Flat Back Deformity

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Fixed sagittal imbalance in which the C7 sagittal vertical axis lies significantly anterior to the sacrum.
Definition – Flatback

- Fixed Loss of Lumbar Lordosis
- Fixed Sagittal Imbalance
- Chronic Low Back Pain/Fatigue
Sagittal Alignment

- Normal Sagittal Alignment
  - Head over hips
  - Influenced by combination of cervical, thoracic, lumbar, and pelvic alignment.

- Imbalance
  - Impaired walking
  - Pain
  - Easy fatigue
  - Increased Energy Consumption
Sagittal Vertical Axis (SVA)

- **Sagittal Vertical Axis** (SVA), is the horizontal offset from a plumbline dropped from C7 to the postero-superior corner of S1.

- Normative value is \(-0.5 \pm 25 \text{mm}\)
  - Range: -60mm to +65mm.

- In a well aligned spine, the SVA plumbline falls behind or over the sacral endplate.

- When the SVA falls in front of the femoral heads, the spine is malaligned.

- Strongly correlated to clinical outcomes

*Jackson R.P et al. spine 1994*
**Lumbar Lordosis (LL)**

- Lumbar Lordosis (LL) is the angle between the upper endplate of L1 and the sacral endplate
  - Anatomical lordosis defined by inflexion points of the lordotic curvature
  - “Most” of LL is located at L4-S1
- Normative value is -60.5° ± 12°
  - Range: -31° to -88°
- LL correlates with PI, normative values are inadequate for individual subjects
- Simple rule: LL with 10° of PI
  - PI<35° => LL ~ -45°
  - PI<50° => LL ~ -55°
  - PI<85° => LL ~ -70°


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**Cranial Lumbar Lordosis (L1-L4)**

- Cranial Lumbar Lordosis (L1-L4) is the angle between the upper endplate of L1 and the lower endplate of L4
- L1-L4 represents 37% of the L1-S1 lordosis. Of note, this percentage increases with age and Pelvic Incidence
- L1-L4 percentage based on PI
  - 31% for Small PI
  - 38% for Average
  - 42% for Large PI

* Nemaris Internal Data

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**Caudal Lumbar Lordosis (L4-S1)**

- Caudal Lumbar Lordosis (L4-S1) is the angle between the upper endplate of L1 and the upper endplate of S1
- L4-S1 represents 63% of the L1-S1 lordosis. Of note, this percentage decreases with age and Pelvic Incidence
- L1-L4 percentage based on PI
  - 69% for Small PI
  - 62% for Average
  - 58% for Large PI

* Nemaris Internal Data
Pelvic Incidence (PI)

- Pelvic Incidence (PI) is the angle between a line from the center of the femoral head axis to the midpoint of the sacral plate and the perpendicular to the sacral plate.

- Normative value is $51.9 \pm 10^\circ$
  - Range: $35^\circ$ to $85^\circ$

- PI is a morphological parameter, fixed in adult, and determines spino-pelvic alignment.

$PI = PT + SS$

*Duval-Beaupeure G et al., Ann Biomed Eng 1992*
Pelvic Tilt (PT)

- Pelvic Tilt (PT) is the angle between a line from the center of the femoral head axis to the midpoint of the sacral plate and the vertical.
- Normative value is $13^\circ \pm 6^\circ$ in young adult
  - Range: $-4.7^\circ$ to $27^\circ$
- In asymptomatic subjects PT correlates with PI but varies less than SS.
  - PI=35° => PT ~6°
  - PI=50° => PT ~11°
  - PI=85° => PT ~24°
- PT is a compensatory mechanism and increases with loss of lumbar lordosis. PT correlates with patient reported outcomes (disability)

Viollet R. et al., JBJS 2005
Lofage V. et al. Spine 2009
Spinal Alignment

- Compensatory Mechanisms for Sagittal Imbalance
  - Flexible Spine
    - Increased Lordosis
  - Less Thoracic Kyphosis
  - Pelvic Retroversion
    - PT Increases
  - Hyperextension of Hips
  - Flexed Knees and Ankles
Conus of Economy: Compensation
Degenerative Flatback

- Rigid Deformity
- Associated with Stenosis
- Decompression Alone?
Iatrogenic Flatback

Poor patient positioning during instrumented fusion.
Iatrogenic

- Posterior distraction instrumentation
- Multilevel Instrumented degenerative disorders
Correction Options: Spinal Deformity

Move the Spine to the Rod
Adult Deformity: Surgical


- Retrospective
- 20 pts.
- Decompression
- Fusion, Inst 3 to 15 levels
- Extended PLIF
- Measured coronal correction only
  - Mean Cobb angle improvement 36 to 14.7 degrees
Flexed posture of the lumbar spine increases the diameter of spinal canal and neuroforamina

- relieve symptoms of neurogenic claudication.
- Increased pelvic retroversion

Conclusion: in flexible sagittal imbalance, the cause of the misalignment may be from the **Spinal stenosis**. **Pelvic retroversion** can be **Compensatory For lumbar stenosis as well as sagittal imbalance**
Patient Presentation

- Patient unable to stand fully erect.
- Flexion of Hips/Knee.
- Fatigue with ambulation.
Patient Presentation

- Hyperextended Flexible Spinal Segments
  - Paraspinous Fatigue
  - Facet Pain = Hyperextension
- Hip and Knee Flexion to Maintain Balance
- Thigh and Gluteal Fatigue
- Buttock pain
- DJD of Hips and Knees
Flat Back Etiologies (Cont.)

Causes (cont.):
- Post Traumatic
- Post Infection
- Pseudoarthrosis
- Ankylosing Spondylitis
- Congenital i.e. Fixed Kyphosis
Physical Exam

Evaluate:
- Flexibility of Spine
- Coronal/Sagittal Balance
- Hip Range of Motion
- Visual Horizon
- Flat Butt - Retroverted Sacrum
Treatment

- Conservative – Exercise, PT
  - Gait, Balance, Proprioception
  - Postural Exercise
  - Core strengthening
- Poor Results – 27% success (Farsi, Swab, 1997)
- Assistive device- Cane, quad cane, rolling walker
Treatment

Meds:
- Injections

Other:
- Aquatics
- Pilates
- Yoga
- Stretching
- Tai Chi
- TENS/ E Stim
- SCS
Surgical Correction

Considerations:
- Patient Physiology/Size
- Sagittal Balance
- Coronal Balance
- Bone Quality
- Previous Surgery
- Amount of Correction Needed
- Opportunities
Where is the opportunity?
Deformity Correction: Spine Osteotomies

- Smith Peterson/Ponte Osteotomy
- Pedicle Subtraction Osteotomy
Osteotomy Set
Steps In Pedicle Subtraction Osteotomy

Put in the Screws First

Bridwell et al, Pedicle Subtraction Osteotomy For Treatment of Fixed Sagittal Imbalance, JBJS, March 2004
Bottom Line:
Restore Spinopelvic Balance

- SVA < 50mm
- PT < 20°
- Spino-Pelvic Harmony
  - LL = PI +/- 9°
Case

37yo disabled female teacher
- Work-related injury at age 22 (cheerleading coach) 1992
- Surgery after failure of conservative care – (L2-S1 360° fusion) 1994
- Post op - Worse LBP and Sagittal Imbalance
- Fusion extended T11, 2006
- Needed a walker or cane to walk

Exam
- 5’ 10” 220 lbs.
- Forward Lean
- Neuro – Normal
Case 1
Case
Case

L4 PSO attached to existing fixation
Conclusion

- Flat Back Deformity = Rigid Deformity
- “Sagittal Awareness”
- Every Spinal Fusion should try to maintain/improve sagittal alignment
- Take advantage of opportunities
  - L5/S1
  - Solid Fusion
  - Non union
  - Previously placed hardware

- Fixed sagittal malalignment often requires osteotomy correction
- Reestablishing harmonious spinopelvic alignment is associated with significant improvement in health-related quality-of-life outcome measures and patient satisfaction.
Thank You
Compared: PSO between patients with the flat back syndrome after lumbar fusion versus patients who had surgery for adult spinal deformity.

Methods: retrospective 104 patients
All underwent PSO
28 patients had spinal fusion prior to PSO
76 patients had various forms of ASD.

Conclusion: PSO is safe and effective for correcting sagittal plane and balance due to multiple etiologies.

Patient satisfaction was found to be high and HRQOL was greatly improved by the procedure in patients with adult spinal deformity.
Fusion group - sub optimal outcome was observed and the cautious use of PSO seems warranted in the subset of patients.