





Sagittal Balance




Radiographic Assessment
And
Surgical Goals

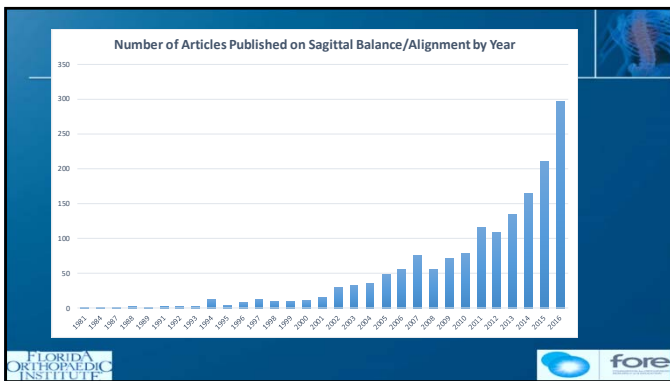
Steven J. Tresser, MD



Disclosures

- Nuvasive – consultant, royalties, speaking
- K2M – consultant, royalties
- Centinel Spine – consultant, speaking
- CTL Medical – advisory board





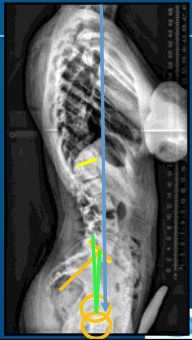
Sagittal Balance

- How do we determine/measure it
- Why should we care about it?
- Defining surgical goals
- History of the problem and thought development
- How to plan surgeries using this information
- Future directions

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The Spinopelvic Parameters


1. Lumbar Lordosis (LL)
2. Pelvic Incidence (PI)
3. Pelvic Tilt (PT)
4. Sagittal Vertical Axis (SVA)



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Lumbar Lordosis



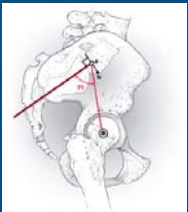
- L1-S1 angle
- Normal lumbar lordosis is within the range of $63^\circ \pm 15^\circ$
- Relates to pelvic incidence
 - Normal PI -LL = $\pm 9^\circ$
- **At least 2/3 of LL is at L4-S1**



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Pelvic Incidence

- Angle between the perpendicular to mid-sacral endplate and femoral heads
- PI determines relationship to rest of spine
- Everyone's pelvis is different
- Stays constant throughout adult life
- Not affected by patient position
- Rocking your pelvis backwards doesn't change it







So What is The PI/LL Connection?



Normal Sagittal Alignment


Pelvic Incidence and Lordosis



 <p>Large PI Horizontal sacrum Marked, long lordosis</p>	 <p>Small PI Vertical sacrum Flat lordosis</p>
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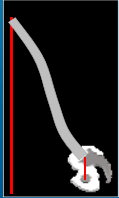
Pelvic Tilt

- Angle between the vertical and line drawn from mid-sacral endplate to femoral heads
- Normal pelvic tilt is **less than 20 degrees**
- Compensatory mechanism to reduce positive balance





Compensation and Pelvic Tilt



Large SVA, No PT





Moderate SVA / PT

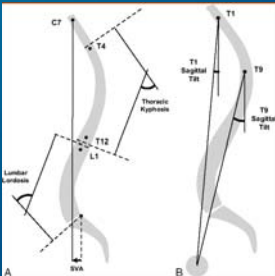




No SVA, Large PT

**Large Pelvic Tilt => Hip Hyper-extension
Compromises Walking**

SVA/T_rSP



T1 Pelvic Angle

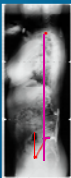
A New Predictor for Postoperative Sagittal Balance and Clinical Outcomes in Adult Scoliosis

Jun Qiao, MD, Feng Zhu, MD, Leilei Xu, MD, Zhen Liu, MD, Zezhang Zhu, MD, Bangping Qian, MD, Xu Sun, MD, and Yong Qiu, MD
SPINE Volume 39, Number 25, pp 2103-2107

- Angle from T1 to femoral head to mid-sacral endplate
- Combines information from SVA or T1-SP and PT
- Angular measurement like T1-SP
- Immune to patient posture
- Better correlation with HRQOL than SVA



Need for good Radiographs



- Regional/focal x-rays can be misleading
- Long films without pelvis do not permit assessment of compensatory mechanisms
- Films including lower limbs are even better!



At a minimum

- Lumbar radiographs that include the femoral heads
 - Able to derive a PI, LL, and PT
 - Allows awareness of 'at risk' patients



The Spinopelvic Parameters

So....

How can we use all this to help our patients??

fore

Radiographical Spinopelvic Parameters and Disability in the Setting of Adult Spinal Deformity

A Prospective Multicenter Analysis

Frank J. Schwab, MD^{1*}, Benjamin Blondel, MD^{2*}, Shu Ross, MD³, Richard Haidich, MD⁴, Christopher J. Shaffner, MD⁵, Jason S. Smith, MD, PhD⁶, Othman Boucraie-Ajdel, MD⁷, Douglas C. Burton, MD⁸, Richard A. Allread, MD⁹, Gregory M. Alexander, MD¹⁰, Christopher P. Ames, MD¹¹, Khalid Khatib, MD¹², Richard A. Hart, MD¹³, Jean-Francoisarcy, MD¹⁴, Vincent Lafage, PhD¹⁵, and the International Spine Study Group (ISSG)

Thresholds for Disability (ODI>40)

- PI -LL > 11°
- SVA > 47mm
- PT > 20°

PI minus LL

- 0 : within 2.0°
- + : moderate 10-20°
- ++ : marked >20°

Global alignment

- 0 : SVA < 4cm
- + : SVA 4 to 9.5cm
- ++ : SVA > 9.5cm

Pelvic Tilt

- 0 : PT < 20°
- + : PT 20-30°
- ++ : PT > 30°

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Impact of Sagittal Balance


- Adverse health outcomes are highly correlated with positive sagittal balance
- Sagittal balance assessment should be a critical consideration during patient evaluation and surgical planning

fore

Alignment Matters

- Preservation/restoration of lumbar lordosis is crucial to the success (*clinical outcome: pain/disability*) of any lumbar fusion.
- Sagittal balance is directly correlated to clinical outcome: avoid sagittal decompensation.^{1,2}
- If the clinically relevant radiographic parameters are not achieved the patient runs a 10x higher risk of reoperation.²

¹Mehta VA, Amin A, Omeis I, et al. Implications of spinopelvic alignment for the spine surgeon. *Neurosurgery* 2012;70:707-21.
²Rothenthal DA, Mueller DA, Rothenfuhr E, et al. Pelvic incidence-lumbar lordosis mismatch predisposes to adjacent segment disease after lumbar spinal fusion. *Eur Spine J* 2015;24(6):1231-8.




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Goals for Patient Outcomes

Sagittal Balance Restoration aims to

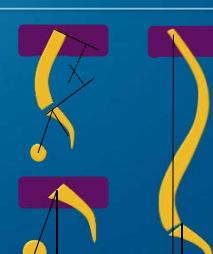
Improve patient quality of life:

- Resolve Pain and dysfunction
- Restore horizontal gaze
- Provide energy conservation
 - Movement requires less muscle engagement and fatigue
 - Restore "Cone of Economy"
- Arrest evolution of deformity



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Goals for Sagittal Balance



Alignment Objectives¹


1. $PI - LL < 10^\circ$
2. $PT < 20^\circ$
3. $SVA < 5cm$

¹Schwab F, Ungar B, Blondel B, et al. Scoliosis Research Society - Schwab adult spinal deformity classification. A validation study. *Spine* 2012;37(12):1077-82.


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Other Considerations

- Cervical sagittal balance
- The role of TK in complete global alignment
 - Effect on T1 slope
 - Effect on degree to which spinopelvic parameter correction will succeed
- Is $LL = PI \pm 9$ too much leeway?
- Age related correction adjustments


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Thank you

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How Can We Use This to Plan?

- Pre-operative planning
 - Identify if sagittal balance needs to be addressed
 - Identify/quantify the extent of problem
 - Plan/simulate cages and osteotomies
- Intra-operative assessment
- Inter-stage assessment
- Post-operative confirmation

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Steps for Pre-operative Planning

- Measure pelvic parameters
- Remove compensation (PT)
- Measure global alignment (SVA, T1SP, TPA)
- Determine amount of correction needed/desired
- Consider other factors
- Plan levels needed to correct balance
- Simulate cages and osteotomies



