

# Adult Spinal Deformity: Principles of Surgical Correction

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**UC Irvine Health**







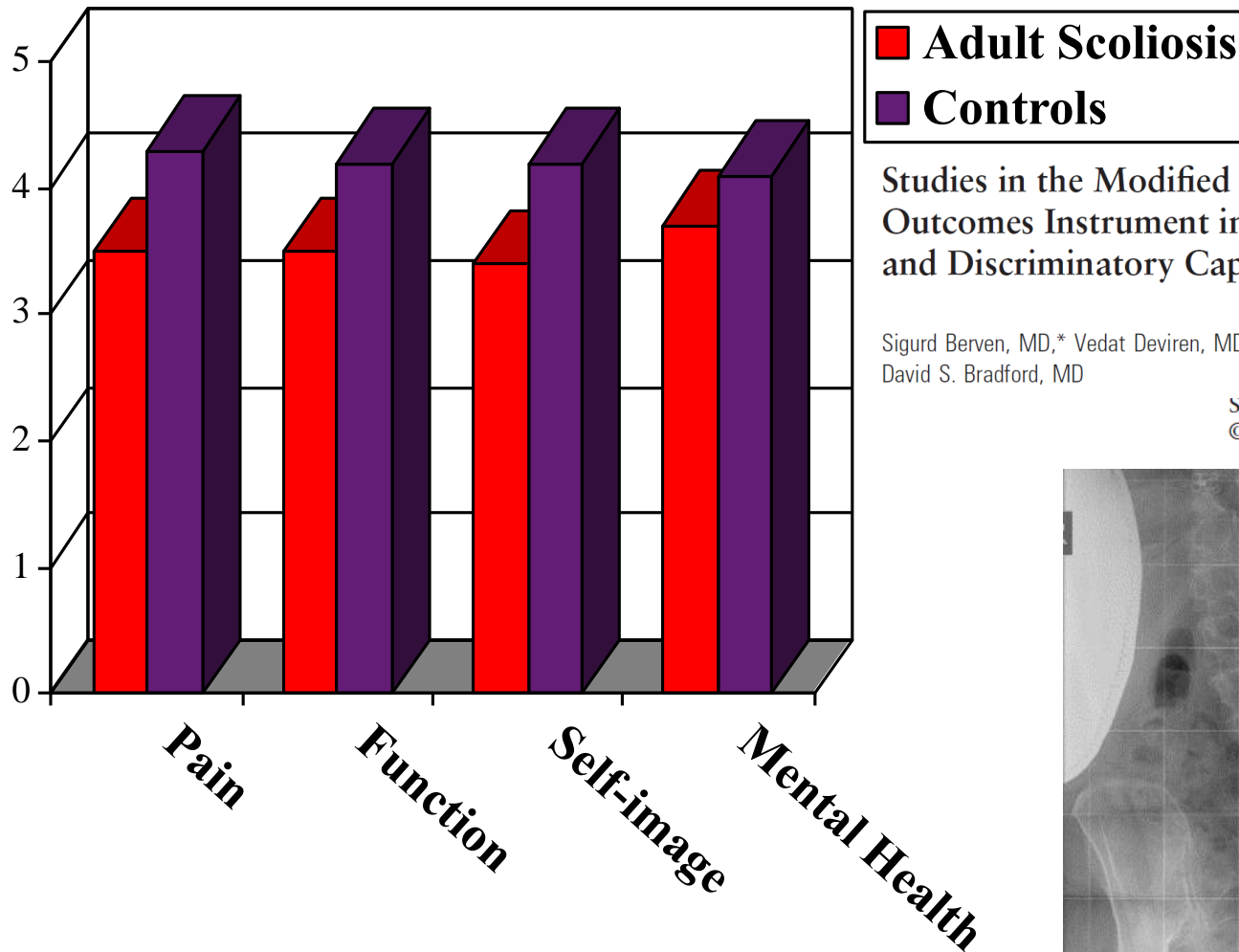
# Adult Scoliosis: How common is it?

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Age > 50: 6-9%  
LBP: 7.5%  
Both: 15-68%



# Impact of Degenerative Scoliosis



**Adult Scoliosis**  
**Controls**

Studies in the Modified Scoliosis Research Society Outcomes Instrument in Adults: Validation, Reliability, and Discriminatory Capacity

Sigurd Berven, MD,\* Vedat Deviren, MD,\* Sibel Demir-Deviren, MD, Serena S. Hu, MD, and David S. Bradford, MD

SPINE Volume 28, Number 18, pp 2164–2169  
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## Adult Scoliosis: Distinct Populations

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	<b>Lumbar Degenerative</b>	<b>Adult Idiopathic</b>
Age	>50y	30s-50s
Etiology	Disc/facet degeneration	Idiopathic
Reason for presentation	Leg pain, back pain	Deformity, back pain
Curve magnitude	20-30 degrees	50-60 degrees
Stenosis	84%	7%

## Natural History

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### Table 1. Risk Factors for Curve Progression

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Factor	Curve Progression	No Curve Progression
Patients 41 (100%)	30 (73%)	11 (27%)
Cobb angle	>30°	<30°
Rotation	Grade 2 or 3	Grade 1 or 2
Intercrest line	Through L5	Through L4
Vertebral translation	≥6 mm	<6 mm

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- Curve progression averaged 3.3 degree per year.
- Those with progression had increased back and leg pain.



# Clinical Assessment

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History

Physical

Imaging

- X-rays
- Bending & Traction films
- MRI
- CT scan +/- myelogram
- Discogram



# History

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## Pain

- Back – more prevalent
- Leg – more commonly the reason for presentation
  - Radicular or Neurogenic claudication

## Postural Imbalance/Deformity Progression

- Stooped Posture
- Coronal imbalance may be painful, fatiguing
- Convexity is the area of greatest pain in 75%
  - 2<sup>nd</sup> most common is concavity

# Physical Examination

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## Overall spine alignment

## Neurological examination

- Many patients have a normal exam

## Other joint pathology

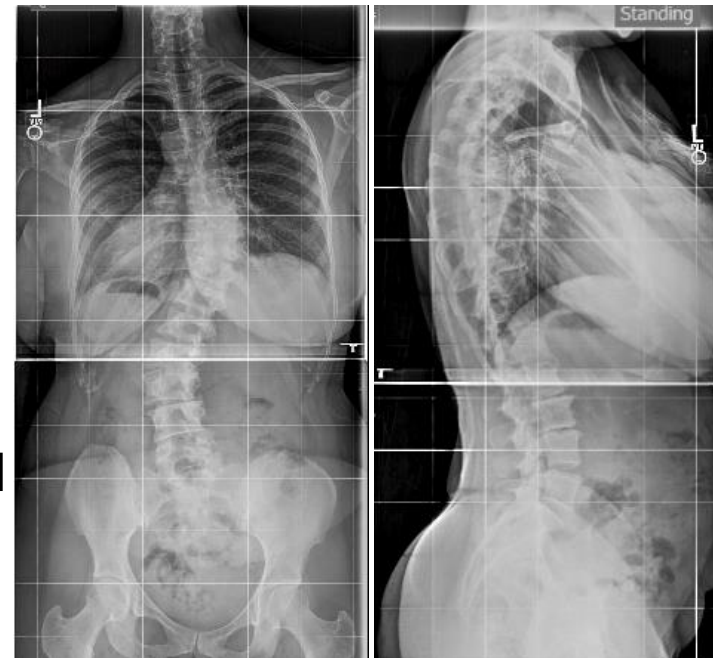
- Hip/Knee – contractures
  - The hip may be maximally extended to compensate for a loss of lordosis
- Cervical spinal stenosis – altered gait



# Imaging

## Plain Radiographs

- Standing PA/lateral full-length spine films
  - 14 x 36”
- Lateral supine bending films
- Traction films in curves > 60 degrees
- Push-prone films
- Flexion/Extension for lumbar flexibility and sagittal instability
  
- Non-weightbearing imaging (supine radiographs, MRI) tend to underestimate curve magnitudes by approximately 10 degrees



# Dynamic Radiographic Studies

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## Lateral Bending

- Less flexible than adult idiopathic scoliosis

## Traction

- Can reveal extent of autofusion from degeneration



Right Bend

Left Bend



# Traction Films



Standing PA



Supine PA with  
Traction

# Advanced Imaging and further testing

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## Cross-sectional imaging

- MRI
- CT +/- myelography

## ?Discography

## PFTs

- For thoracic curves > 70 degrees
- Pulmonary symptoms
- Hx of pulmonary disease
- Thoracoplasty: 27% decline in PF at 3 months
  - Lenke (1995) Spine.



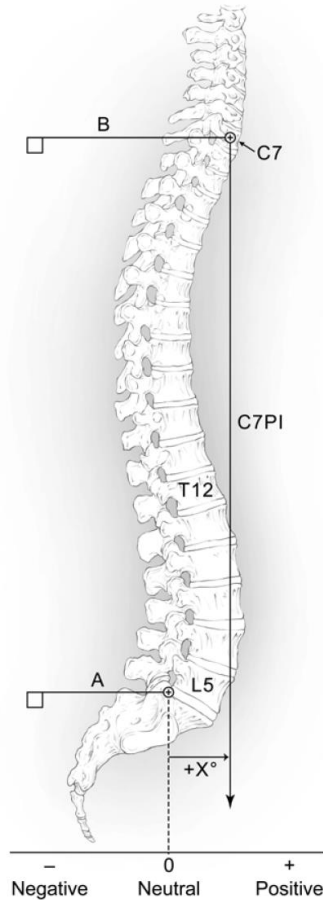
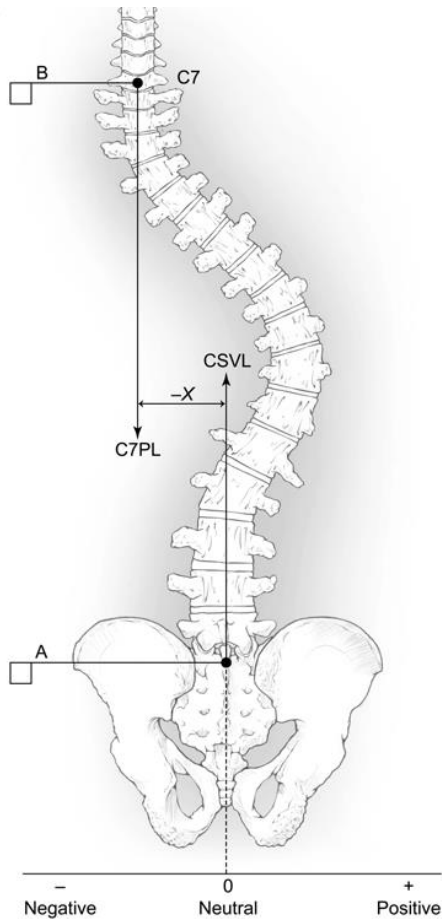
# The Cone of Economy

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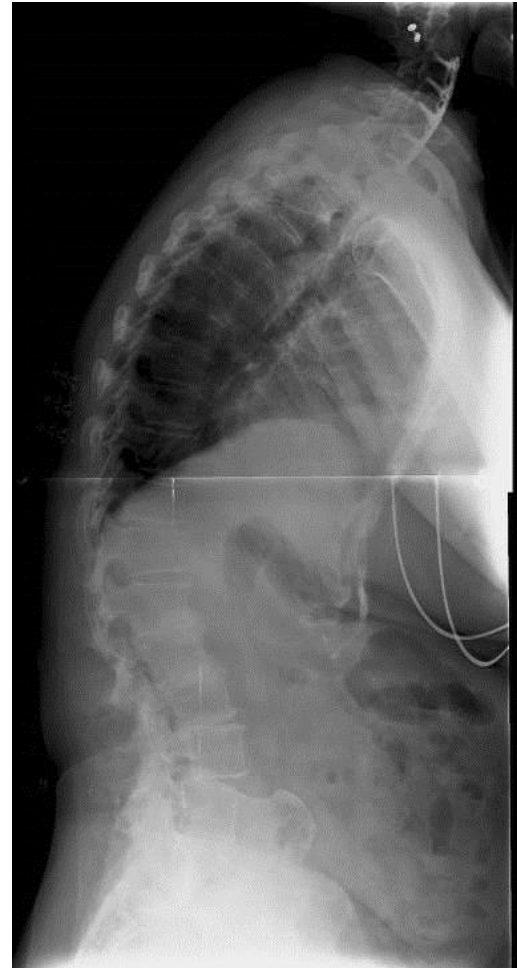
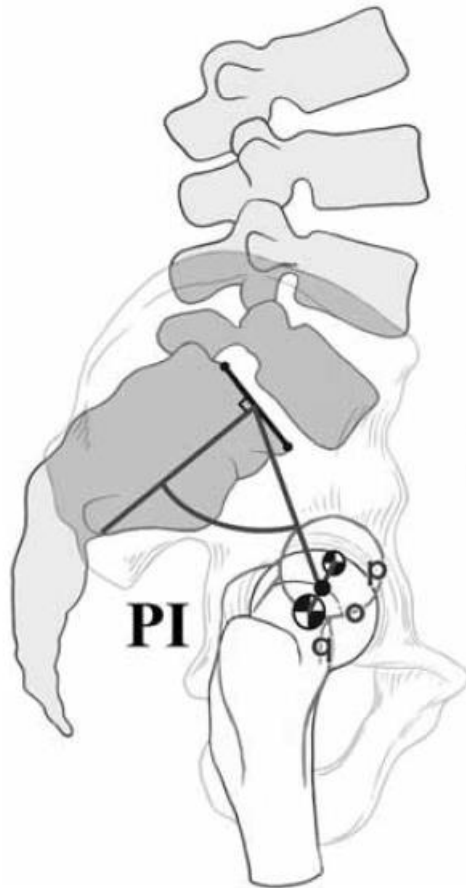
# Coronal and Sagittal Balance



Positive sagittal balance most reliable predictor of clinical symptoms and poor functional outcome in operative and non-operative patients.

# Pelvic Parameters: Sagittal Plane

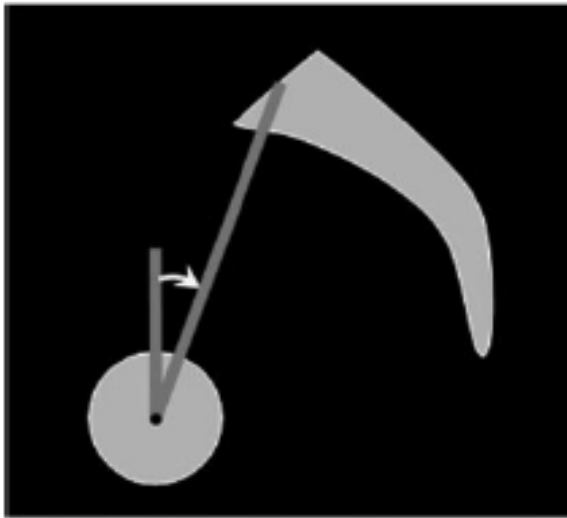
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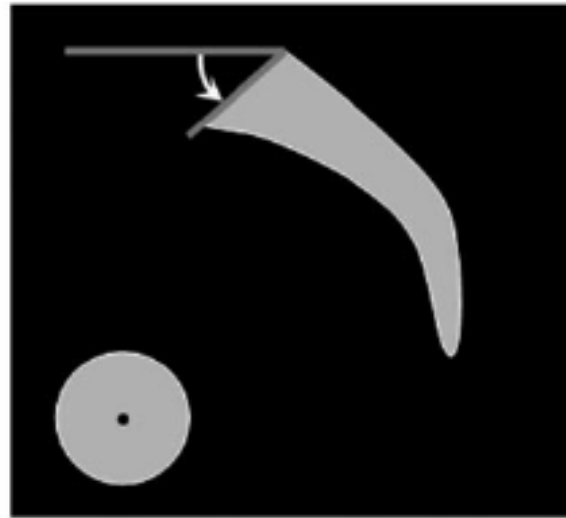
# Pelvic Parameters

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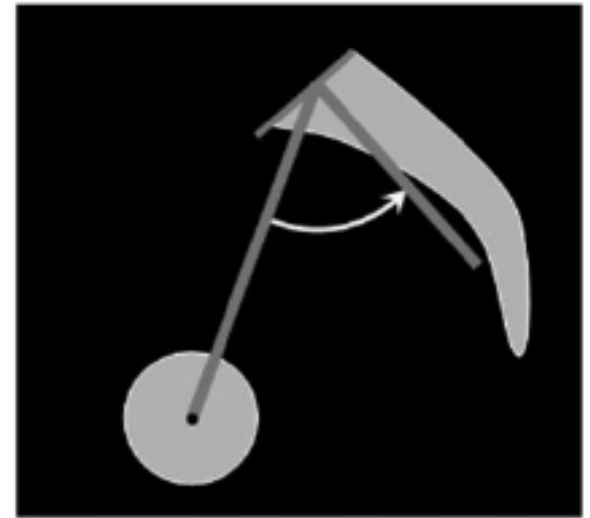
$$PT + SS = PI$$



**Pelvic Tilt**

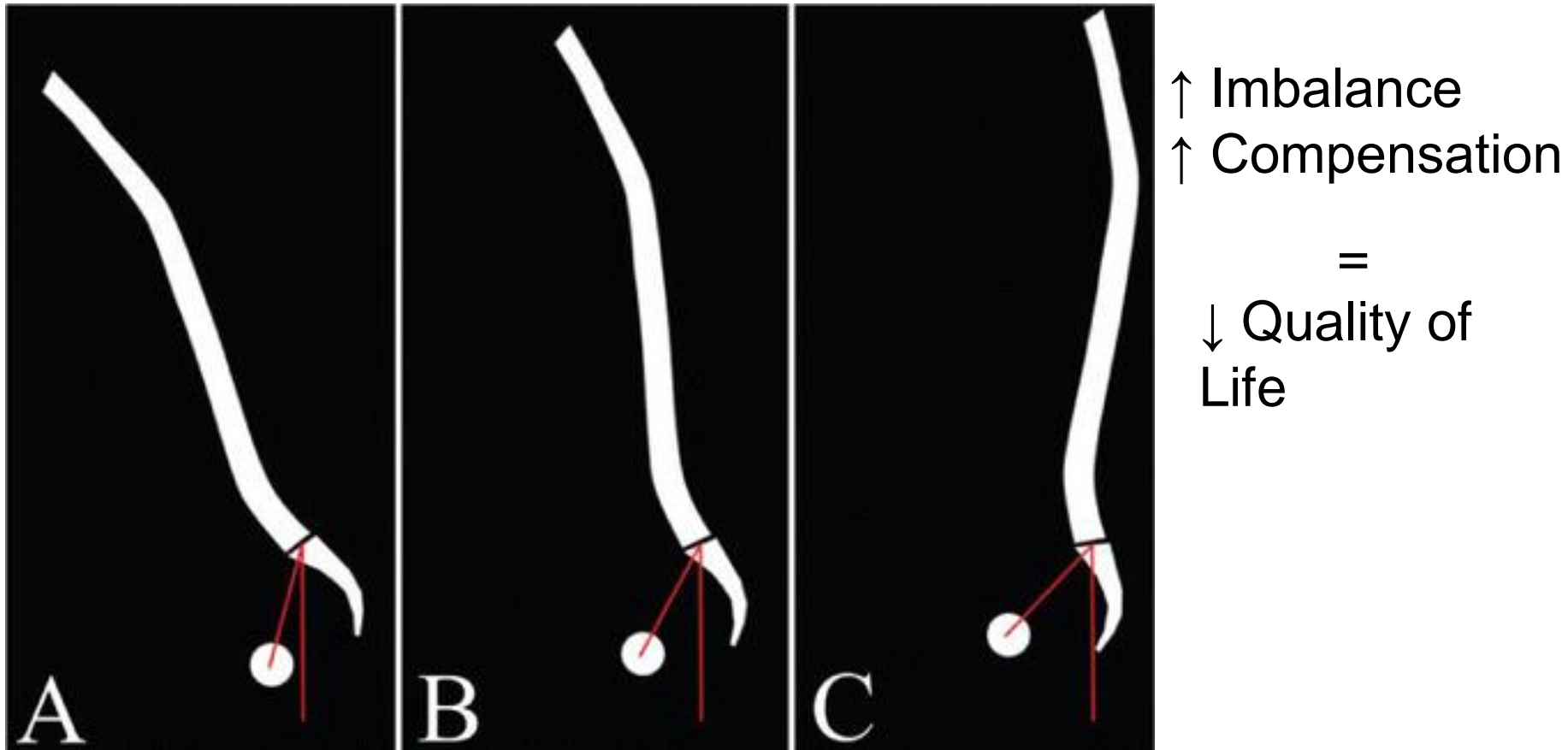


**Sacral Slope**



**Pelvic Incidence**

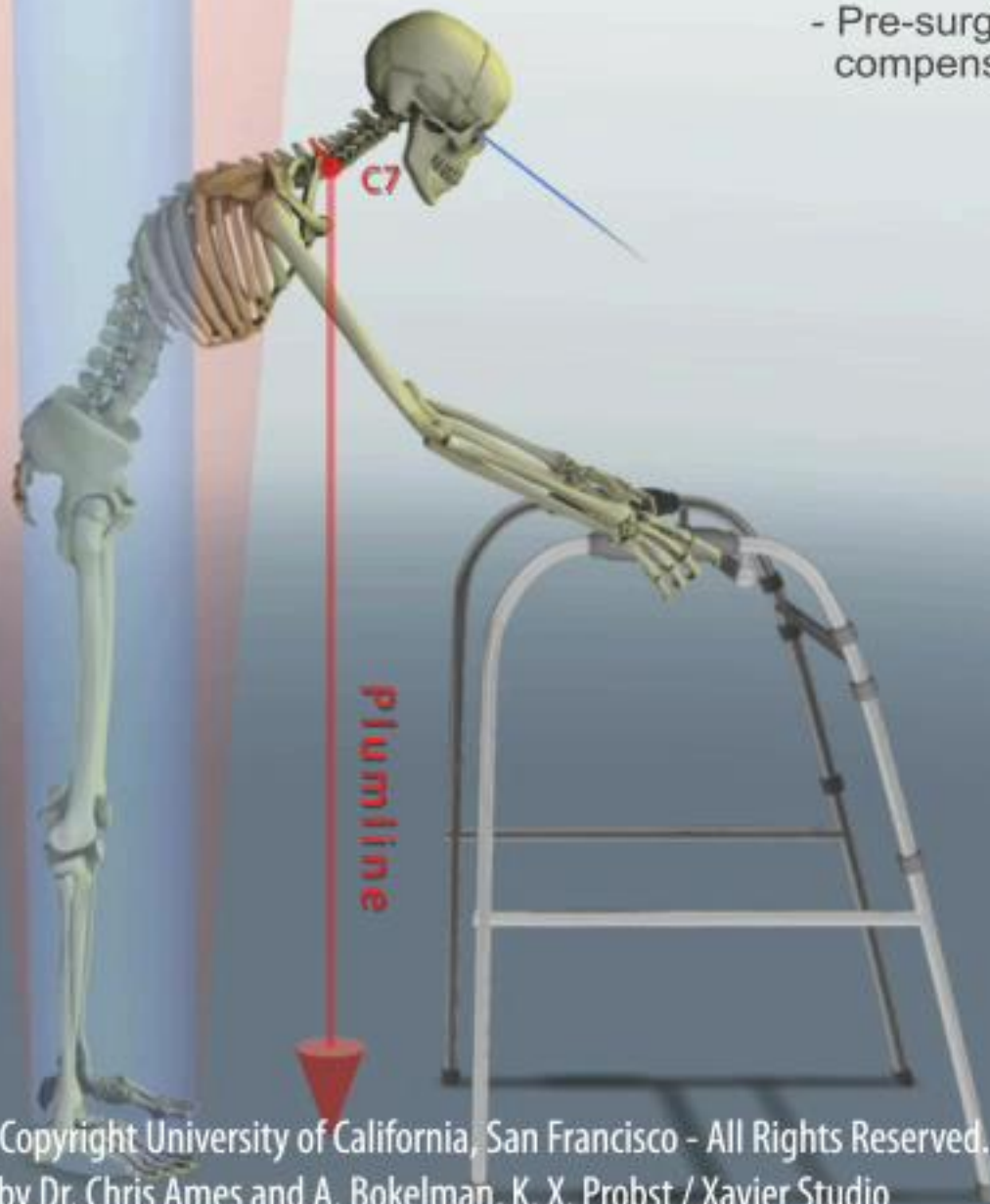
## Compensation with Pelvic Retroversion



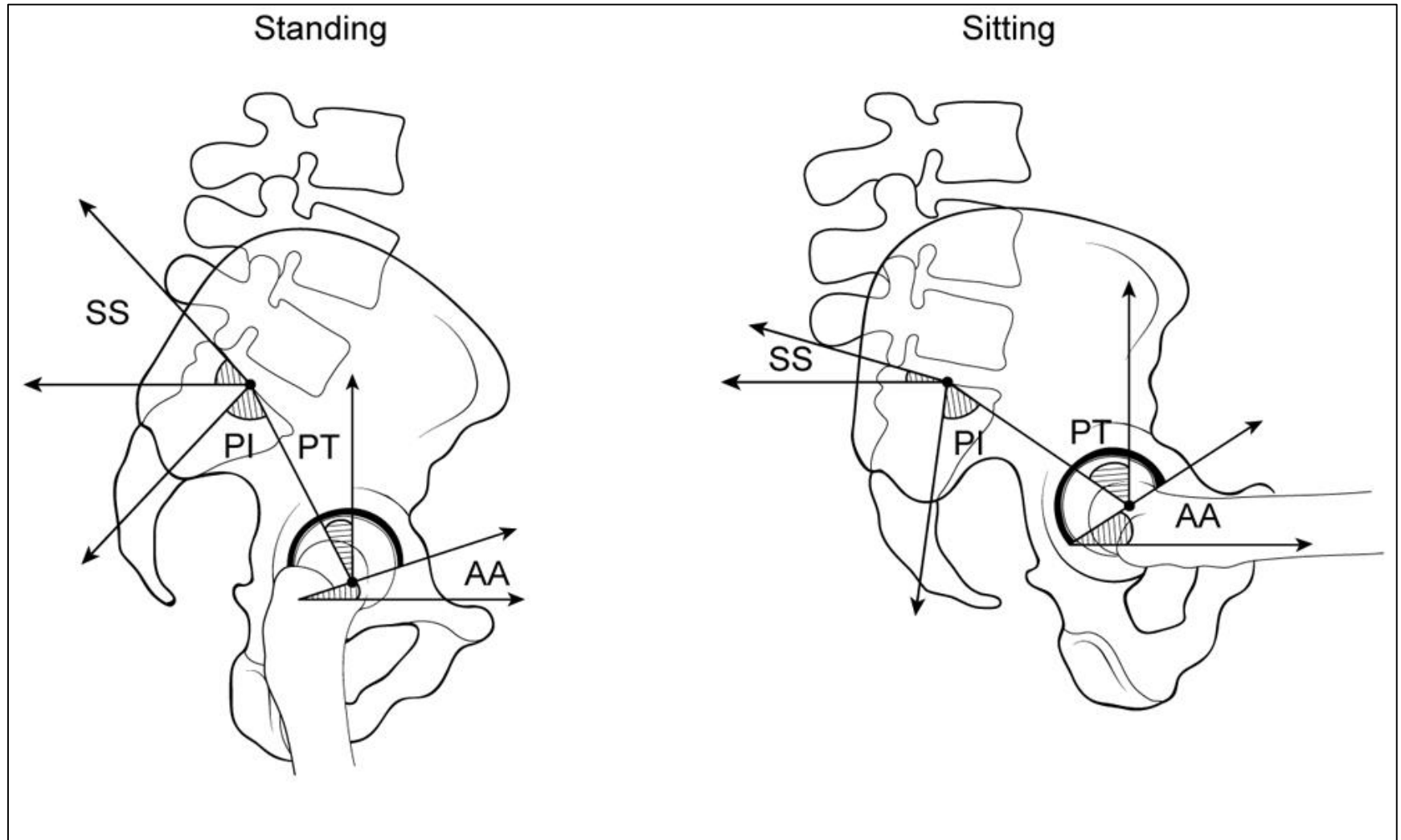
Similar functional outcome improvements in compensated and uncompensated flatback deformities following surgical correction

## COMPENSATORY EFFECTS

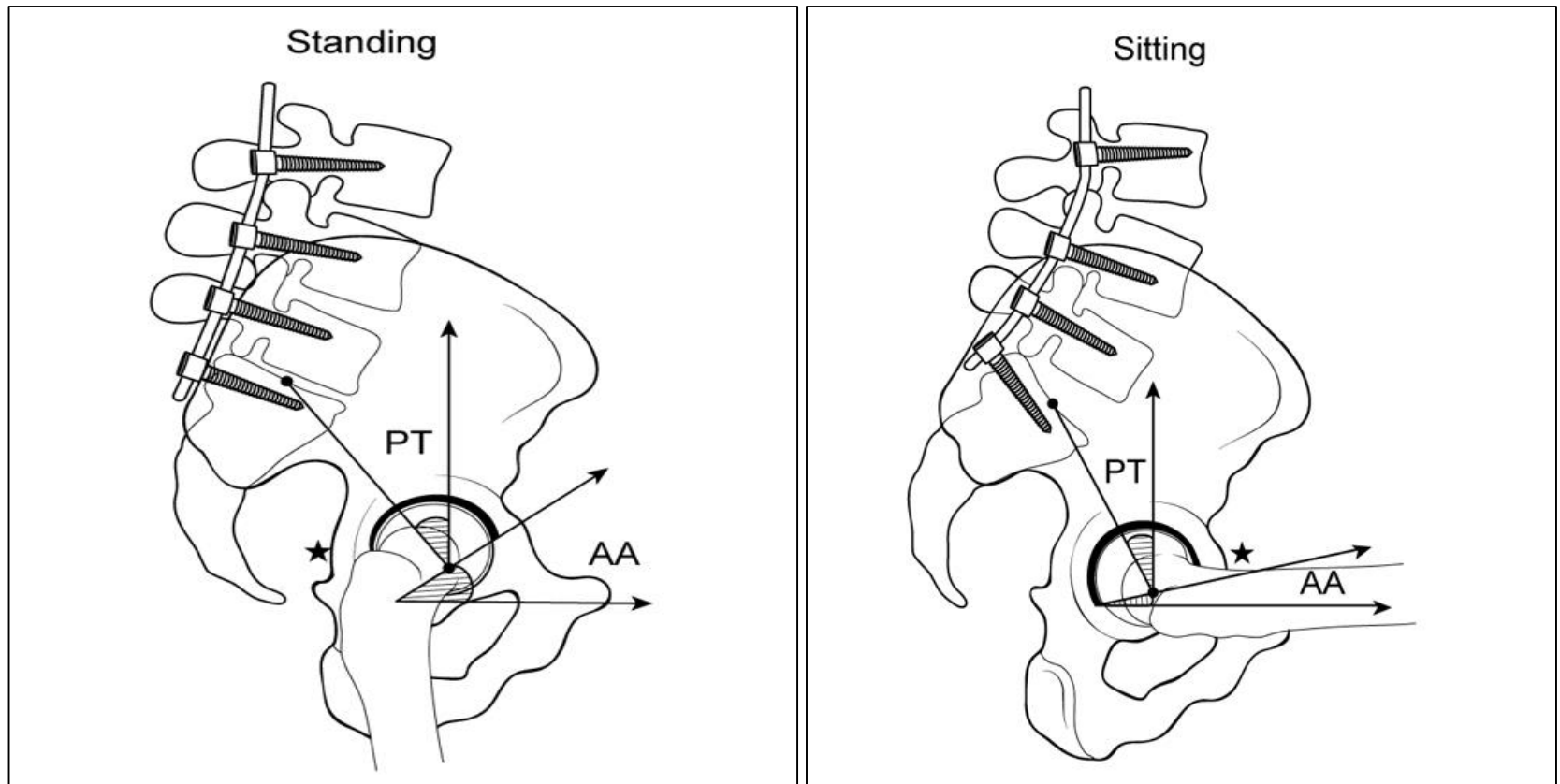
- Pre-surgical condition without compensatory effects



# Reciprocal Changes around the Hip and Pelvis

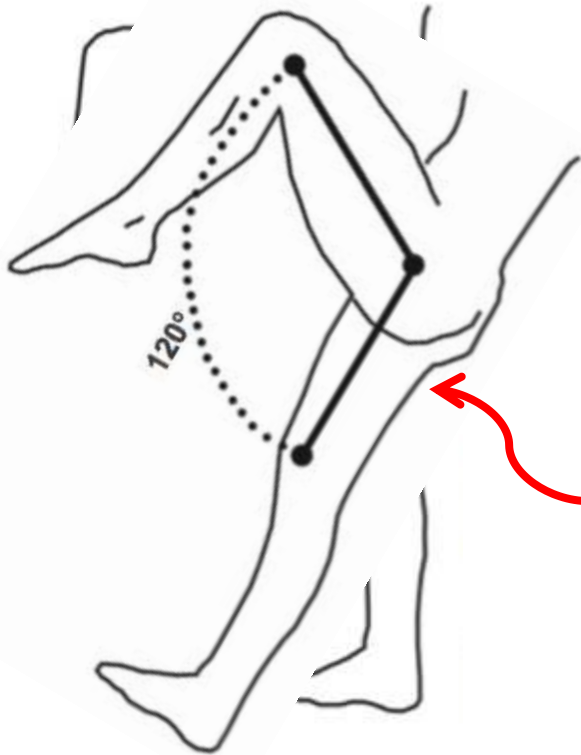


# Reciprocal Changes around the Hip and Pelvis



# Reciprocal Changes: *Pelvic Compensation*

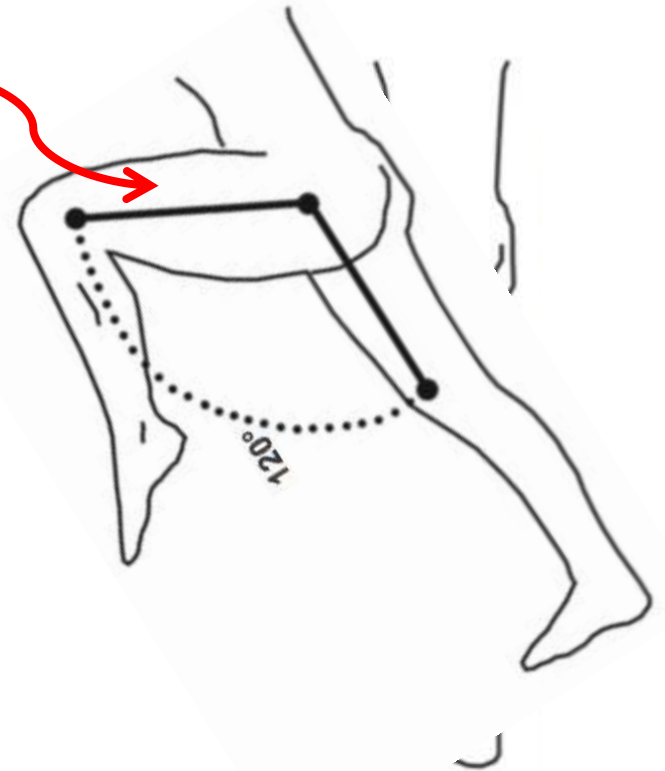
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**Retroversion**

Anterior  
Impingement

Posterior  
Impingement

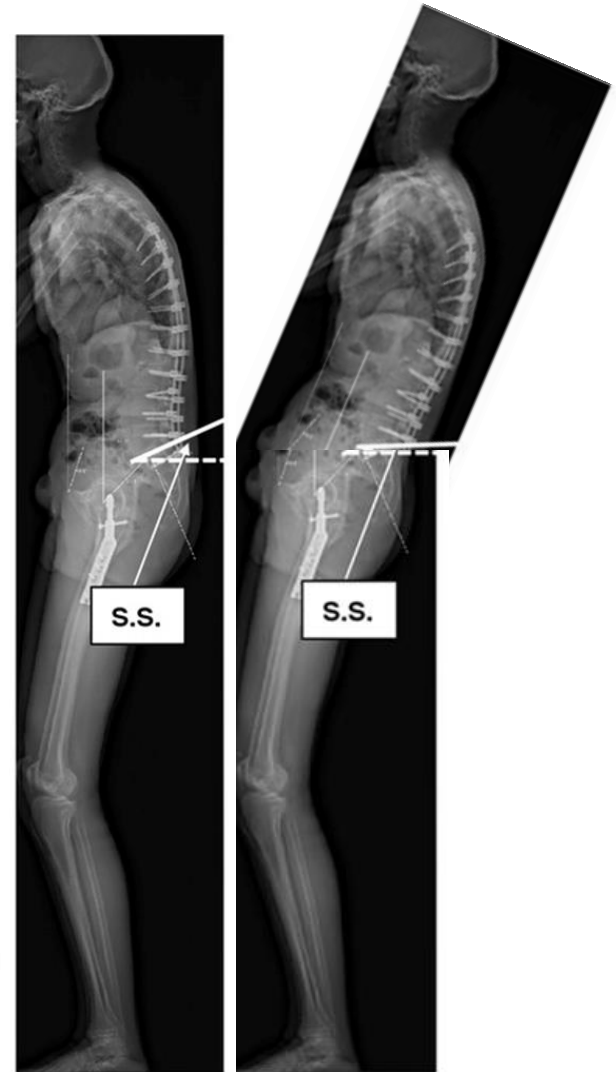


**Anteversion**



# Knee Flexion Contractures

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## Case Example

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75F

Back and leg pain

Unable to stand upright

Prior ACDF C3-7





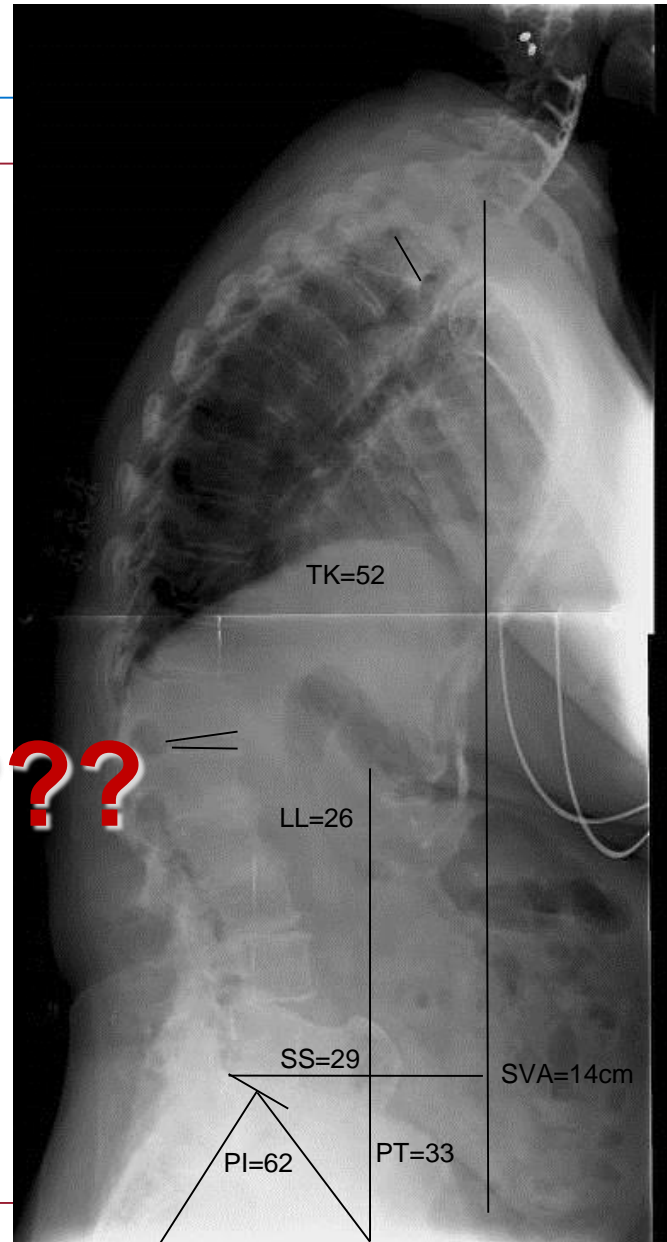
$$PI = PT + SS$$

$$PT < 25$$

$$PI = LL$$

# Treatment???

- $PI - LL = 62 - 26 = 36$



# Surgical Decision Making

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## General Indications

Pain

Neuro deficit

Deformity

## Surgical Options

Decompression

Stabilization

Deformity correction

# Stand-Alone Decompression

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## Rarely indicated

No back pain

No up-down foraminal stenosis

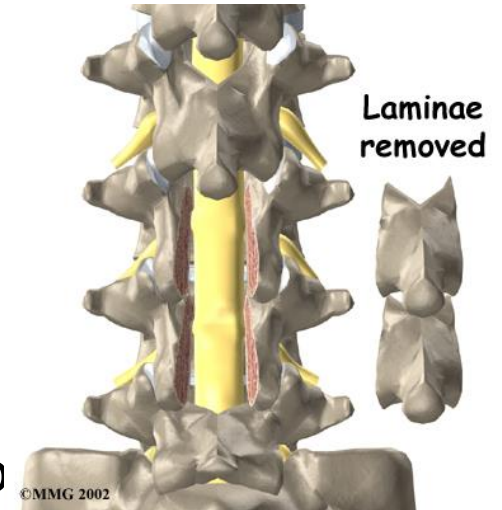
No gross instability at selected levels

## Stability preserving

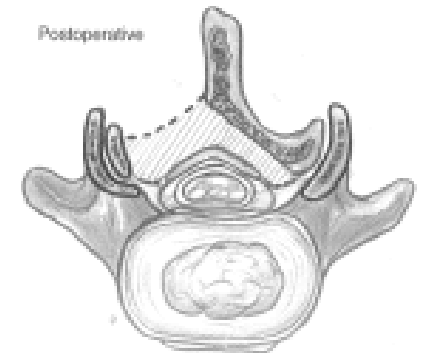
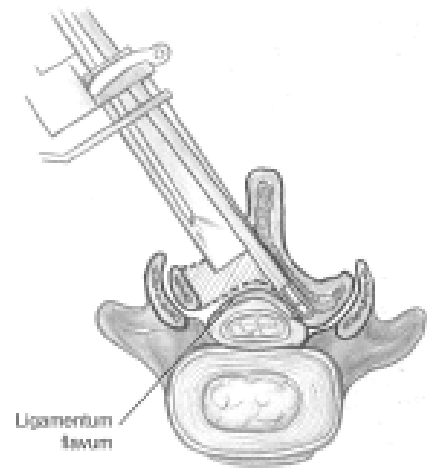
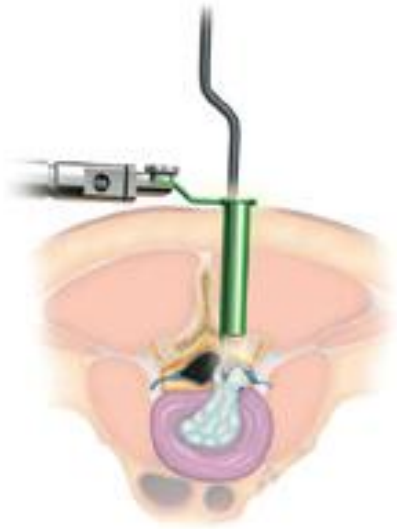
Laminotomy

Unilateral approach for bilateral decompression

McCullough laminoplasty, Spinous process osteotomy



# Minimally Disruptive Approaches



# Decompression/Limited Fusion

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Limited fusion with decompression

Short segment

Interbody for height restoration

Fusion w/o correction if balanced in coronal and sagittal plane

Especially below a rigid or fused curve

Risk of adjacent segment disease

Risk of progression of deformity





## Deformity Correction

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Addresses all anatomical causes of pain – deformity, degeneration, and neural element compression

Decreases likelihood of revision to address problems within the deformity

May still have risk of adjacent segment disease

Higher amount of overall morbidity



# Controversy: Decompression vs. Limited Fusion vs. Correction

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## Surgical Outcomes of Decompression, Decompression With Limited Fusion, and Decompression With Full Curve Fusion for Degenerative Scoliosis With Radiculopathy

SPINE Volume 35, Number 20, pp 1872–1875  
©2010, Lippincott Williams & Wilkins

Ensor E. Transfeldt, MD, Raymond Topp, MD, Amir A. Mehbod, MD,  
and Robert B. Winter, MD

85 patients with degen scoliosis and radiculopathy

Treated by decompression, decompression and limited fusion,  
decompression and curve correction

All 3 had good and poor results

- D: fewest complications, most would not have done again
- DCC: highest complications, most successful
- DLF: in between

## The Good News

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Leg pain is reliably treated operatively when compared with non-operative treatment  
Smith, et al. Spine 2009

Back pain is reliably treated operatively when compared with non-operative treatment  
Smith, et al. Neurosurgery 2009

Good deformity correction can be achieved surgically  
Pateder, et al. Spine 2007

# Functional Improvement

## Results of Surgical Treatment of Painful Adult Scoliosis

Spine 2004

Stephen A. Grubb, MD, Hester J. Lipscomb, MPH, and Paul B. Suh, MD

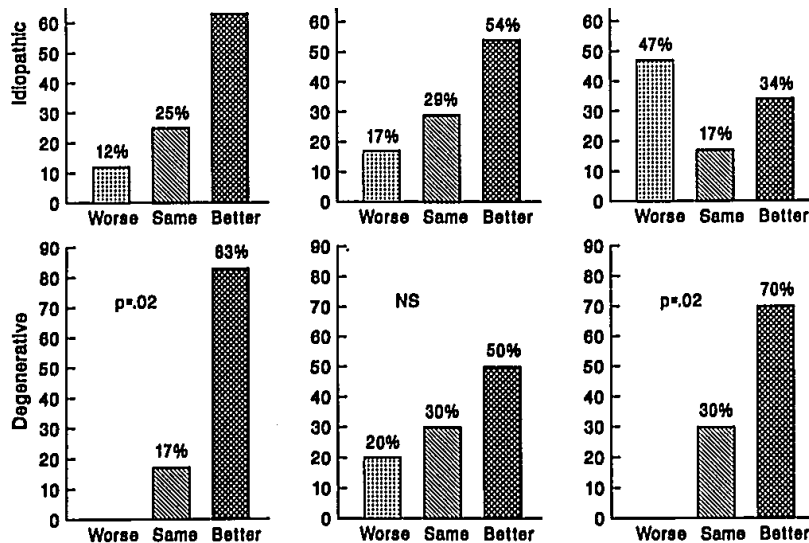


Figure 1. Activity tolerance change (pre- to postop) by scoliosis type.

Patients consistently walk and stand better than pre-op

They usually tolerated sitting the same or better than pre-op

Pain was consistently reduced in patients w/ successful fusion

## The Bad News

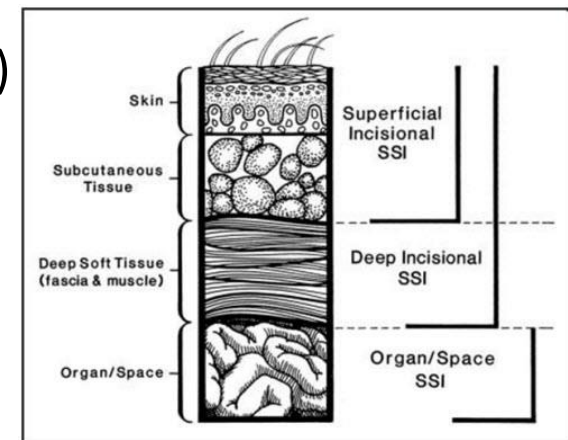
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### Major Complications

Residual pain	5-15%
Neurologic injury	Up to 5%
Infection	1-5%
Pseudarthrosis	5-27%
Thromboembolism	1-20%

# Rates of Complications, by Age Group, SRS Database

- Studies found surgical complications for scoliosis ranging from 10-40%
- 25-44 years (n = 47 cases) = 17% developed complications
  - Highest major complication: deep wound infection (25% major complications)
- 45-65 years (n = 121) = 42%
  - Highest minor complications:
    - cerebrospinal fluid leak (8% minor complications)
    - symptomatic pulmonary effusion (8%)
    - prolong ileus (6%)
  - Highest major complications:
    - excessive blood loss (22% major complications)
    - deep wound infection (22%)
    - nerve root injury, quad weakness (17%)



Source: (Smith, Shaffrey, Glassman, et al., 2011)

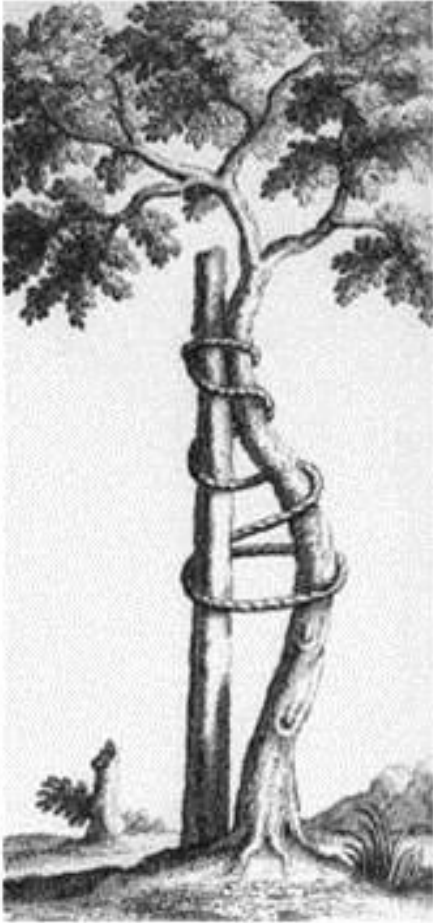
# Rates of Complications, by Age Group, SRS Database

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- 65-85 years (n = 38) = 71%
  - Highest minor complications:
    - superficial infection (25% minor complications)
    - deep venous thrombosis (19%)
    - prolonged ileus (19%)
  - Highest major complications:
    - excessive blood loss (37% major complications)
    - deep wound infection (18%)
    - pulmonary embolism (18%)



Smith, Shaffrey, Glassman, et al., Spine, 2011



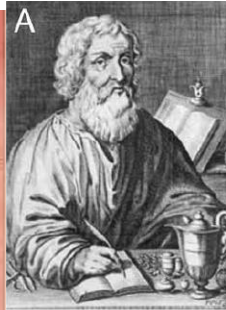
# The Evolution of Scoliosis Treatment

*Orthopaedic*

*“Straight child”*



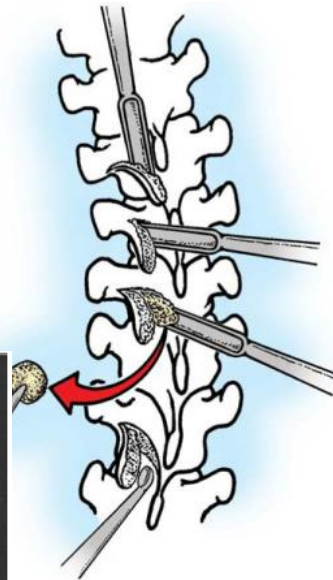
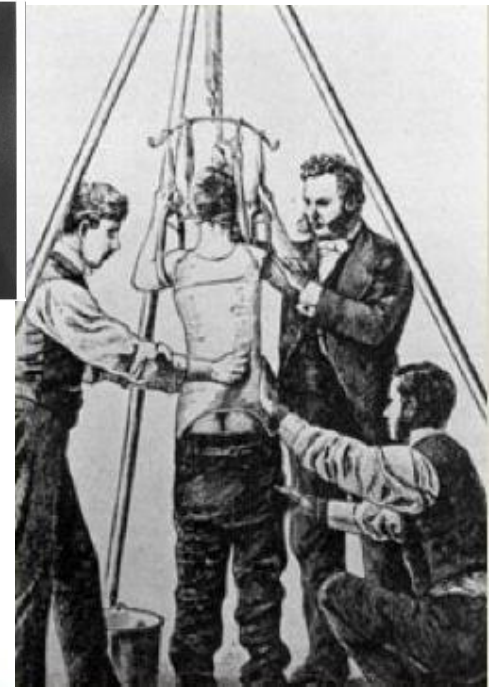
# The Evolution of Treatment



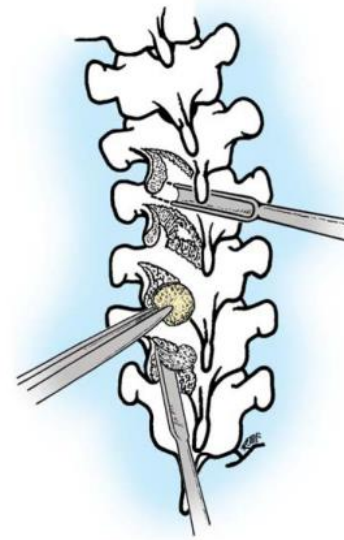
Hippocrates



Paré



Hibbs



B

# The Instrumentation Era



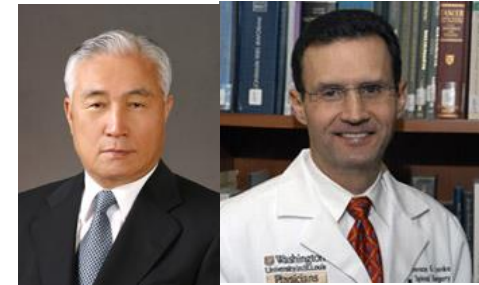
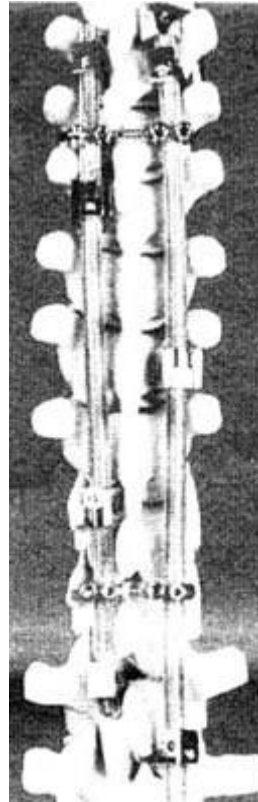
Harrington



Cotrel



Dubousset



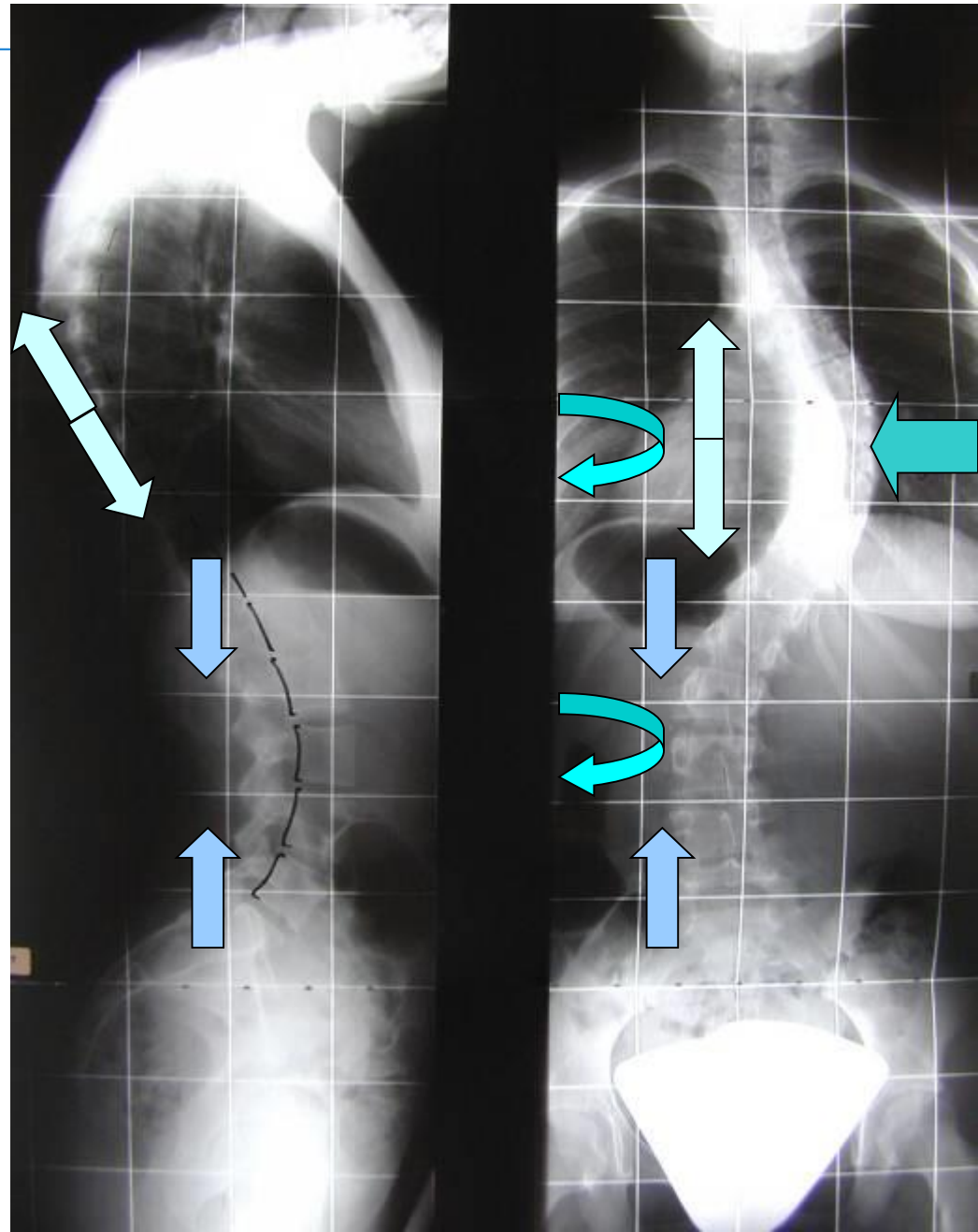
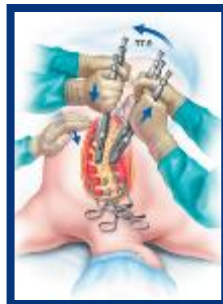
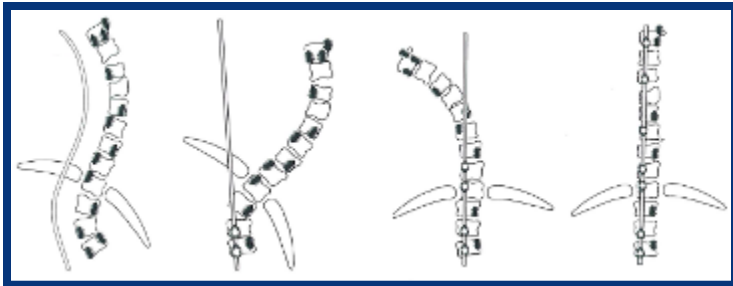
Suk

Lenke



# Techniques of Correction

- Compression
  - on convexity creates lordosis
- Distraction
  - on concavity creates kyphosis
- M/L Translation
- Rod Rotation



# Unique Considerations in Adults

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Stenosis

Disc Degeneration

Joint Ankylosis

Osteoporosis

Risk of Nonunion

Medical Comorbidities







# Adult Deformity Techniques for Sagittal Imbalance

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## Lengthen the front

Interbody fusion (TLIF, XLIF, ALIF)

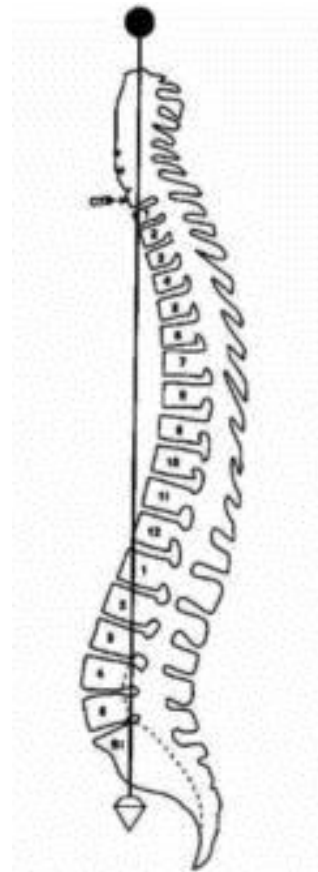
## Shorten the back

Facetectomy, SPO

PSO or VCR (for significant or focal deformity)

Or Both!! (anterior and posterior)

Asymmetric Corrections for Coronal Deformity



# Interbody Fusions

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# Posterior Shortening Procedures

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## Osteotomies





## Smith-Peterson Osteotomy (SPO)

Facetectomy with resection of posterior elements through foramina

Hinges on PLL

Shortens the neuroforamen

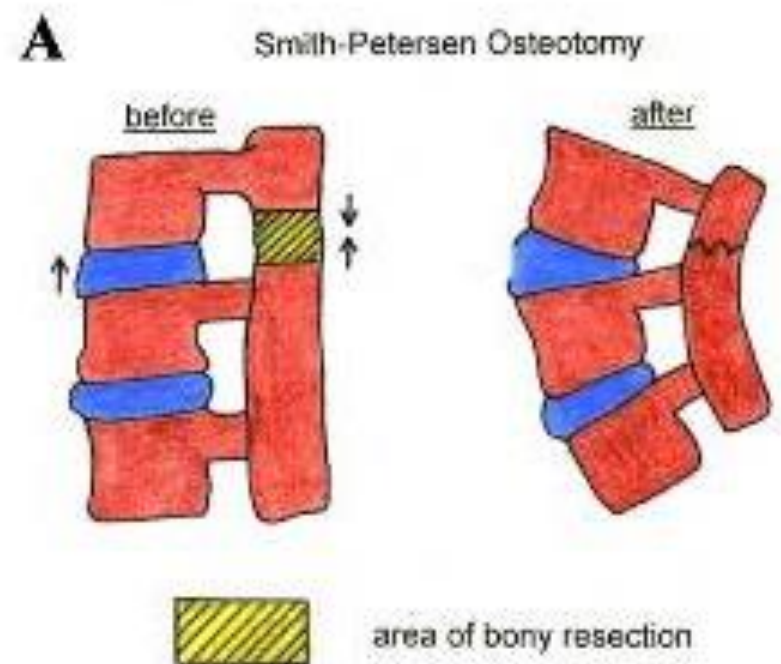
Opens at the disc space

Requires a mobile disc!!!

10-15 degrees per level

Better for global correction

Can be done at multiple levels



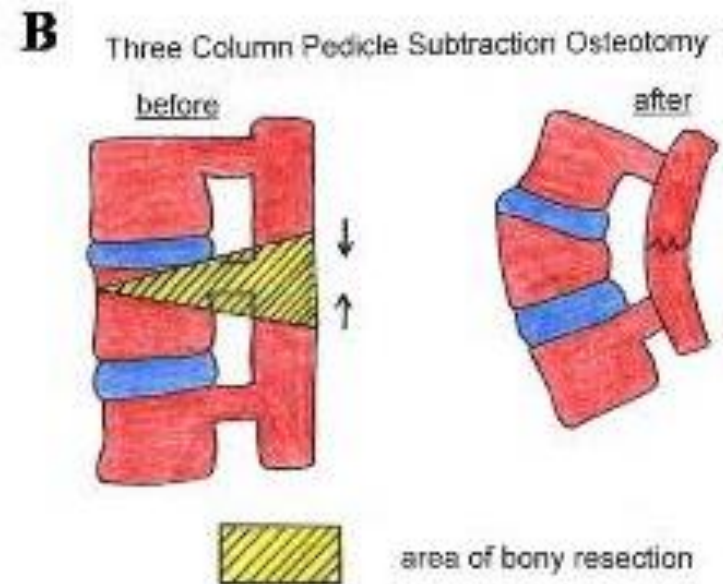
## Pedicle Subtraction Osteotomy (PSO)

Resection of posterior elements including bilateral pedicles of a single vertebral body

Closing wedge osteotomy of a vertebra  
Hinges on anterior column

Can be done through rigid spine

35-50 degrees per level (L-spine)



## Vertebral Column Resection (VCR)

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Resection of entire vertebra with discs  
above and below from posterior  
approach

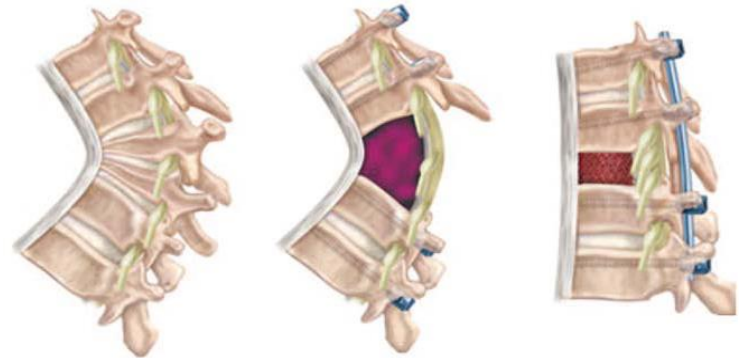
Typically requires insertion of interbody  
device

Hinges on anterior column which may be  
lengthened

Can be done through rigid  
spine

40-60 degrees per level

Most destabilizing = highest risk  
complications



# Approach to Deformity Correction

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Plane of deformity

sagittal, coronal, axial

Global vs. Focal deformity

Rigid vs. Flexible

Mild vs. Severe

Bone Quality

Choosing the ends of the construct



## Case Example

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75F

Back and leg pain

Unable to stand upright

Prior ACDF C3-7

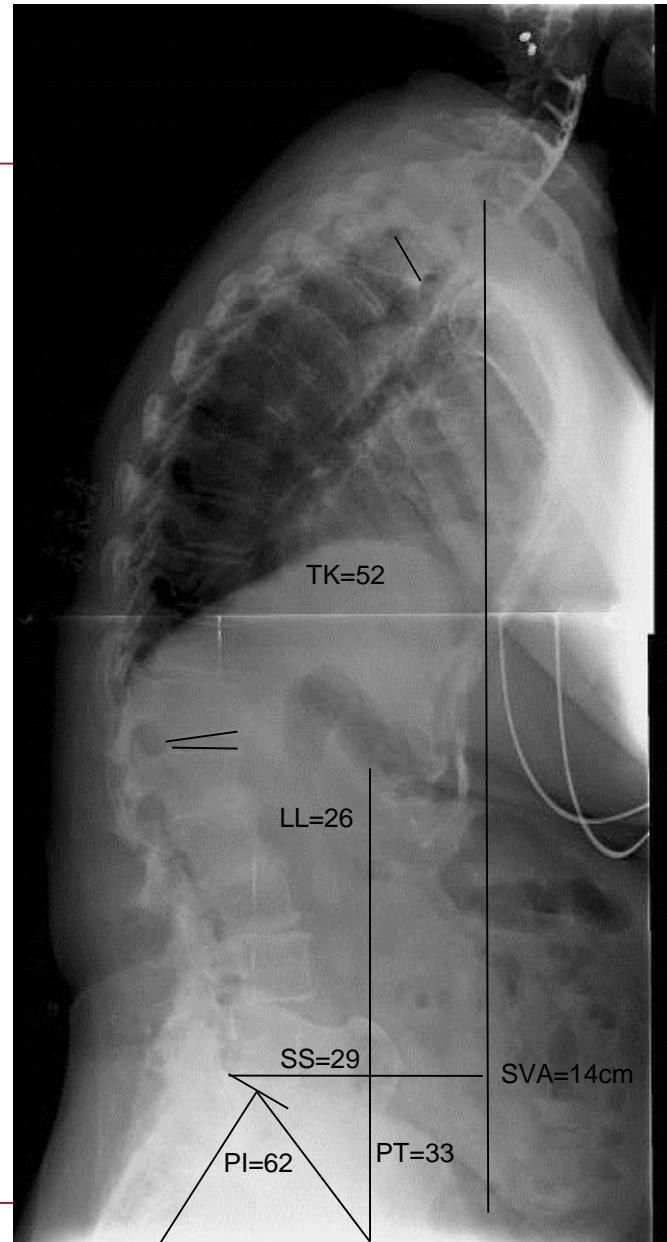


$$PI = PT + SS$$

$$PT < 25$$

$$PI = LL$$

- $PI - LL = 62 - 26 = 36$



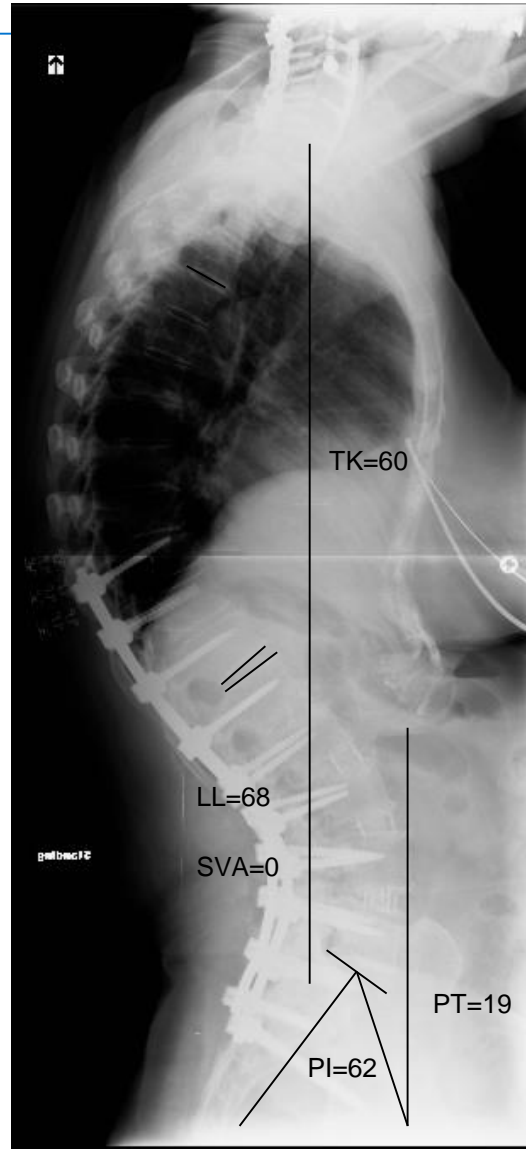
# Case Example

## Stage 1: L1-L5 XLIF



## Stage 2: T10-P PSF







## Case – 68M

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Parkinson's

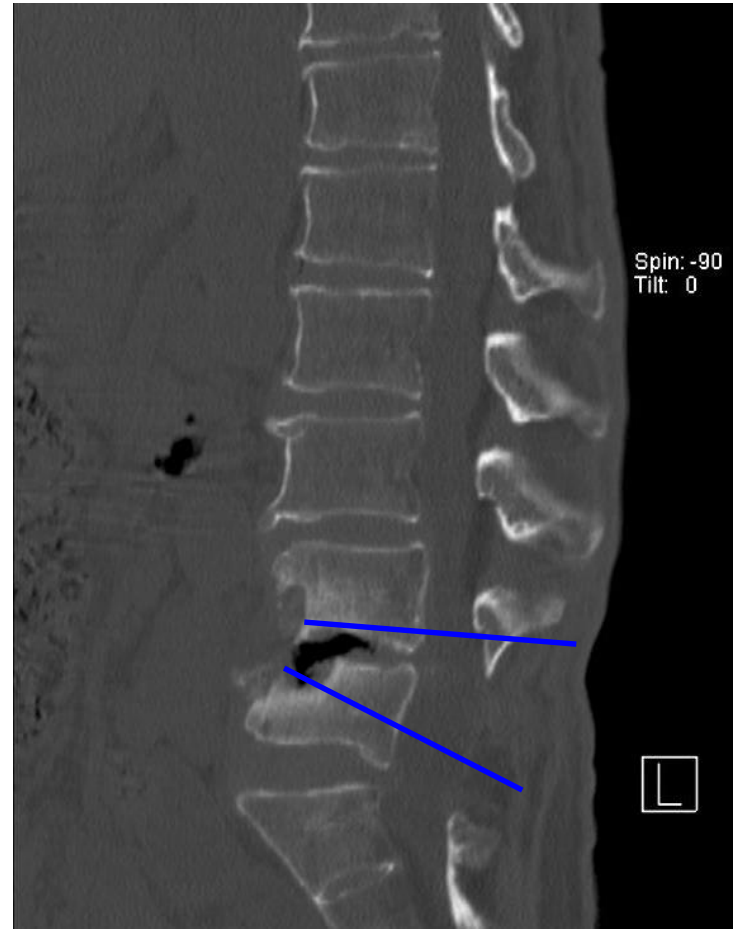
Previous L4-5 Decompression

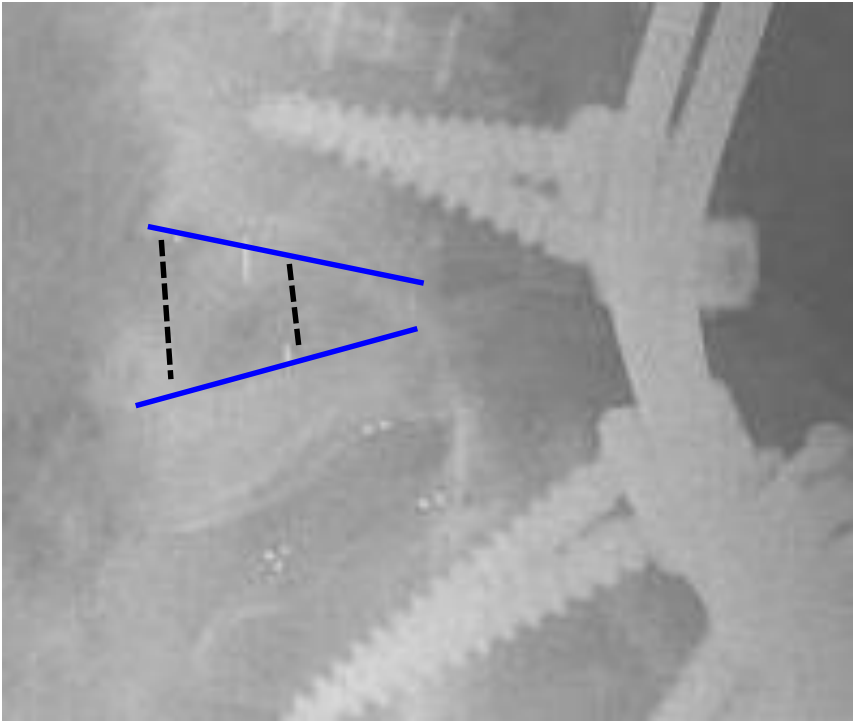
Progressive kyphosis

*Camptocormia*

Postlaminectomy kyphosis



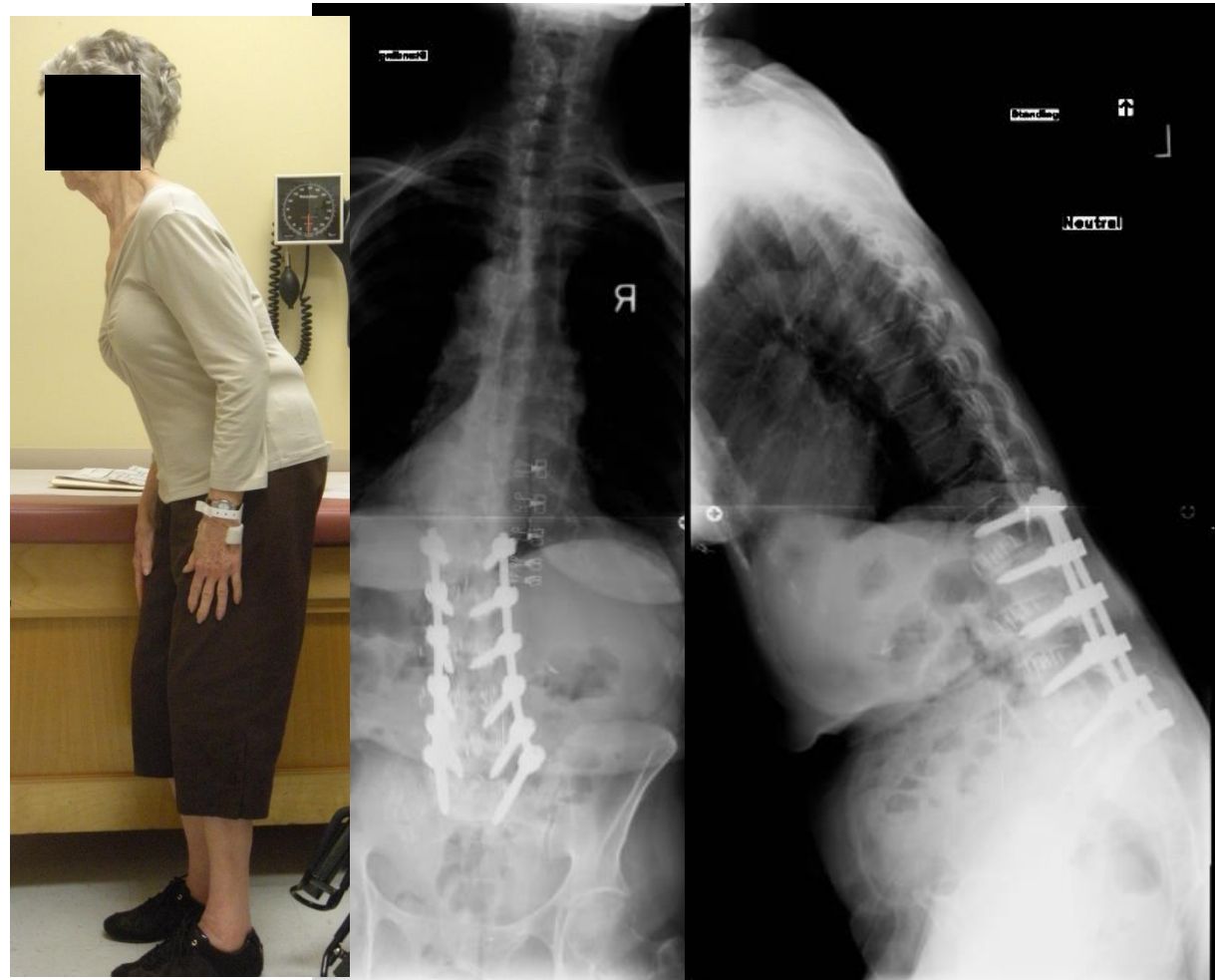






## Case – 81F

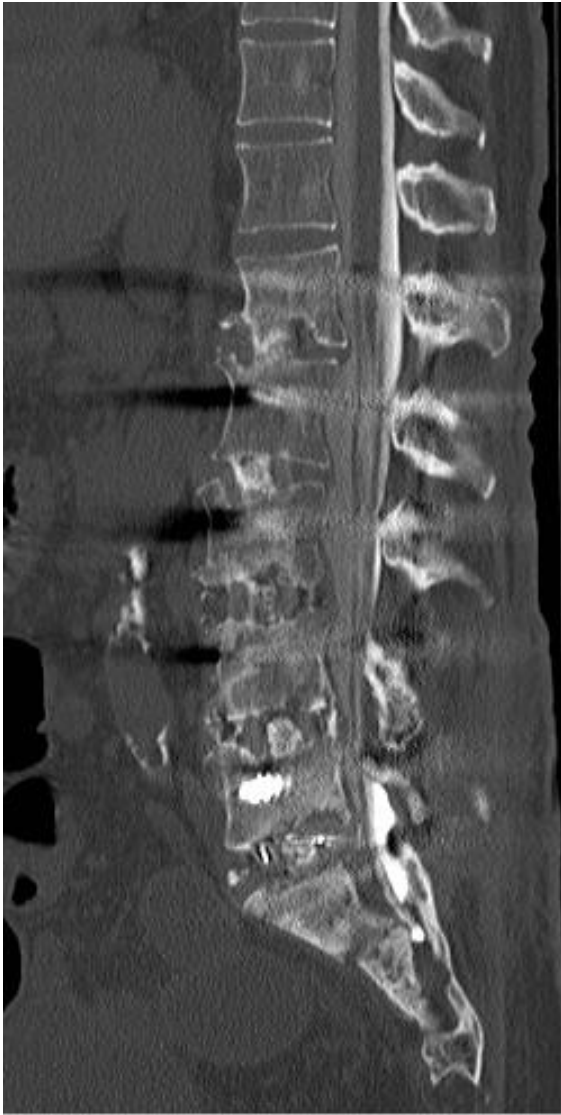
- Hx of Degen Scoliosis
- Underwent MIS Scoliosis correction
  - L1-L5 XLIF
  - Bilateral Wiltse Fusion L1-S1
  - MIS TLIF @ L5-S1
- After surgery:
  - Increased back pain
  - Unable to stand straight





## Case – 81F

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## Case – 81F

- L3 PSO
- Revision L5-S1 TLIF
- Dual Iliac screws
- T10-Pelvis PSF



# Case – 81F







## Case – 61F

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Prior surgery x 2

T7-S1 PSF

Can't stand up straight

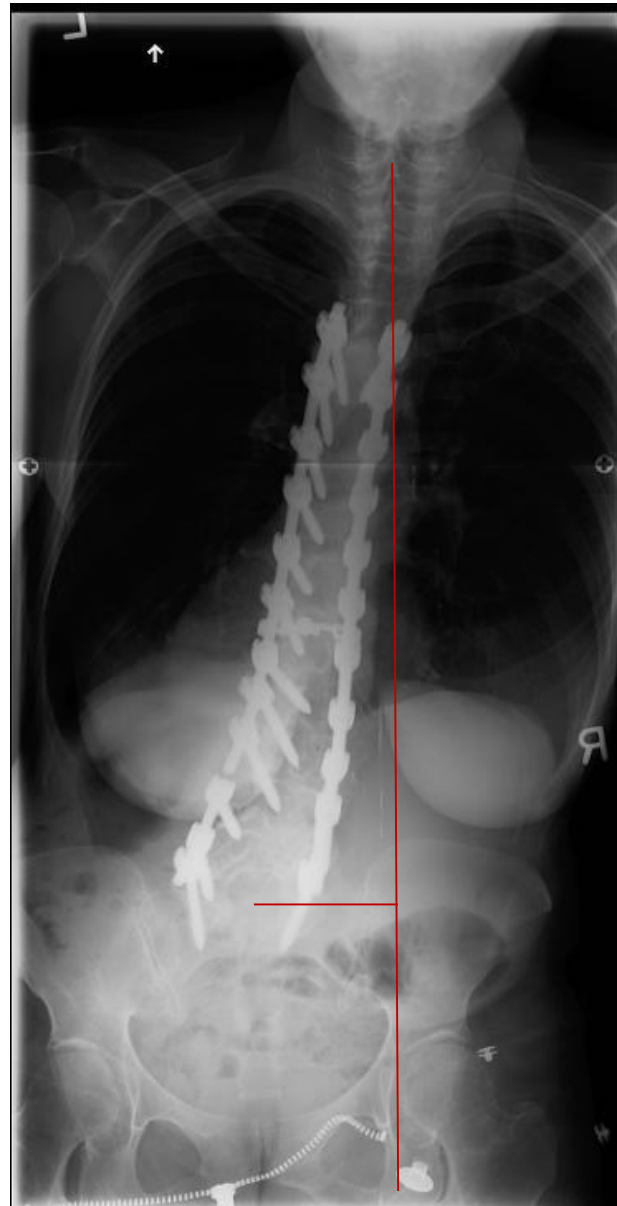
Back and leg pain

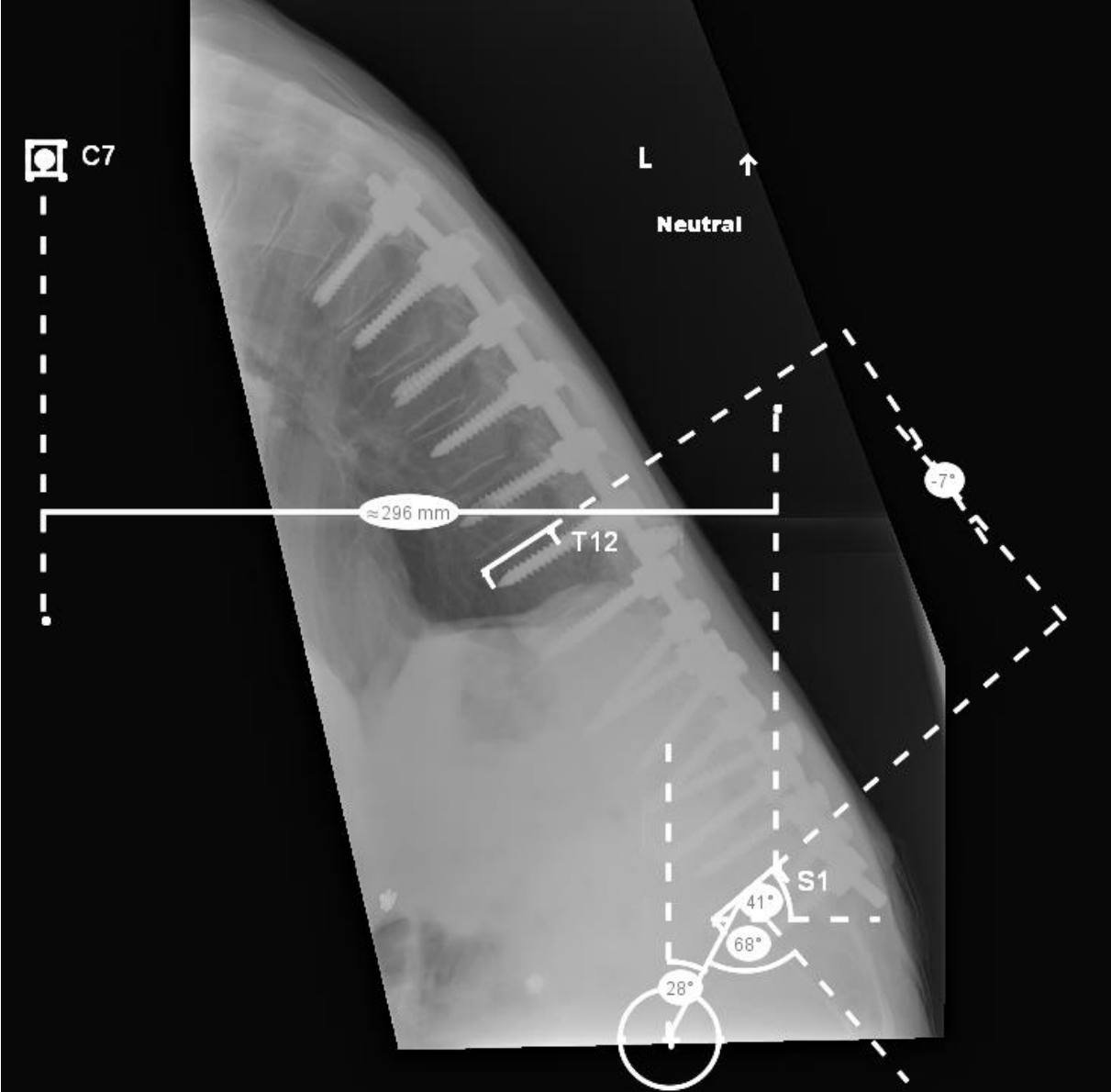
Using a walker to ambulate

Smoker

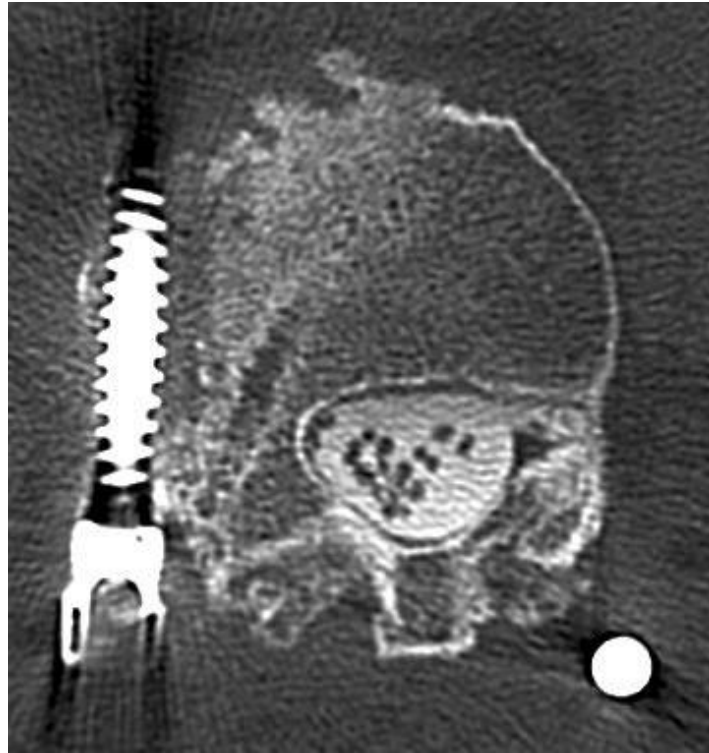
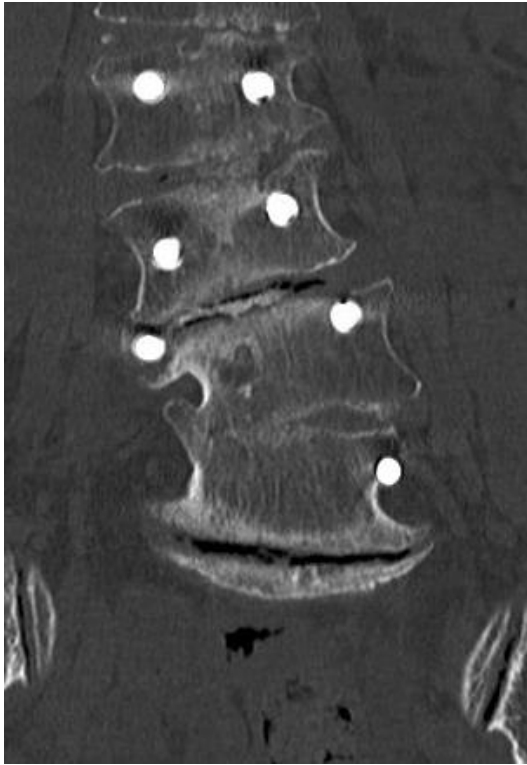
Heavy dose narcotics











# Diagnosis

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Sagittal and Coronal Imbalance

Spinal Stenosis

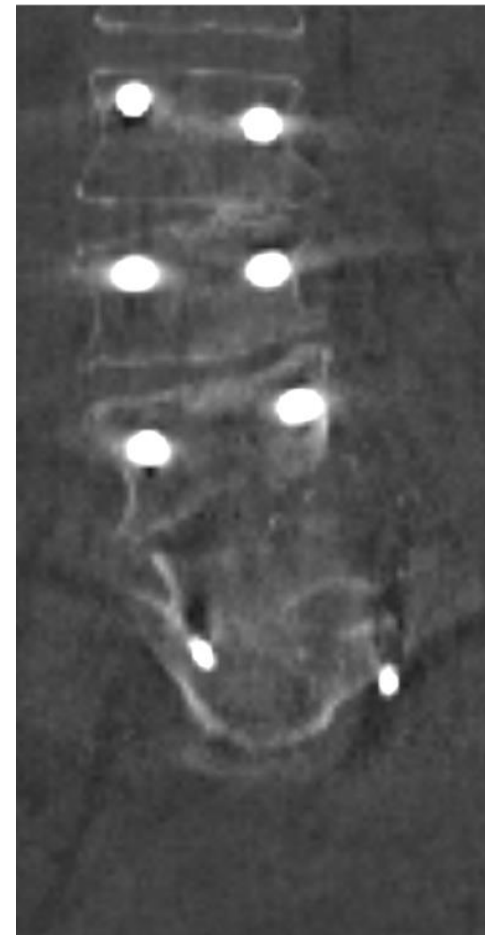
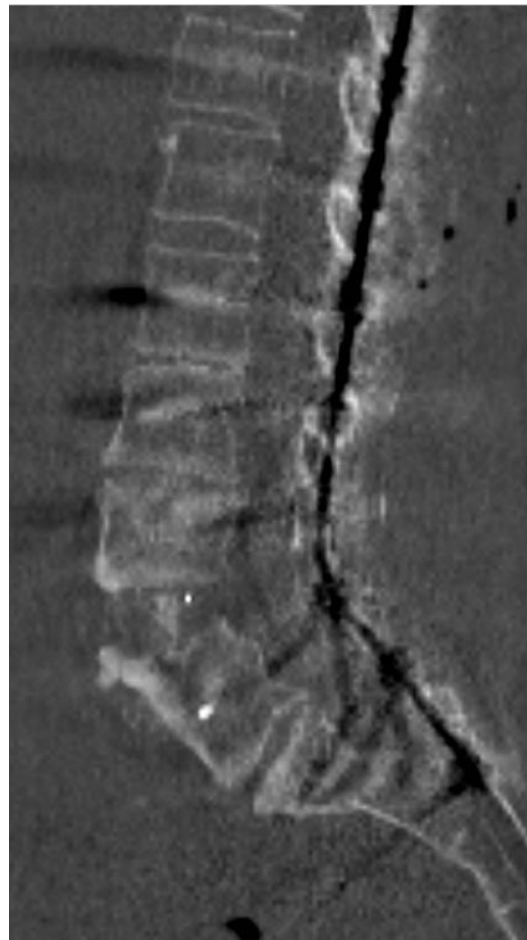
Pseudarthrosis

Broken rod

S/P T7-S1 PSF

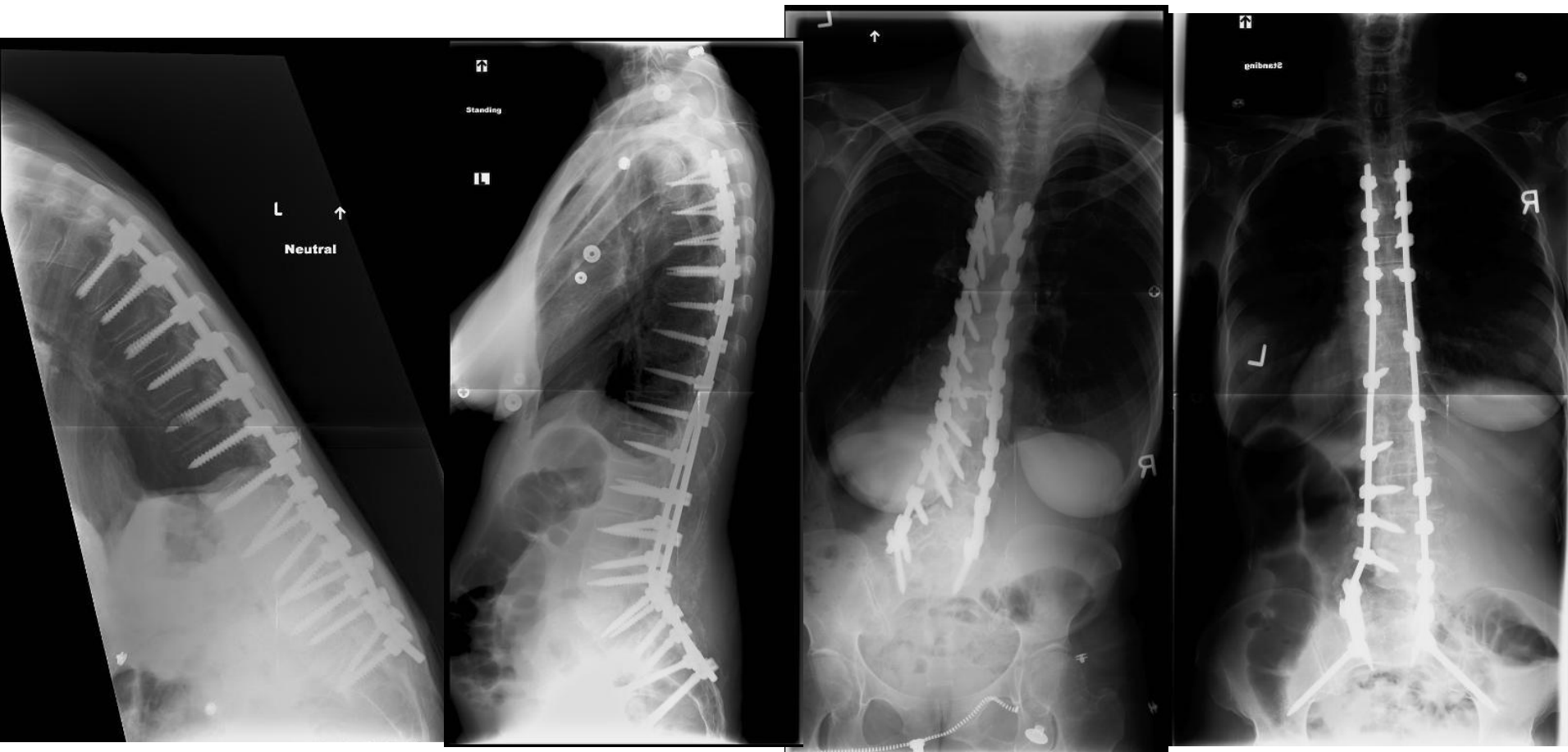
# L4 Asymmetric PSO with TLIF cage, T4-Pelvis PSF

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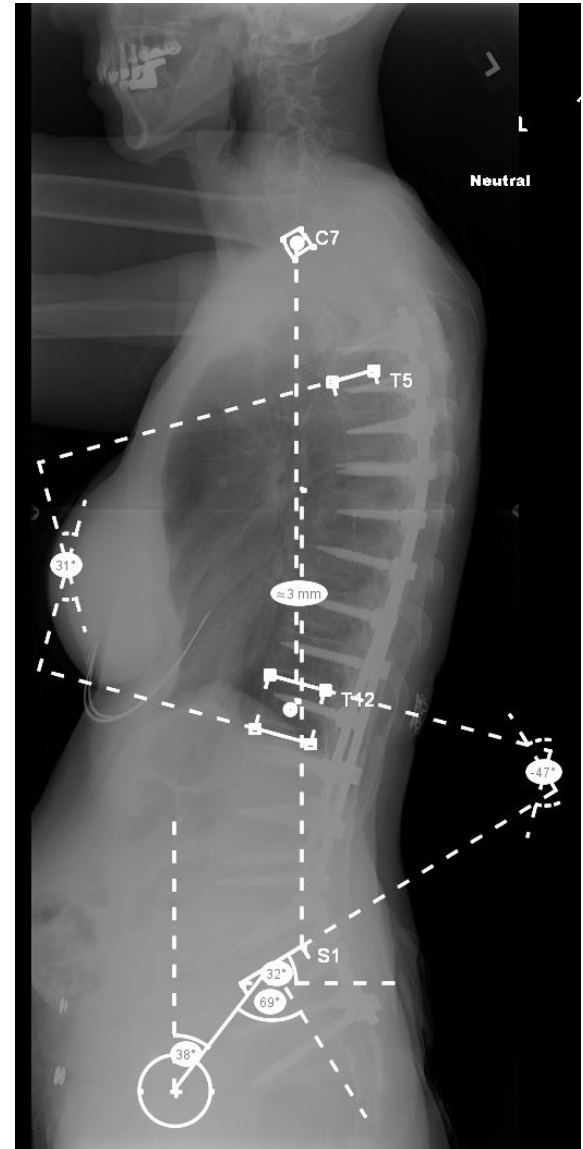
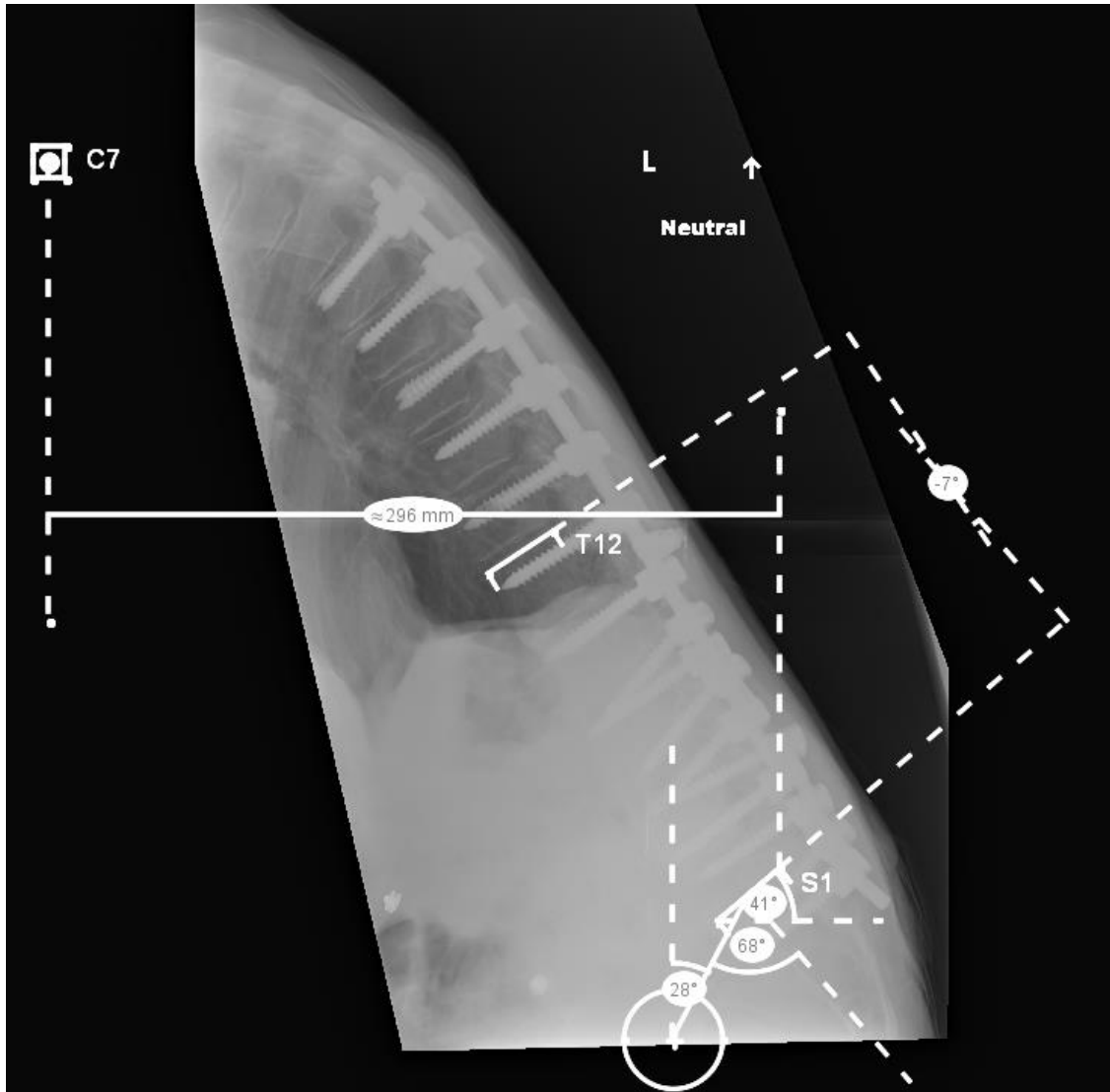


# Post-op

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# Summary

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Important to understand how to:

- Recognize and Assess Adult Spinal Deformities (Coronal, Sagittal, Combined) and understand the burden of disease
- Quantify Magnitude and Planes of Deformity to Plan for appropriate correction
- Anticipate potential for reciprocal changes after correction
- Minimize Complications while Achieving Treatment Goals



# Thank You!



**UC Irvine Health**