AANS Spinal Deformity Course
for Senior Residents

Global Spinal Alignment

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• Especially Virginie Lafage and Frank Schwab from NYU
Adult Spinal Deformity

Large variety of ‘deformities’
• Surgery that corrects neural impingement or spinal instability but causes poor sagittal or coronal balance usually gives a bad result
Coronal Cobb Angles

- Proximal Thoracic (PT)
- Main Thoracic (MT)
- Thoracolumbar/Lumbar (TL/L)

Fig 2
"normal" TK (T2-T12) = 20-45°

"normal" LL = 40-70°

"normal" T10-L2 = 0-10°
Pelvic Parameters
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
PI = PT + SS

PT = \alpha (complimentary \Delta)
SS = \delta (complimentary \Delta)
\delta + \delta = 90 (definition)
\beta + \delta = 90 (definition)
\because \beta = \delta = SS (above)
\alpha + \beta = PI
\because PT + SS = PI
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”

Poor alignment = disability

• Must compensate for anatomic deformation

• Mechanical disadvantage challenges balance mechanisms

Deviation from stable zone = Increase muscular / energy use

Jean Dubousset
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 Sagittal Alignment

SVA = Sagittal Vertical Axis
Global Spinal Alignment

SVA (Jackson)  
C7 Plumbline – Posterior Superior Corner of Sacrum

0 to 5cm

T1 Tilt (Duval-Beaupeire)  
Vertical vs line between femoral heads and T1

-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

Thoracic kyphosis
Lumbar lordosis
Pelvic morphology/version
Lower extremity

Global Alignment

Biospace / LBM
Alignment... More than just the spine

The ‘Pelvic Vertebra’
J Dubousset

Regulator of Alignment
Link between Above and Below

Courtesy of Dr. Virginie Lafage
Same structural deformity... different compensation

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.
"Pelvic retroversion" … Compensatory mechanism increases when trunk tilts forward

#2: PT correlates with
- SRS (appearance, activity, total)
- ODI (Walk, stand)
- SF12 (PCS)

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

Alignment Objectives

- SVA: <5cm
- T1 Tilt: <0°
- PT: <25°
- Proportional: \( \text{LL} = \text{PI} \pm 9° \)
Spino-Pelvic Chain of Correlation

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

* Adult asymptomatic volunteers – Schwab Spine 2006
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.
Clinical Study

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 Lafage²

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

\[
SVA = -52.87 + 5.90 \times (PI) - 5.13 \times (LL_{max}) - 4.45 \times (PT) - 2.09 \times (TK_{max}) + 0.57 \times \text{age}
\]

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.

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.

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.

JS Smith, et al. Submitted for publication.
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