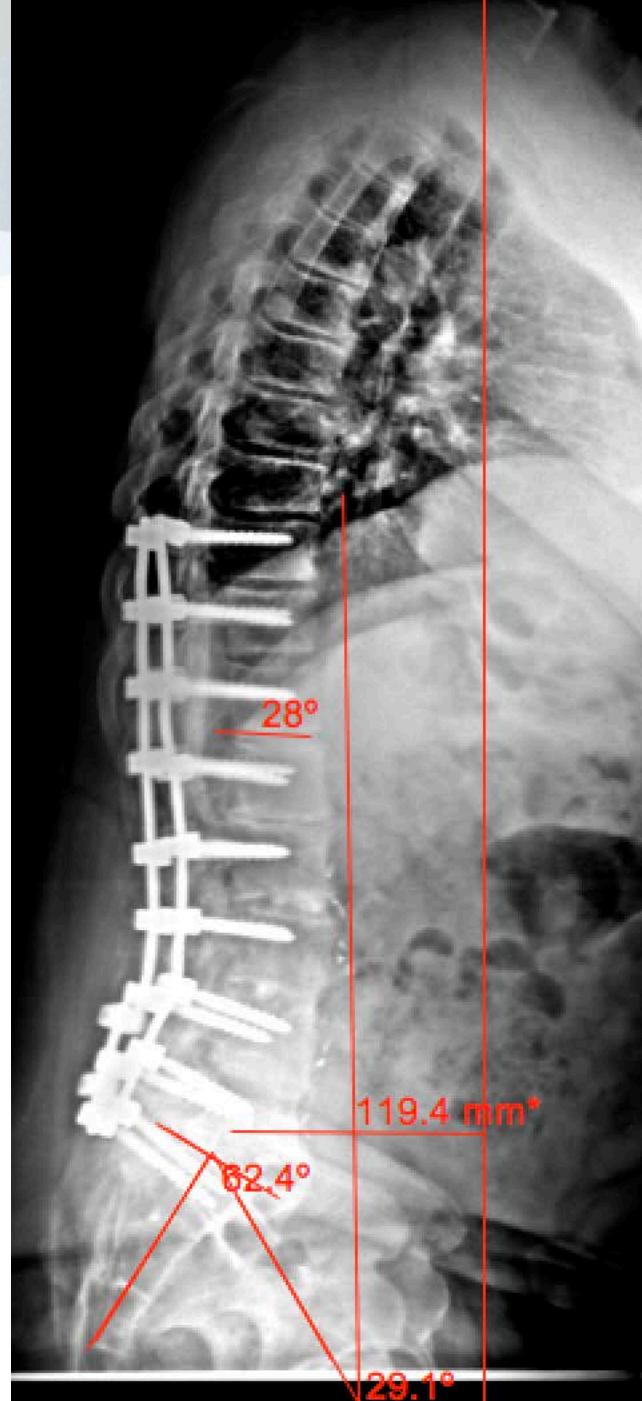
20 deg kyphosis

52 deg LL

- 68yo m



- Post
- ALIF-30deg hyperlordotic
- Post drop rods

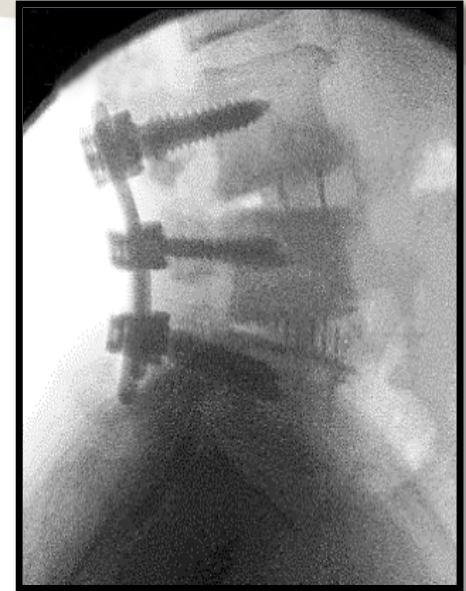




- Posterior
  - PLIF/TLIF
    - Minimal correction ability
  - Osteotomy
    - SPO, PSO, VCR
- Anterior
  - ALIF +/- hyperlordotic
  - Lateral +/- hyperlordotic

# Direct Lateral Interbody Fusion

- Safe and reproducible
- Conventional surgery
- Minimal soft tissue/muscle damage
- Reduced postoperative morbidity
- Meets or exceed traditional results



# Lateral Fusion For Scoliosis

Early outcomes and safety of the minimally invasive, lateral retroperitoneal transpsoas approach for adult degenerative scoliosis

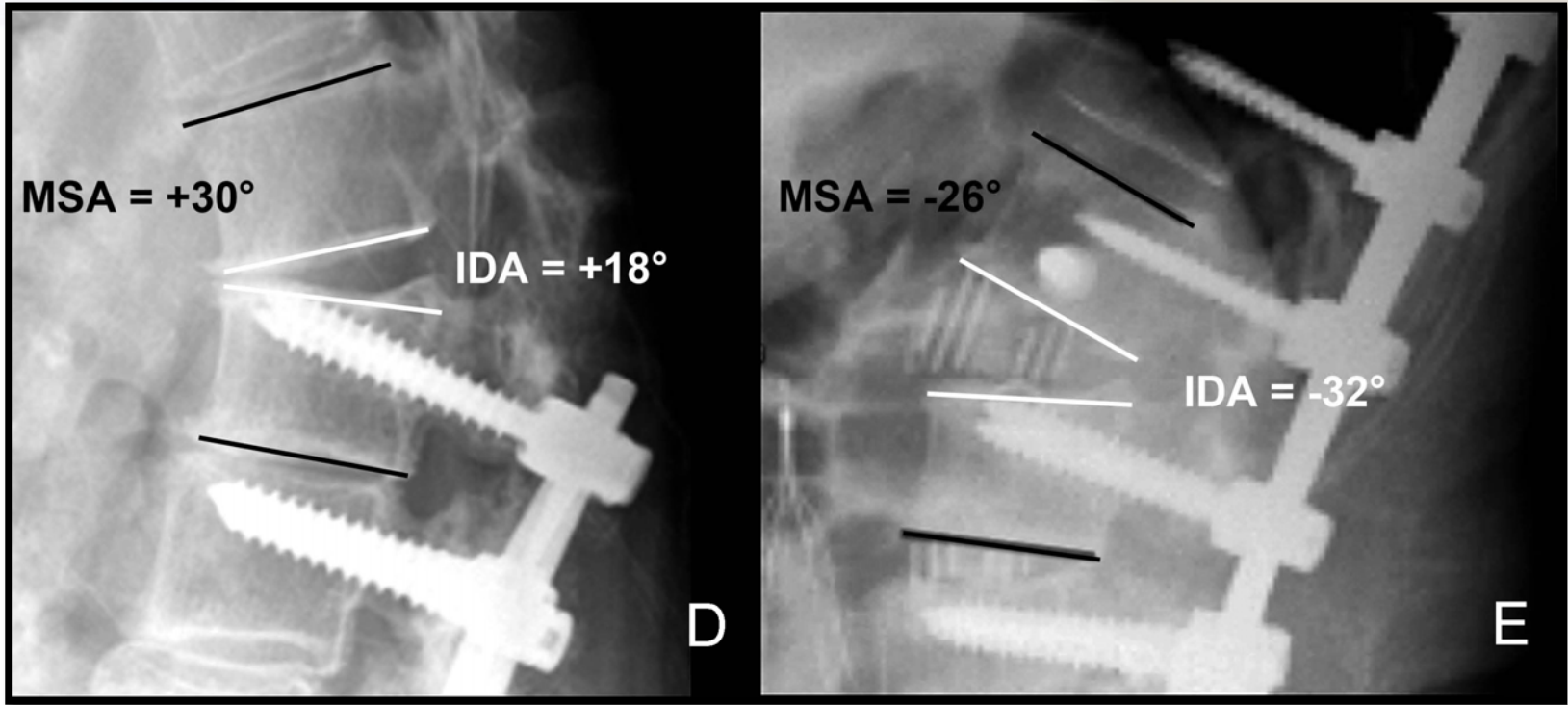
**ELIAS DAKWAR, M.D., RAFAEL F. CARDONA, M.D., DONALD A. SMITH, M.D.,  
AND JUAN S. URIBE, M.D.**

*Department of Neurological Surgery, University of South Florida, Tampa, Florida*

**Neurosurg Focus 28 (3):E8, 2010**

- 25 patients, 11 month follow-up
- EBL 53ml
- VAS improved 5.7; ODI improved 23.7%
- Complications: rhabdomyolysis (1), subsidence (1), anterior thigh numbness (3; 12%)

# Direct Lateral Hyperlordotic Anterior Column Realignment



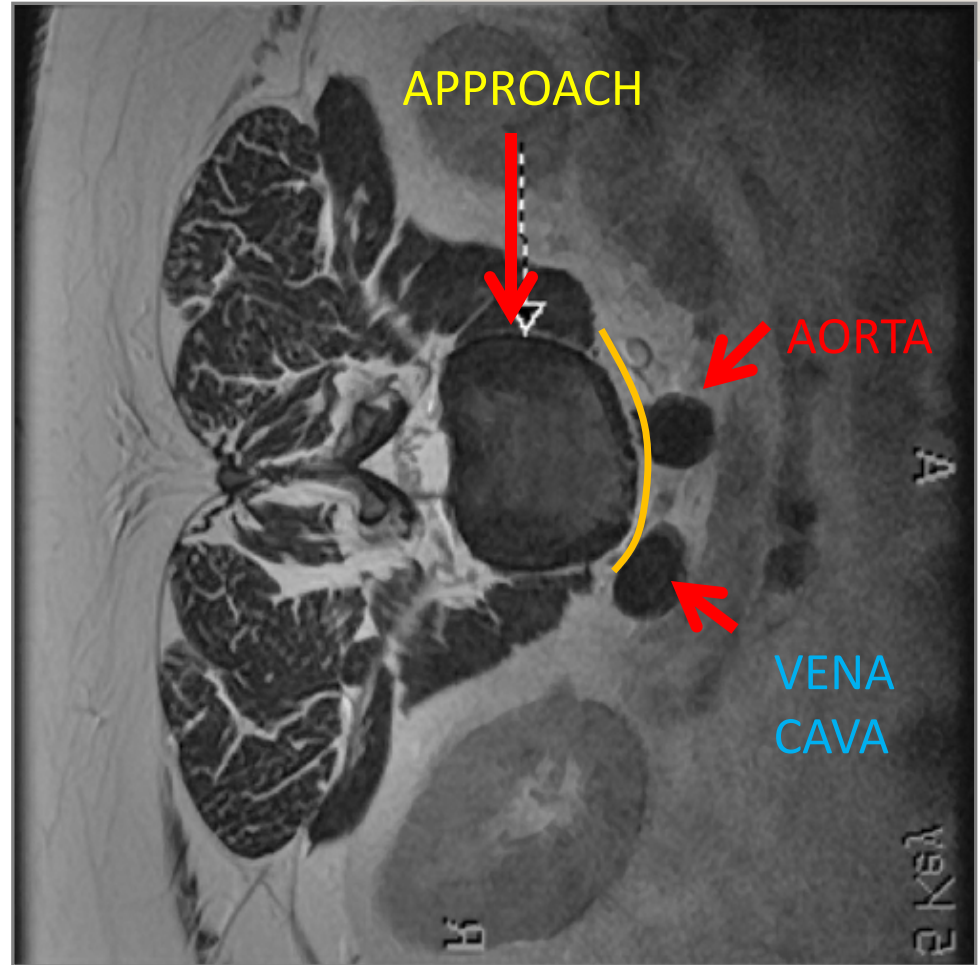
# Direct Lateral Anatomic Considerations

- Abdominal aorta
- Segmentary arteries
- Iliac arteries
- Iliac veins
- Vena cava
- Bowel
- Kidney
- Sympathetic Plexus



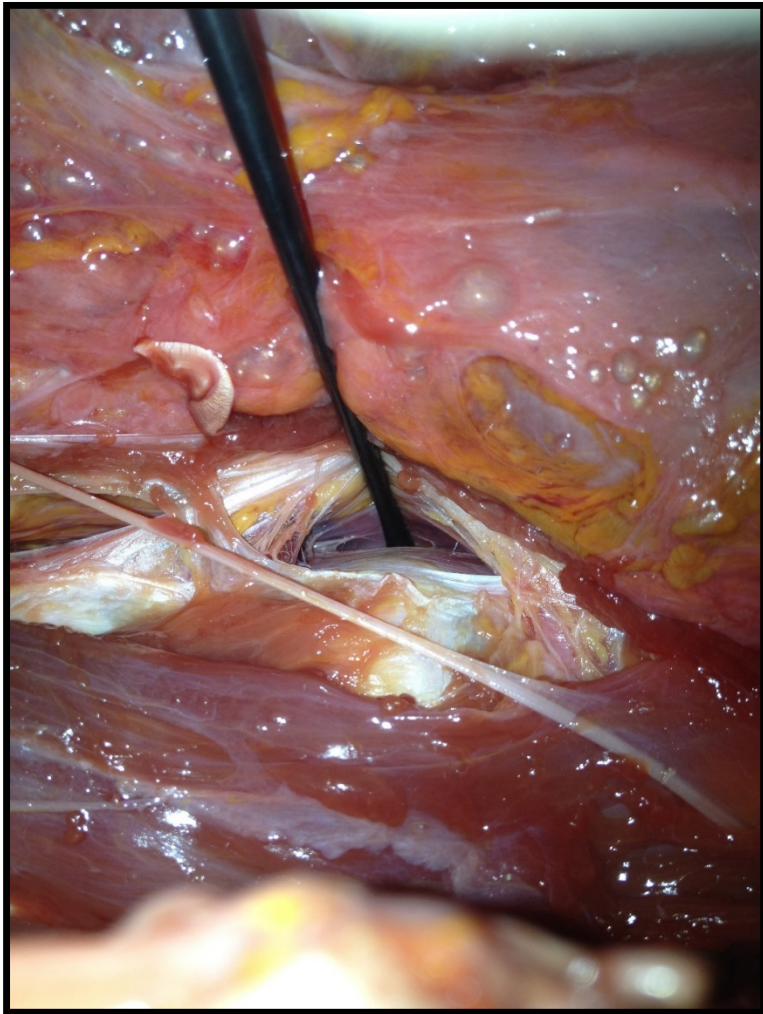
# Release ALL, mobilize vessels

- Must carefully mobilize vessels in order to release entire anterior longitudinal ligament
- Must release contralateral annulus, posterior/lateral



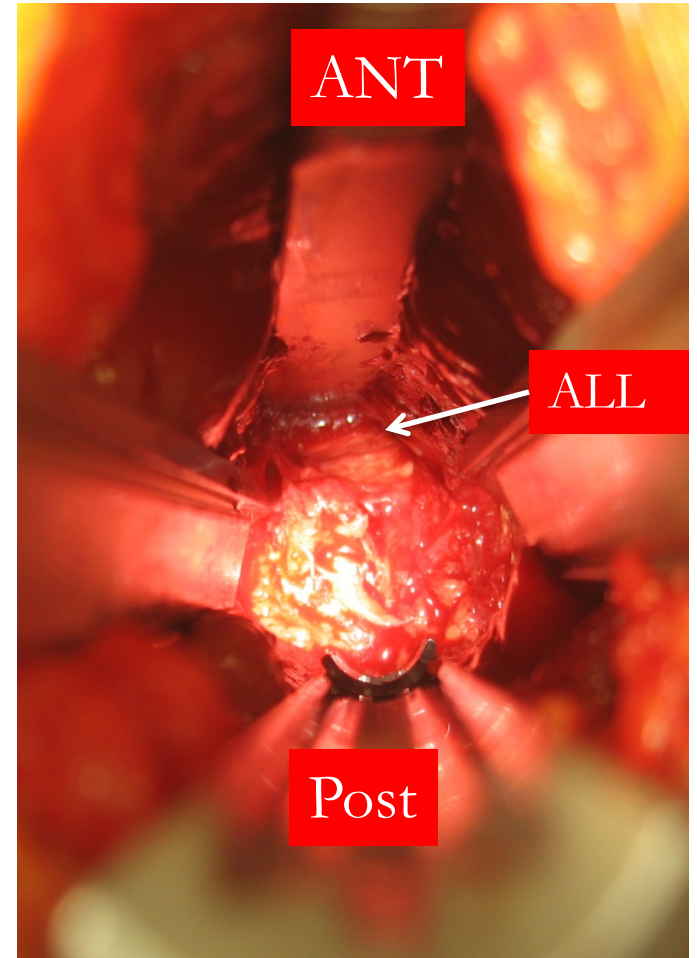
# ACR<sup>®</sup> Technique

ALL Exposure



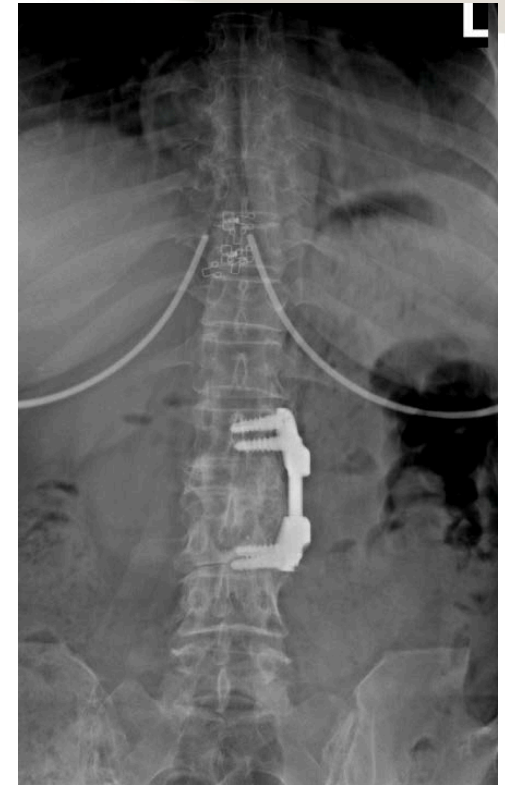
# Anterior Column Realignmnet Technique

- Release ALL sharply or with curved Bovie





- 45 yo female s/p fall 1989
- L2 burst fx tx with corpectomy ICBG + L1-L3 anterior fusion
- c/o back pain L groin/thigh pain
- 80mg oxycontin QID





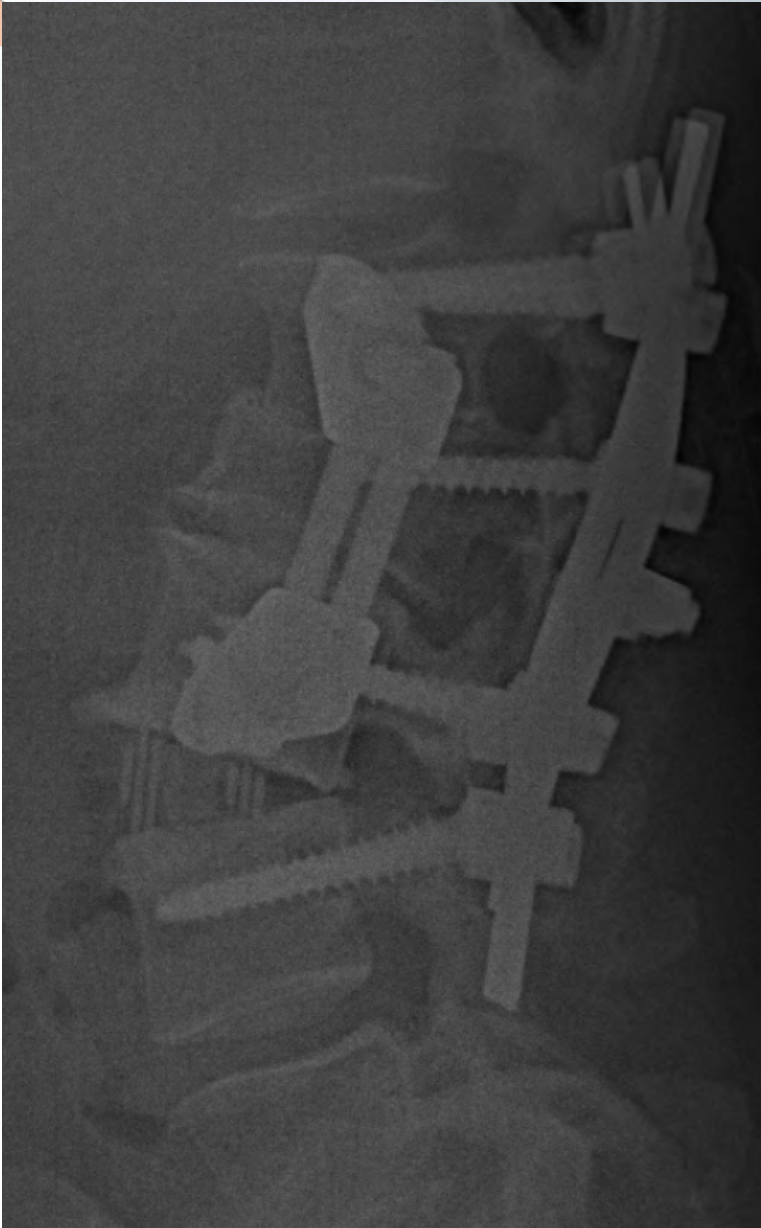
LL-28° kyphosis

PI-55°

PT-28°

Thoracic hypokyphosis





- Right sided lateral
- Anterior column realignment
- Hyperlordotic cage  
– 30°
- Posterior L1-L4. SPO at L3/4
- 150cc blood loss
- 1 day in hospital



LL-28° kyphosis

PI-55°

PT-28°



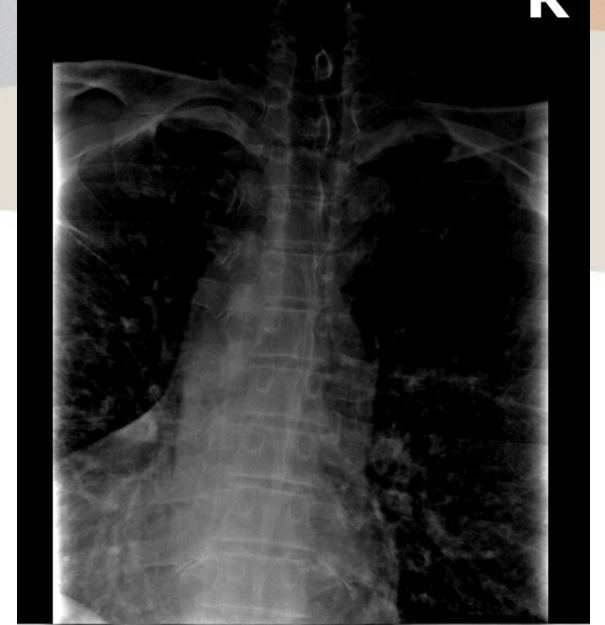
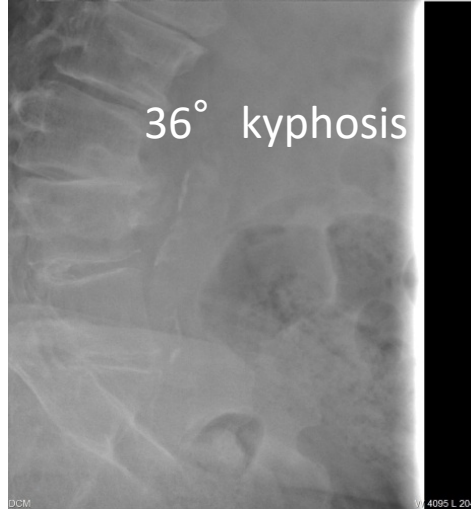
LL-35°

PI-55°

PT-23°

1 year

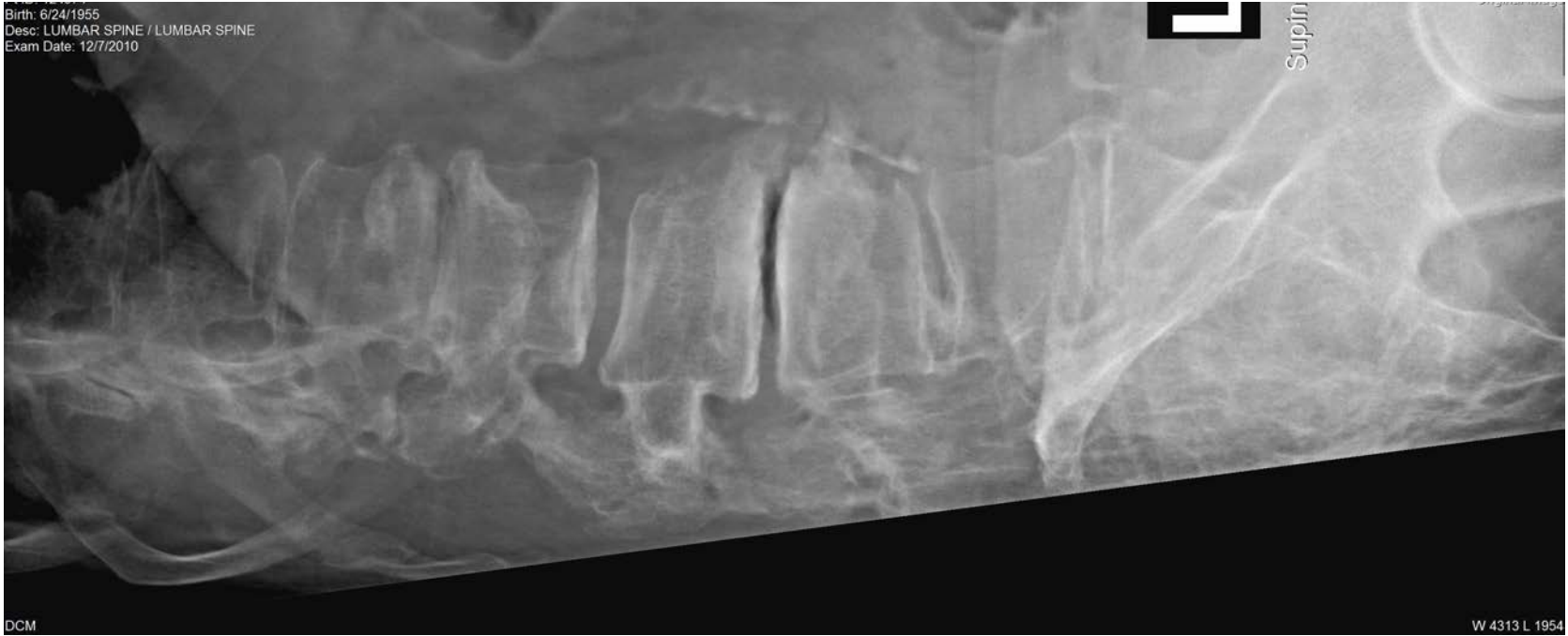




- 55 yo male
- 7 previous surgeries
- L4-S1 fusion
- Laminectomy above

supine

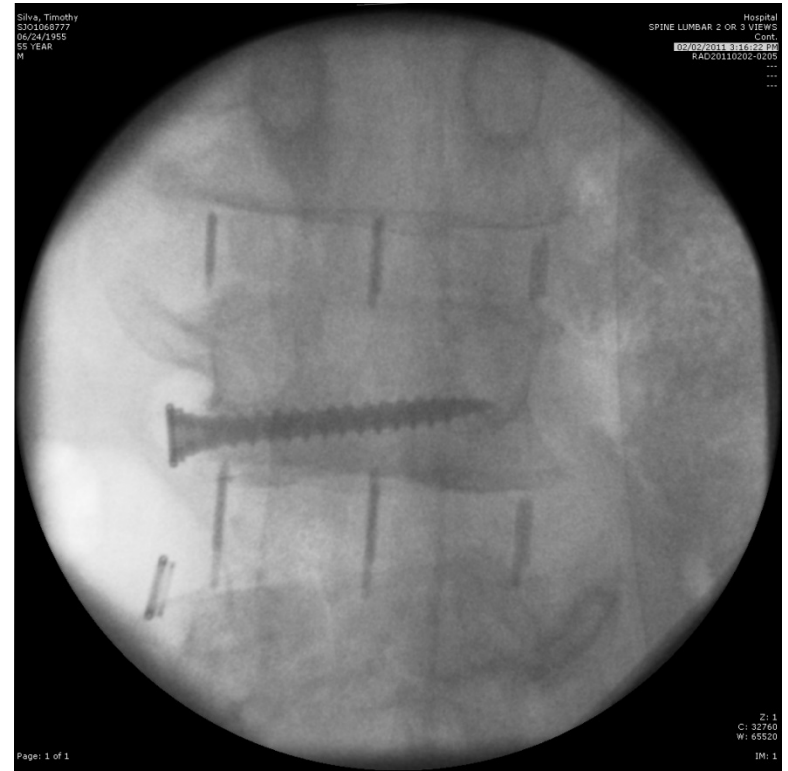
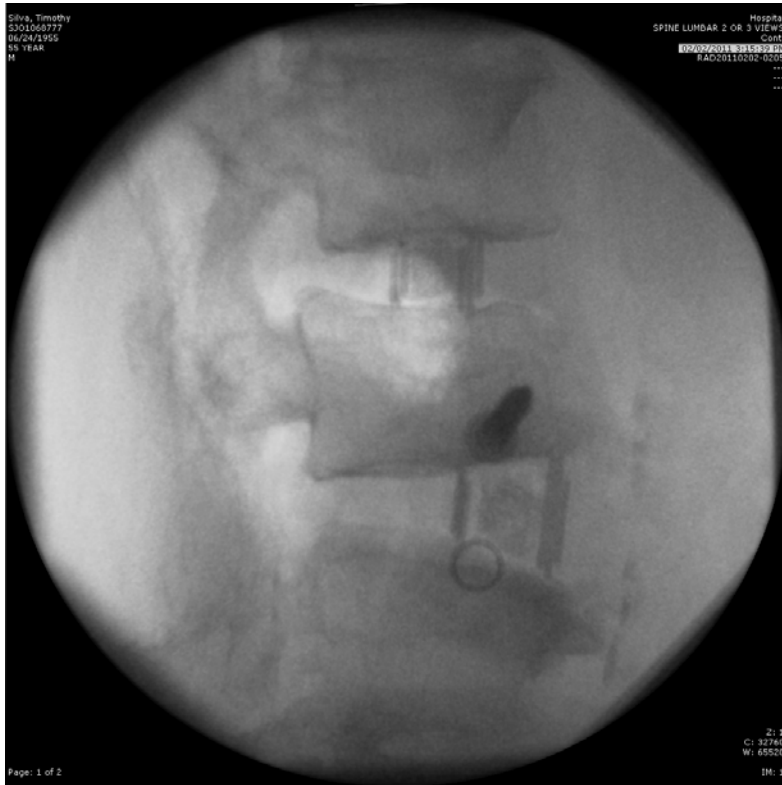
Birth: 6/24/1955  
Desc: LUMBAR SPINE / LUMBAR SPINE  
Exam Date: 12/7/2010



DCM

W 4313 L 1954





# 34° kyphosis to 36° to lordosis





- Correction needed
- flexibility
- Bone quality
- Available disk space
- Patient factors
  - Age, comorbidities

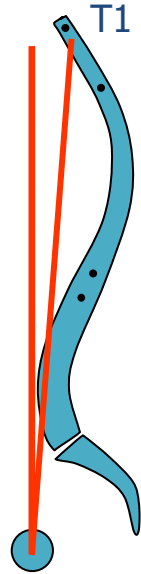


# Alignment objectives



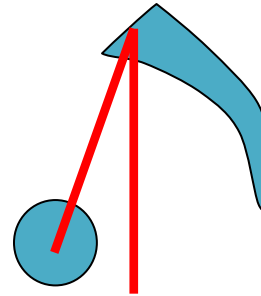
SVA

**<5cm**



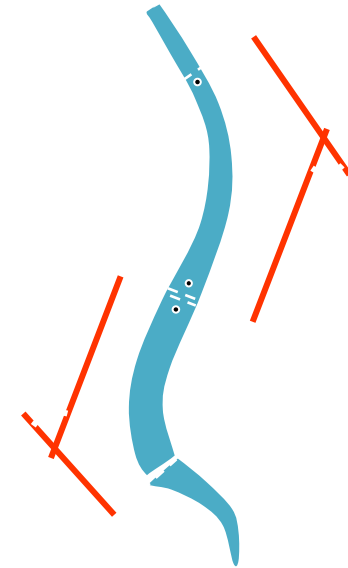
T1 Tilt

**<0°**



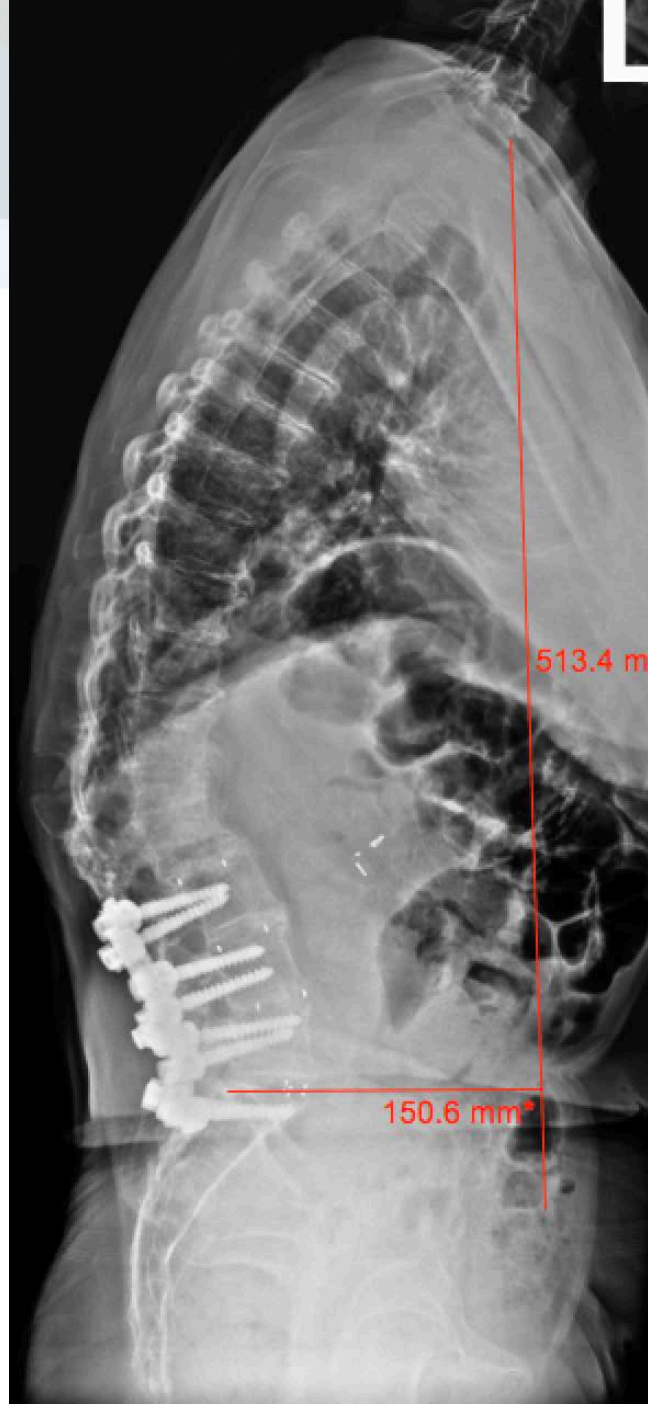
PT

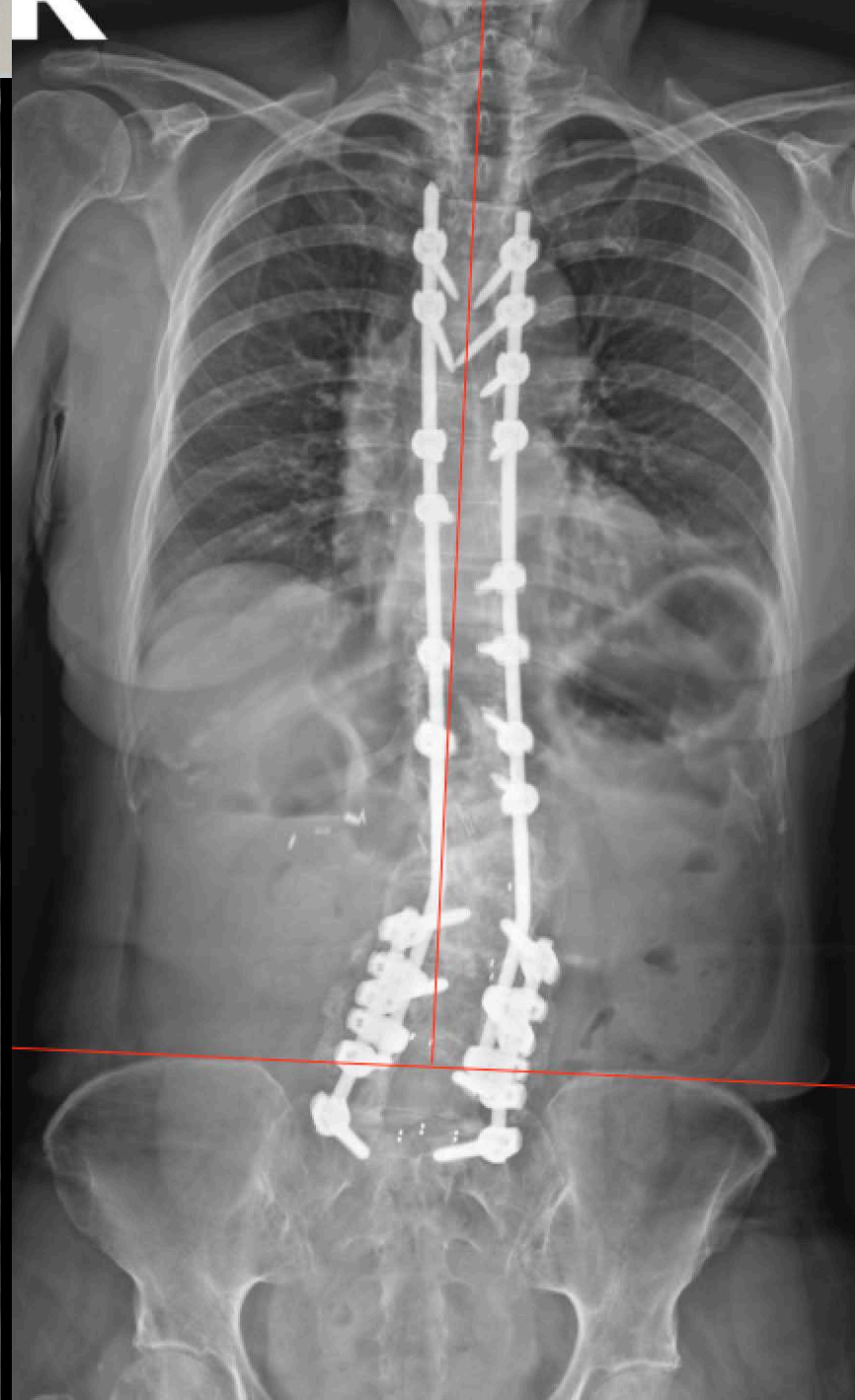
**<25°**

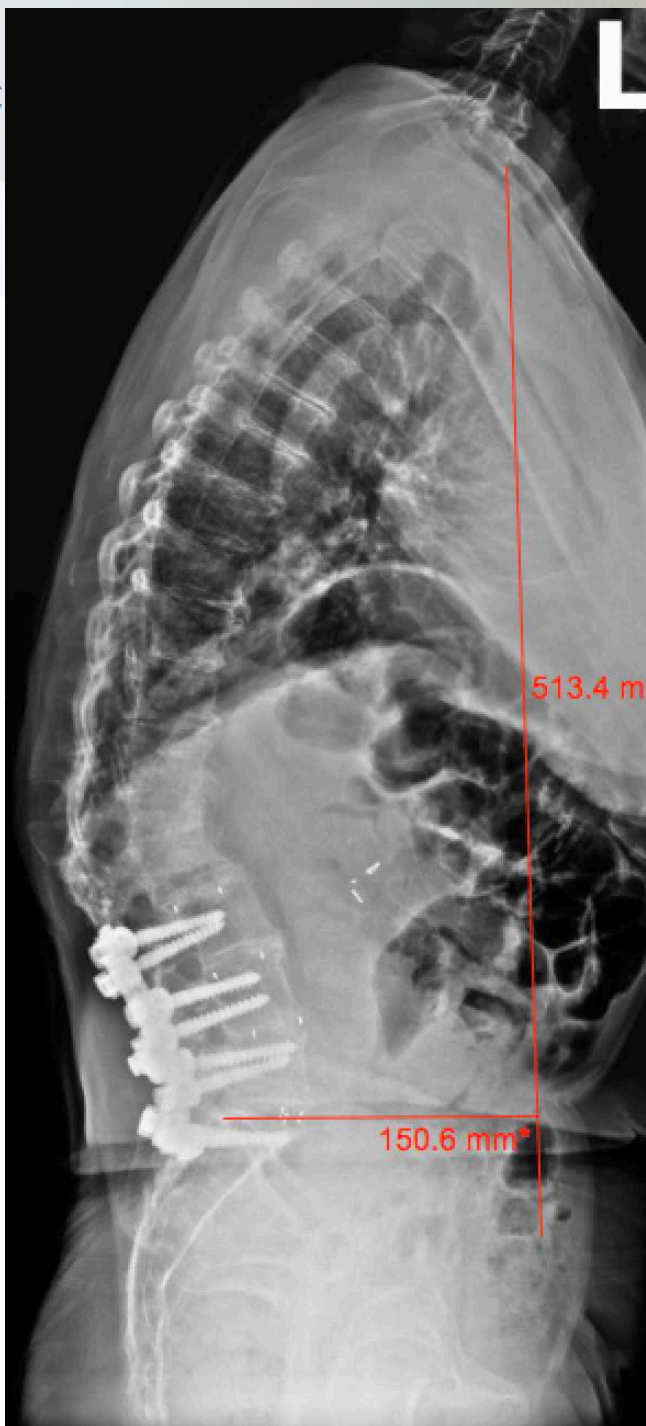


Proportional:  
**LL=PI +/- 9°**

- 80yo f



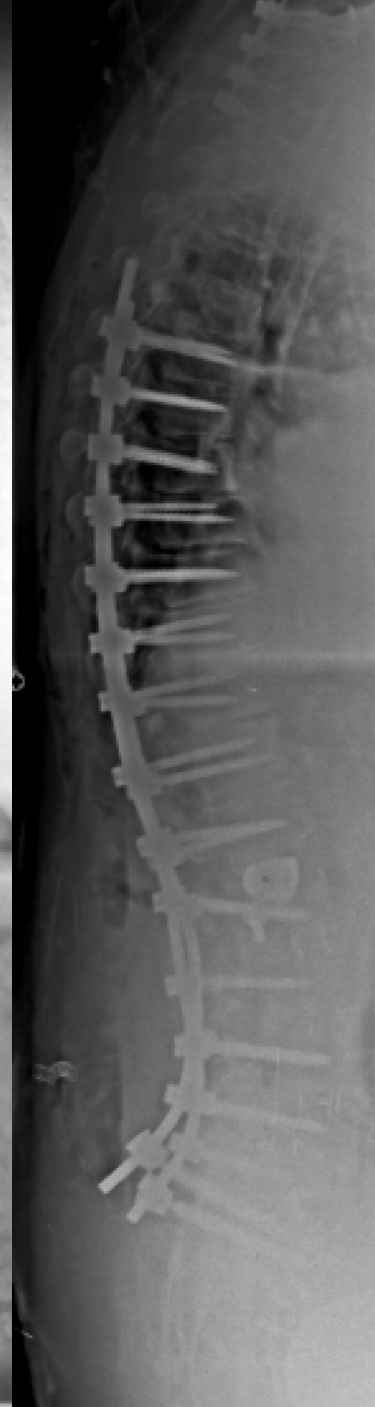








- 68m
- Obese
- Diabetic



1 year

# Conclusions

- Sagittal balance is the dominant predictor of symptoms in adult deformity
- Deformity correction requires attention to regional and global alignment issues
- Osteotomies are important tools in deformity correction

# Conclusions

-New techniques provide powerful corrections with limited morbidity

Hyperlordotic, ACR

-Use preoperative planning to determine the type, number and location of corrections

Pelvic parameters

Undercorrect?

Use novel less invasive options?



- 55m
- obese
- Dialysis dependent



# 3 months





1 year





