AANS Spinal Deformity Course
for Senior Residents

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Disclosures

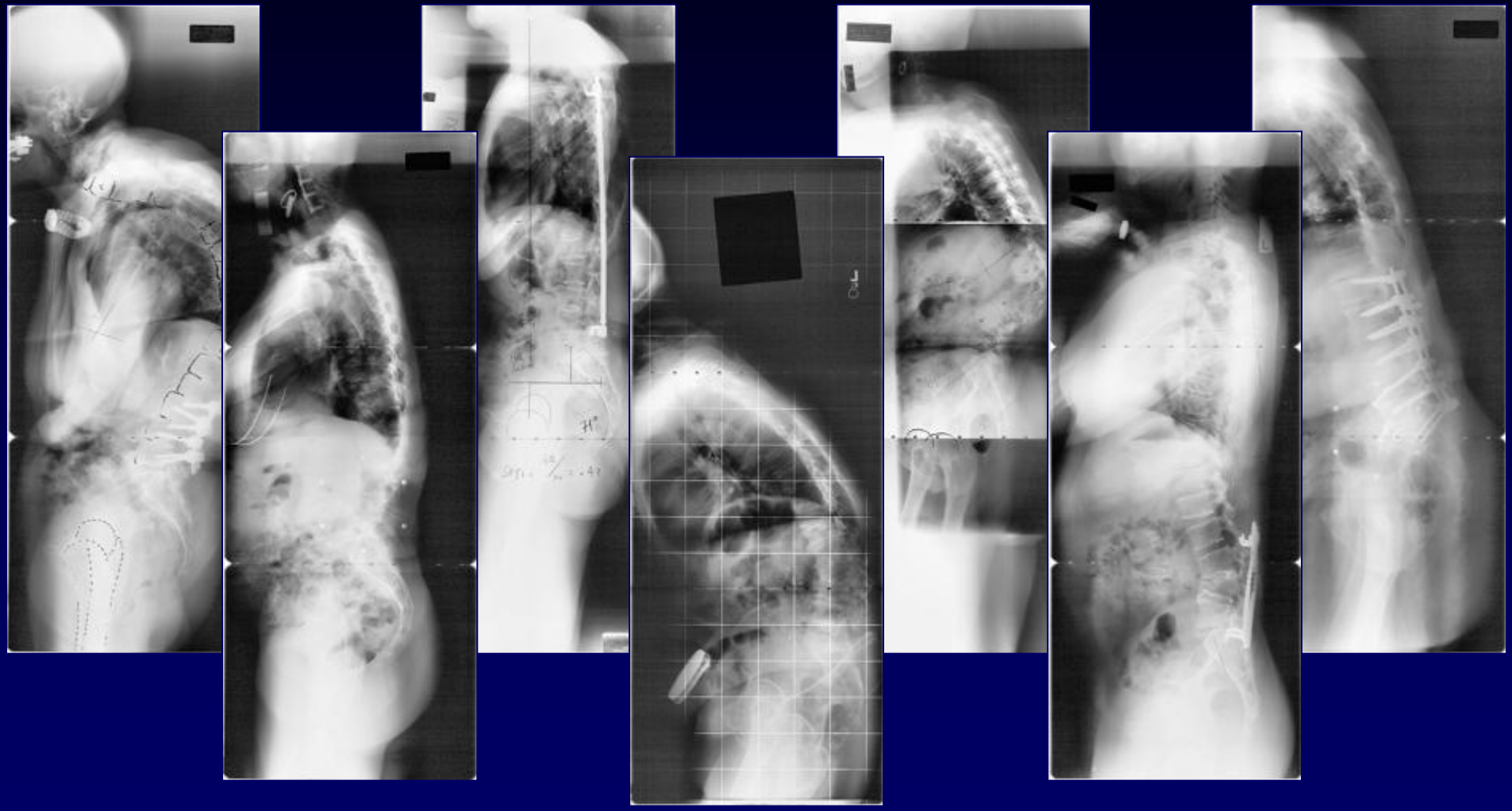
- Biomet: educational and development consultant
- Medtronic: consultant, research study group support
- DePuy: educational consultant, research study group support
- Globus: honorarium for educational course
- AANS/CNS Joint Spine Section: research grant support

Aknowledgements

- **Membership of the International Spine Study Group (ISSG)**

- **Especially Virginie Lafage and Frank Schwab from NYU**

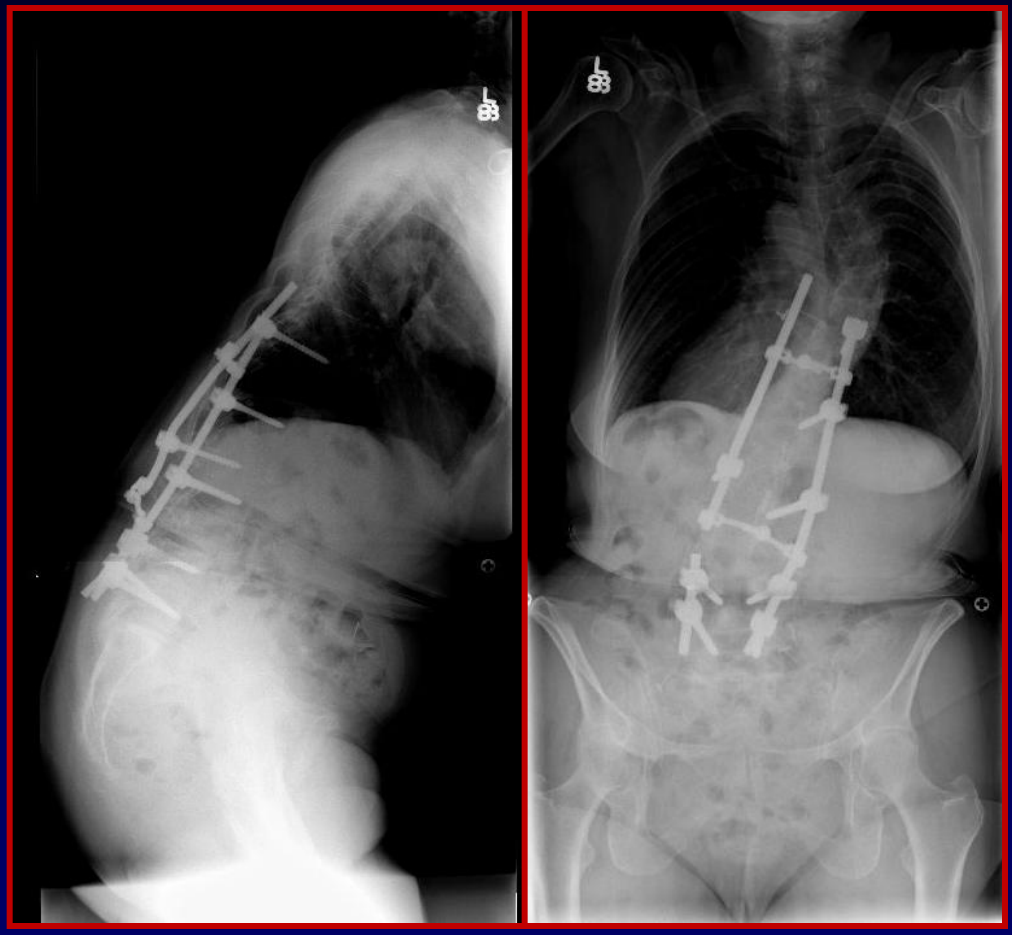
Adult Spinal Deformity

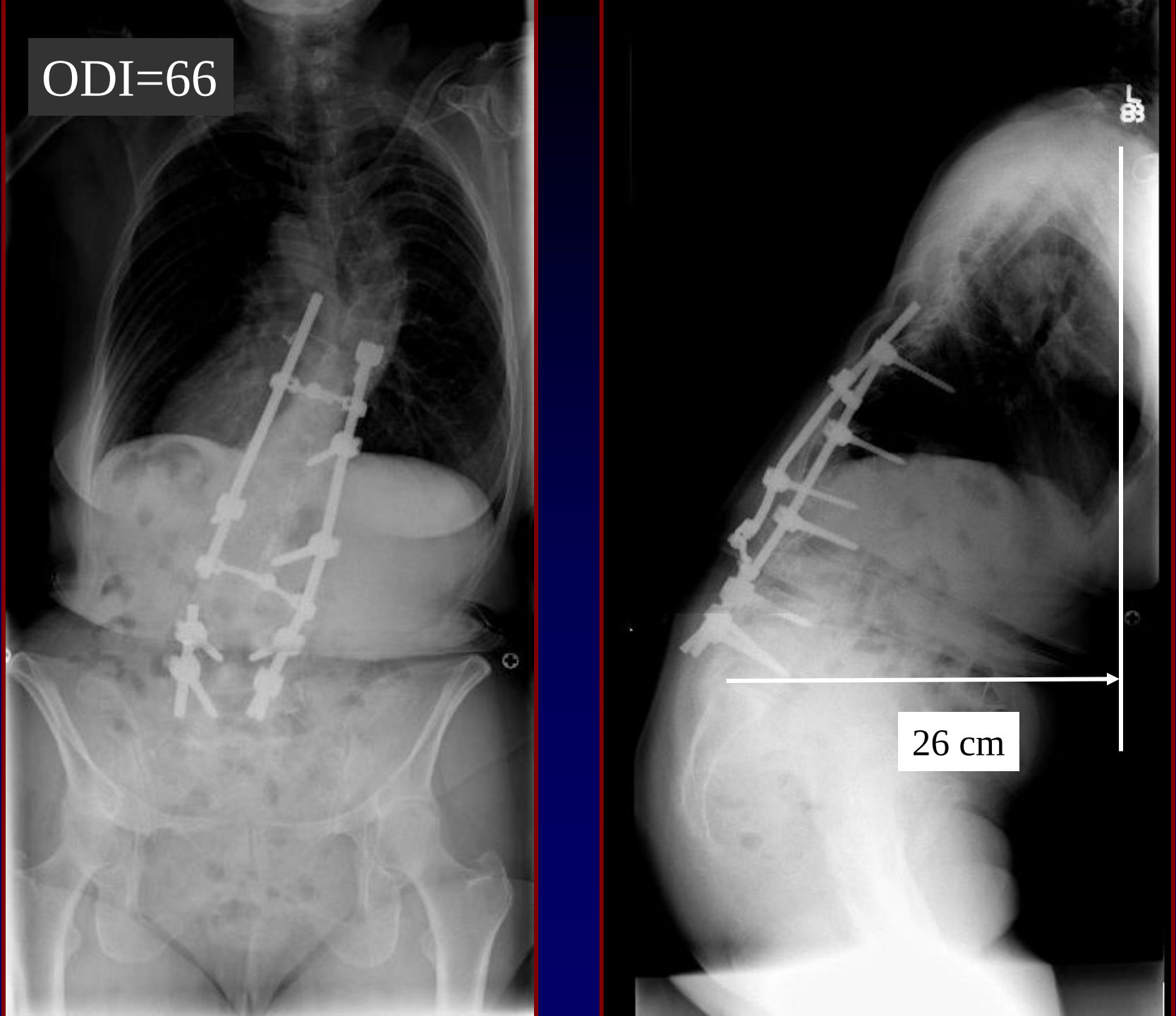


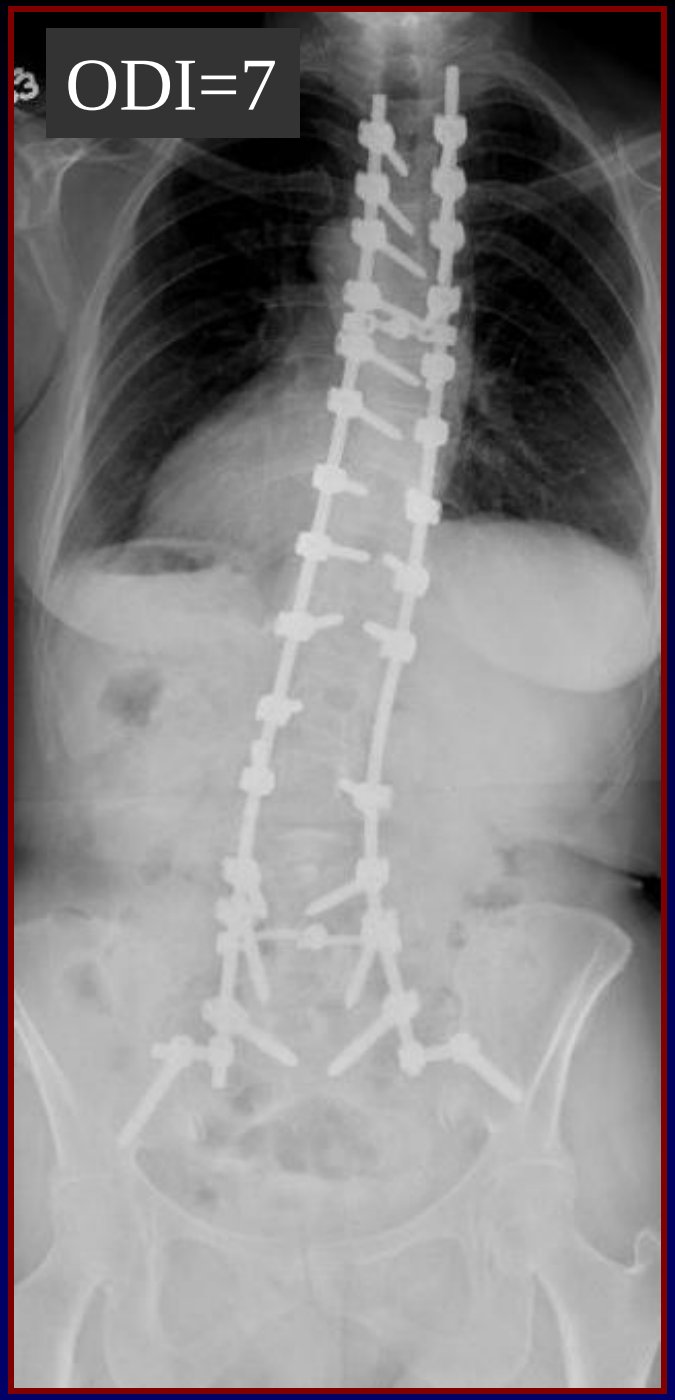
Large variety of ‘deformities’

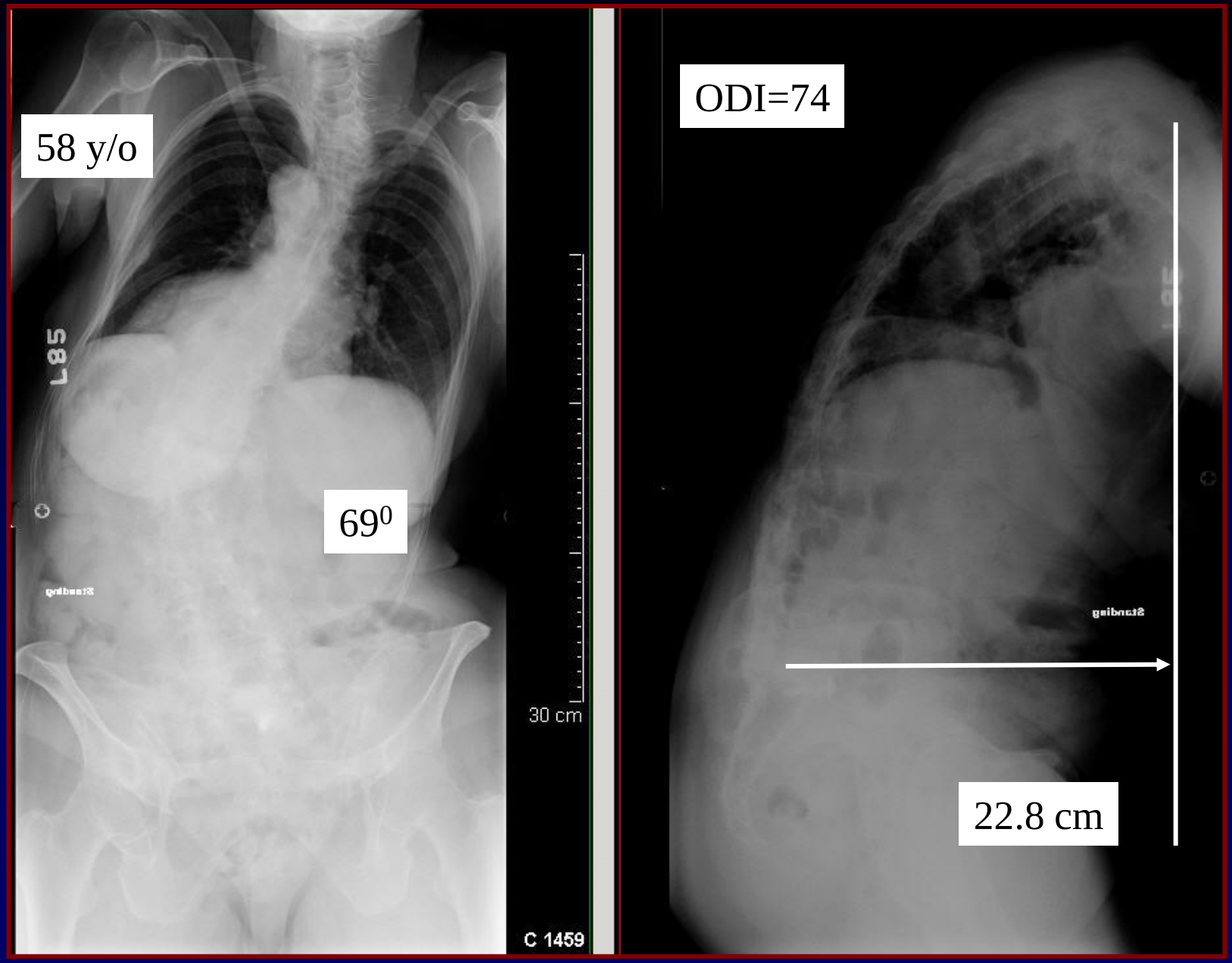
Spinal Balance

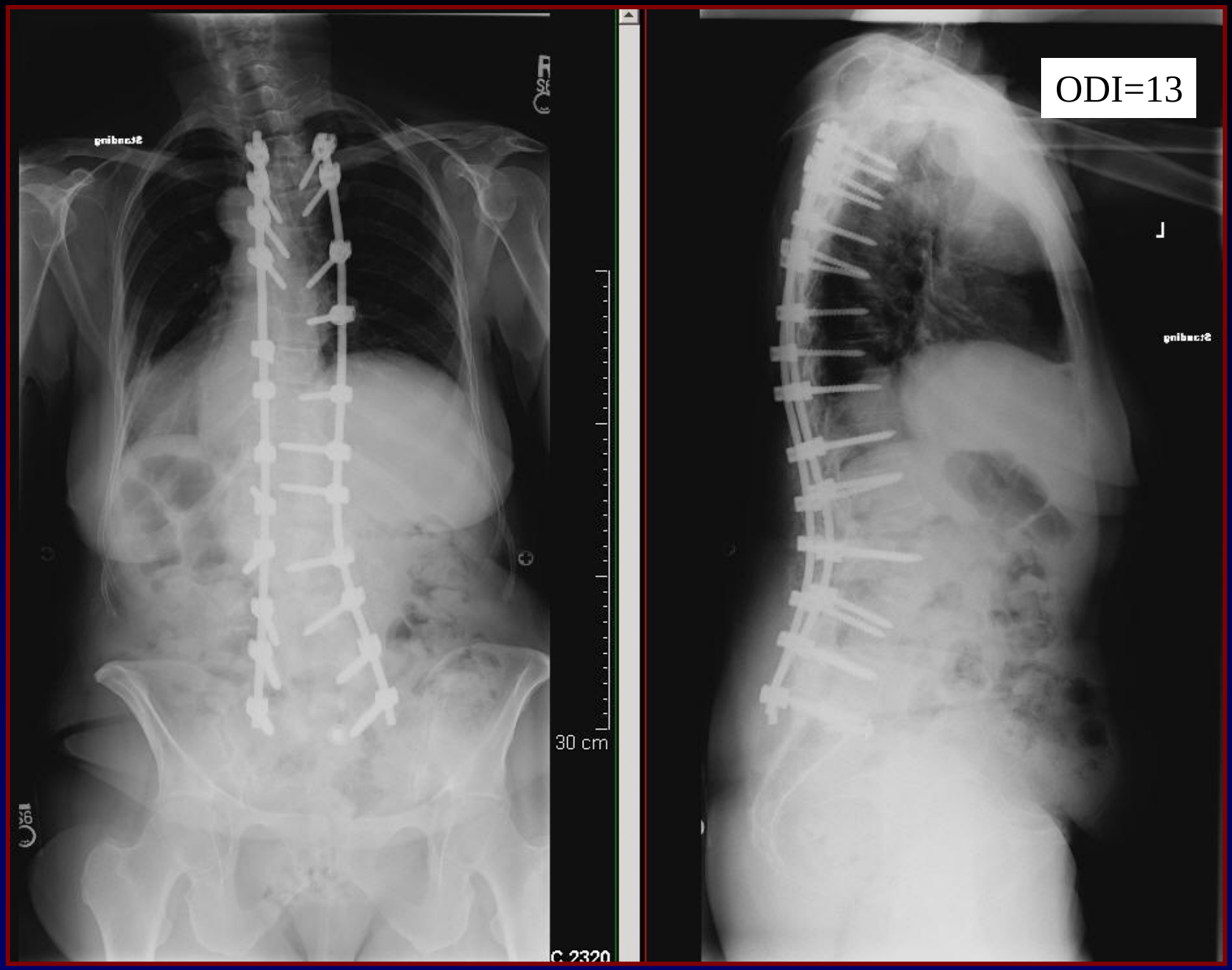
- **Surgery that corrects neural impingement or spinal instability but causes poor sagittal or coronal balance usually gives a bad result**



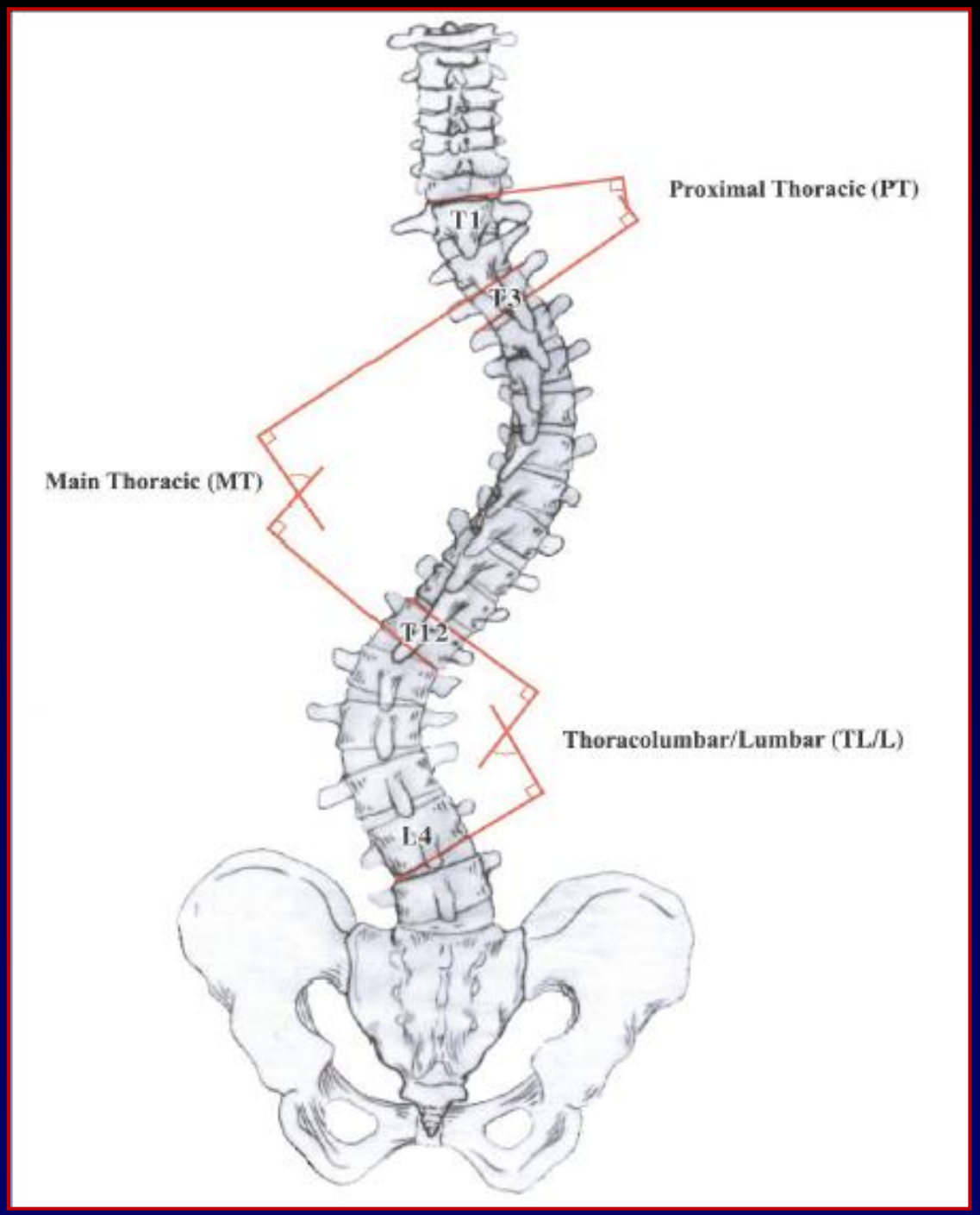

ODI=66
26 cm

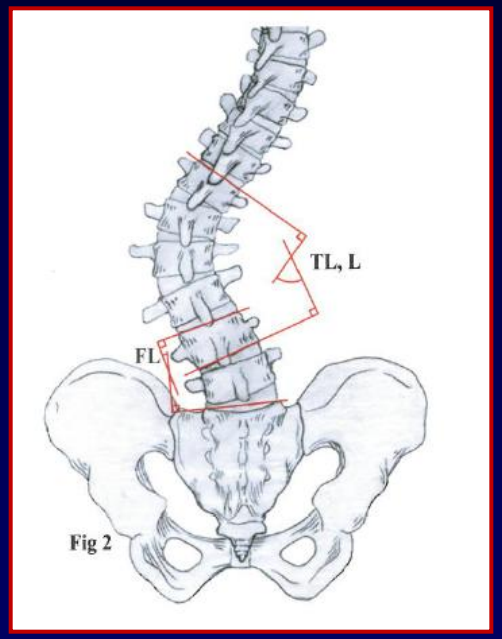

ODI=7


58 y/o
69^0
30 cm
C 1459
ODI=74
22.8 cm

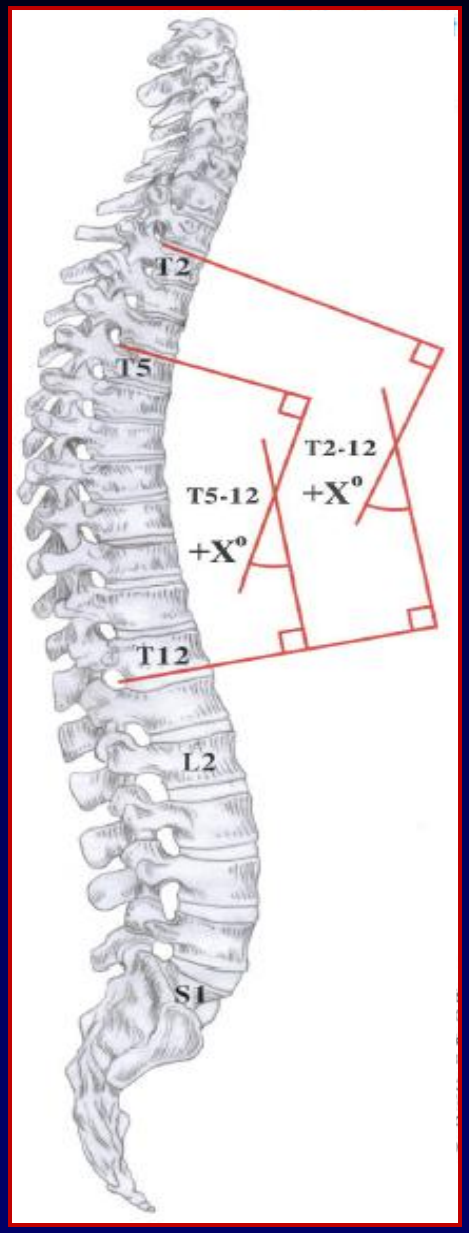

ODI=13
30 cm

Coronal Cobb Angles

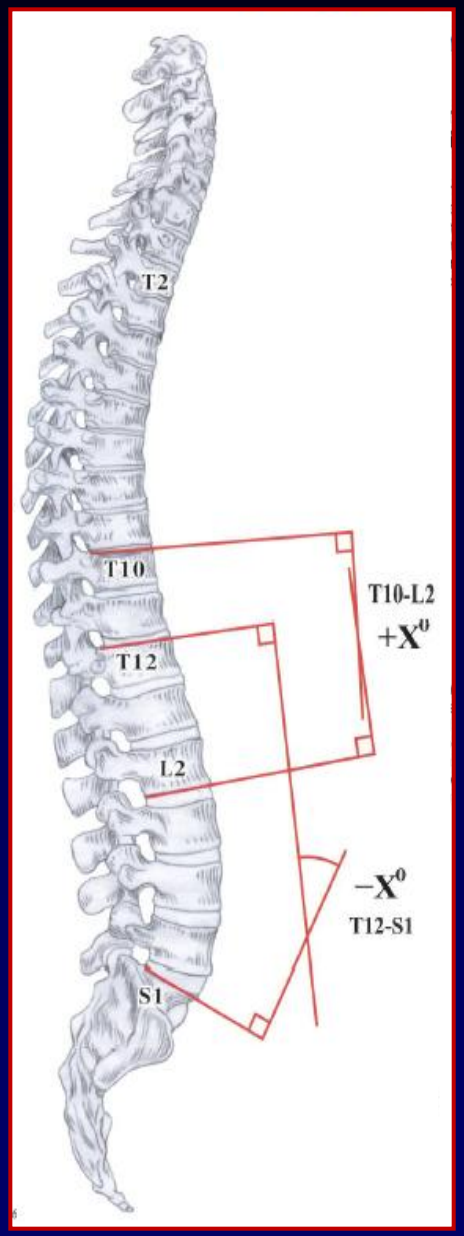




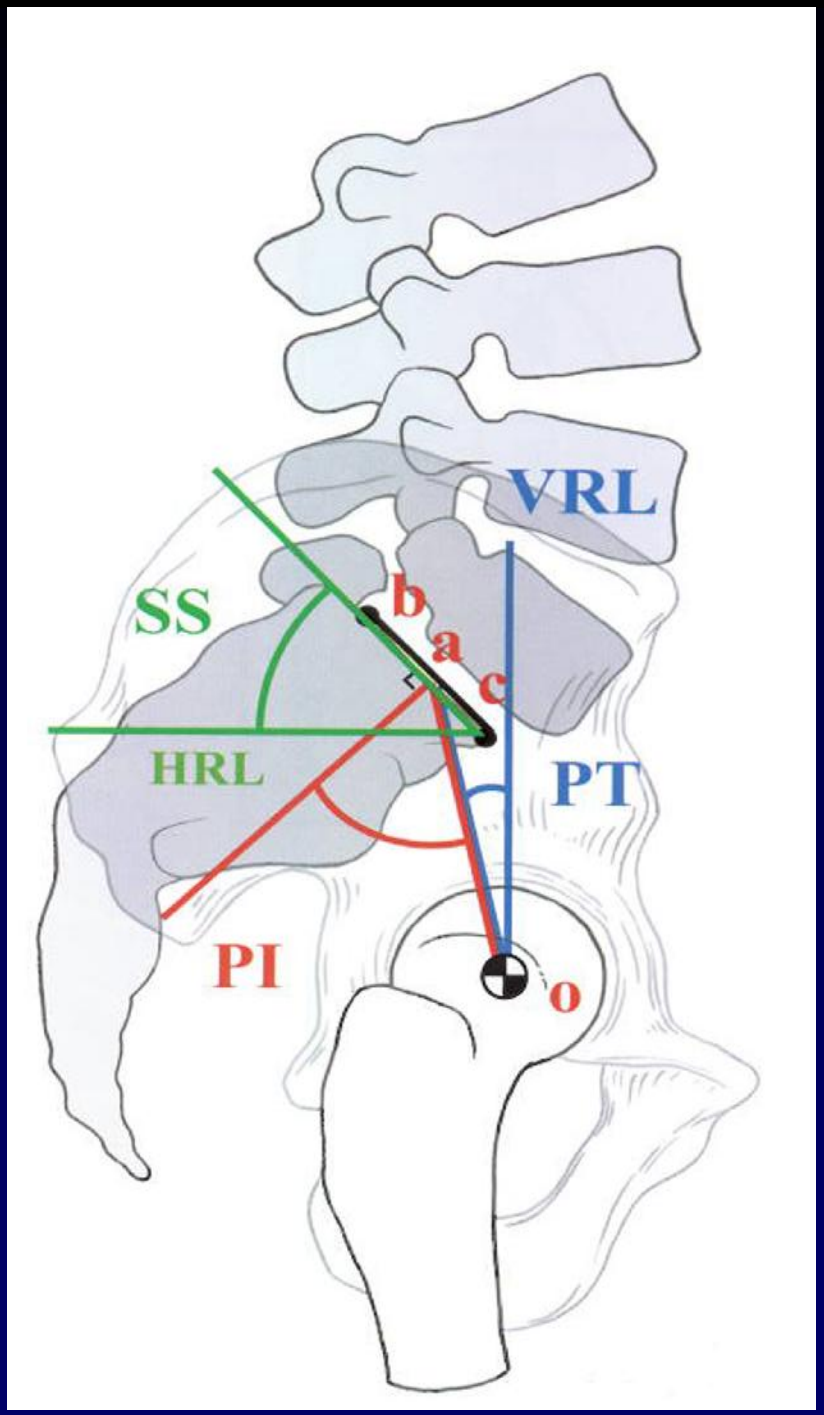
“normal” TK
(T2-T12) = 20-45°



“normal” LL = 40-70°
“normal” T10-L2 = 0-10°

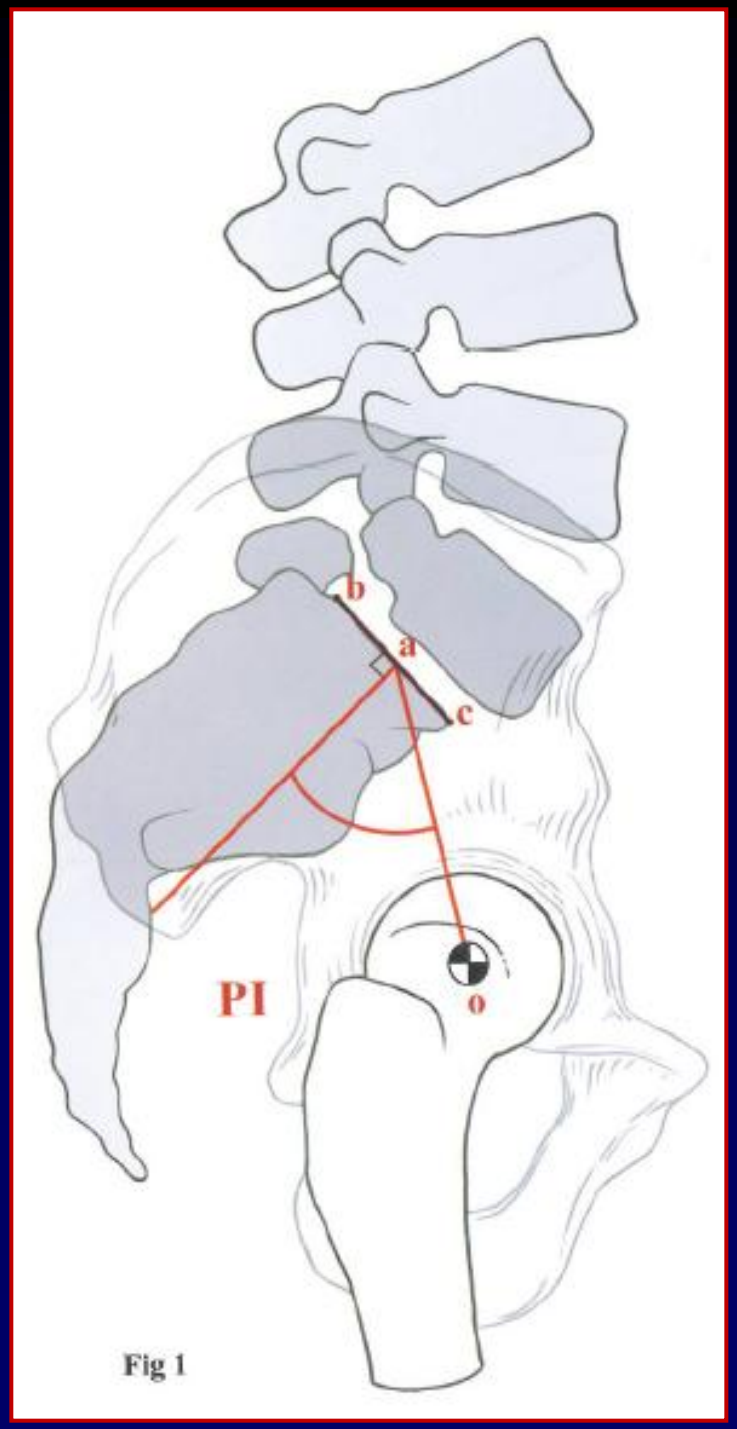


SDSG Radiographic
Measurement Manual



Pelvic Parameters

SDSG Radiographic Measurement Manual

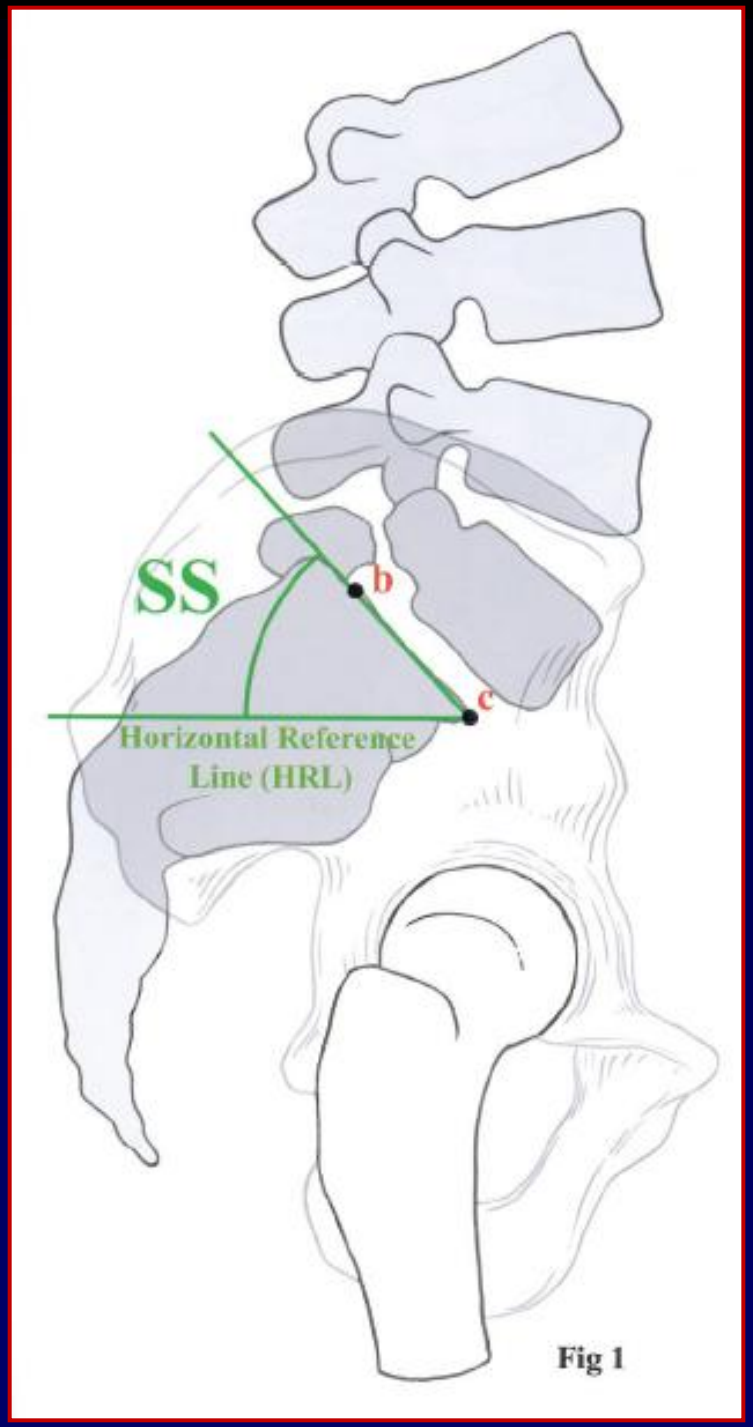


Pelvic Incidence

(40° -65°)

Morphologic Parameter

SDSG Radiographic Measurement Manual

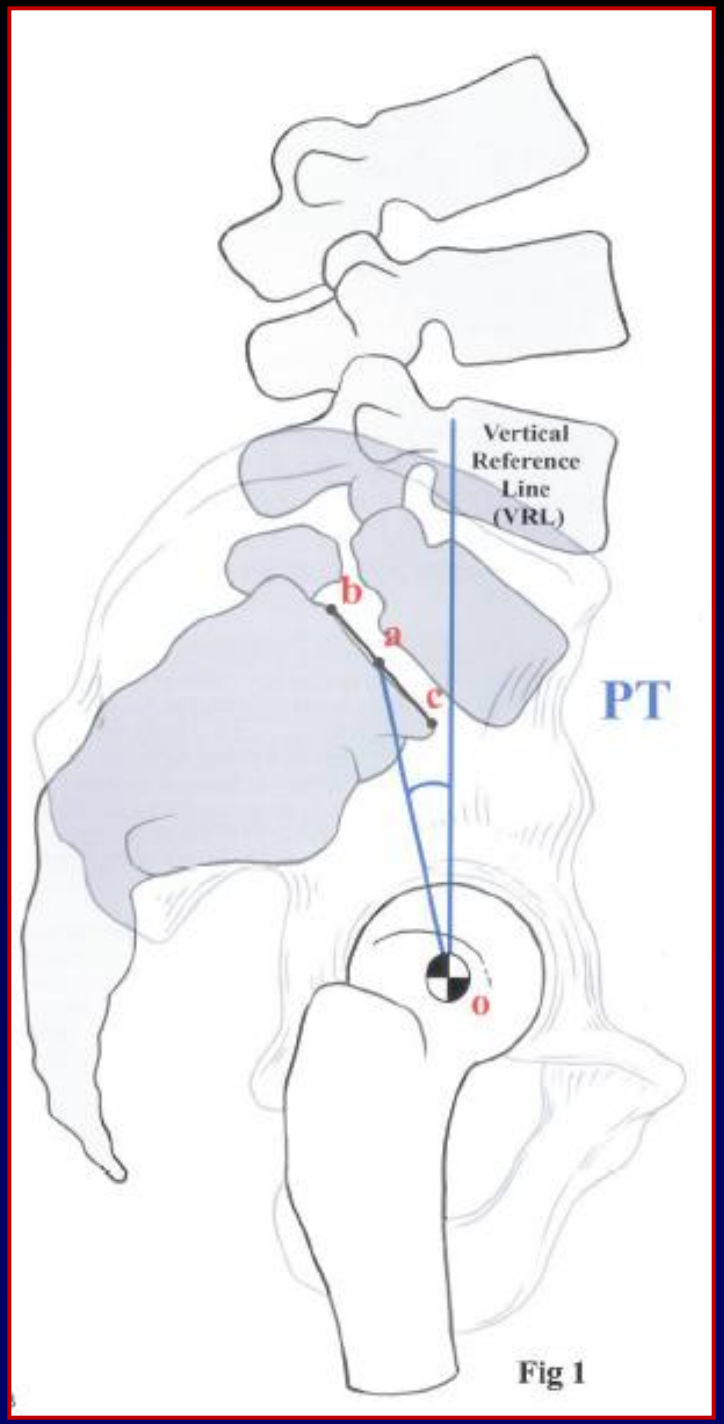


Sacral Slope

(30° -50°)

Compensatory Parameter

SDSG Radiographic Measurement Manual

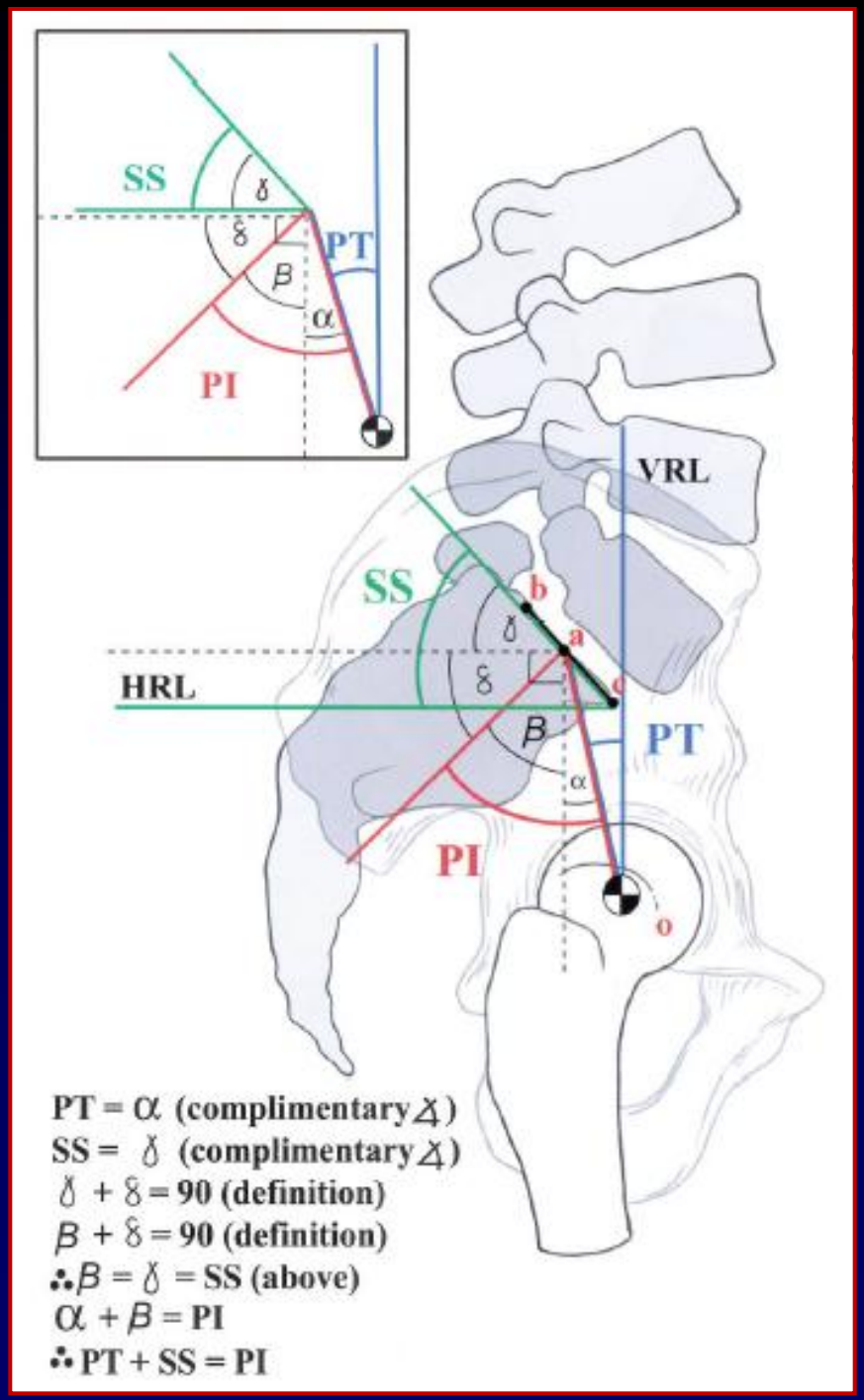


Pelvic Tilt

(10° -25°)

Compensatory Parameter

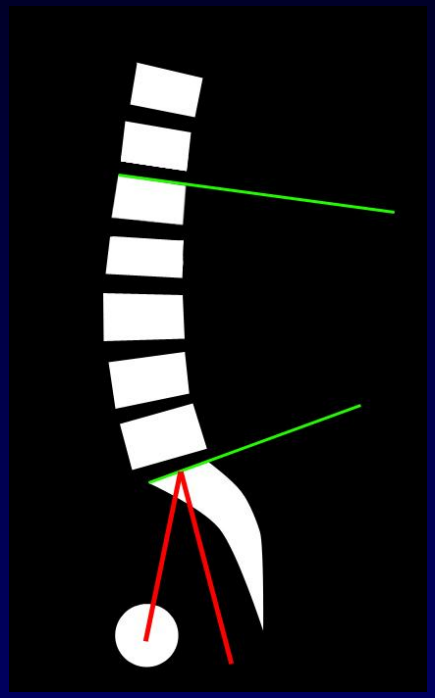
SDSG Radiographic Measurement Manual



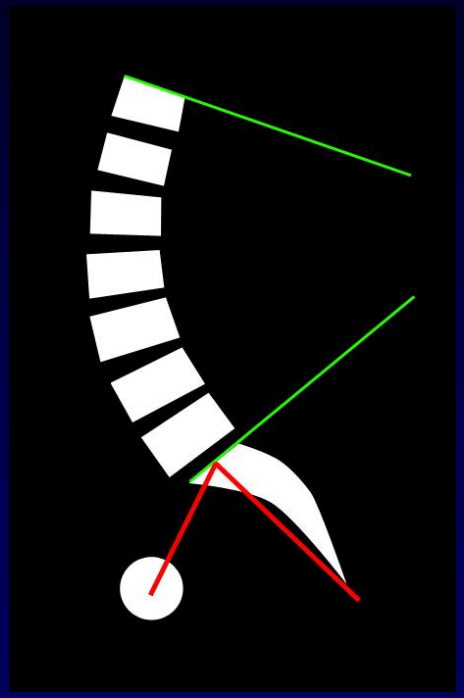
PI = PT + SS

SDSG Radiographic Measurement Manual

Pelvic Incidence and Lordosis



Small PI
Small Sacral Slope
Flatten Lordosis



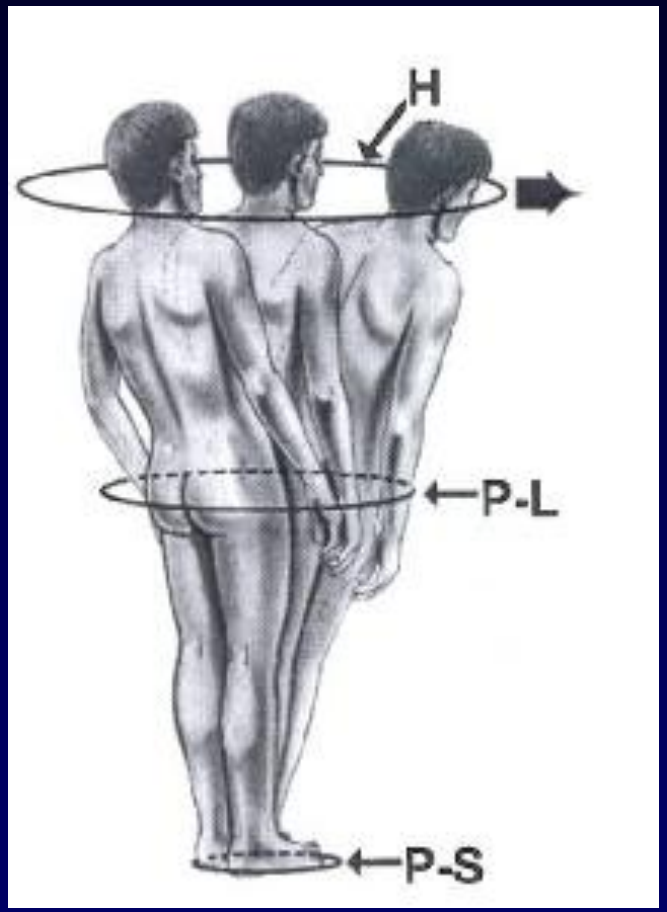
Large PI
Large Sacral Slope
Marked, long lordosis

Pragmatic Estimate:
LL = PI + 10deg

Courtesy of
Dr. Virginie Lafage

Why is Global Spinal Alignment Important?

"Cone of Balance"



Jean Dubousset

Poor alignment = disability

- Must compensate for anatomic deformation

- Mechanical disadvantage challenges balance mechanisms

Deviation from stable zone = Increase muscular / energy use

Compensatory Mechanisms

Pelvic retroversion

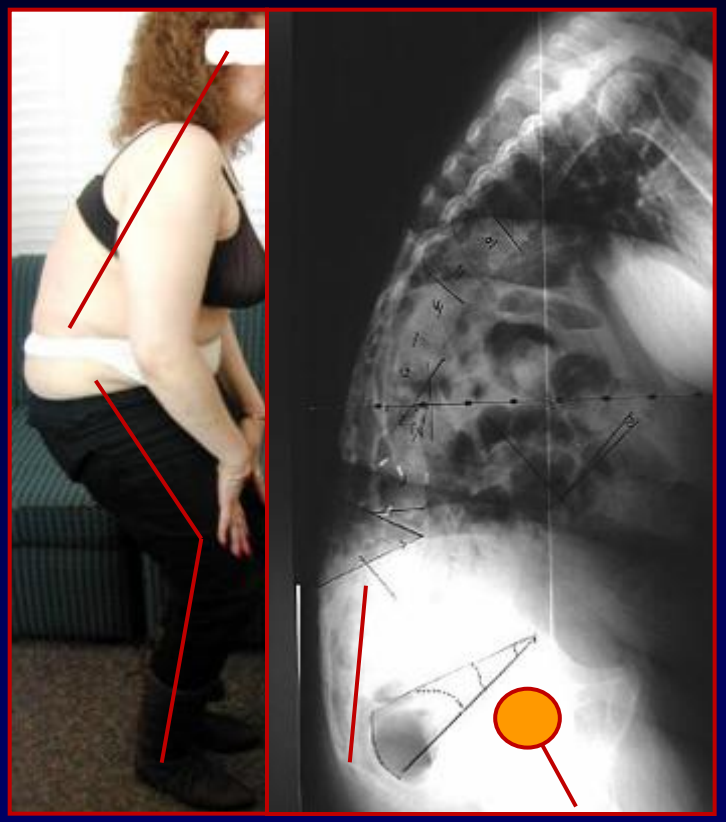
- acetabulum more anterior

Hip Extension

- for mild pelvic retroversion

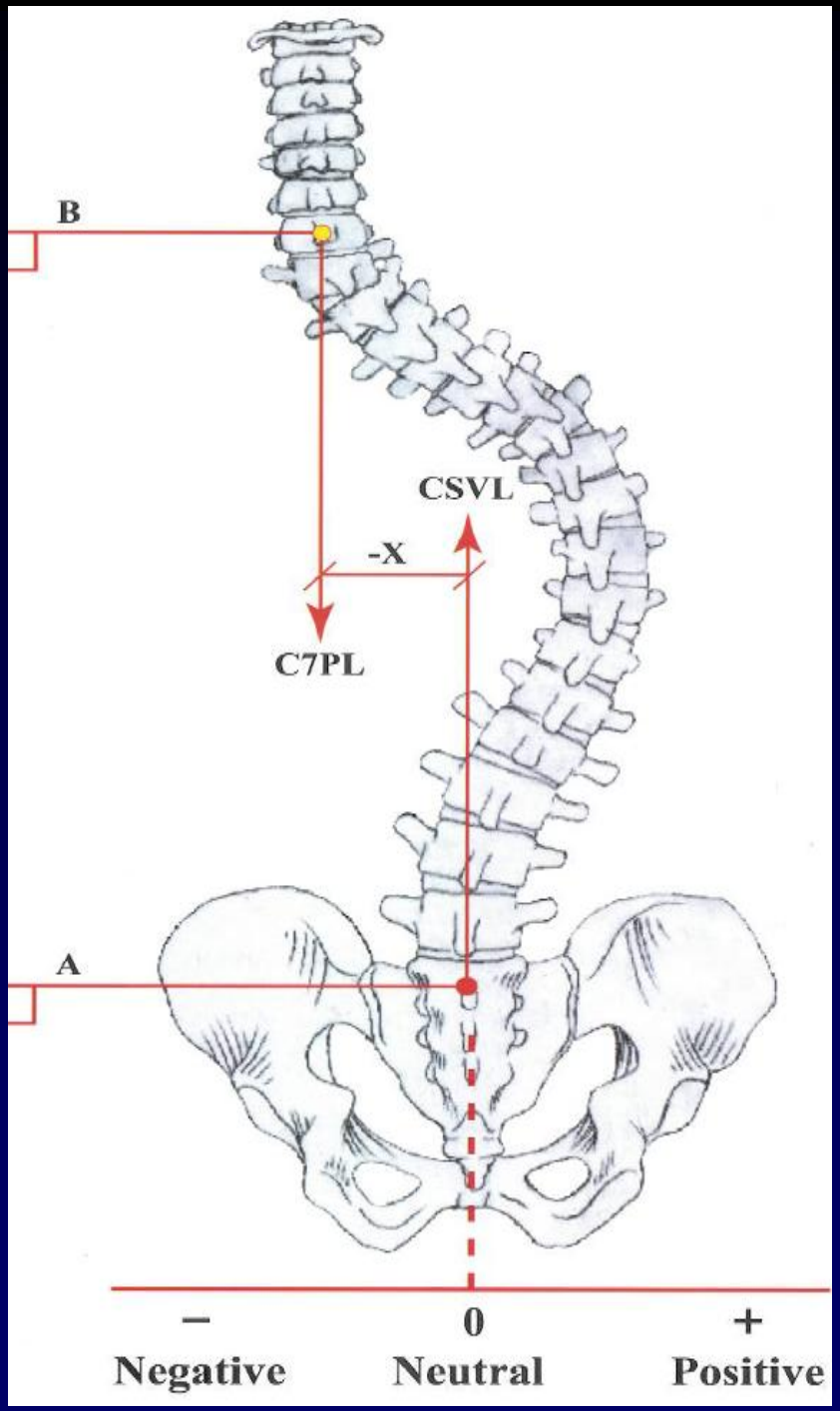
Hip flexion/ Knee flexion

- in severe/fixed deformity

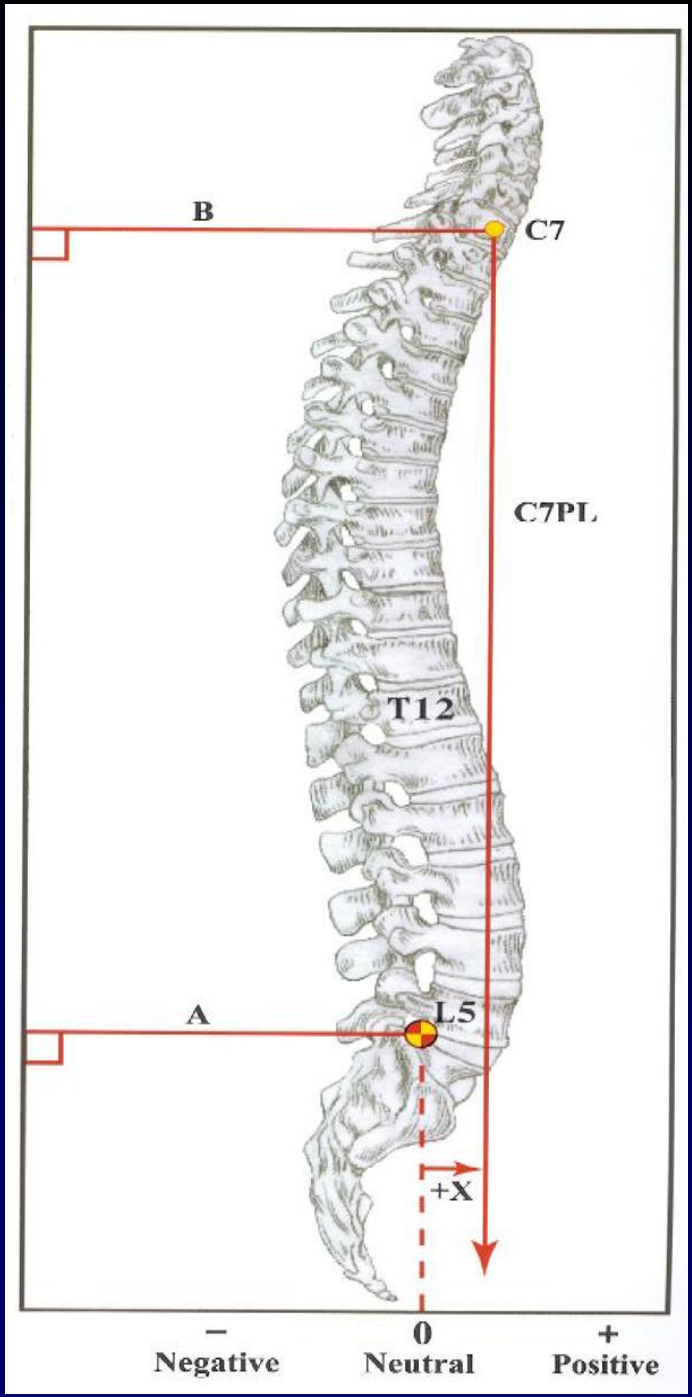


Courtesy of
Dr. Frank Schwab

Global Coronal Alignment



SDSG Radiographic Measurement Manual



Global Sagittal Alignment

SVA=
Sagittal Vertical Axis

SDSG Radiographic Measurement Manual

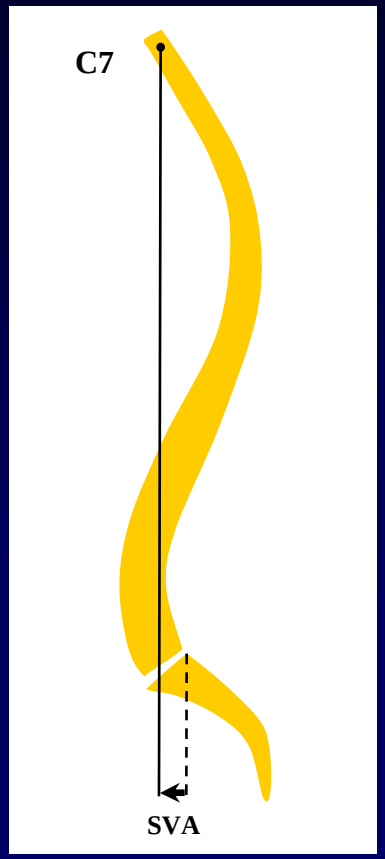
Global Spinal Alignment

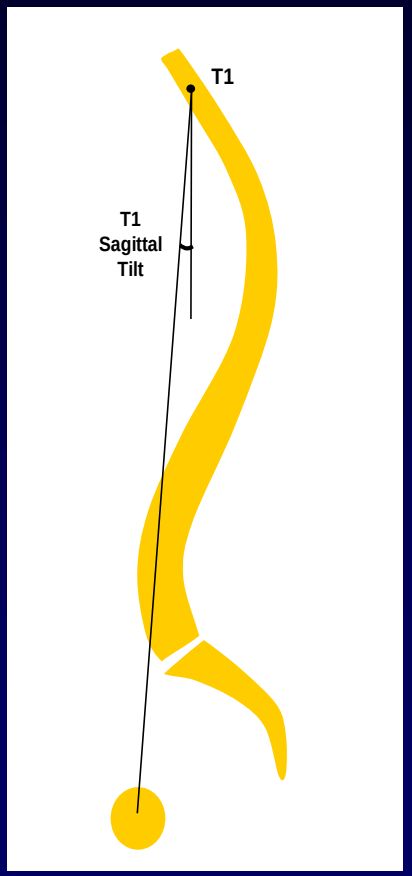
SVA (Jackson)

T1 Tilt (Duval-Beaupere)

Distance

C7 Plumbline – Posterior Superior Corner of Sacrum





Angle

Vertical vs line between femoral heads and T1

0 to 5cm

-9° to +7°

Loss of Global Alignment

Glassman, Bridwell, Dimar, Horton, Berven, Schwab. SPINE 2005

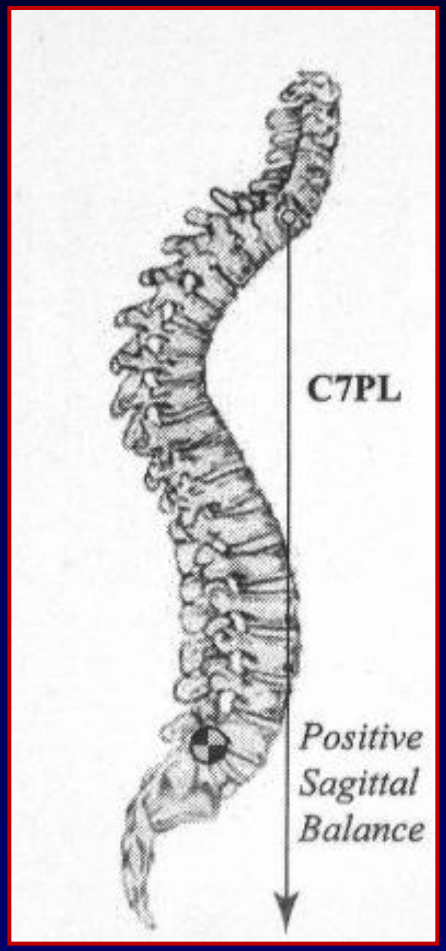
- **Plumbline Shift Anteriorly**

=> Increasing disability

SF-12, SRS-29, ODI ($p<0.001$)

=> Lumbar kyphosis marked disability

SRS-29, ODI ($p<0.05$)



Sagittal Plane Alignment

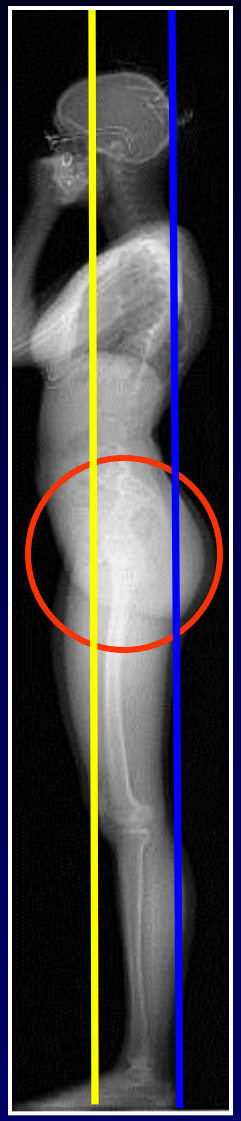
… More Than Just the Spine

Biospace / LBM

- Thoracic kyphosis
- Lumbar lordosis
- Pelvic morphology/ version
- Lower extremity

Global Alignment

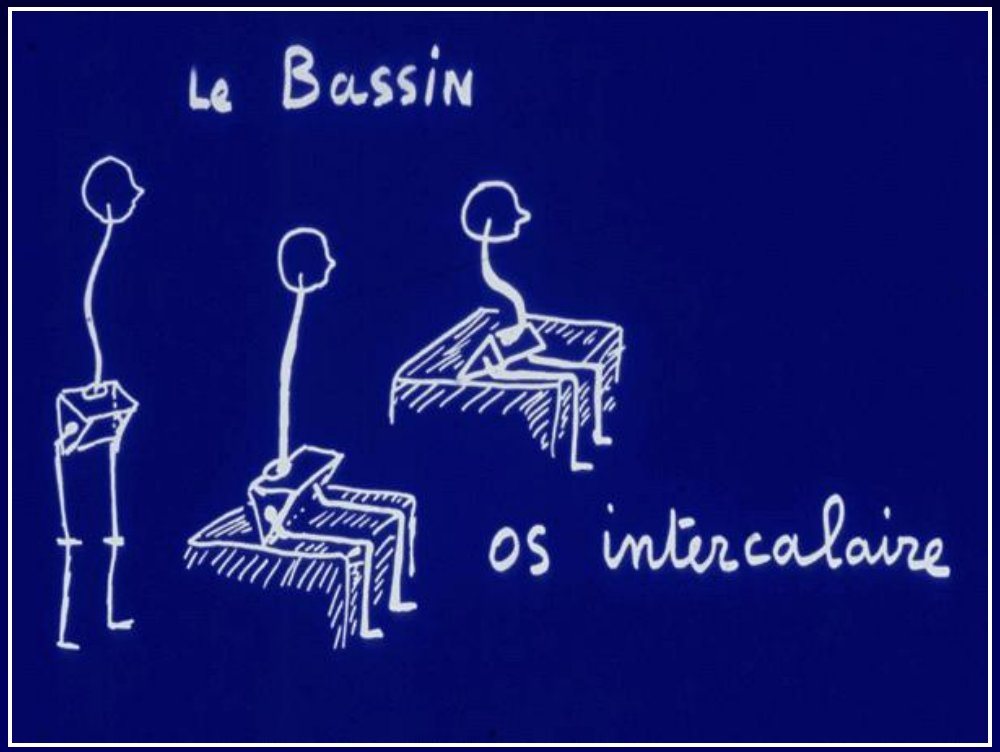
Alignment… More than just the spine



Biospace / ENSAM

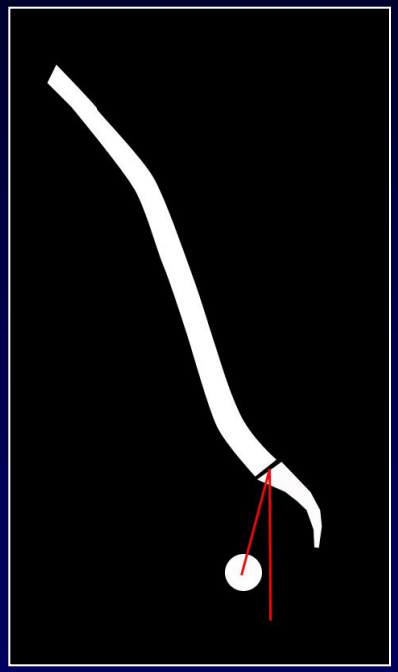
Regulator of Alignment Link between Above and Below

The ‘Pelvic Vertebra’
J Dubousset

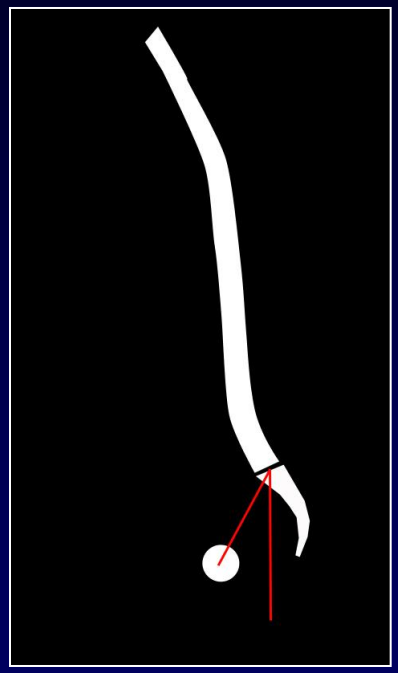


Courtesy of
Dr. Virginie Lafage

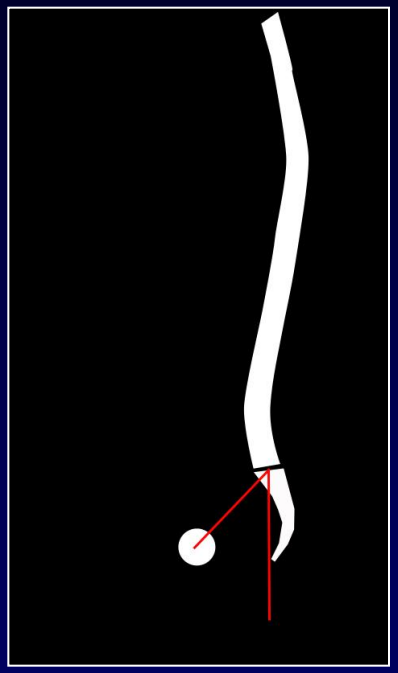
Same structural deformity… different compensation



Large SVA, No PT



Moderate SVA / PT



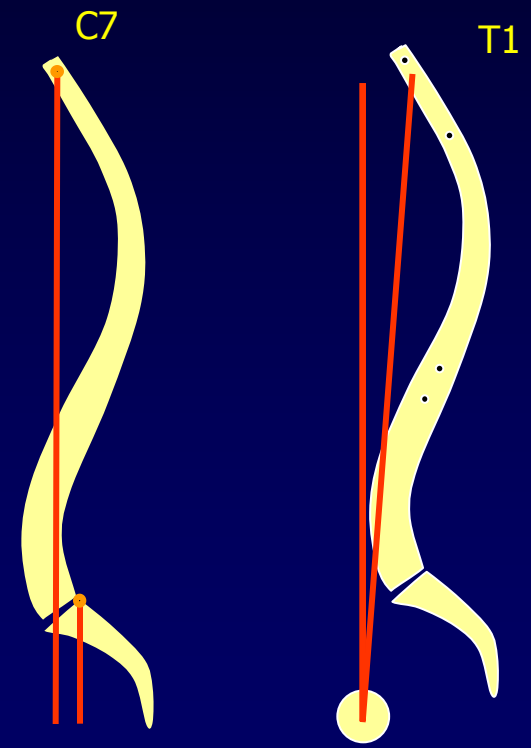
No SVA, Large PT

Pelvis = base of the spine, regulator of the standing posture ….
“Pelvic Vertebra”

Courtesy of
Dr. Virginie Lafage

Key Parameters in Sagittal Alignment

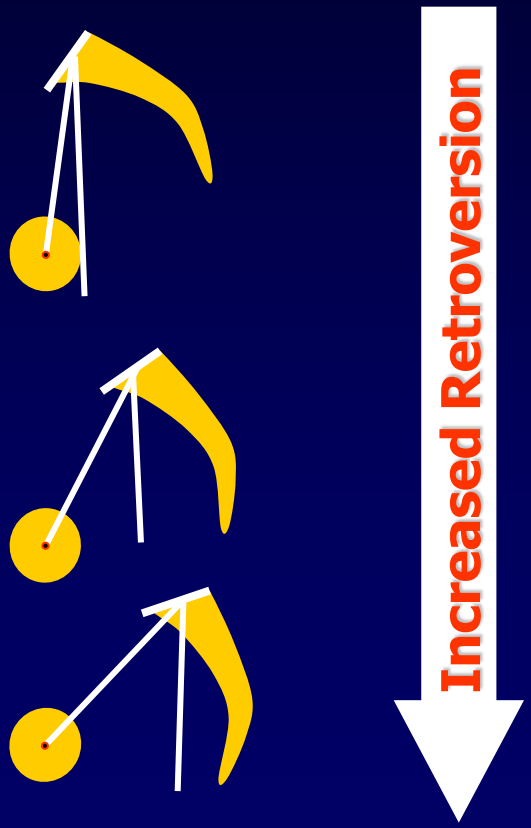
186 adult: spinal deformity, 300 radiographic parameters analyzed
Outcomes correlations



- **#1: SVA and T1 sagittal Tilt correlate with:**
  - **SRS (appearance, activity, total)**
  - **ODI**
  - **SF12 (PCS)**
  - **Correlation**
    - $0.42<r<0.55$
    - $p<0.0001$
- **T1 tilt had greater correlation with HRQOL compared to SVA.**

Key Parameters in Sagittal Alignment

"Pelvic retoversion" … Compensatory mechanism increases when trunk tilts forward



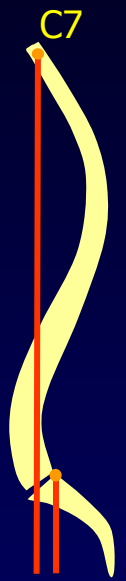
#2: PT correlates with

- **SRS (appearance, activity, total)**
- **ODI (Walk, stand)**
- **SF12 (PCS)**

- **Correlations with HRQOL**
  - $0.33<r<0.42$
  - $p<0.000$

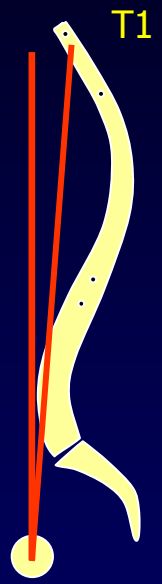
Lafage, Schwab et al. *Spine* 1(34):E599-606, 2009.

Alignment Objectives



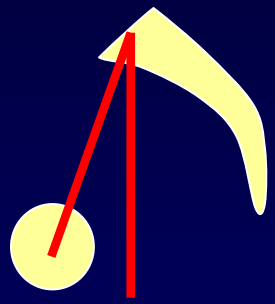
SVA

<5cm



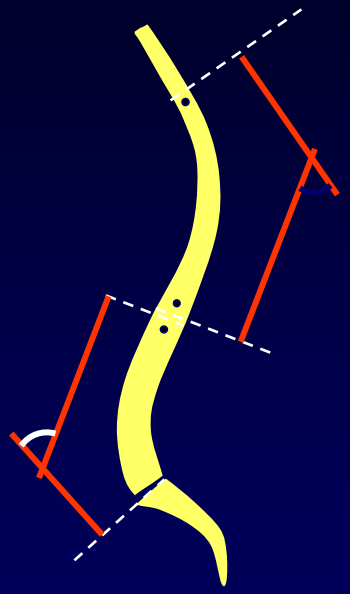
T1 Tilt

<0^0



PT

<25^0

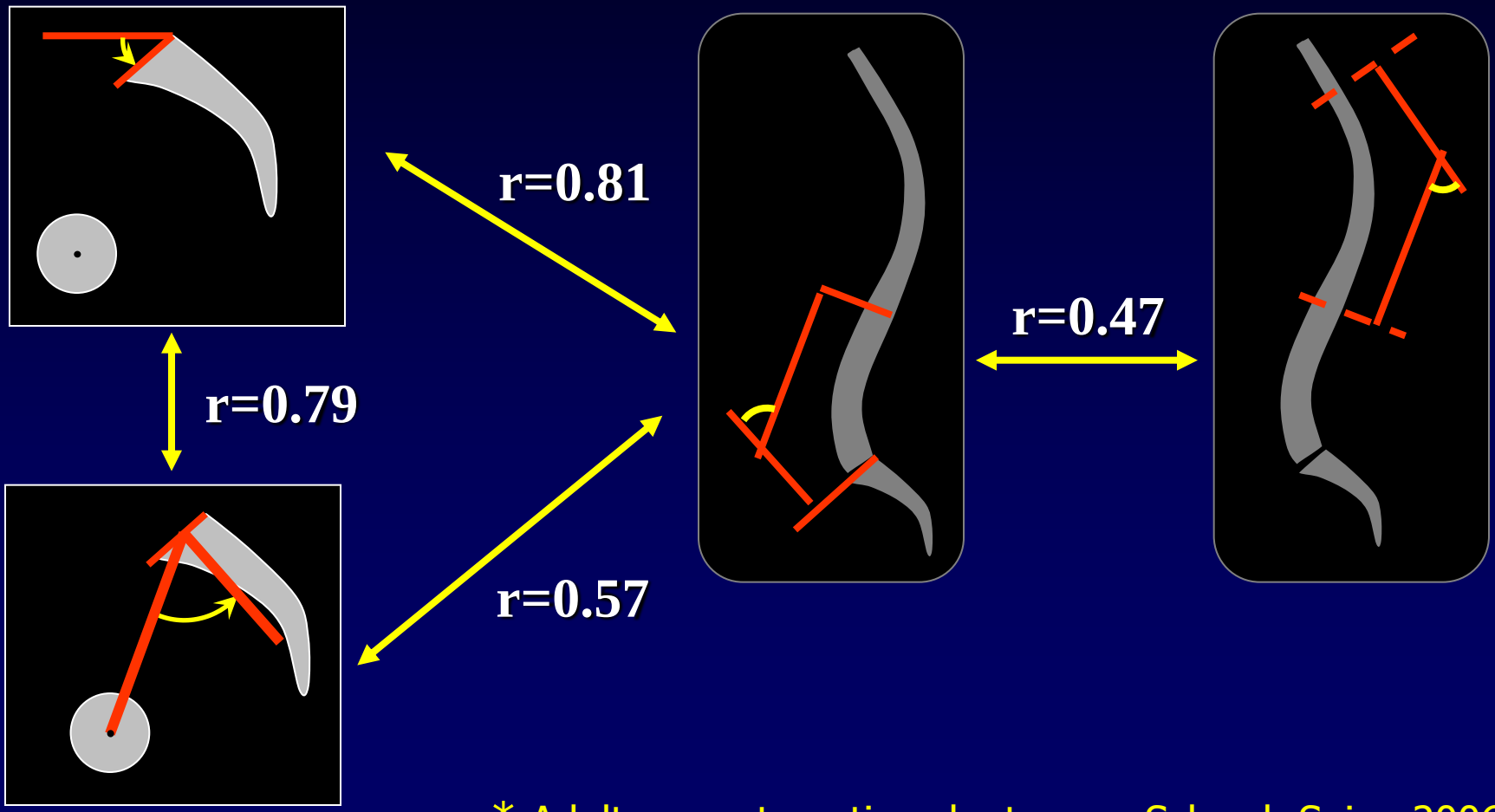


Proportional:

LL=PI +/- 9^0

Spino-Pelvic Chain of Correlation

Duval-Beaupere, Legaye, Vialle, Roussouly, Berthonnaud, ….



* Adult asymptomatic volunteers – Schwab Spine 2006

Spine

SPINE Volume 37, Number 3, pp E180–E187

DEFORMITY

Changes in Thoracic Kyphosis Negatively Impact Sagittal Alignment After Lumbar Pedicle Subtraction Osteotomy

A Comprehensive Radiographic Analysis

Virginie Lafage, PhD,* Christopher Ames, MD,§ Frank Schwab, MD,* Eric Klineberg, MD,† Behrooz Akbarnia, MD,‡ Justin Smith, MD,‡‡ Oheneba Boachie-Adjei, MD,¶ Douglas Burton, MD,‖ Robert Hart, MD,** Richard Hostin, MD,†† Christopher Shaffrey, MD,‡‡ Kirkham Wood, MD,§§ Shay Bess, MD,¶¶; and International Spine Study Group

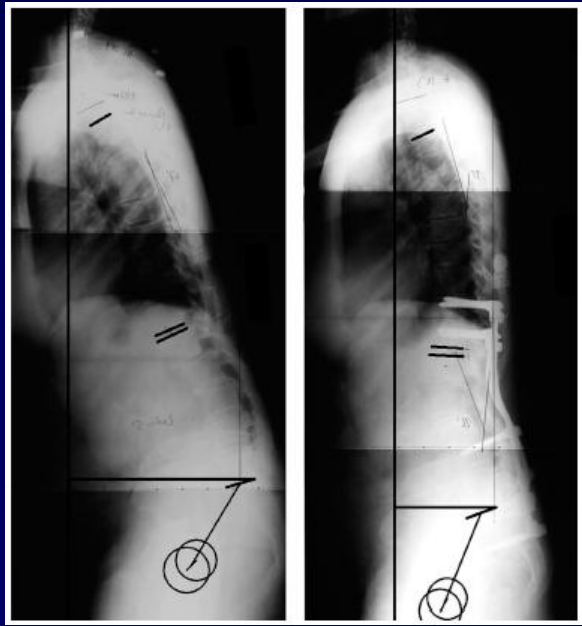


Figure 4. Example of "unfavorable reciprocal change." As demonstrated by the pre- and postoperative measurements (Table 2), the application of a 30° PSO at L3 led to an increase of LL (+35.1°) with normalization of the PI minus LL offset (postoperative offset = 32.8°). As a result, optimal postoperative alignment was not obtained (postoperative SVA = 128 mm, postoperative PT = 33.5°) due in part to an increase of the TK (+19°). The increase in TK of 19° is the reciprocal change, a secondary effect of modifying other spinopelvic conditions.

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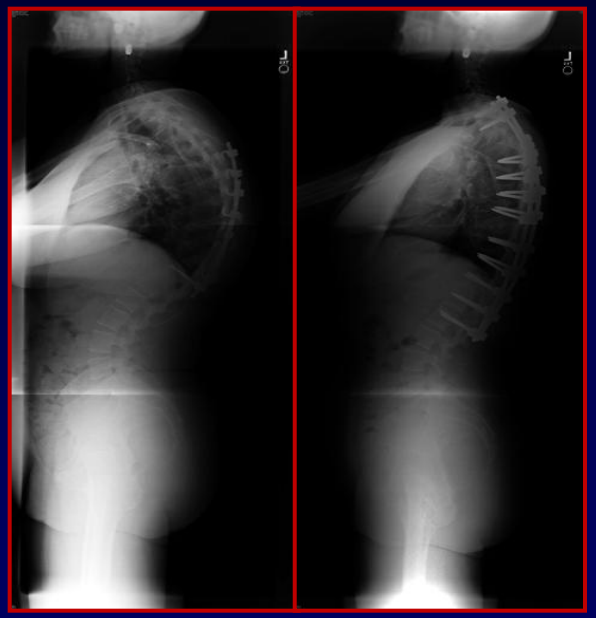
Clinical Study

Advances in Orthopedics
Volume 2011, Article ID 415946, 7 pages
doi:10.4061/2011/415946

Acute Reciprocal Changes Distant from the Site of Spinal Osteotomies Affect Global Postoperative Alignment

Eric Klineberg,[1] Frank Schwab,[2] Christopher Ames,[3] Richard Hostin,[4]
Shay Bess,[5] Justin S. Smith,[6] Munish C. Gupta,[1] Oheneba Boachie,[7] Robert A. Hart,[8]
Behrooz A. Akbarnia,[9] Douglas C. Burton,[10] and Virginie Lafage[2]



- Lumbar PSO with selective lumbar fusion increases TK
- Thoracic PSO with selective thoracic fusion decreases LL (flattens L-spine)

Spine

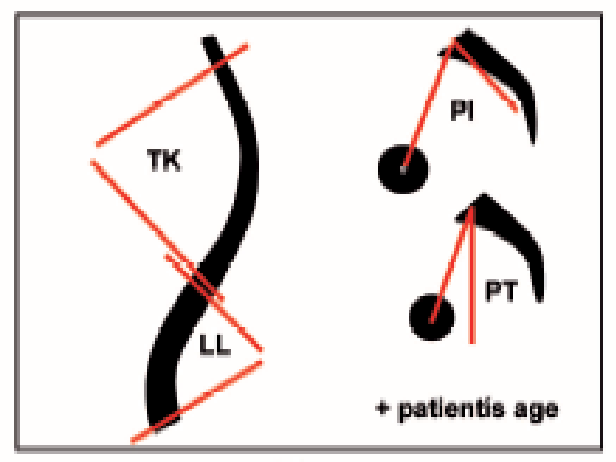
SPINE Volume 37, Number 10, pp 1–9

DIAGNOSTICS

Dynamic Changes of the Pelvis and Spine Are Key to Predicting Postoperative Sagittal Alignment After Pedicle Subtraction Osteotomy

A Critical Analysis of Preoperative Planning Techniques

Justin S. Smith, MD, PhD,* Shay Bess, MD,† Christopher I. Shaffrey, MD,* Douglas C. Burton, MD,‡ Robert A. Hart, MD,§ Richard Hostin, MD,¶ Eric Klineberg, MD,** and the International Spine Study Group



SVA = -52.87 + 5.90*(PI) – 5.13*(LL_{max}) – 4.45*(PT) – 2.09 * (TK_{max}) + 0.57*(age)

Lafage V *et al*. Spine 36(13):1037-45, 2011.

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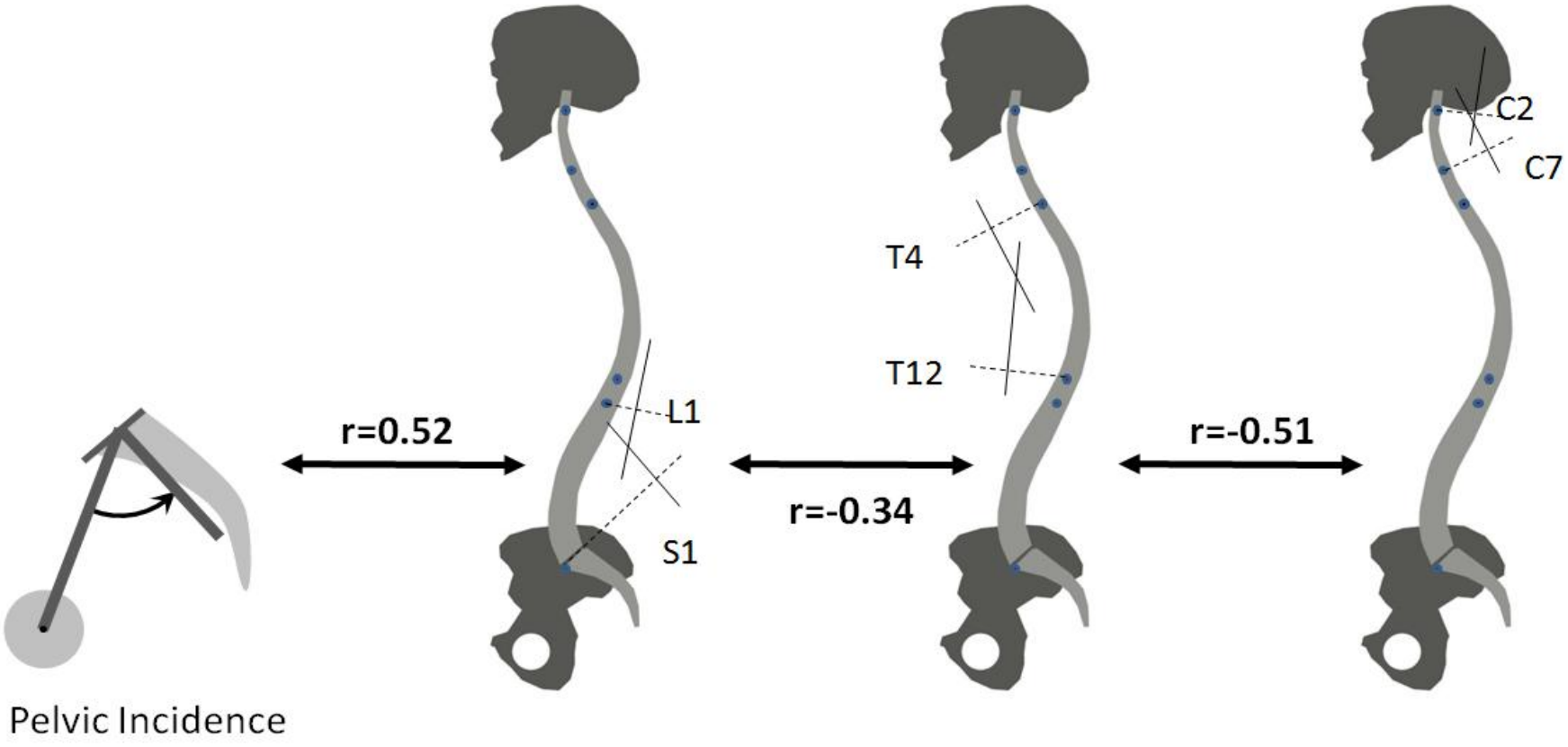
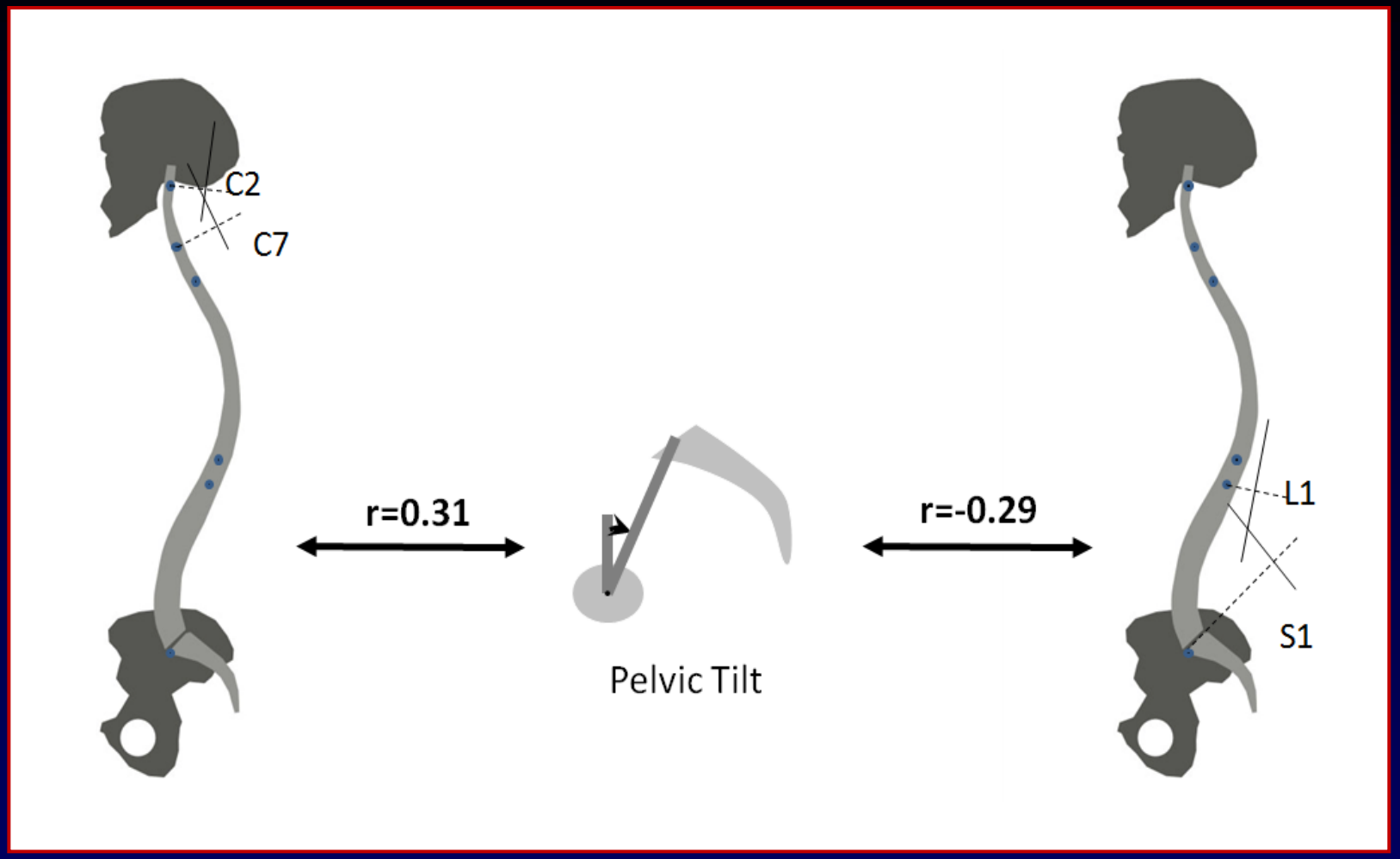


Chain of correlation between PI and regional sagittal parameters. A large PI requires a large lumbar lordosis. An increase of Lumbar lordosis is correlated with an increased thoracic kyphosis which is correlated with an increased cervical lordosis.

Blondel B, Schwab F, *et al*. Submitted for publication.



Correlation between Pelvic Tilt and regional sagittal parameters. A loss of lumbar lordosis is correlated with a pelvic retroversion acting as compensatory mechanisms. Pelvic retroversion is also correlated with an increased cervical lordosis.

Blondel B, Schwab F, *et al*. Submitted for publication.

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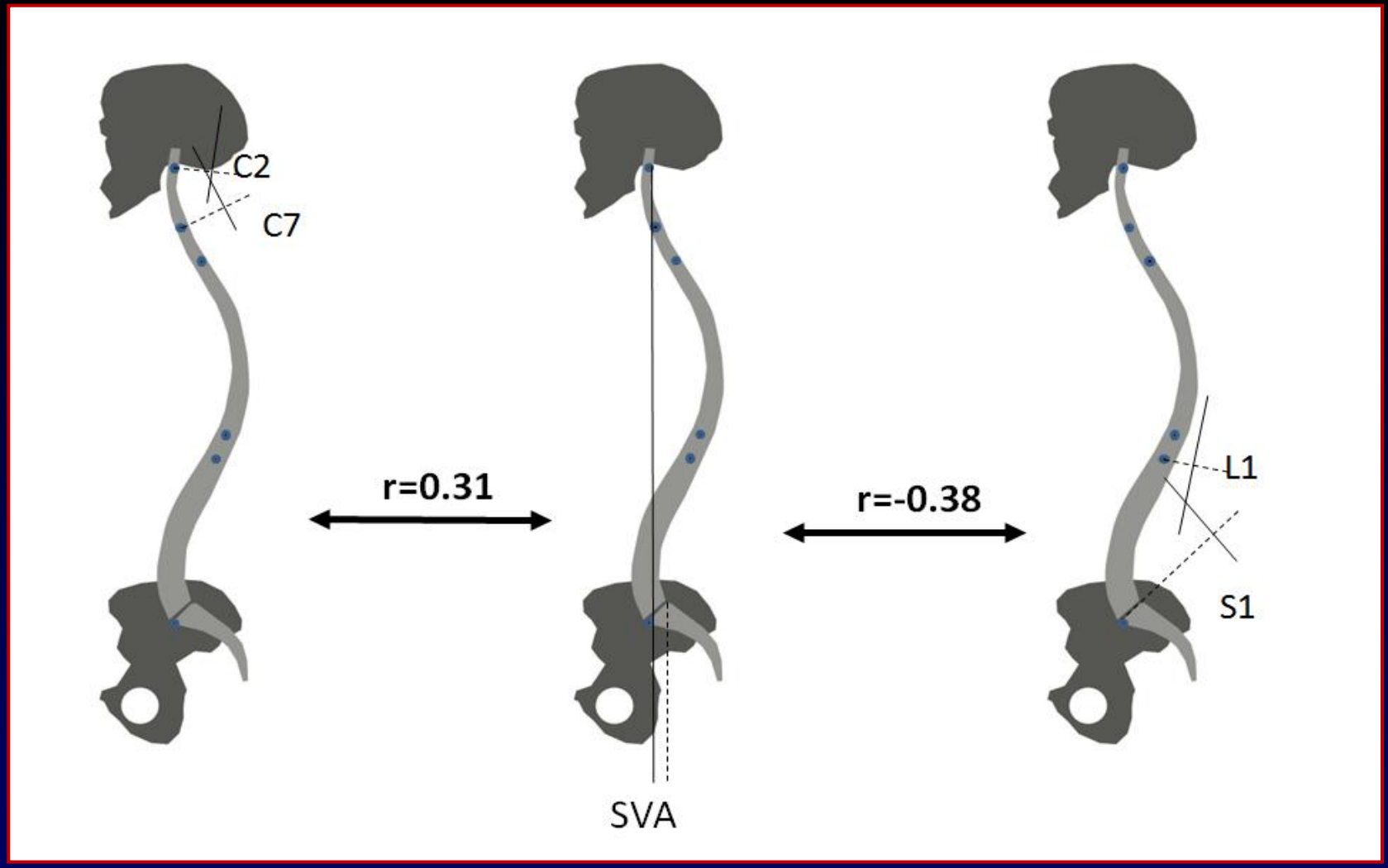
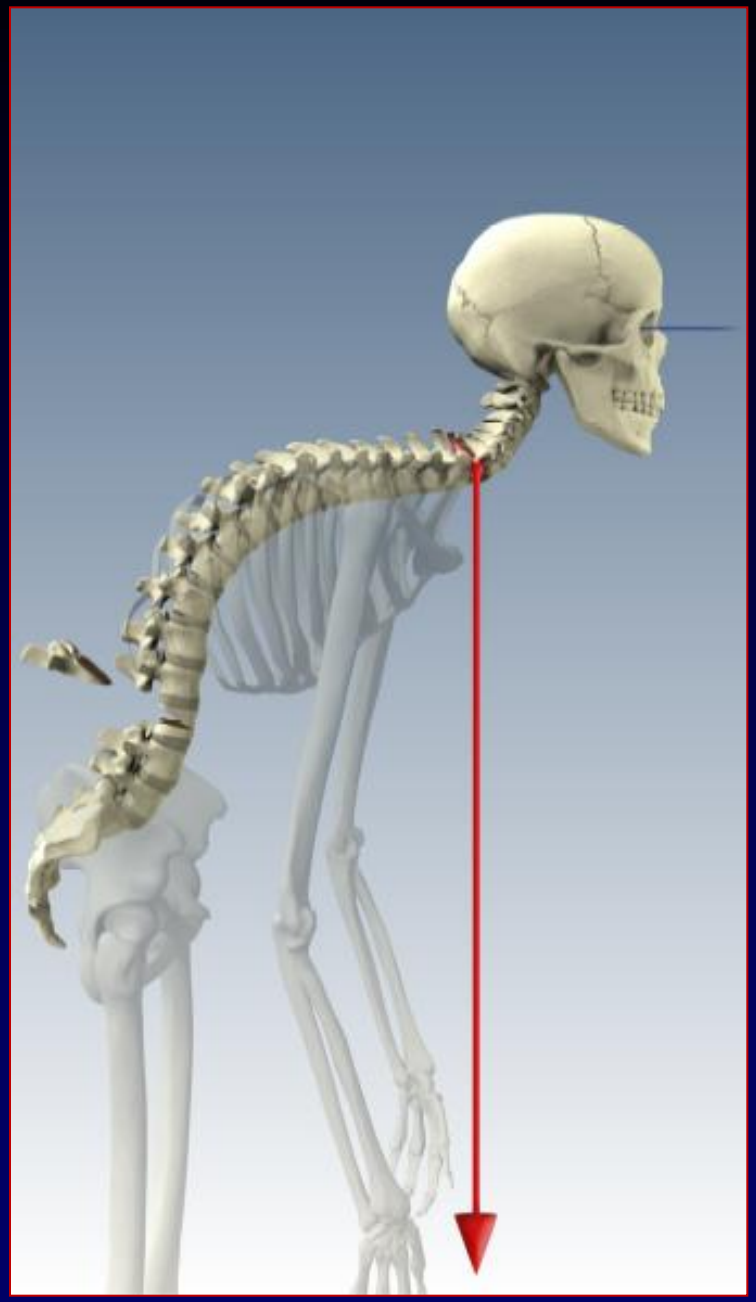
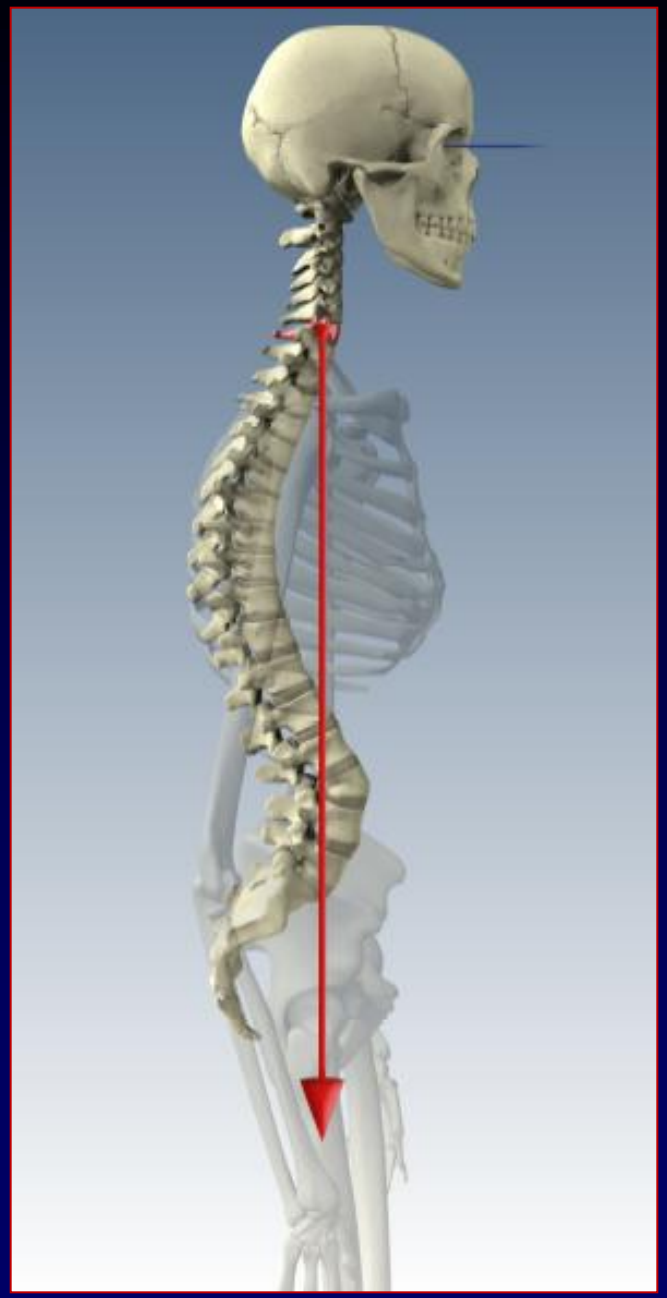


Correlation between SVA, CL and LL. A loss of lordosis is correlated to an increase of SVA. This anterior sagittal malalignment is correlated with an increased cervical lordosis.

Blondel B, Schwab F, *et al*. Submitted for publication.





JS Smith, *et al*. Submitted for publication.

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Global Spinal Alignment: Summary

- **Surgery that corrects neural impingement or spinal instability but causes poor sagittal or coronal balance usually gives a bad result**
- **Goals of global sagittal spino-pelvic alignment include:**
  - **SVA <5 cm**
  - **PT <25˚**
  - **PI – LL mismatch ≤10˚**
- **Regional spino-pelvic alignments are inter-related and significant compensatory changes in uninstrumented regions can occur**


Thank You