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# SAGITTAL ALIGNMENT

## OVERVIEW & HISTORICAL PERSPECTIVE

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Adult & Pediatric Spine Surgery, Scoliosis

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# Alignment vs. Balance

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# Normal Spinal Alignment

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- Balance
  - Function
  - Durability
  - Reduced risk of pain
- 



# Abnormal Spinal Alignment

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- Negative effect on HRQL
    - Pain
    - Deformity
    - Functional impairment
-

# Malalignment of the Spine

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- Coronal
  - Axial
  - Sagittal
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# Sagittal Malalignment

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Much more likely to lead to **Pain**  
and **Functional Impairment**

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# Normal Sagittal Alignment

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- No one “Normal Alignment”
  - Each person has a unique Sagittal Profile
    - Cervical
    - Thoracic
    - Thoraco-lumbar
    - Lumbar
    - Pelvis
    - Lower extremities
-





# Normal Sagittal Alignment

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- Proportional
  - Harmonious
- 



# Abnormal Sagittal Alignment

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- **Compensatory Mechanisms** occur in an attempt to restore **Balance**
    - ie. Loss of Lumbar lordosis
      - T-Spine hyperextension (if flexible)
      - Pelvic retroversion
      - Hip extension
      - Knee flexion
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# Compensatory Mechanisms

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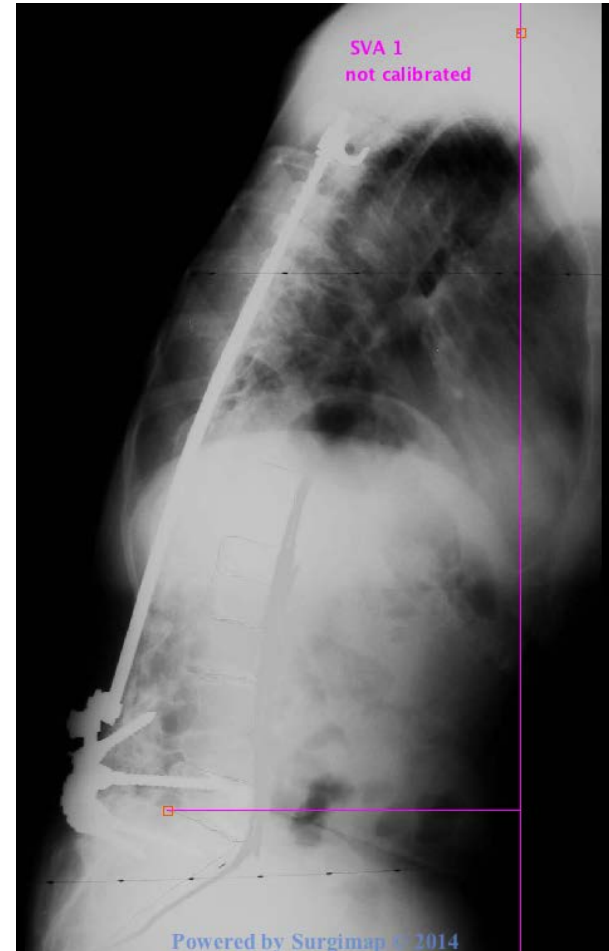
- Unnatural
  - Require increased muscle energy
  - Can lead to fatigue and pain
- 



# Severe Malalignment

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- Compensatory mechanisms overwhelmed
- Sagittal **Imbalance**



# Causes of Sagittal Malalignment

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- Aging
  - Trauma
  - Congenital Malformations
  - Neuromuscular Disorders
  - Post-surgical (Flatback Syndrome)
- 



# FLATBACK SYNDROME

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- Iatrogenic complication of surgical tx for spinal deformity
- Postural disorder
  - Forward inclination of the trunk
  - Inability to stand erect
  - Back pain



# FBS

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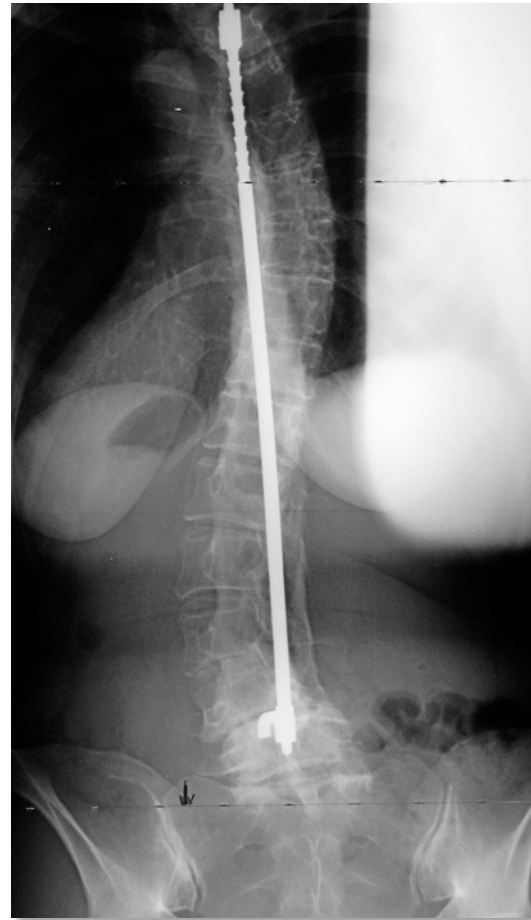
- Now widely recognized as a complication of surgical tx of spinal deformity
- But....



# FBS

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- Early surgical tx of scoliosis focused on the coronal plan
- Lateral x-rays often not obtained





# Doherty

“Complications of Fusion in Lumbar Scoliosis”

SRS,1972, JBJS,1973 (abstr)

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- Postural complication in pts with T/L scoliosis
  - PSF/HRI
  - Bilateral pelvic osteotomies (Salter)
  - “Upright posture restored”
  - No follow-up reported
- 



# John Moe

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- Realized what the HR was doing to the sagittal plane
- Began the process of making surgeons aware of FBS



# Moe & Denis

SRS, 1976

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- 16 patients
  - Coined the term “flatback syndrome”
  - Introduced the C-7 plumbline
  - Reported “satisfactory” results with extension osteotomy and Harrington compression rods
  - First to emphasize prevention
  - Developed the “Moe Rod”
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# Grobler & Moe

SRS, 1978

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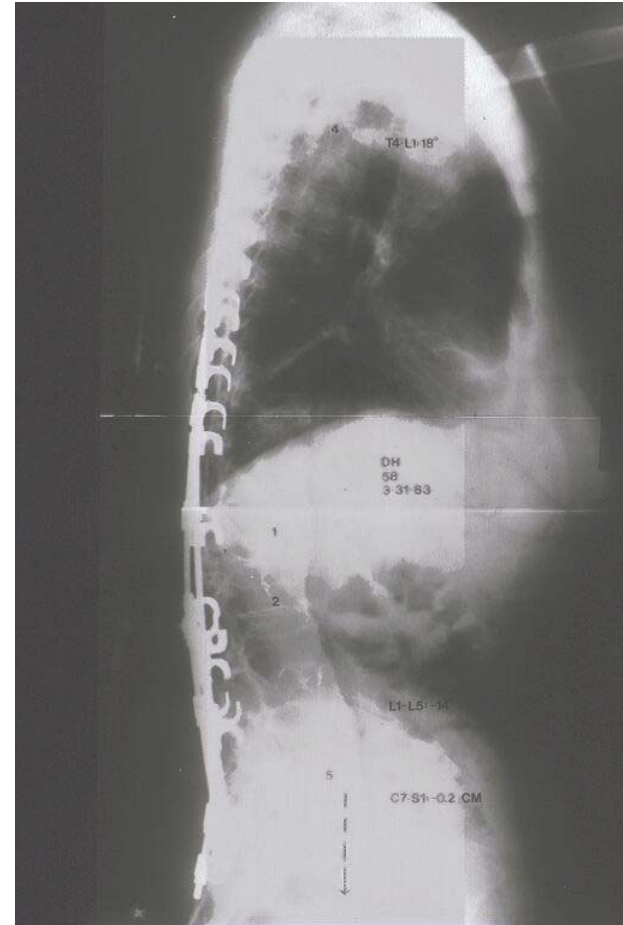
- 29 patients with FBS (incl previous pts)
  - Further defined symptom complex
  - All pts improved at 26 month f/u
  - 6/29 with persistent sagittal imbalance
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# LaGrone, Bradford, Moe, et al

## SRS, 1986

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- Cumulative Minneapolis experience
- 55 patients with post-surgical Flatback Syndrome



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Copyright 1988 by *The Journal of Bone and Joint Surgery, Incorporated*

# Treatment of Symptomatic Flatback after Spinal Fusion\*

BY MAJOR MICHAEL O. LAGRONE, MEDICAL CORPS, UNITED STATES ARMY †‡, DAVID S.  
BRADFORD, M.D. §, JOHN H. MOE, M.D. §, JOHN E. LONSTEIN, M.D. #, ROBERT B. WINTER, M.D. #,  
AND JAMES W. OGILVIE, M.D. §,  
MINNEAPOLIS, MINNESOTA

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# LaGrone, Bradford, Moe, et al

1988

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55 patients

Ave follow-up 6 years (2-14)

Ave loss of correction 3.1 cm

61% with one or more complications  
(38% Pseudarthrosis)

47% reported persistent imbalance

36% with mod to severe back pain

95% felt they benefited

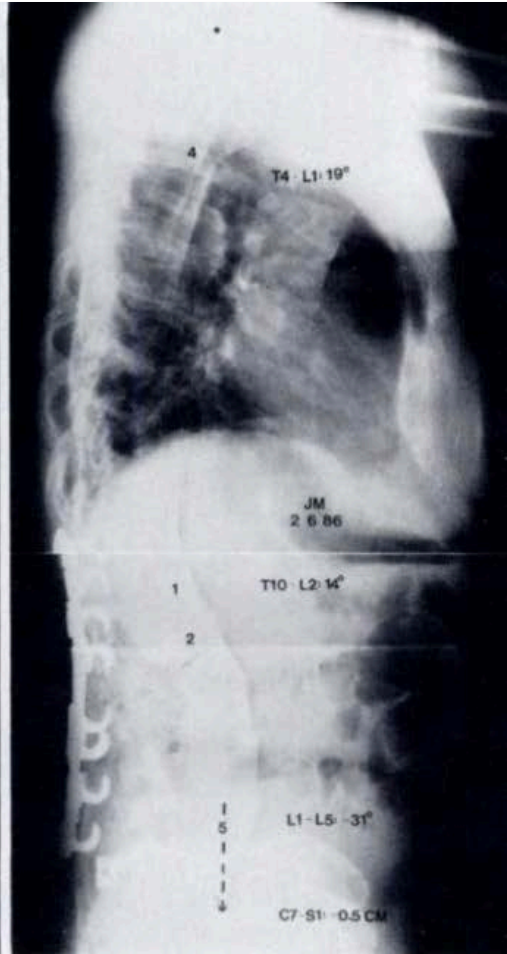
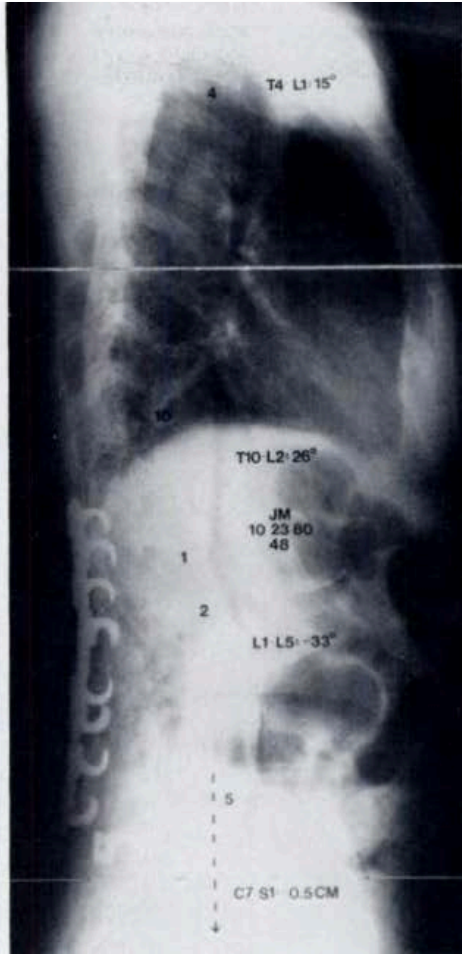
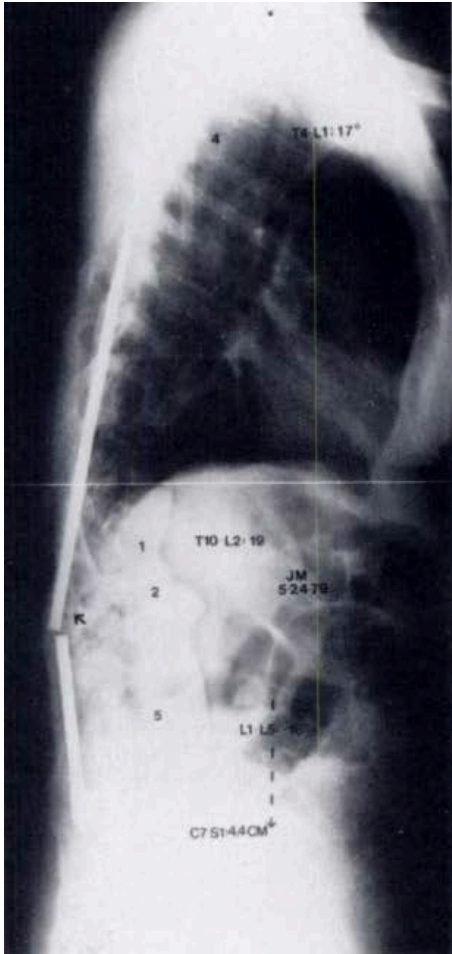
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# CONCLUSIONS

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- FBS is a disabling complication of scoliosis surgery
  - Revision is complex with frequent complications
  - Inadequate correction associated with:
    - more pseudos
    - greater risk for loss of correction
  - Addition of ASF
    - fewer pseudos
    - less loss of correction
  - **PREVENTION MOST IMPORTANT**
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# Treatment of Symptomatic Flatback After Spinal Fusion

JBJS 1988

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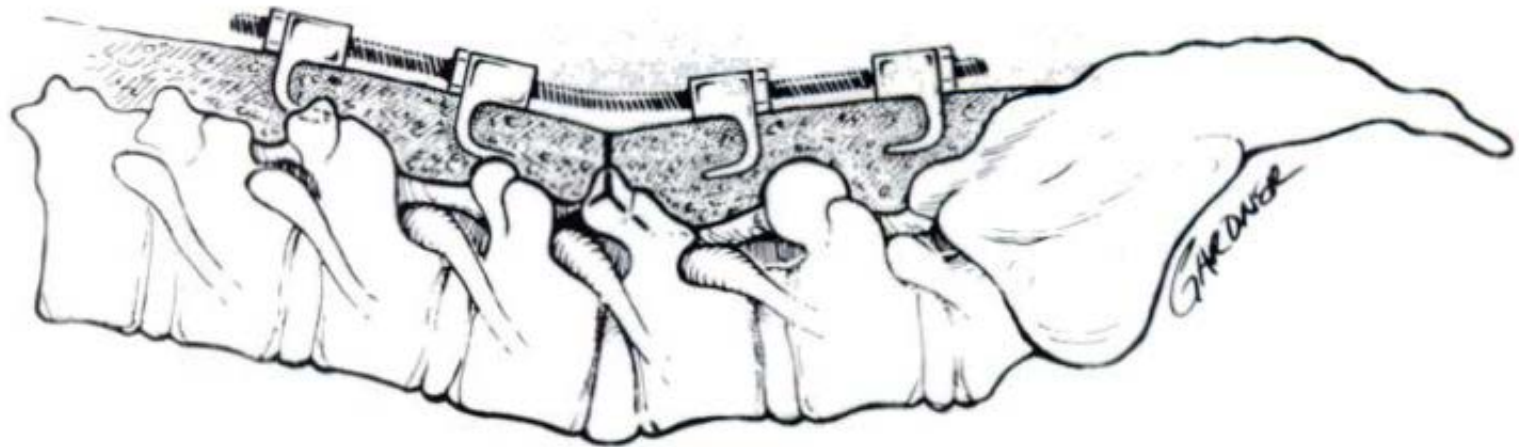


FIG. 4

Completed osteotomy.

Note the undersurface of the osteotomy has been undercut to prevent neural entrapment.

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# Pathogenesis of FBS

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- Loss of lumbar lordosis
    - Distraction
    - Positioning
    - »plus
  - Fixed thoracic kyphosis
  - Thoracolumbar kyphosis (preexisting or PJK)
  - Pseudarthrosis
  - Distal junctional degeneration
  - Hip flexion contractures
-

# Pathogenesis of FBS

(role of instrumentation)

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- Not reported prior to spinal instrumentation
  - Moskowitz, Moe, Winter, et al (JBJS, 1980)
    - 110 patients—PSF without instrumentation
    - >20 year follow-up
    - None with symptomatic loss of lordosis
-

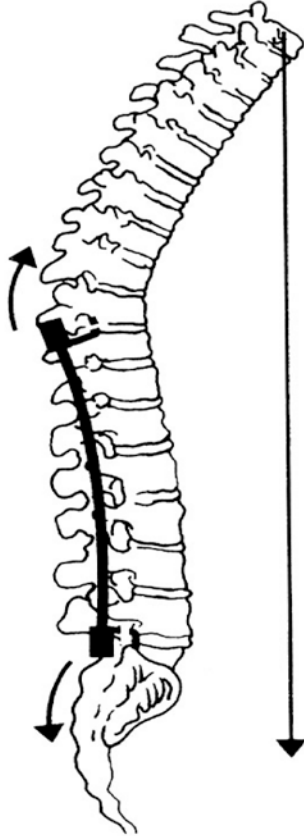
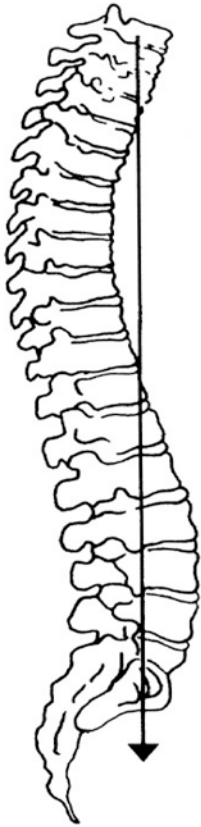
# Pathogenesis of FBS

(role of distraction)

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- Contoured HR (Moe) did not prevent FBS
  - Kostuik and Hall (Spine, 1983)
    - 8/11 patients with Moe rods to pelvis developed symptomatic loss of lordosis
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# Clinical Presentation

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- Forward inclination of trunk
- Inability/difficulty standing erect
- Back pain
- Neck pain
- Thigh pain



# Radiographic Assessment (global)

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- Standing 36" X-ray
- Knees extended
- C-7 Plumb-line (SVA)





# Radiographic Assessment (regional)

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- Lumbar lordosis
- Thoracic kyphosis
- Thoracolumbar junction
- Pelvic parameters
  - PT
  - PI
  - SS



# Classification

Booth, et al, Spine, 1999

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- Compensated (Type 1)
  - segmental/regional malalignment
  - global balance

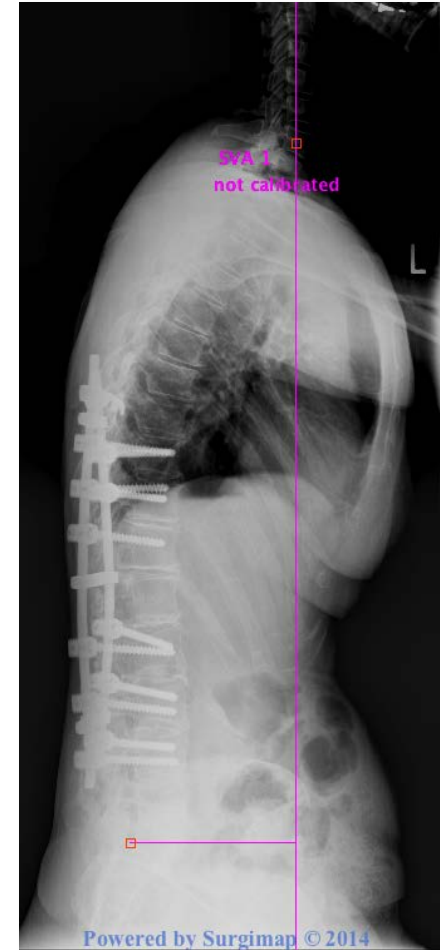


# Classification

Booth, et al, Spine, 1999

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- Uncompensated (Type 2)
  - Global imbalance
  - $SVA > 5\text{cm}$



# Both Type 1 and Type 2 can negatively affect health status (HQRoL)

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- Glassman et al,
    - Positive sagittal balance is radiographic parameter most correlated with HQRoL
    - Lumbar kyphosis is independent variable ( even in compensated spines)
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# Treatment

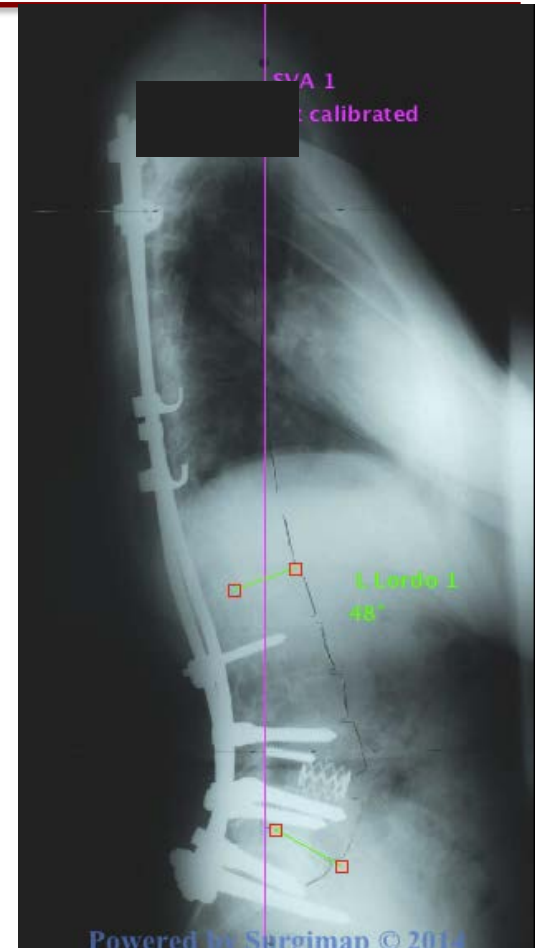
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- Nonsurgical
    - Physical therapy
      - Address hip flexion contractures
      - Strengthen trunk extensors
    - Injections
    - Medication
    - 27% success rate (Farcy and Schwab, 1997)
      - Better if SVA <4cm and 2 intact discs caudally
  - Surgical--most
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# Surgical Goals

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- Restore Normal Alignment
  - Balanced spine
- Solid fusion
  - Durability



# Surgical Decision Making

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- Assess.....
    - Segmental, regional and global factors
      - Includes pelvic parameters
    - Neurology
    - Cervical spine
    - Bone quality
    - Co-morbidities
- 



# Osteotomy

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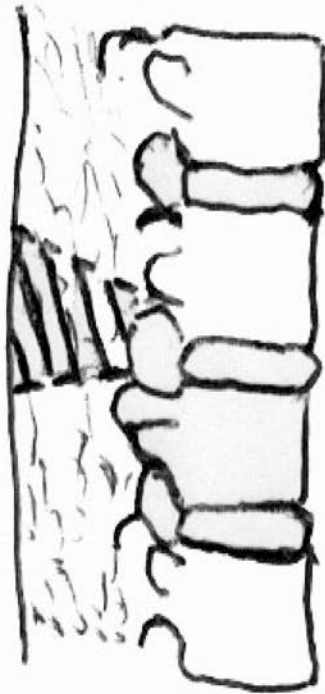
- Type
  - Location
  - Number
- 





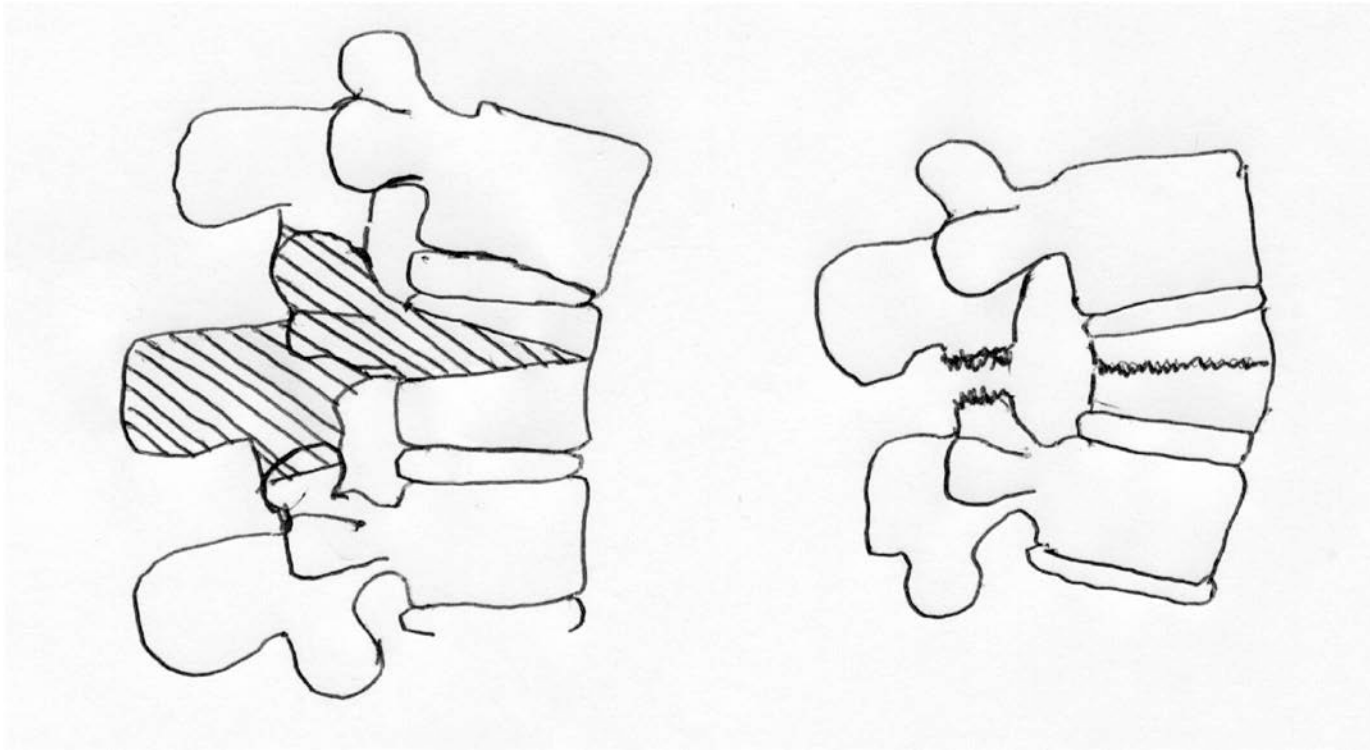
# Smith-Petersen Osteotomy

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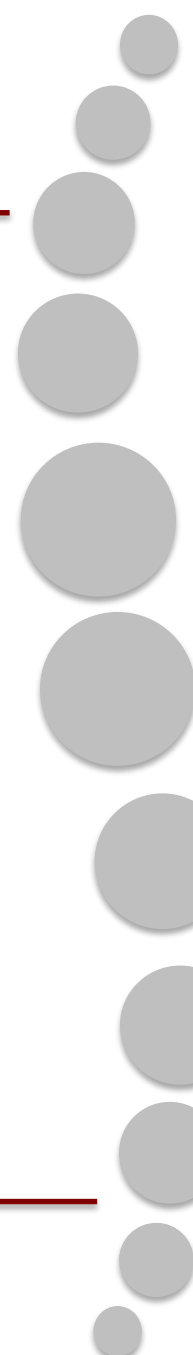


# Pedicle Subtraction Osteotomy

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Correction of segmental,  
regional and global deformity  
correlates with clinical results

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Understanding the **Spinopelvic Relationship** is fundamental for interpreting sagittal alignment

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# Duval-Beaupere et al., 1992

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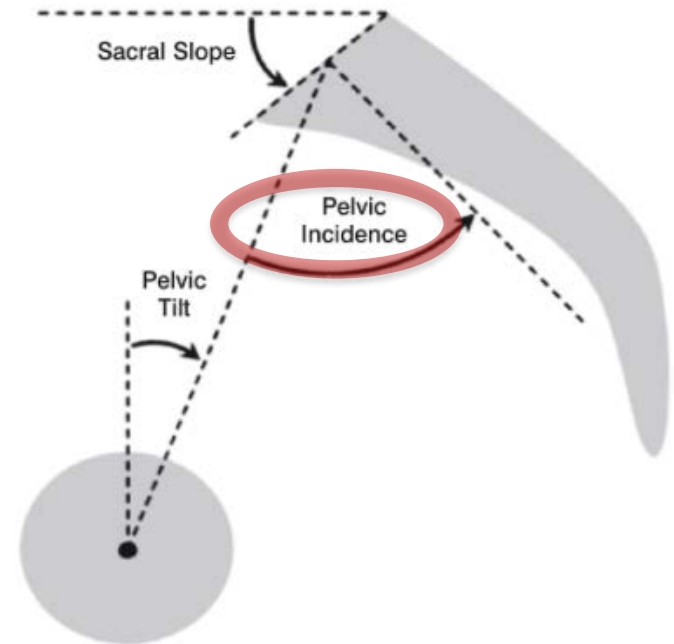
- 3 parameters to evaluate morphology and orientation of the pelvis
  - Conditions required for an “economic standing position”
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# Pelvic Incidence

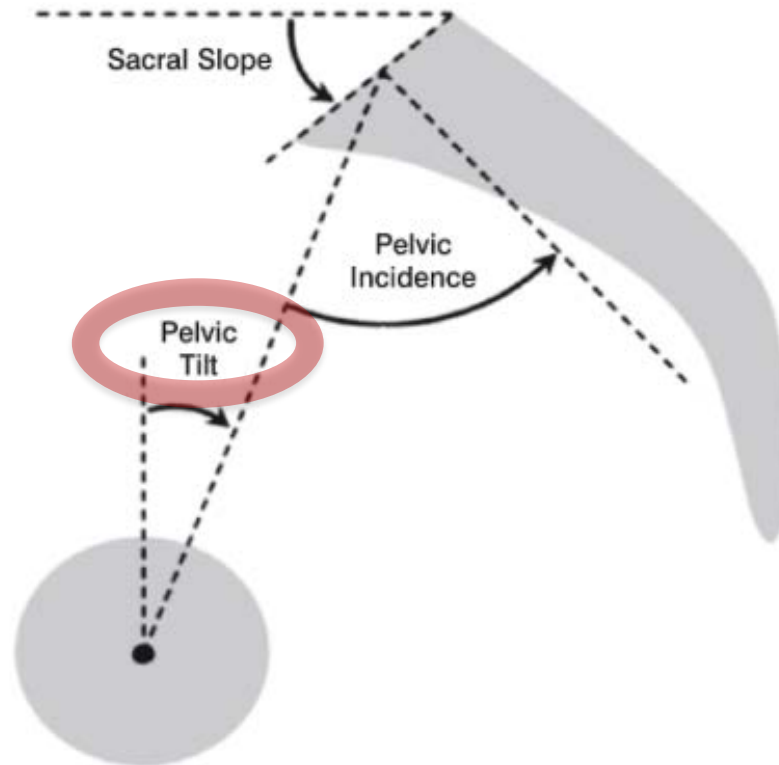
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- Morphologic parameter  
(Fixed)
- 27-90 degrees

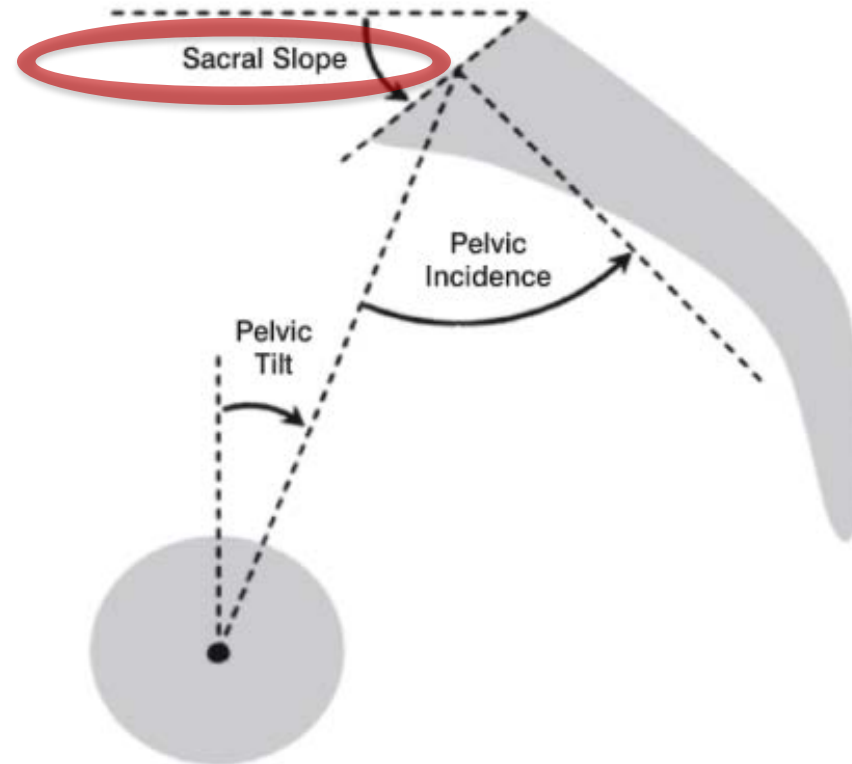




# Pelvic Tilt



# Sacral Slope



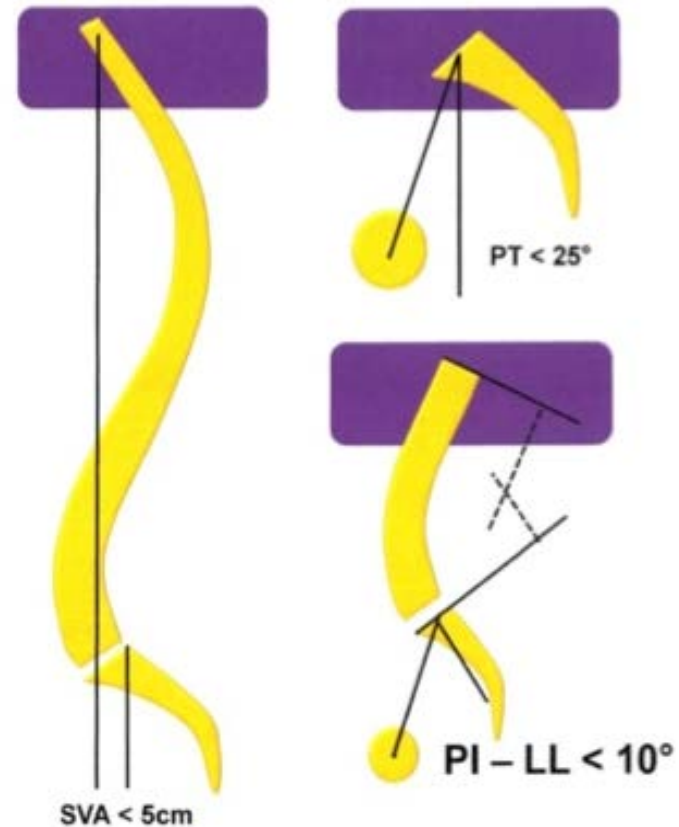
# Alignment Tips

(Lafage, Schwab)

Pelvic tilt  $< 25$   
degrees

Pelvic incidence -  
Lumbar lordosis  
( $\pm 10$  degrees)

SVA  $< 5$  cm

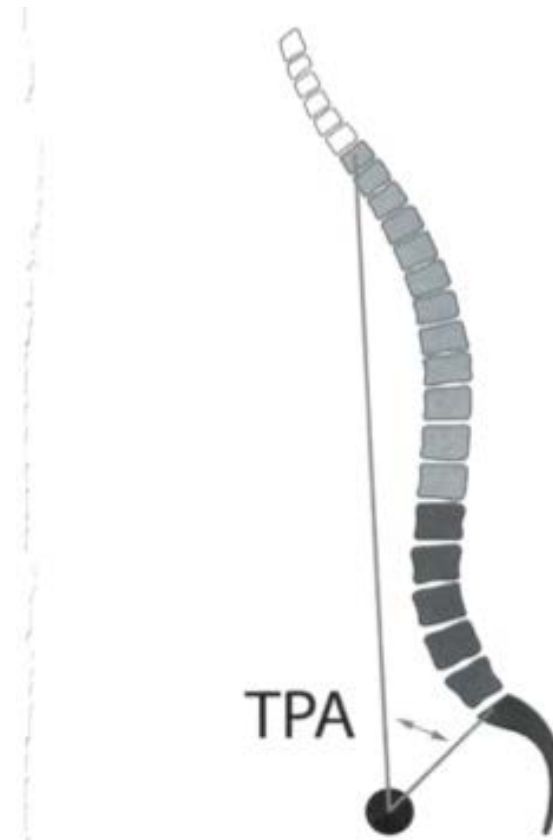


# T1 Pelvic Angle (TPA)

Protopsaltis et al., SRS 2013

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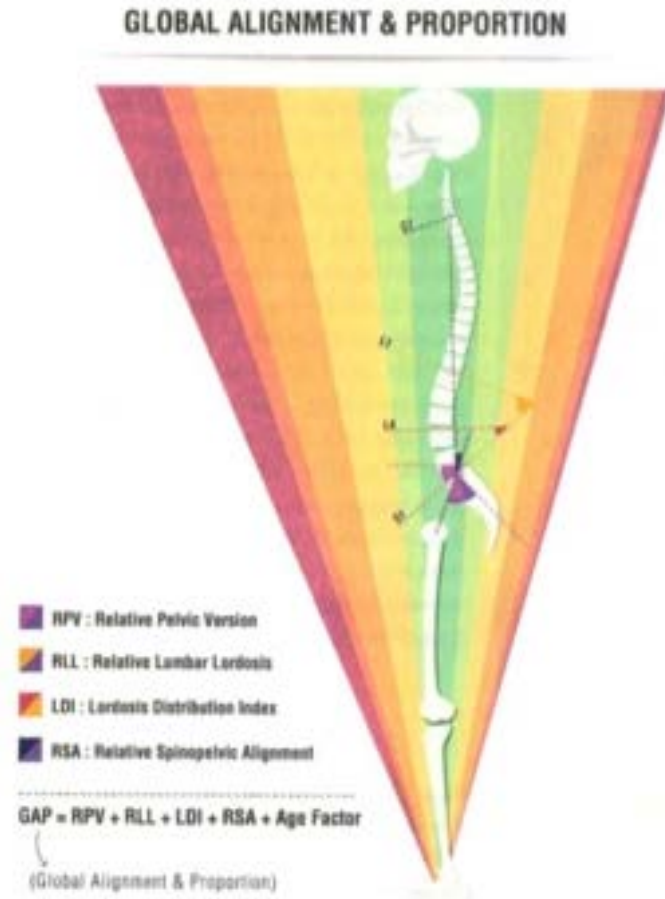
- Accounts for both **SVA** and **Pelvic Tilt**
- No calibration needed



# Global Alignment and Proportion (GAP)

Yilgore et al. JBJS 2017 (ESSG)

- Pelvic Incidence-based
- Relative Pelvic Version
- Relative Lumbar Lordosis
- Lordosis Distribution Index
- Relative Spinopelvic Alignment
- Age Factor
- Predicts Mechanical complications



# Fixed Sagittal Malalignment

## Surgical Treatment

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- With modern techniques.....
  - Radiographic and Clinical results improved
    - Better correction
    - Less LOC
    - Fewer complications
  - Still complex problem
    - High complication rate
    - Greater risk of PJF
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**PREVENTION  
IS STILL  
MOST IMPORTANT!**

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# THANK YOU

LaGrone

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