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# CERVICAL ALIGNMENT

# Disclosure



- Innovasis
- Spinewave- consulting
- Nuvasive- consulting, teaching
- Precision Spine- royalties
- 4-web- consulting



# Agenda

- Historical significance of alignment
- Cervical parameters
- Clinical significance in ant/post fusion and disc arthroplasty

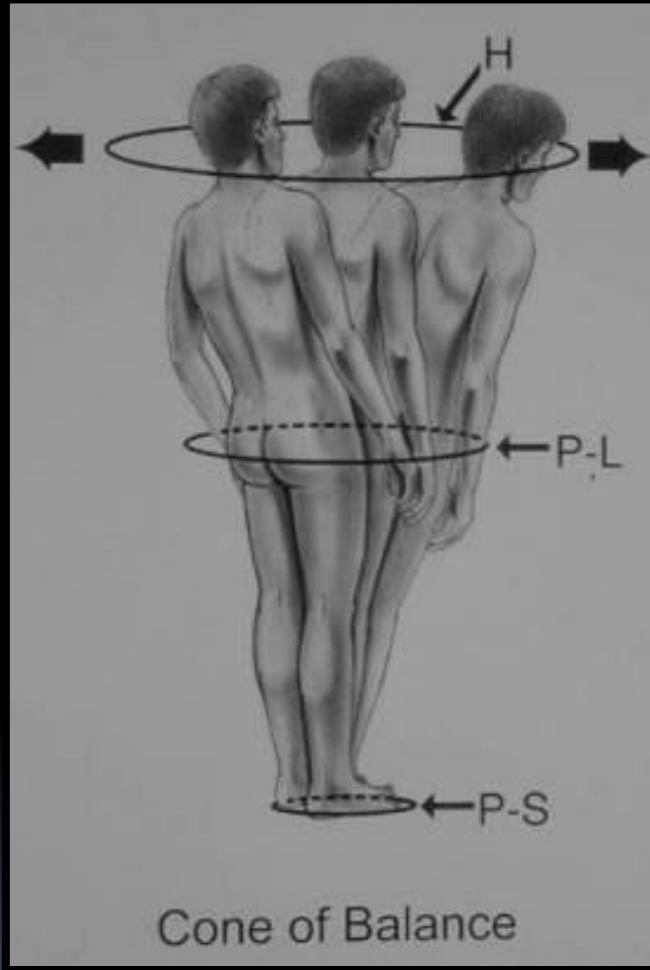
# Goals of Spinal Surgery

- Decompress
- Fuse and/or stabilize
- *Preserve or restore alignment*



COMPENSATED  
ALIGNMENT

# Why is Alignment Important?



- Poor alignment = disability
- Must compensate for anatomic deformation
- Mechanical disadvantage challenges balance mechanisms

**Deviation from stable zone = increased muscular/energy use**

# Loss of Global Alignment

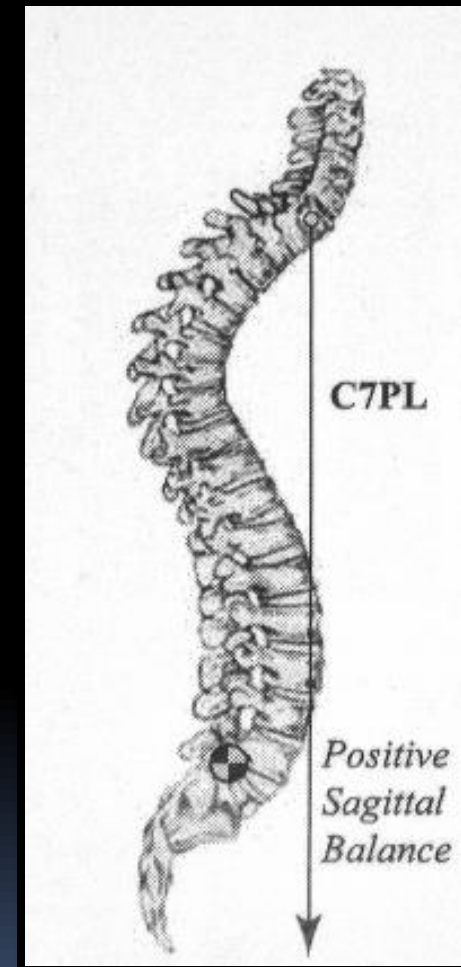


## Plumbline Shift Anteriorly

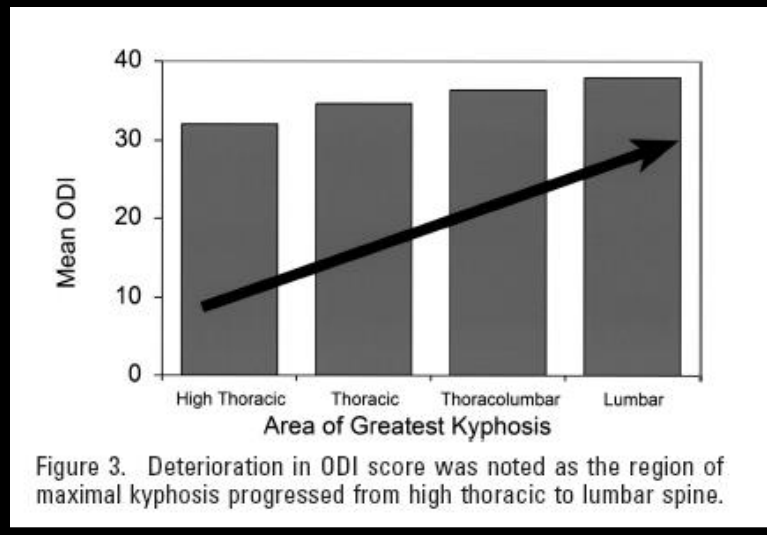
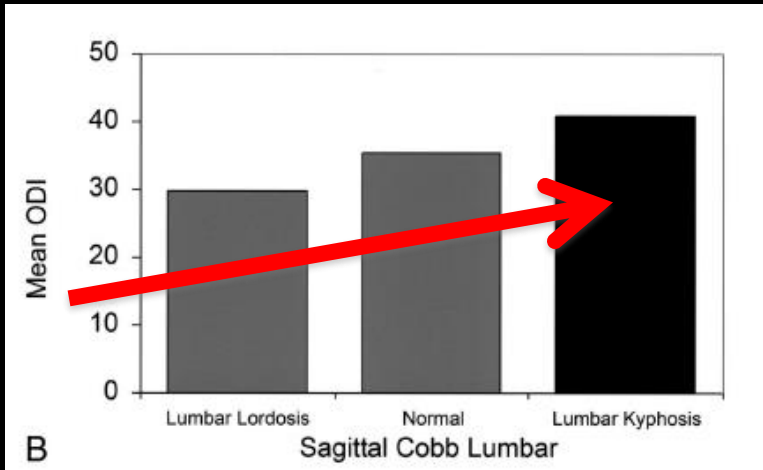


=> Increasing disability  
SF-12, SRS-29, ODI ( $p < 0.001$ )

=> Lumbar kyphosis marked disability  
SRS-29, ODI ( $p < 0.05$ )



Courtesy of Behrooz Akbarnia, MD



- **Loss of lumbar lordosis is especially poorly tolerated and has direct effect on disability**

# Causes of Sagittal Imbalance

1. Multiple levels of spinal canal stenosis – forward posture for pain relief
2. Short or long segment lumbar fusions without restoration of lumbar lordosis
3. Scoliosis progression in adult patients
4. Degenerative changes below a long fusion, particularly at the lumbosacral spine
5. Post-laminectomy kyphosis
6. Fractures above or below a long fusion
7. Posttraumatic deformities
8. Osteoporotic deformities
9. Inadequate anterior column support when indicated
10. Pseudoarthrosis in long posterior spinal fusions
11. Harrington posterior distraction instrumentation
12. Ankylosing spondylitis
13. Older generations anterior instrumentation



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## Adult Spinal Deformity—Postoperative Standing Imbalance

### ■ Clinical Impact of Spinopelvic Alignment on Pain/Disability

Various etiologies are tied to spinopelvic malalignment; however, degenerative and iatrogenic causes comprise the majority of cases.



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

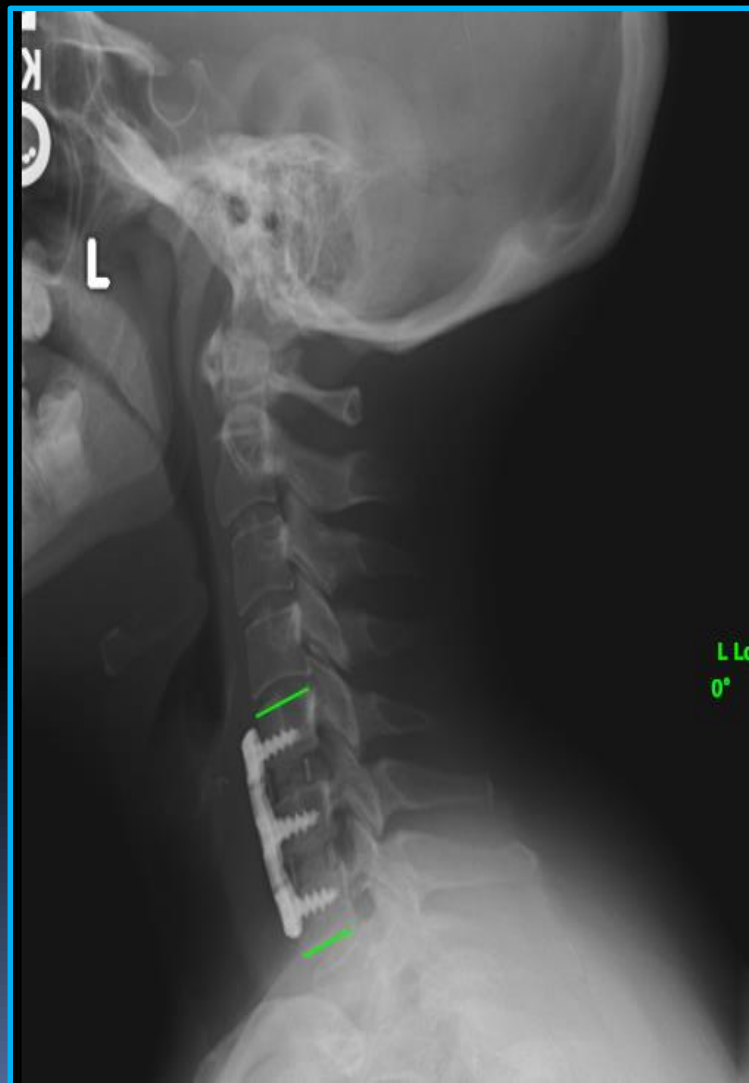


**MALALIGNMENT**

<sup>1</sup>Mehta VA, Amin A, Omeis I, et al. Implications of spinopelvic alignment for the spine surgeon. *Neurosurgery* 2012;70:707-21.

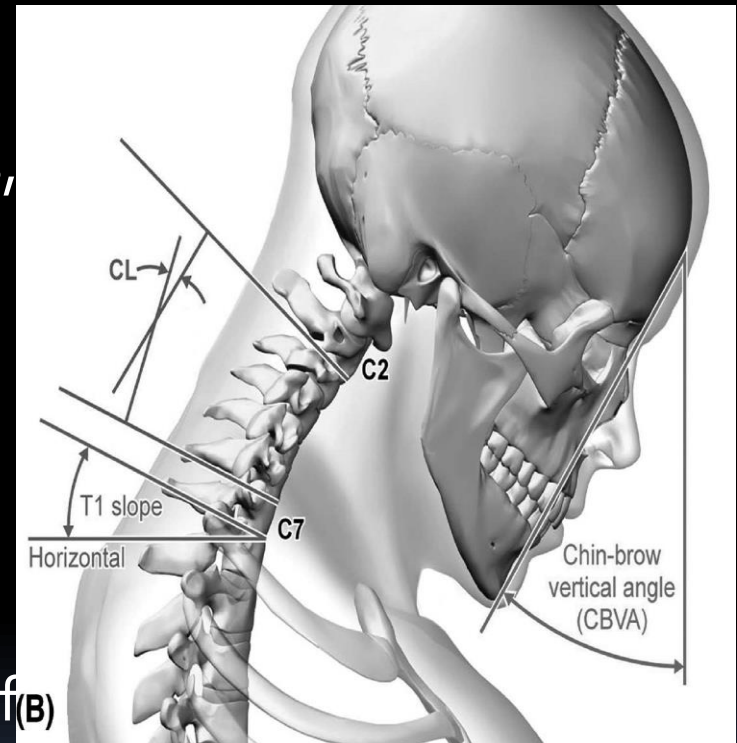
<sup>3</sup>Rothenfluh DA, Mueller DA, Rothenfluh E, et al. Pelvic incidence-lumbar lordosis mismatch predisposes to adjacent segment disease after lumbar spinal fusion. *Eur Spine J* 2014;Epub ahead of print.

# What do we measure in the cervical spine?



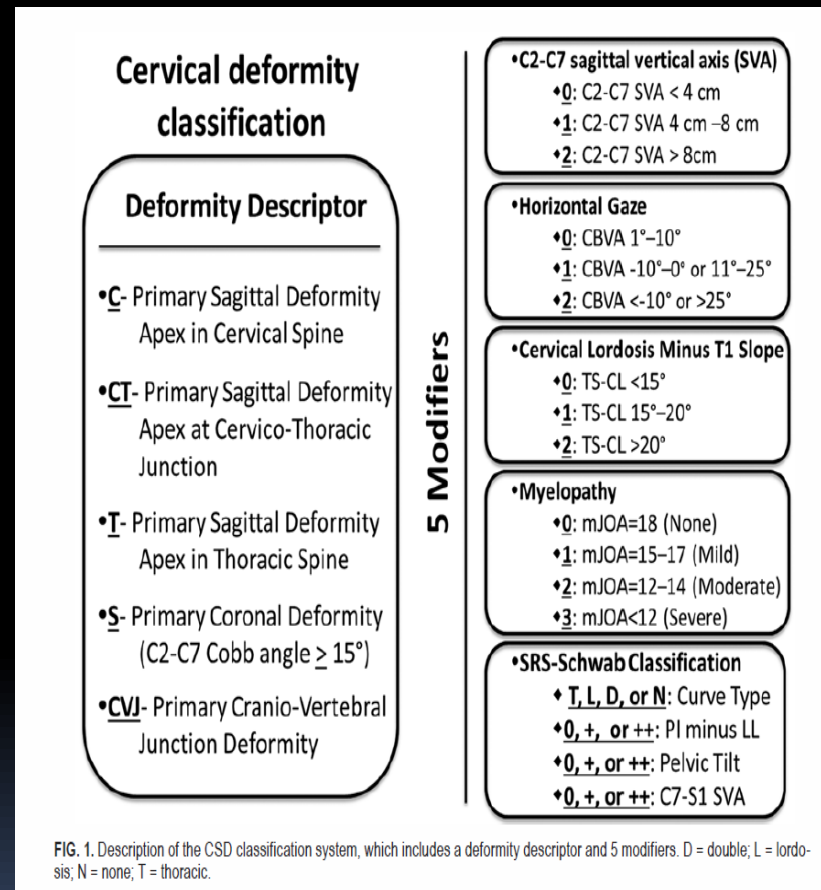
## Ames, Spine 2013:<sup>1</sup>

- “When performing decompressive surgery for CSM, consideration should be given to correction of cervical kyphosis and cervical sagittal imbalance (C2-C7 Sagittal Vertical Axis, CSVA)”
- Chin Brow Vertical Angle (CBVA), C2-C7 SVA, and regional Cervical Lordosis (CL) should be considered
- Patients with poor alignment can develop painful compensatory mechanisms including hyperlordosis of (B) subaxial segments



# Ames J Neurosurg Spine 2015:<sup>1</sup>

- Assess cervical spine deformity within the framework of global spinopelvic alignment



<sup>1</sup> Ames CP, Smith JS, Eastlack R, Blaskiewicz DJ et al. Reliability assessment of a novel cervical spine deformity classification system. *J Neurosurg Spine* 2015; 23(6);673-83.



# Cervical parameters

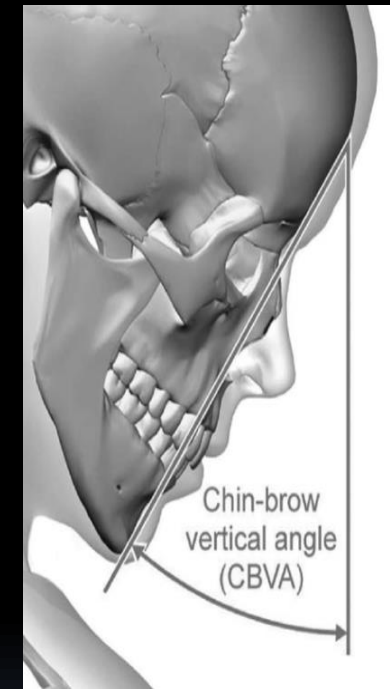
- Chin Brow Vertical Angle
- T<sub>1</sub> slope
- Cervical Sagittal Vertical Axis
- Cervical Lordosis

# Chin Brow Vertical Angle



## Suk Spine 2003:<sup>1</sup>

- Chin Brow Vertical Angle (CBVA) associated with, such as improved gaze, ambulation, and activities of daily living.
- Normal not defined but clinical outcomes are good if  $-10$ - $+10$  degrees



CBVA: measured between a line from the brow to the chin to the vertical while patient stands with hips and knees extended

<sup>1</sup> Suk KS, Kim KT, Lee SH. Significance of chin-brow vertical angle in correction of kyphotic deformity of ankylosing spondylitis patients. *Spine* 2003;28(17):2001-5.

# T1 Slope: Is There Deformity Regionally or Globally?



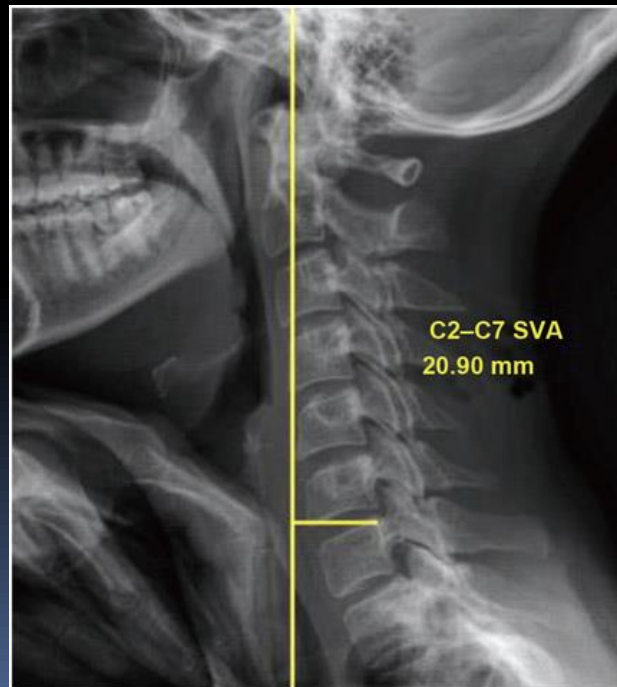
## Knott Spine J 2010:<sup>1</sup>

- Patients whose T<sub>1</sub> tilt falls outside the range 13 to 25° should be sent for full spine radiographs
- T<sub>1</sub> tilt
  - Angle between horizontal line and superior endplate of T<sub>1</sub>



# Cervical Sagittal Vertical Axis

- Distance between plumb line dropped from centroid of C2 and posterior superior corner of C7

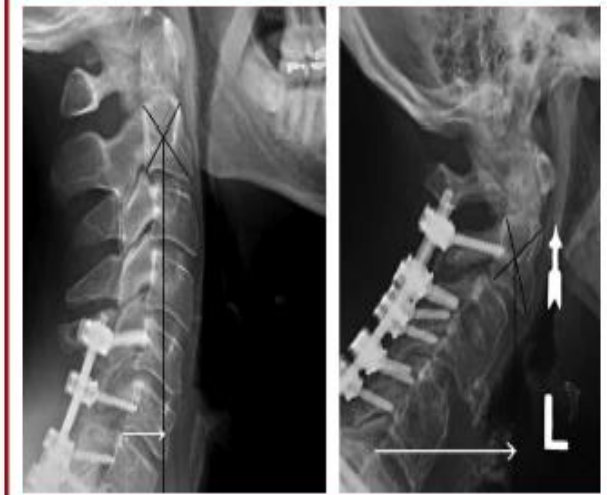




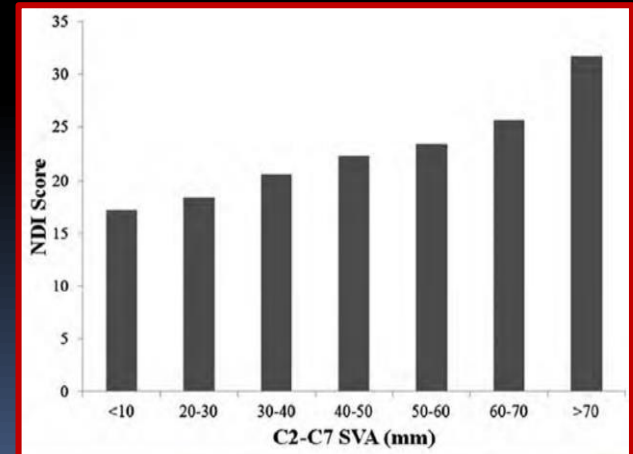
# Cervical SVA

## Tang Neurosurgery 2012:<sup>1</sup>

- Looked at relationship to patient-reported HRQOL scores following multilevel posterior cervical fusion
- Standing radiographs needed to get true alignment assessment
- Disability increases with sagittal malalignment following surgery
- **Cervical SVA >40mm was correlated to worse outcomes assessed by NDI**



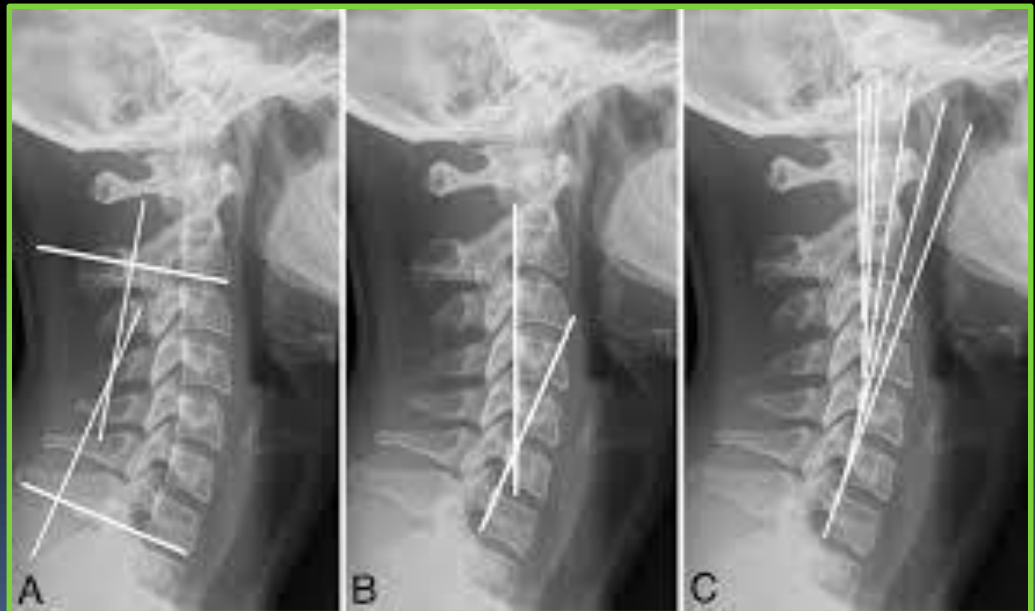
**FIGURE 4.** Comparison of effects of positive sagittal alignment on NDI and PCS scores. **Left,** patient with C2-C7 SVA of 20.9 mm exhibiting PCS score of 55.1 and NDI score of 3 (no disability). **Right,** patient with C2-C7 SVA of 59.2 mm exhibiting PCS score of 28 and NDI score of 37 (severe disability). SVA, sagittal vertical axis; NDI, neck disability index; PCS, physical component score.



(1) Tang JA, Scheer JK, Smith JS, et al. The impact of standing regional cervical sagittal alignment on outcomes in posterior cervical fusion surgery. *Neurosurgery* 2012;71:662-9; discussion 9.

# Cervical Lordosis

- Measured from C2-C7
- Can greatly be affected by thoracic deformity
- 20-40 degrees

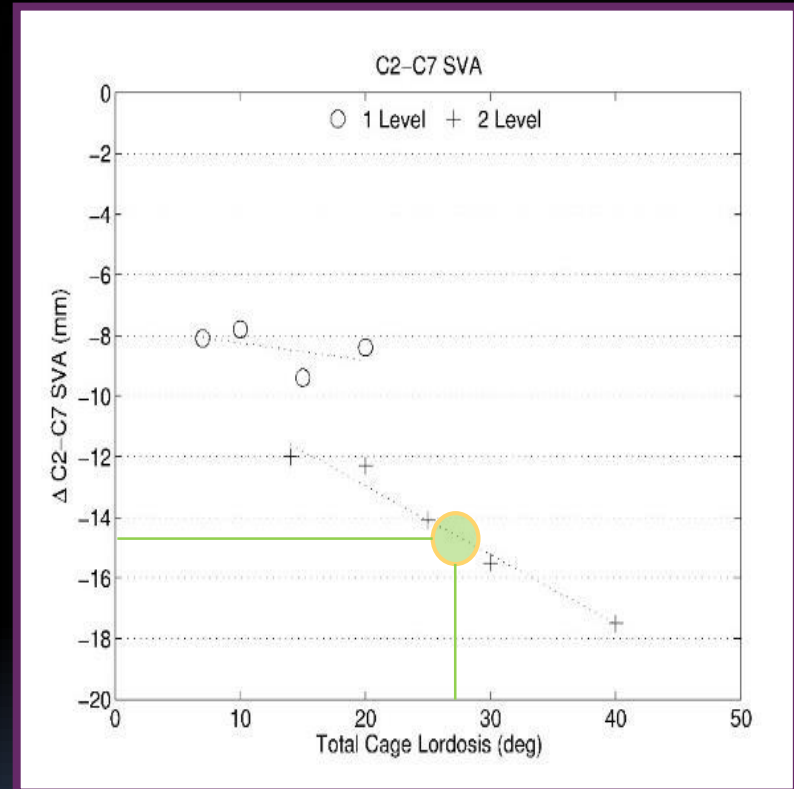


# Cervical Lordosis



## Blaskiewicz ISASS 2015:<sup>1</sup>

- An increase in implant lordosis corresponds with a compensatory reduction in CSVA
- In order to reduce a 55mm CSVA to a ~40mm CSVA you would need ~25-30 degrees of implant lordosis between the two operative levels



<sup>1</sup> Blaskiewicz DJ, Han PP, Harris JE. Adjacent Level Lordosis Changes In The Cervical Spine Adjacent To Deformity Correction With Supraphysiologic Lordotic Implants: In Vitro Evaluation. 15<sup>th</sup> annual International Society for the Advancement of Spine Surgery (ISASS) 2015; April 15-17, 2015, San Diego, CA.



# Outcomes

- Evidence against posterior alone in kyphotic cervical spine in myelopathy patients
  - 13 deg or more of kyphosis associated with worse outcome neurologically
    - Suda et al. Spine (Phila Pa 1976), 28 (2003), pp. 1258-1262
  - More recently, 8.5 deg of kyphosis

- Some have shown decreased upper extremity improvement in myelopathy if there is anterior compression of cord
- Taniyama et al. developed modified K-Line
- Distance of less than 4mm



## Park Spine J 2014:<sup>1</sup>

- The alignment of the cervical spine can affect ASD
- Those patients who did not have adequate lordosis had higher rate of adjacent segment disease



<sup>1</sup> Park MS, Kelly MP, Lee DH. Sagittal alignment as a predictor of clinical adjacent segment pathology requiring surgery after anterior cervical arthrodesis. *Spine J* 2014;14(17):1228-1234

- Adjacent level ossification shown to be higher in patients with kyphotic or neutral alignment





# Alignment in disc arthroplasty

- Many authors have tried to assess preoperative alignment and ROM as a predictor of CDA success and decreases ASD
- A preop high T<sub>1</sub> slope was associated with significant increase in operative ASD with Bryan disc (medtronic)

- [Yang et al. Ther Clin Risk Manag.](#) 2017; 13: 1119–1125





# How do we use all of this?

- Always get standing cervical xrays
  - Even sitting xrays can give false assessment of alignment
- Consider full length 36 in films especially if high T<sub>1</sub> slope with normal lordosis
- CSVA correction most strongly correlated to clinical outcome
- May affect surgical plan if studies continue to support its relevance as it has in thoracolumbar spine



- Further study needed specifically looking at clinical outcome and ASD with cervical disc arthroplasty



**THANK YOU**