

ALIGNMENT OF THE CERVICAL SPINE

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Disclosures:

Consulting: NuVasive, Medicrea, Innovasis

Research Support: CSRS, Zimmer Biomet

The Impact of Positive Sagittal Balance in Adult Spinal Deformity

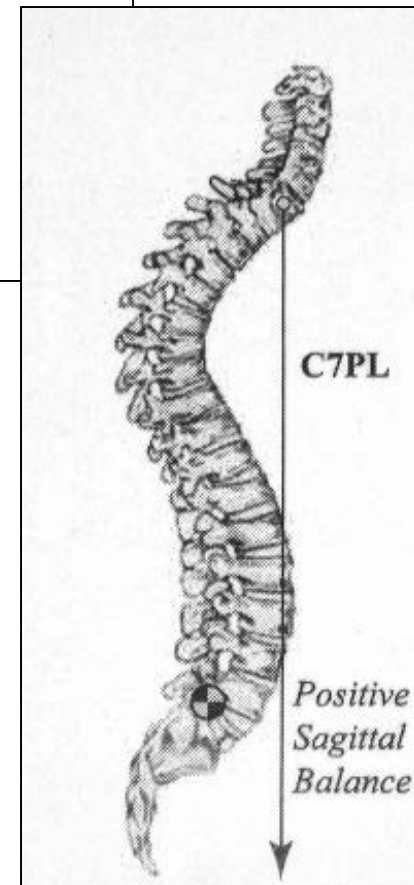
Steven D. Glassman, MD,* Keith Bridwell, MD,† John R. Dimar, MD,* William Horton, MD,§
Sigurd Berven, MD,† and Frank Schwab, MD||

⊙ Anterior Plumbline Shift in Sagittal Vertical Axis (SVA)



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

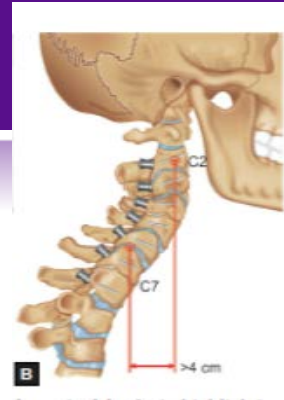
Glassman, Bridwell, Dimar, Horton, Berven, Schwab. SPINE 2005



Glassman et al. Spine 2005

Neurosurgery 2012

The Impact of Standing Regional Cervical Sagittal Alignment on Outcomes in Posterior Cervical Fusion Surgery



Jessica A. Tang, BS*
 Justin K. Scheer, BS‡
 Justin S. Smith, MD, PhD**
 Vedat Deviren, MDS
 Shay Bess, MD¶
 Robert A. Hart, MD||
 Virginie Lafage, PhD#
 Christopher I. Shaffrey, MD**
 Frank Schwab, MD#
 Christopher P. Ames, MD*
 the ISSG

C2-C7 SVA is the primary descriptor of cervical deformity

- ⊙ cSVA > 4cm associated with higher disability

INFLUENCE OF SPINAL DEFORMITY ON OUTCOME OF CERVICAL SPONDYLOMYELOMA

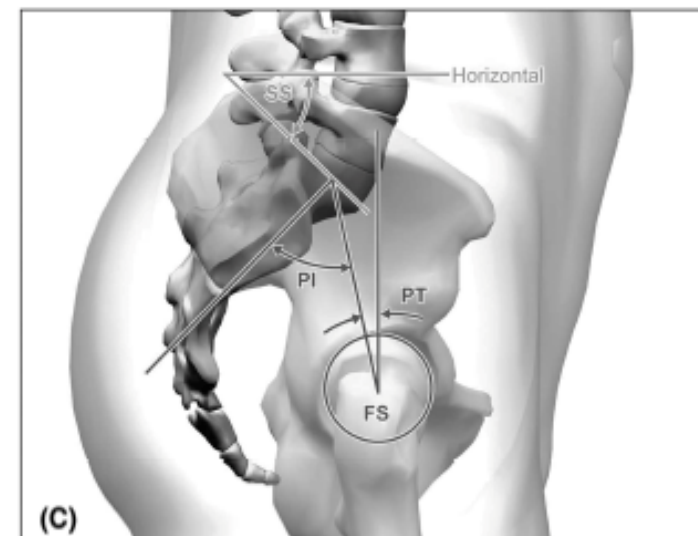
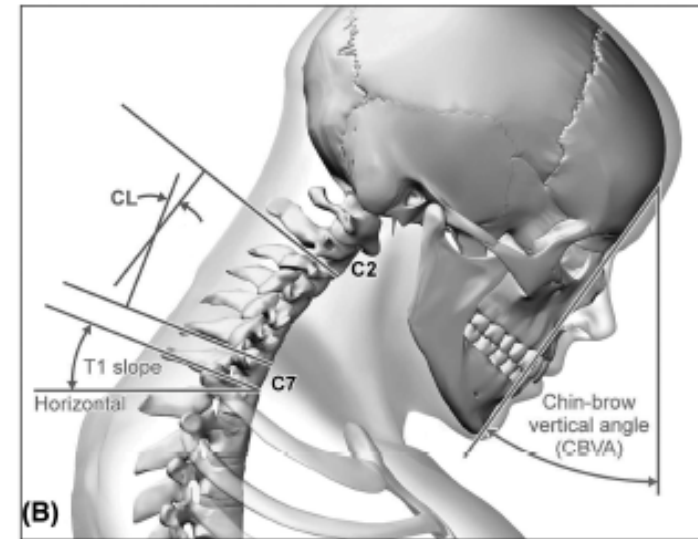
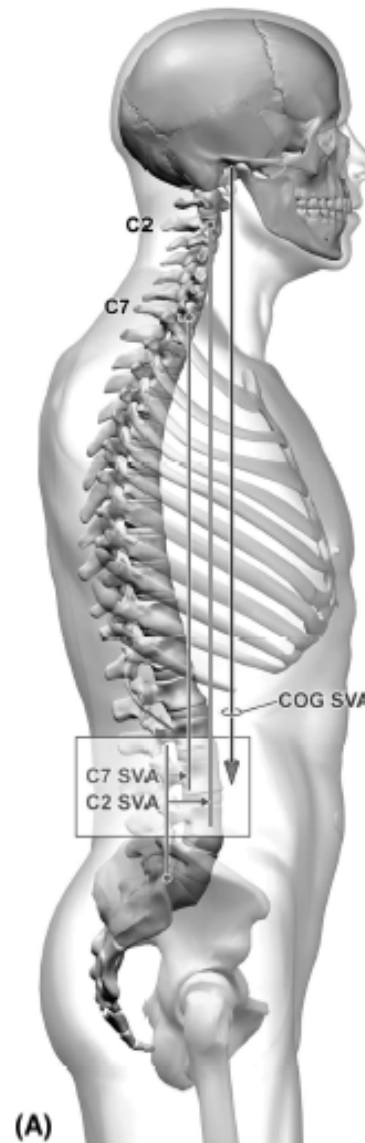
Cervical Radiographical Alig

Comprehensive Assessment Techniques and Potential

Christopher P. Ames, MD,* Benjamin Blondel, MD,†‡ Justin Jean-Charles Le Huec, MD, PhD,¶ Eric M. Massicotte, MD, Vincent C. Traynelis, MD,†† Han Jo Kim, MD,‡‡ Christophe and Virginie Lafage, PhD†

Cervical alignment and Myel related

- 🎯 **Cervical deformity leads to sp and tension**

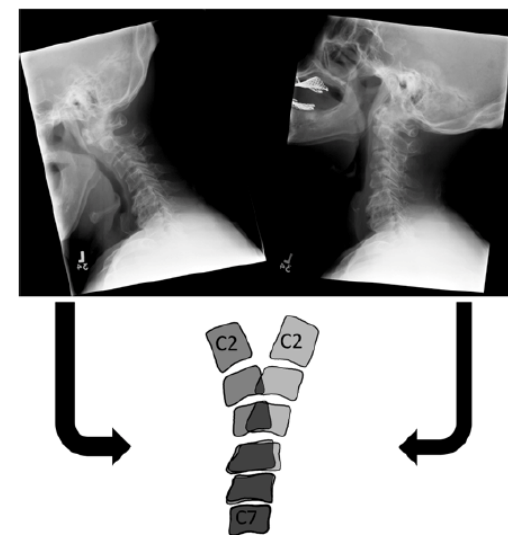


Impact of dynamic alignment, motion, and center of rotation on myelopathy grade and regional disability in cervical spondylotic myelopathy

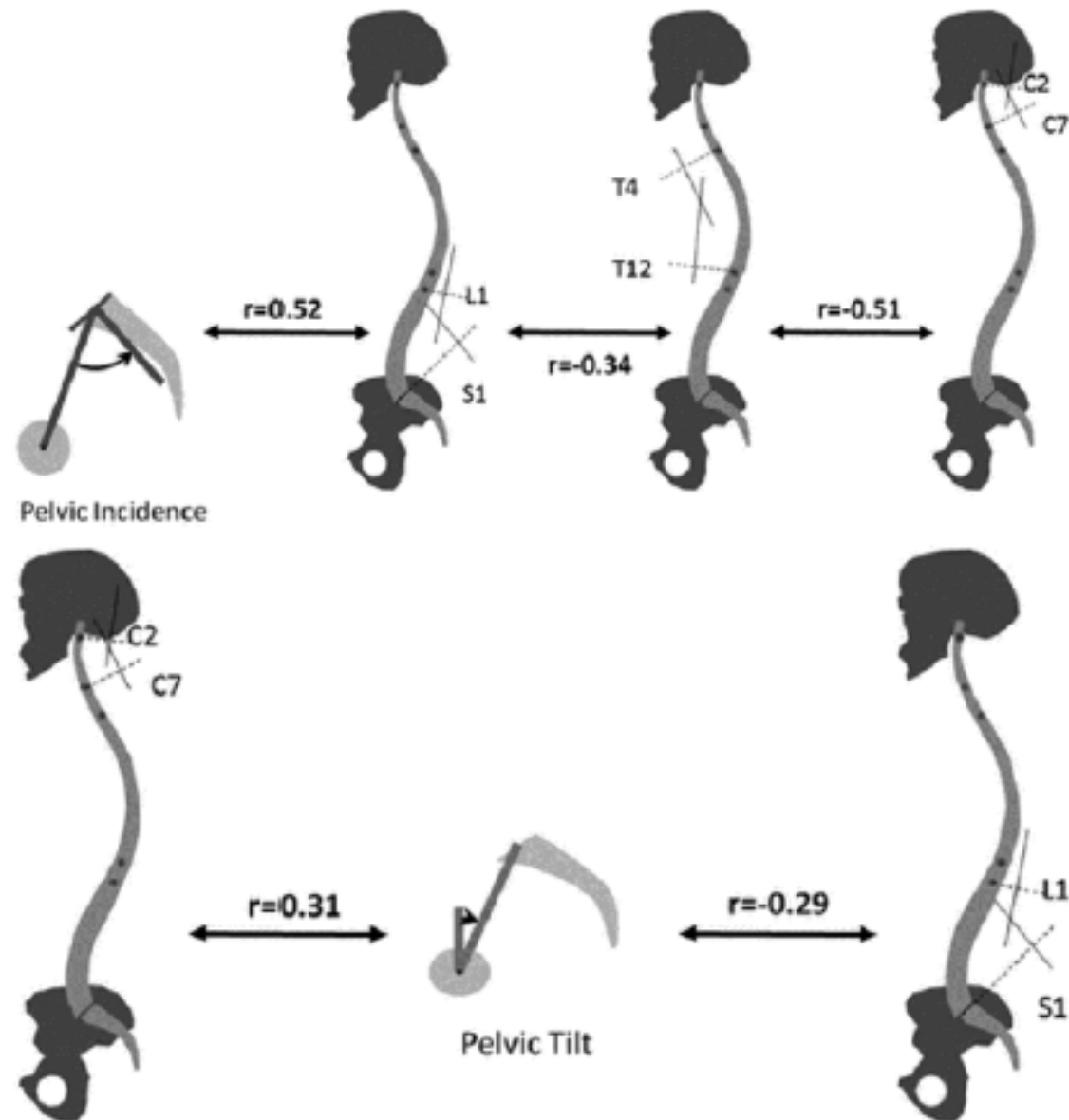
Shian Liu, MD,¹ Renaud Lafage, MS,¹ Justin S. Smith, MD, PhD,²
Themistocles S. Protopsaltis, MD,¹ Virginie C. Lafage, PhD,¹ Vincent Challer, MD,¹
Christopher I. Shaffrey, MD,² Kris Radcliff, MD,³ Paul M. Arnold, MD,⁴ Jens R. Chapman, MD,⁵
Frank J. Schwab, MD,¹ Eric M. Massicotte, MD,⁶ S. Tim Yoon, MD, PhD,⁷
Michael G. Fehlings, MD, PhD,⁶ and Christopher P. Ames, MD⁸

Dynamic alignment and Myelopathy are closely related

- Smaller “cones of kinesis”, olisthesis of C7 and posterior COR correlated with worse myelopathy grades and lower general health scores



CHAIN OF CORRELATION FROM THE PELVIS TO THE CERVICAL SPINE



Scheer, Ames et al.
NJS-S 2013

How the neck affects the back: changes in regional cervical sagittal alignment correlate to HRQOL improvement in adult thoracolumbar deformity patients at 2-year follow-up

Themistocles S. Protopsaltis, MD,¹ Justin K. Scheer, BS,² Jamie S. Terran, BS,¹ Justin S. Smith, MD, PhD,³ D. Kojo Hamilton, MD,⁴ Han Jo Kim, MD,⁵ Greg M. Mundis Jr., MD,⁶ Robert A. Hart, MD,⁴ Ian M. McCarthy, PhD,⁷ Eric Klineberg, MD,⁸ Virginie Lafage, PhD,¹ Shay Bess, MD,⁹ Frank Schwab, MD,¹ Christopher I. Shaffrey, MD,³ Christopher P. Ames, MD,¹⁰ and the International Spine Study Group

Protopsaltis et al. *JNS-S* 2015

- ◎ **Cervical malalignment affects HRQOL in patients with thoracolumbar deformity**

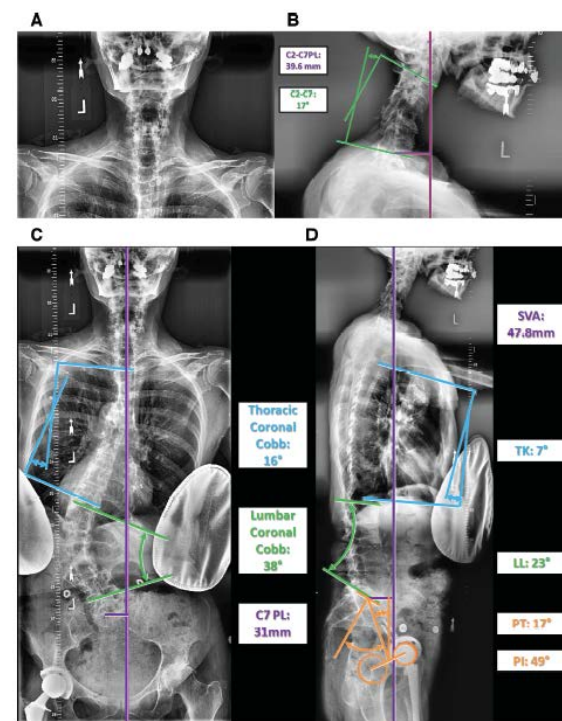
CERVICAL SPINE

Prevalence and Type of Cervical Deformity Among 470 Adults With Thoracolumbar Deformity

Justin S. Smith, MD, PhD,* Virginie Lafage, PhD,† Frank J. Schwab, MD,† Christopher I. Shaffrey, MD,* Themistocles Protopsaltis, MD,† Eric Klineberg, MD,‡ Munish Gupta, MD,‡ Justin K. Scheer, BS,§ Kai-Ming G. Fu, MD, PhD,¶ Gregory Mundis, MD,|| Richard Hostin, MD,** Vedat Deviren, MD,†† Robert Hart, MD,‡‡ Douglas C. Burton, MD,§§ Shay Bess, MD,¶¶ Christopher P. Ames, MD,||| International Spine Study Group

Smith et al. *Spine* 2014

- Prevalence of cSVA > 4cm was found to be 29%
- Prevalence of CK was found to be 31%



- ◎ CK can be a physiologic state of normal global standing equilibrium
- ◎ Gore et al. *Spine* 1986
- ◎ Kuntz et al. *Neurosurgery* 2008



Eur Spine J
DOI 10.1007/s00586-014-3632-0

ORIGINAL ARTICLE

Sagittal parameters of global cervical balance using EOS imaging: normative values from a prospective cohort of asymptomatic volunteers

J. C. Le Huec · H. Demezon · S. Aunoble

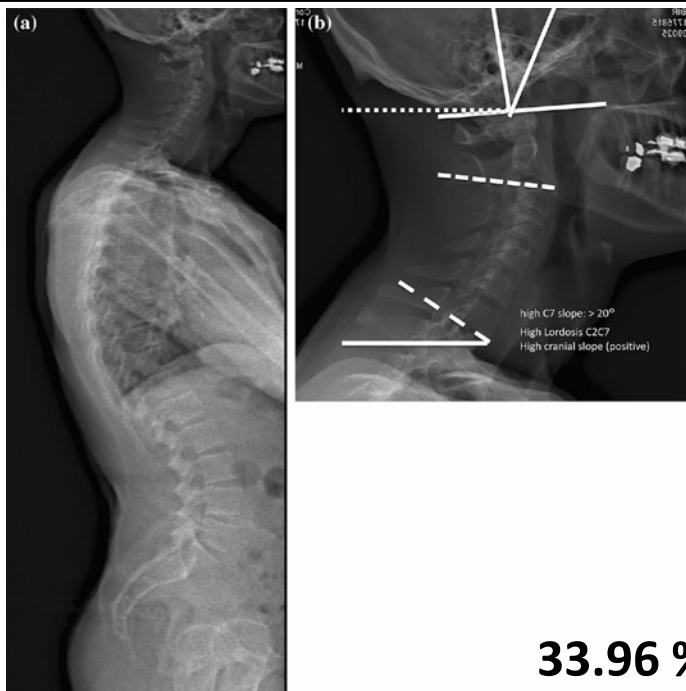


Table 3 Cranial, cervical and cranio-cervical parameters

| | Unit | <i>n</i> | Mean values | SD | Extreme |
|-------------------|--------|----------|-------------|-------|-----------------|
| Cranial incidence | Degree | 106 | 27.32 | 4.24 | [14.00; 36.00] |
| Cranial slope | Degree | 106 | 1.59 | 6.81 | [−18.00; 16.00] |
| Cranial tilt | Degree | 106 | 25.04 | 8.54 | [0.00; 47.00] |
| OC2 | Degree | 106 | 15.81 | 7.15 | [0.00; 35.00] |
| C1–C7 | degree | 106 | 34.03 | 12.18 | [6.00; 60.00] |
| C1–C2 | Degree | 106 | 29.16 | 7.24 | [9.00; 45.00] |
| C2–C7 | Degree | 106 | 4.89 | 12.84 | [−25.00; 44.00] |

33.96 % of the subjects presented with C2–C7 kyphosis

CERVICAL SAGITTAL ALIGNMENT IMPROVES AFTER GLOBAL SAGITTAL CORRECTION OF TLD

Spontaneous improvement of cervical alignment after correction of global sagittal balance by pedicle subtraction osteotomy

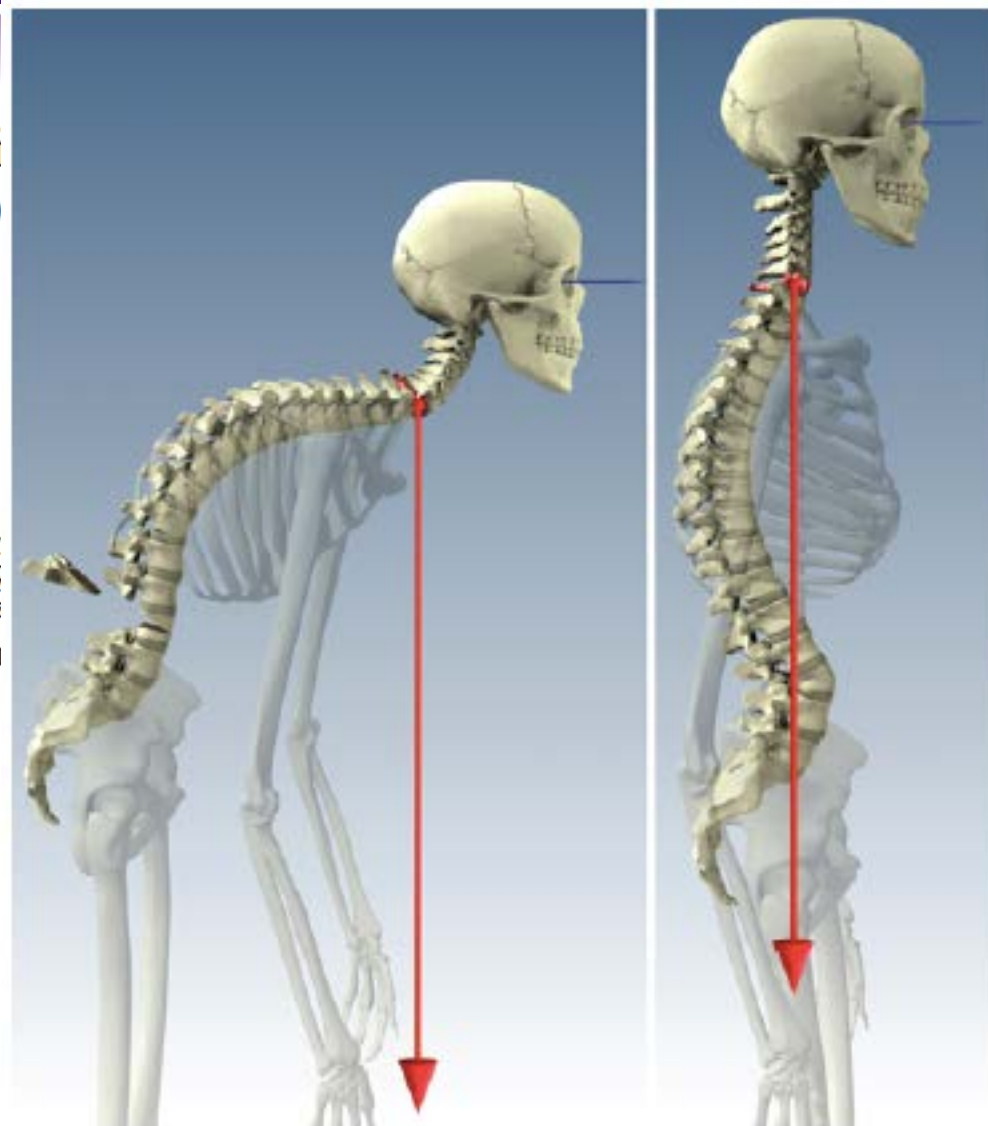
Presented at the 2012 Joint Spine Section

Clinical article

JUSTIN S. SMITH, M.D., Ph.D.,¹ CHRISTOPHER I. SHAFER, M.D.,² BENJAMIN BLONDEL, M.D.,² FRANK SCHWAB, M.D.,² FRANK J. RYAN, M.D.,³ ROBERT HART, M.D.,⁴ BRIAN O'SHAUGHNESSY, M.D.,⁵ SERENA S. HU, M.D.,⁷ VEDAT DEVIREN, M.D.,⁷ CHRISTOPHER J. HART, M.D.,⁶ AND INTERNATIONAL SPINE STUDY GROUP

⊙ **Reciprocal change in Cervical alignment occurs after TL PSO**

⊙ Smith et al. ISSG, Journal of Neurosurgery Spine 2012



Adult Spinal Deformity—Postoperative Standing Imbalance

How Much Can You Tolerate? An Overview of Key Parameters in Assessing Alignment and Planning Corrective Surgery

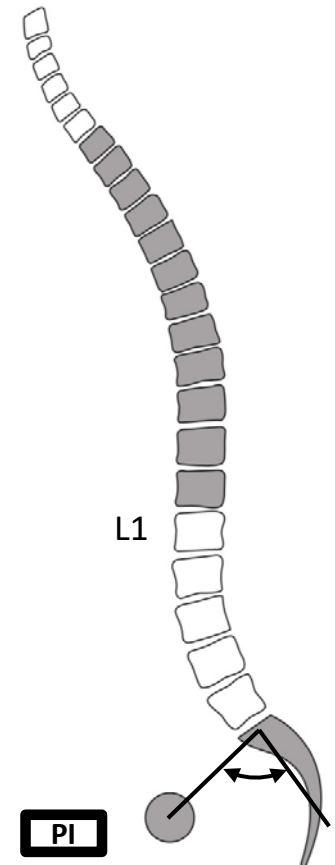
Frank Schwab, MD, Ashish Patel, MD, Benjamin Ungar, BA, Jean-Pierre Farcy, MD, and Virginie Lafage, PhD

Spine 2010

⊙ Important Concept for Adult Throacolumbar Spinal Deformity:

- ⊙ Loss of lumbar lordosis
- ⊙ Quantified by spino-pelvic mismatch:
 - ⊙ PI-LL, *Schwab et al 2010*.⁵

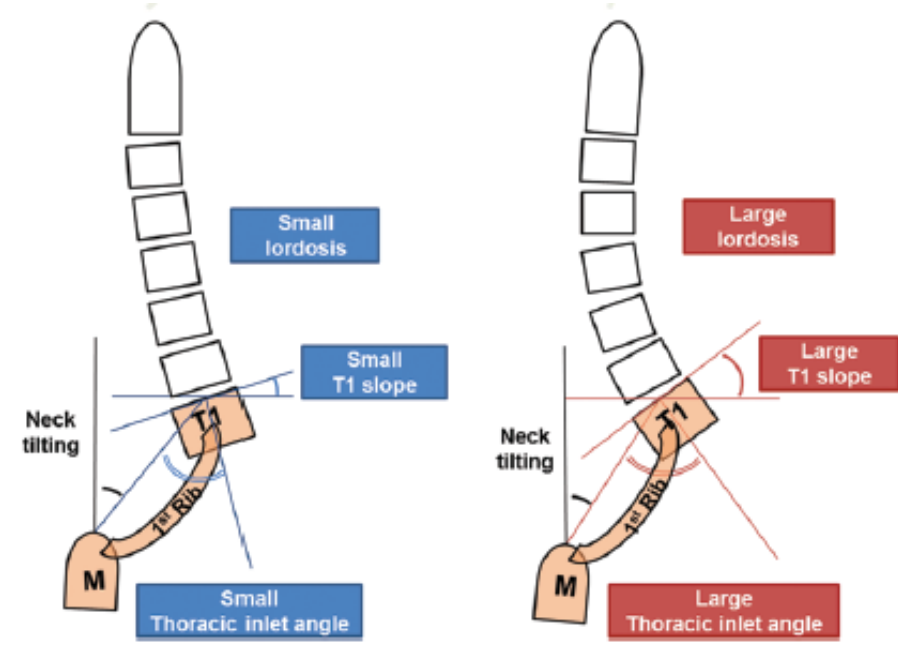
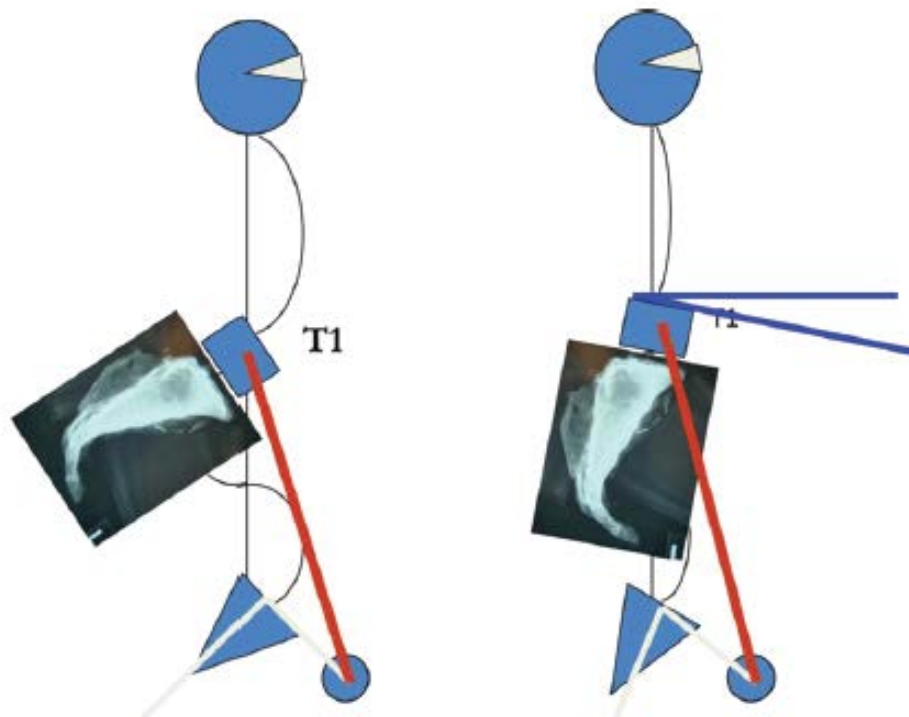
**Spino-Pelvic
harmony:
 $LL = PI \pm 9^\circ$**



CERVICAL LORDOSIS VERSUS T1 SLOPE

- ⊙ T1 Slope correlates with Cervical Lordosis
- ⊙ When this relationship breaks down
 - ⊙ Cervical Deformity results

Scheer, Ames et al. *NJS-S* 2013



T1 SLOPE MINUS CERVICAL LORDOSIS (TS-CL) THE CERVICAL ANSWER TO PI-LL DEFINES CERVICAL SAGITTAL DEFORMITY IN PATIENTS UNDERGOING THORACOLUMBAR OSTEOTOMY

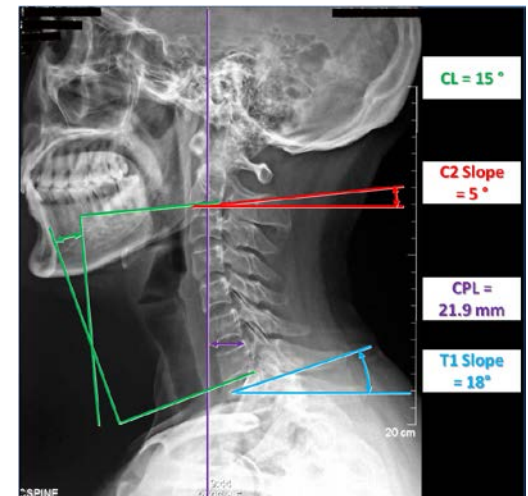


Protopsaltis TS, Terran JS, Bronsard N, Smith JS, et al., ISSG
Accepted *Int J Spine Surg* 2017



CSRS Podium 2013, Accepted //SS2017

© **New Definition of Cervical Deformity**



SPINE An International Journal for the study of the spine Publish Ahead of Print

DOI : 10.1097/BRS.0000000000001264

Relationship between T1 slope and cervical alignment following multi-level posterior cervical fusion surgery: impact of T1 slope minus cervical lordosis

Seung-Jae Hyun, M.D., Ph.D., Ki-Jeong Kim, M.D., Ph.D., Tae-Ahn Jahng, M.D., Ph.D., Hyun-Jib Kim, M.D., Ph.D.

Department of Neurosurgery, Spine Center, Seoul National University Bundang Hospital, Seoul National University College of Medicine, Seongnam, South Korea

- ◎ TS-CL correlated with cSVA ($r = 0.87$, $P < 0.001$) and NDI scores ($r = 0.470$, $P = 0.009$)
- ◎ Logistic regression model predicted TS-CL = 24° had p values that were most significant for the correlations

Reliability assessment classification system

Christopher P. Ames, MD,¹ Jonathan
Donald J. Blaskiewicz, MD,³ (C)
Han Jo Kim, MD,⁶ Gregory M.
Michael O'Brien, MD,⁸ Richard
Themistocles S. Protopsaltis
K. Daniel Riew, MD,¹³ Michael
and the International Spine Society

- Established classification of
cervical deformity
- Key parameters
 - cSVA,
 - CBVA
 - TS-CL
 - mJOA

Cervical deformity classification

Deformity Descriptor

- C**- Primary Sagittal Deformity
Apex in Cervical Spine
- CT**- Primary Sagittal Deformity
Apex at Cervico-Thoracic
Junction
- T**- Primary Sagittal Deformity
Apex in Thoracic Spine
- S**- Primary Coronal Deformity
(C2-C7 Cobb angle $\geq 15^\circ$)
- CVJ**- Primary Cranio-Vertebral
Junction Deformity

5 Modifiers

- C2-C7 sagittal vertical axis (SVA)**
 - 0**: C2-C7 SVA $< 4^\circ$
 - 1**: C2-C7 SVA $4^\circ - 8^\circ$
 - 2**: C2-C7 SVA $> 8^\circ$

- Horizontal Gaze**
 - 0**: CBVA $1^\circ - 10^\circ$
 - 1**: CBVA $-10^\circ - 0^\circ$ or $11^\circ - 25^\circ$
 - 2**: CBVA $< -10^\circ$ or $> 25^\circ$

- Cervical Lordosis Minus T1 Slope**
 - 0**: TS-CL $< 15^\circ$
 - 1**: TS-CL $15^\circ - 20^\circ$
 - 2**: TS-CL $> 20^\circ$

- Myelopathy**
 - 0**: mJOA=18 (None)
 - 1**: mJOA=15-17 (Mild)
 - 2**: mJOA=12-14 (Moderate)
 - 3**: mJOA <12 (Severe)

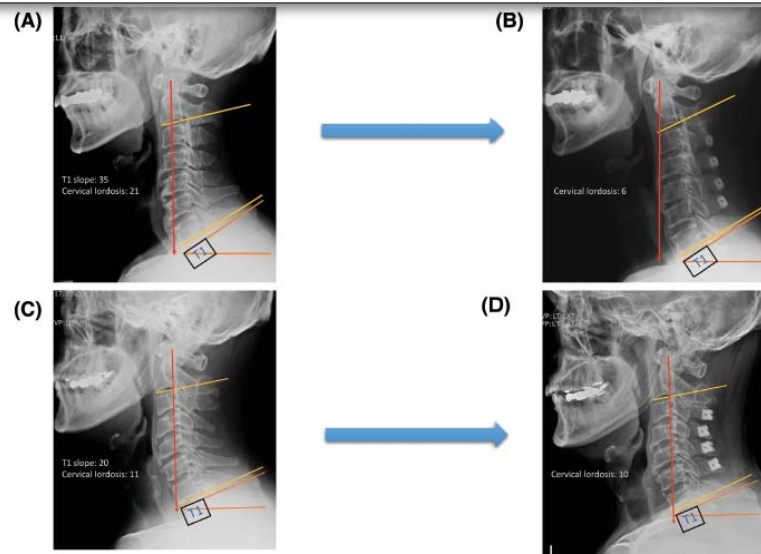
- SRS-Schwab Classification**
 - T, L, D, or N**: Curve Type
 - 0, +, or ++**: PI minus LL
 - 0, +, or ++**: Pelvic Tilt
 - 0, +, or ++**: C7-S1 SVA

FIG. 1. Description of the CSD classification system, which includes a deformity descriptor and 5 modifiers. D = double; L = lordosis; N = none; T = thoracic.

CERVICAL SPINE

T1 Slope as a Predictor of Kyphotic Alignment Change After Laminoplasty in Patients With Cervical Myelopathy

Tae-Hwan Kim, MD, Seung Yeop Lee, MD, Yong Chan Kim, MD, Moon Soo Park, MD, and Seok Woo Kim, MD, PhD



High T1 Slope

Low T1 Slope

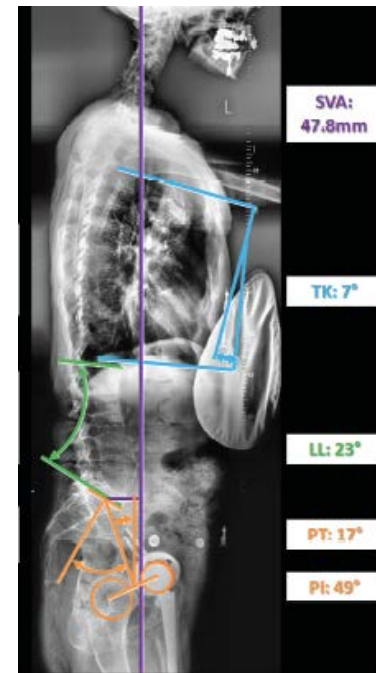
High T1 Slope predicts postoperative kyphotic alignment after laminoplasty

Assessment of Impact of Long-Cassette Standing X-Rays on Surgical Planning for Cervical Pathology: An International Survey of Spine Surgeons.

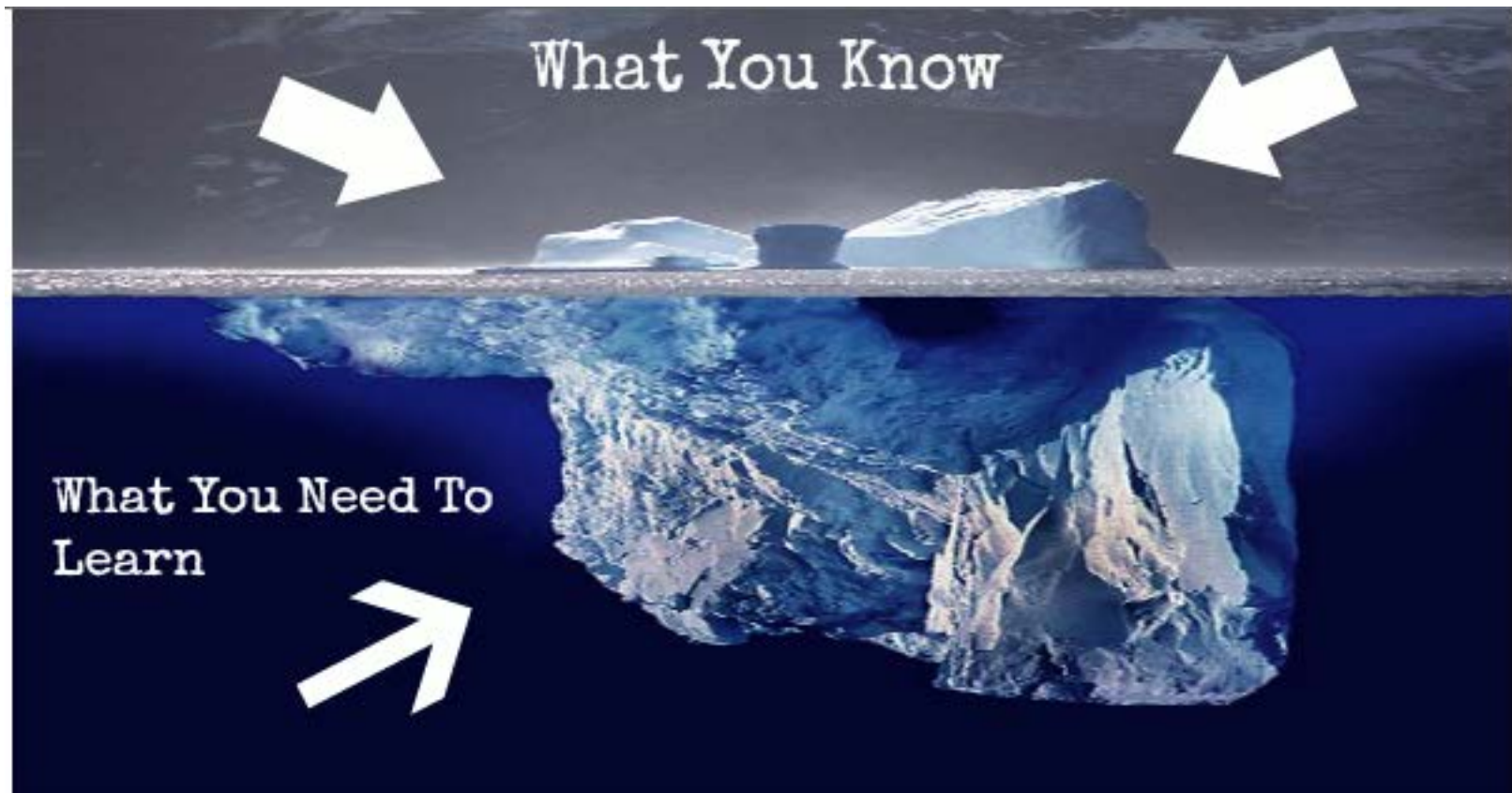
Ramchandran S, Smith JS, Ailon T, Klineberg E, Shaffrey C, et al.

© IMAST 2015, Kuala Lumpur, Malaysia

- © 58% of 157 surgeons presented with full spine radiographs opted for longer fusions to the mid or lower thoracic spine



◎ T1 Slope is just the tip of the Iceberg





ELSEVIER

The Spine Journal 10 (2010) 994–998

THE
SPINE
JOURNAL

Technical Report

The use of the T1 sagittal angle in predicting overall sagittal balance of the spine

Patrick T. Knott, PhD, PA-C^{a,*}, Steven M. Mardjetko, MD^b, Fernando Techy, MD^c

^aCollege of Health Professions, Rosalind Franklin University, 3333 Green Bay Rd., North Chicago, IL 60064, USA

^bIllinois Bone and Joint Institute, 9000 Waukegan Rd., Morton Grove, IL 60053, USA

^cDepartment of Orthopaedic Surgery, University of Illinois Medical Center, 1740 West Taylor St., Chicago, IL 60612, USA

Received 27 January 2010; revised 11 August 2010; accepted 27 August 2010

Knott et al. *The Spine Journal* 2010

- ⊙ When the T1 slope is higher than 25°, all patients had at least 10 cm of “positive sagittal imbalance” (C7 SVA)



Figure. X-ray showing T1 sagittal angle (measured as the angle between a horizontal line and the superior end plate of T1).

Determining a Threshold for Full Length Spinal Radiographs: High T1 Slope Correlates with Thoracolumbar Spinal Deformity

Klineberg E, Carlson B, Protopsaltis TS, Passias P, Burton D, et al.

⊙ NASS 2015, Chicago

- ⊙ T1 Slope $> 32^\circ$ on Cervical radiographs, indicates the need to perform full-length spine radiographs to identify potential concurrent TL deformity
 - ⊙ T1S $> 32^\circ$ predicts TK $> 50^\circ$ (92% sensitivity, 50% specificity) and TPA $> 20^\circ$ (69% sensitivity, 63% specificity)



WHEN DO YOU NEED FULL SPINE FILMS?

Low C2 Tilt (<20)

High T1 Slope (>30)

High C2 Tilt (>20)

Low T1 Slope (<30)

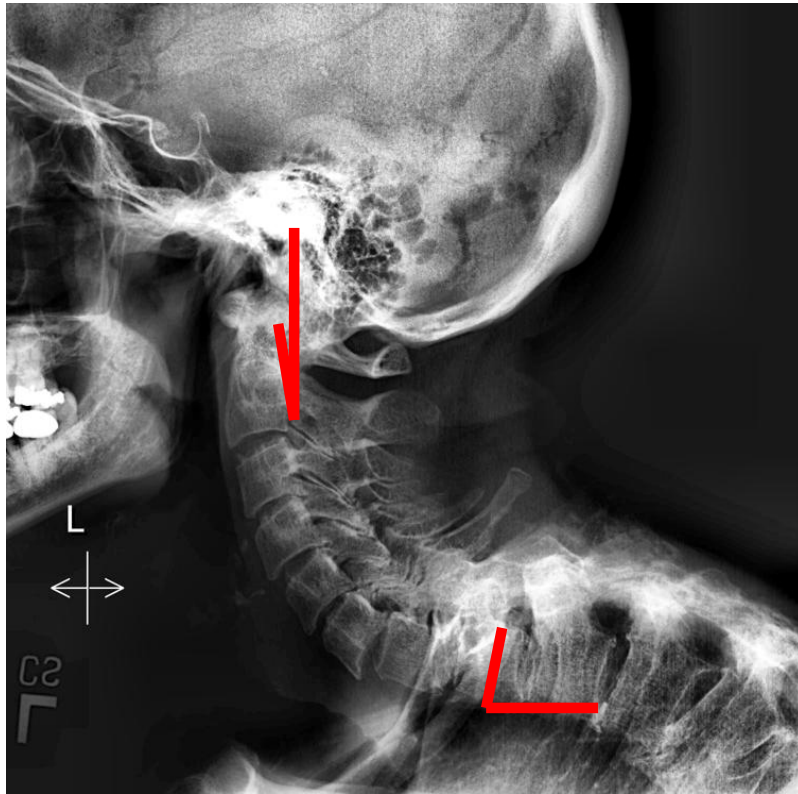
High C2 Tilt (>20)

High T1 Slope (>30)

WHEN DO YOU NEED FULL SPINE FILMS?

Low C2 Tilt (<20)

High T1 Slope (>30)



**Full Length Spine
X-rays are
necessary**

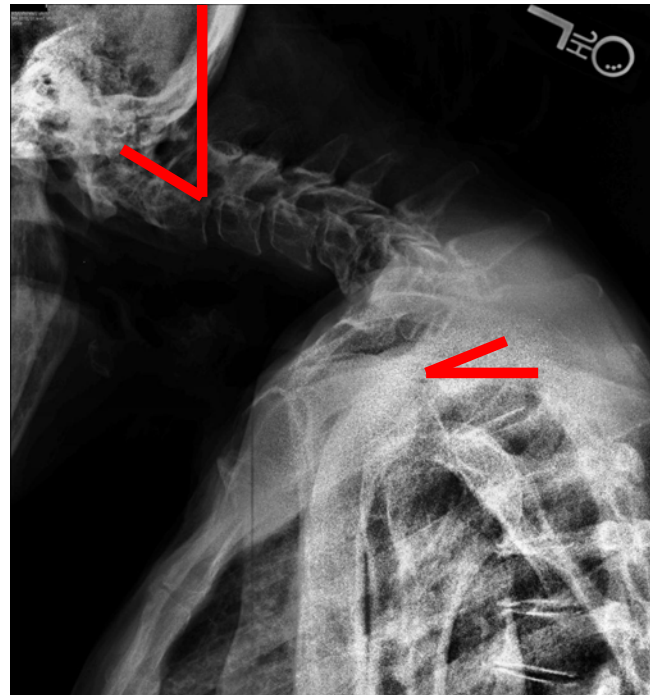


WHEN DO YOU NEED FULL SPINE FILMS?

High C2 Tilt (>20)

Low T1 Slope (<30)

Deformity is in
Cervical region



Full Length Spine X-ray may
not be necessary



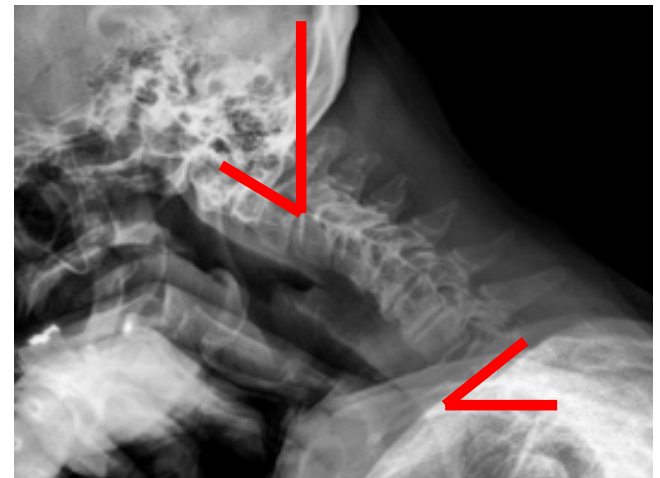
WHEN DO YOU NEED FULL SPINE FILMS?



**Full Length Spine
X-rays are
necessary**

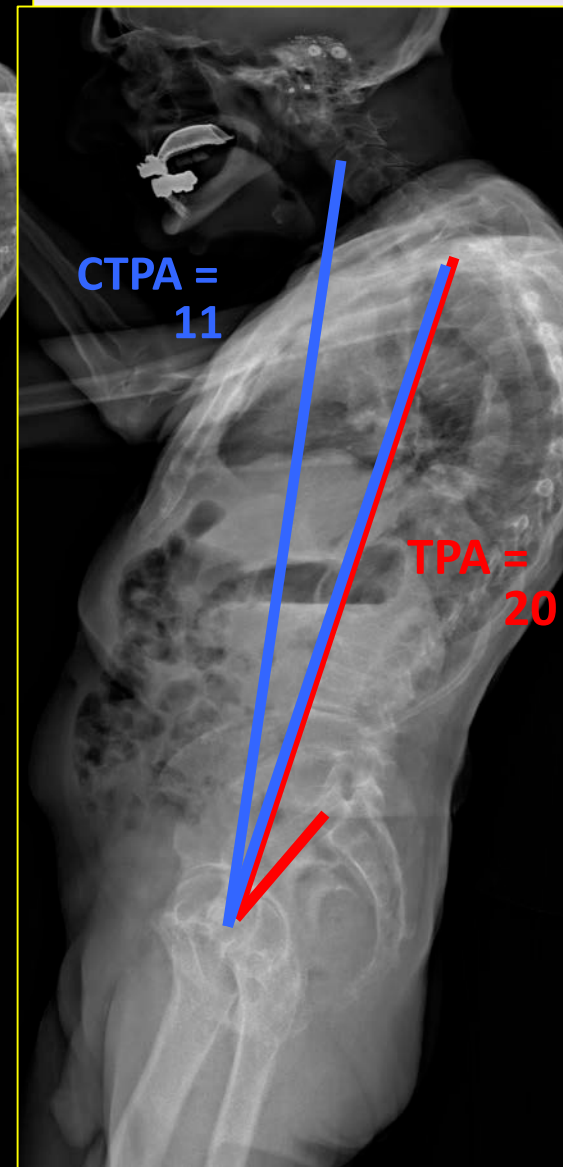
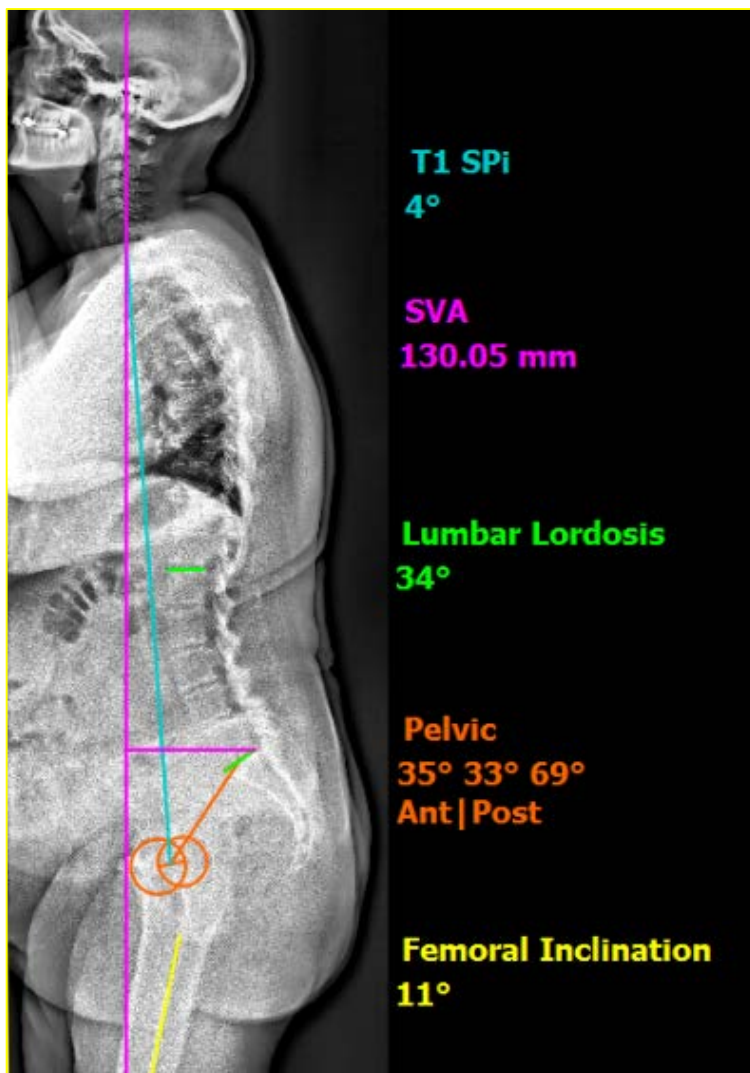
High C2 Tilt (>20)

High T1 Slope (>30)



**Deformity is in both Cervical
and Thoracolumbar spine
w/out cervical
compensation**

◎ Full Spine Parameters

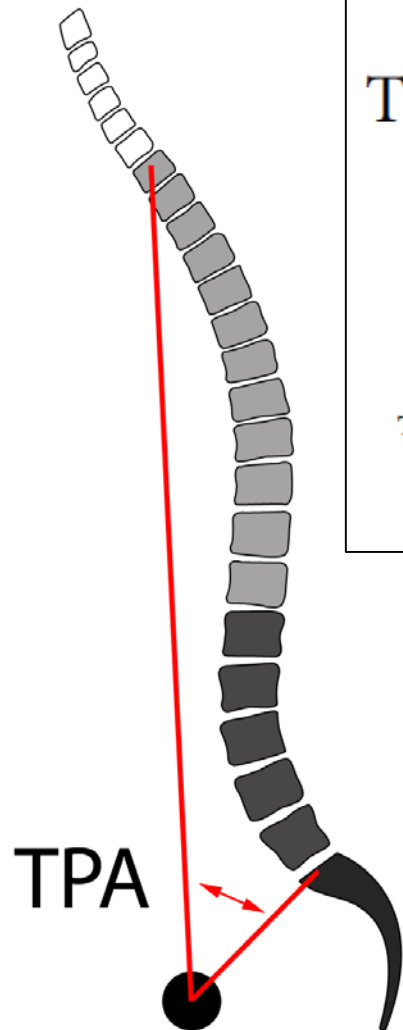


T1 PELVIC ANGLE (TPA)

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The T1 Pelvic Angle, a Novel Radiographic Measure of Global Sagittal Deformity, Accounts for Both Spinal Inclination and Pelvic Tilt and Correlates with Health-Related Quality of Life

Themistocles Protopsaltis, MD, Frank Schwab, MD, Nicolas Bronsard, MD, Justin S. Smith, MD, PhD, Eric Klineberg, MD, Gregory Mundis, MD, Devon J. Ryan, BA, Richard Hostin, MD, Robert Hart, MD, Douglas Burton, MD, Christopher Ames, MD, Christopher Shaffrey, MD, Shay Bess, MD, Thomas Errico, MD, and Virginie Lafage, PhD, on behalf of the International Spine Study Group

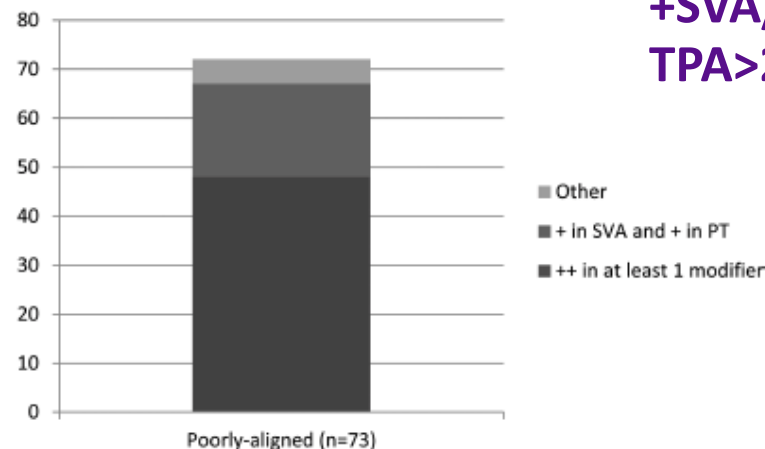
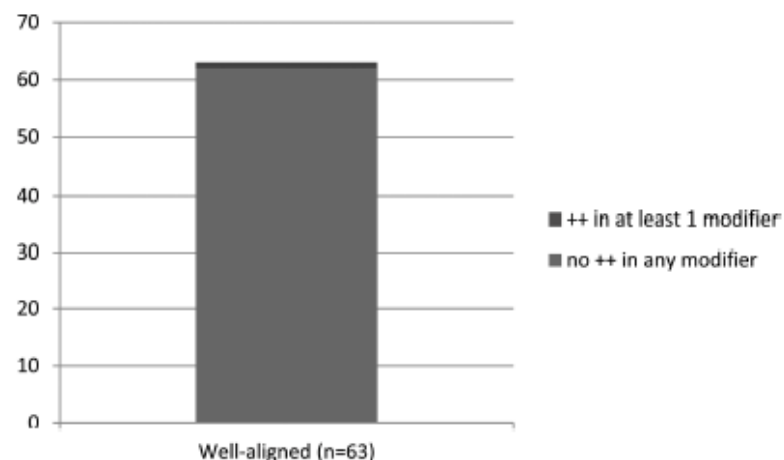


- TPA is the angle from T1 to femoral heads and a line from femoral heads to the center of S1 endplate
- TPA combines the information from both SVA and PT

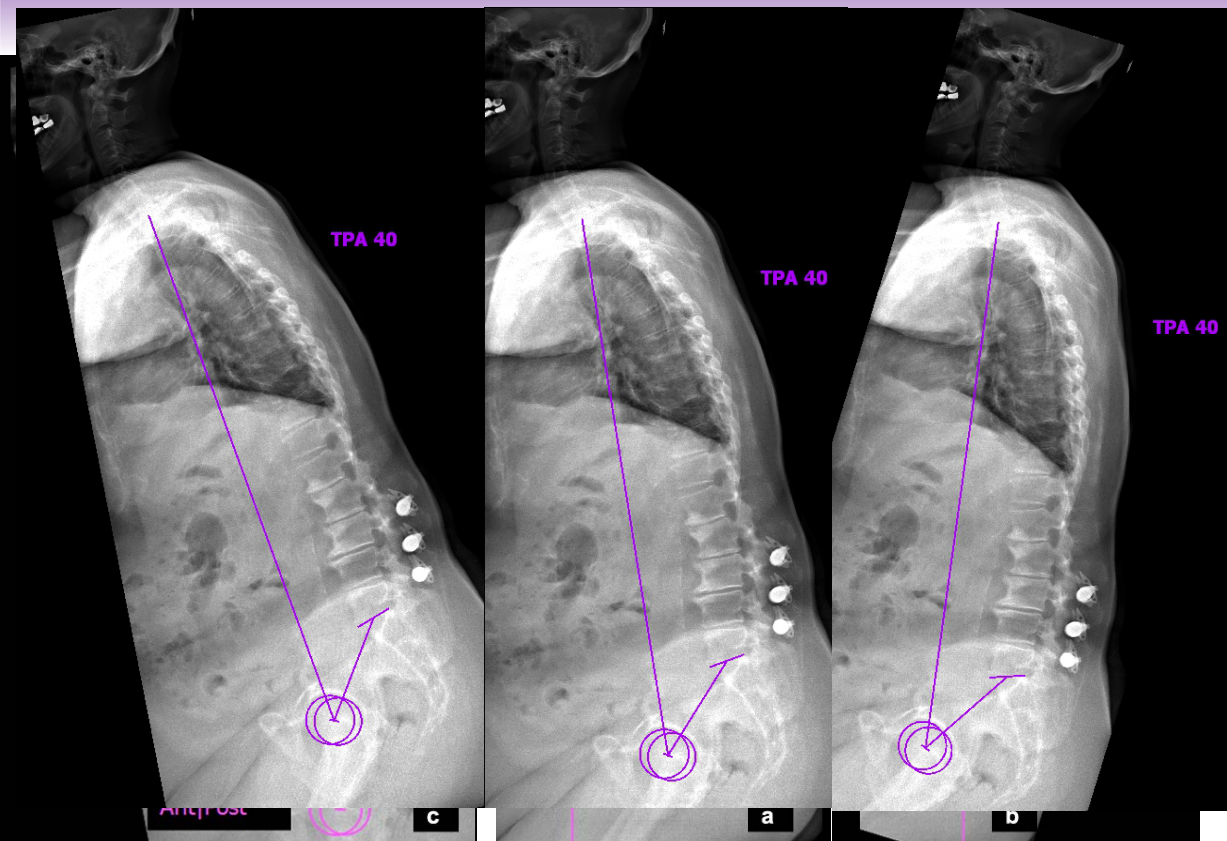
T1 Pelvic Angle (TPA) Effectively Evaluates Sagittal Deformity and Assesses Radiographical Surgical Outcomes Longitudinally

Devon J. Ryan, BA,* Themistocles S. Protopsaltis, MD,* Christopher P. Ames, MD,† Richard Hostin, MD,‡ Eric Klineberg, MD,§ Gregory M. Mundis, MD,¶ Ibrahim Obeid, MD,|| Khaled Kebaish, MD,** Justin S. Smith, MD, PhD,†† Oheneba Boachie-Adjei, MD,‡‡ Douglas C. Burton, MD,§§ Robert A. Hart, MD,¶¶ Munish Gupta, MD,§ Frank J. Schwab, MD,* Virginie Lafage, PhD,* and International Spine Study Group

- TPA can simplify assessment of deformity
- Only one patient had ++ in any Schwab modifier if TPA < 20°
- Most pts were ++ or +SVA/+PT if TPA > 20°



INCREASE IN PELVIC TILT DOES NOT AFFECT TPA



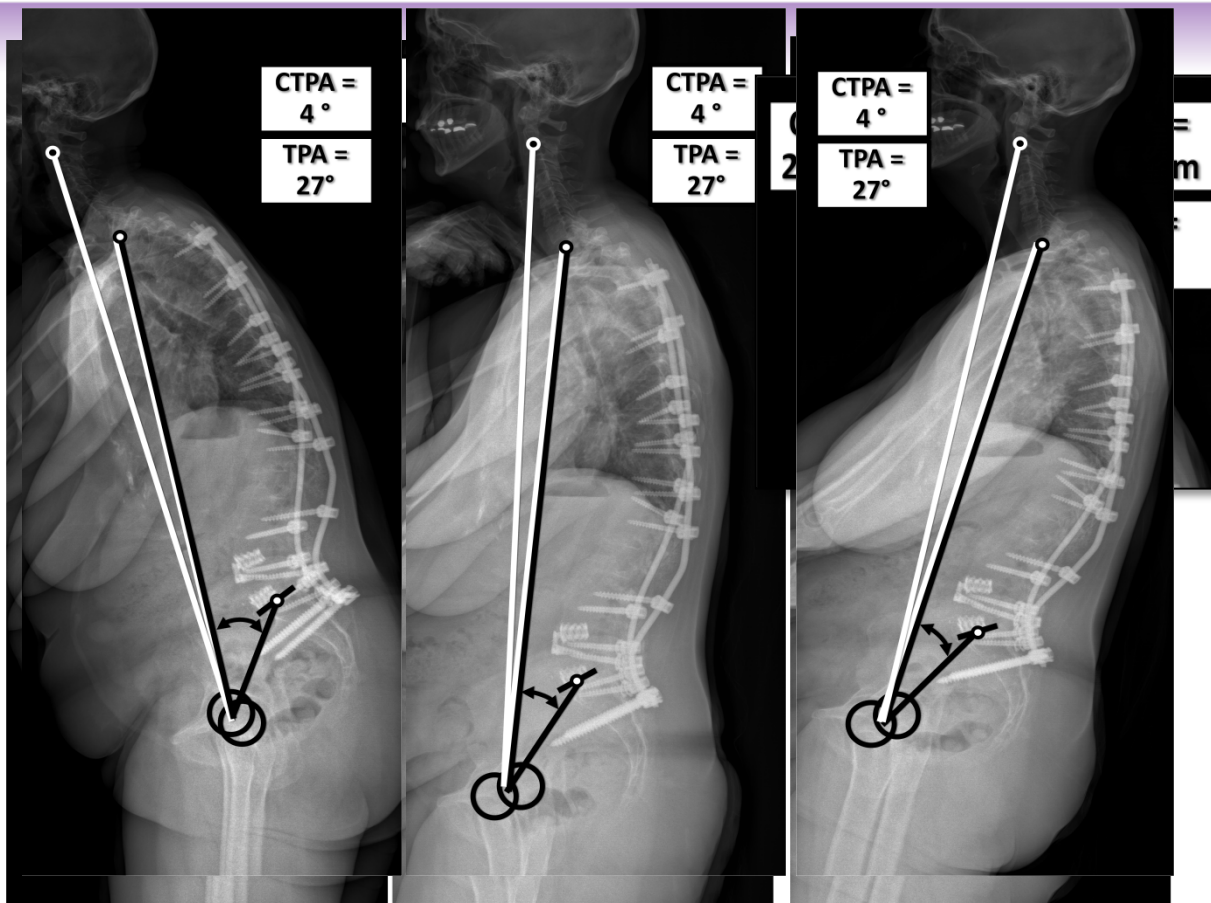
**Extreme Pelvic
Anteversion
PT = 20deg**

**Standing
Position
PT=31deg**

**Extreme Pelvic
Retroversion
PT = 48deg**

- © Increasing PT can “hide” a large sagittal deformity (SVA decreases)
- © TPA remains consistent regardless of pelvic retroversion

INCREASE IN PELVIC TILT DOES NOT AFFECT CTPA



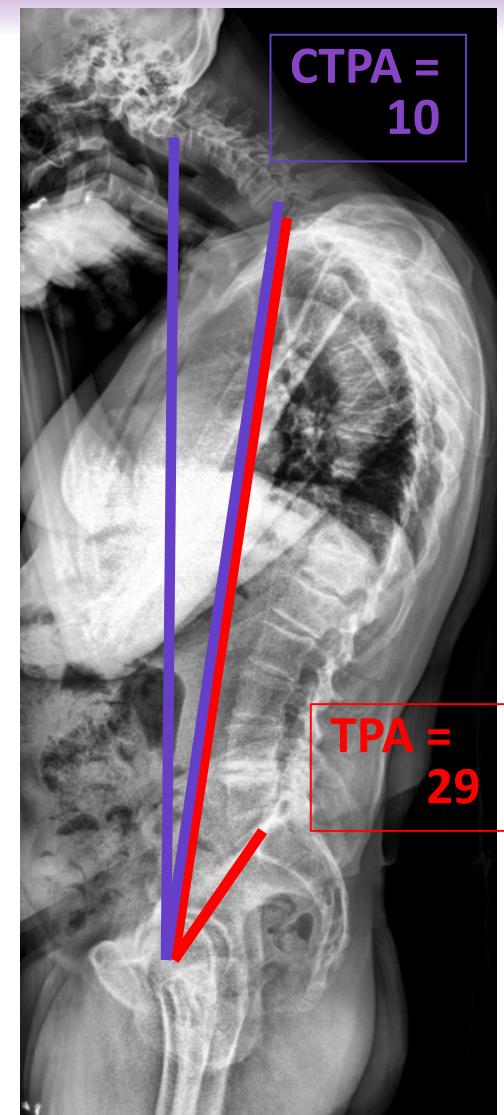
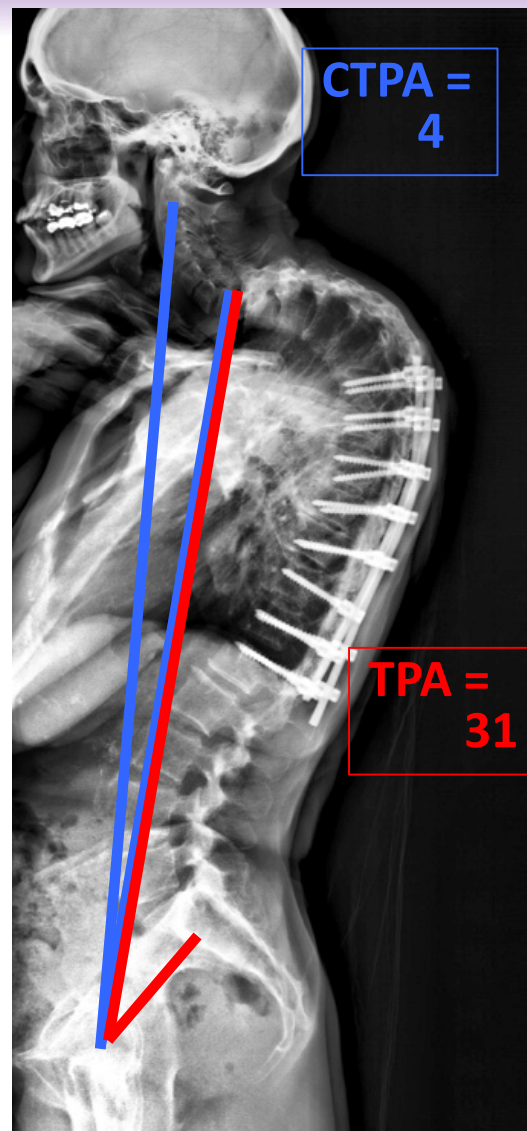
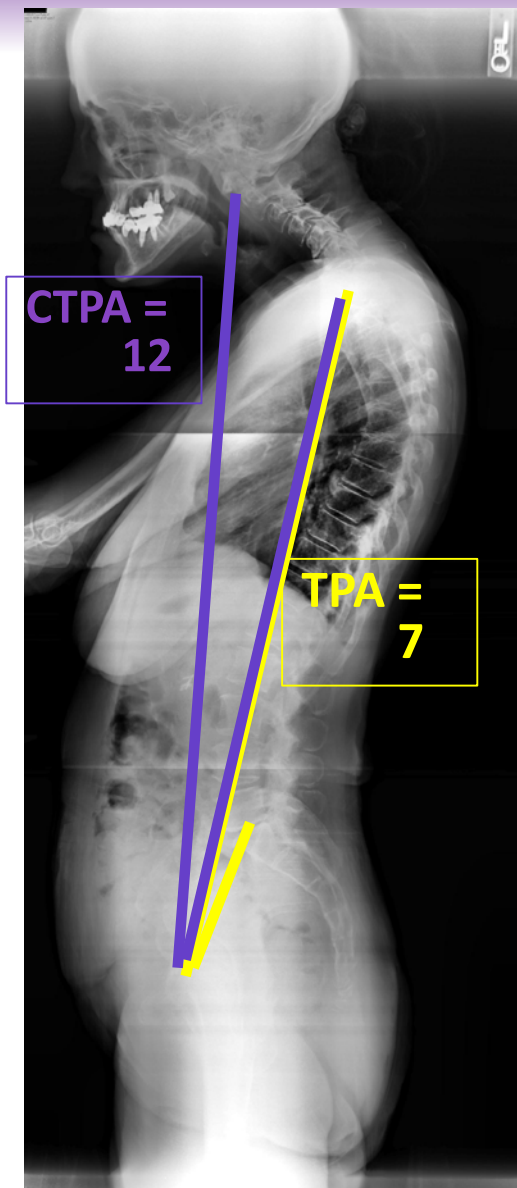
Extreme Pelvic
Anteversion
PT = 15deg

Standing
Position
PT=30deg

Extreme Pelvic
Retroversion
PT = 48deg

- Increasing PT can “hide” a large sagittal deformity (cSVA decreases)
- CTPA remains consistent regardless of pelvic retroversion

CTPA AND TPA DETERMINE THE LOCATION OF DEFORMITY

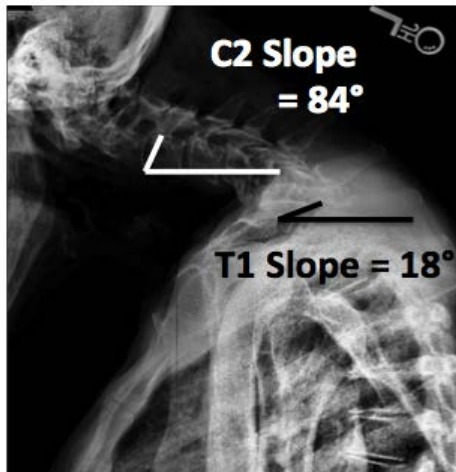


THE IMPORTANCE OF C2 SLOPE AS A SINGULAR MARKER OF CERVICAL DEFORMITY AND THE LINK BETWEEN UPPER-CERVICAL AND CERVICO-THORACIC ALIGNMENT IN PATIENTS WITH PRIMARY CERVICAL DEFORMITY.

Themistocles S. Protopsaltis, MD, Subaraman Ramchandran, MBBS, Han Jo Kim, MD, Daniel Sciubba, MD, Peter G. Passias, MD, Virginie Lafage, PhD, Justin Scheer, BS, Eric Klineberg, MD, Munish Gupta, MD, Robert Hart MD, Greg Mundis, MD, Shay Bess, MD, Justin Smith, MD, Christopher Shaffrey, MD, Christopher Ames, MD, **International Spine Study Group (ISSG)**

C2 SLOPE CORRELATES WITH TS-CL

The extremely high correlation of C2 slope and TS-CL ($R=0.98$, $p<0.001$) is explained by the fact that C2 slope is a mathematical approximation of TS-CL



High C2 Tilt (>20)

Low T1 Slope (<30)

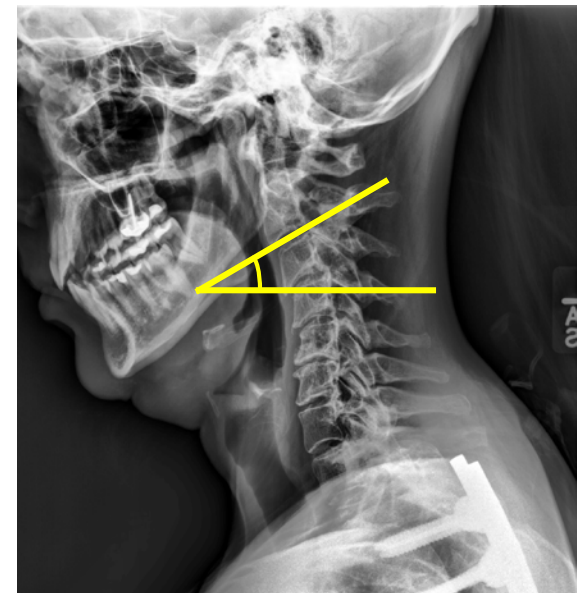
T1 Slope – CL

$$= \text{T1 Slope} - (\text{C7 Slope} - \text{C2 Slope})$$

= C2 Slope

= C2 Tilt

- ⦿ The C2 slope correlated with both upper cervical and sub-axial cervical alignment parameters.
- ⦿ The C2 slope is a useful marker of overall cervical sagittal alignment, acting as a link between the occipitocervical and cervico-thoracic spine
- ⦿ The C2 Slope helps to define the presence of a mismatch between cervical lordosis and thoracolumbar alignment required to maintain the head over the pelvis and to facilitate horizontal gaze



ANALYSIS OF EARLY DISTAL JUNCTIONAL KYPHOSIS (DJK) AFTER CERVICAL DEFORMITY CORRECTION

TS Protopsaltis, S Ramchandran, HJ Kim, et. al, **ISSG
Podiums, SRS, NASS, CSRS 2017**

STUDY OBJECTIVE:

To determine the prevalence, risk factors and consequences of DJK following cervical deformity surgery using a prospective multi-centric database

- **N= 67, 56% females, mean age= 62y, 41 % previous fusion**
- **16 patients had DJK (24%), (11 within 3 months and 5 between 3 and 6 months)**

| Univariate Analysis | Multi-variate analysis |
|--------------------------------|--|
| Osteoporosis | Use of transition rods was the only parameter affecting the occurrence of DJK (OR- 0.3, CI- 0.05- 0.8, p= .03) |
| # posterior levels fused | |
| Posterior osteotomy grade | |
| Use of Transition rods | |
| Secondary driver not corrected | |
| Increased pre-op TK | |
| Increased pre-op LL | |



- ⊙ **DJK occurs in 24% patients following surgery for cervical deformity correction within 6 months**
- ⊙ **Risk factors associated with development of DJK include medical bone disease, higher number of posterior levels fused, higher degree of posterior osteotomies, use of transition rods, high pre-operative lumbar lordosis and thoracic kyphosis and failure to address the secondary driver of the deformity**
- ⊙ **Use of transition rods is the only factor associated with increased risk of DJK following a multi-variate analysis**
- ⊙ **Occurrence of radiographic DJK was not associated with poor clinical outcomes**

Comparison of Smith-Petersen Osteotomy *Versus* Pedicle Subtraction Osteotomy *Versus* Anterior-Posterior Osteotomy Types for the Correction of Cervical Spine Deformities

Han Jo Kim, MD,* Chaiwat Piyaskulkaew, MD,† and K. Daniel Riew, MD‡

J Spine 2015

- 61 pts over 10 year period
- Mean angular corrections
 - SPO 10°, PSO 35°, AntO 17°
 - AntO/SPO 28°
- Mean EBL
 - PSO: 712 mL vs. AntO/SPO: 325 mL

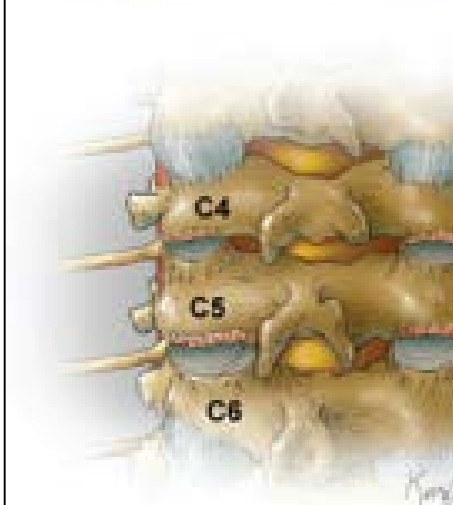
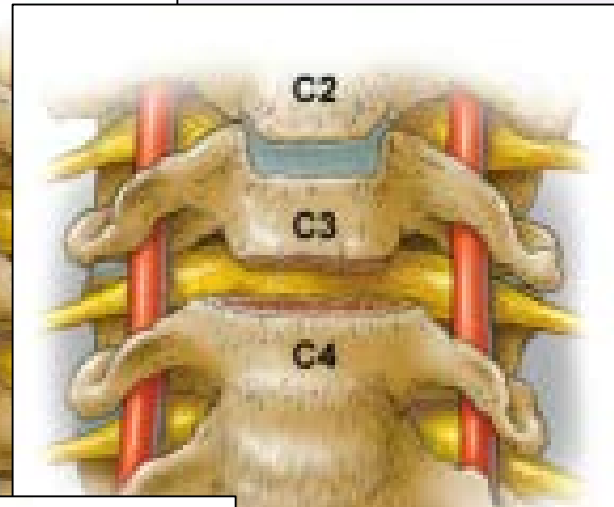
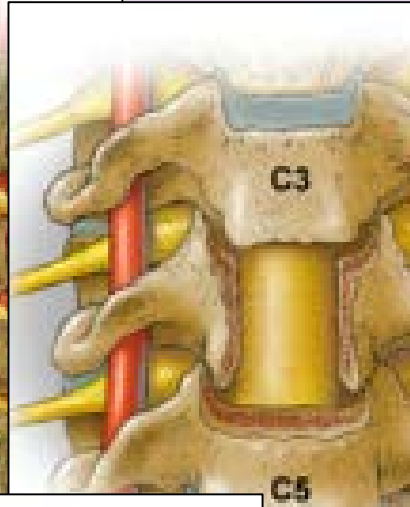
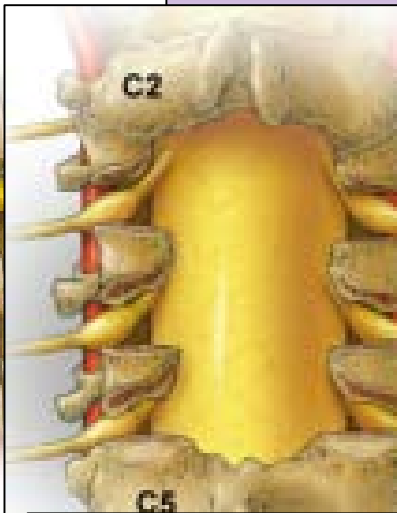
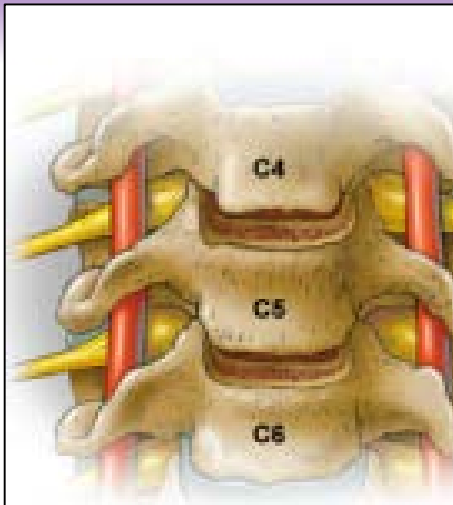
J Neurosurg Spine 19:269–278, 2013
©AANS, 2013

A standardized nomenclature for cervical spine soft-tissue release and osteotomy for deformity correction

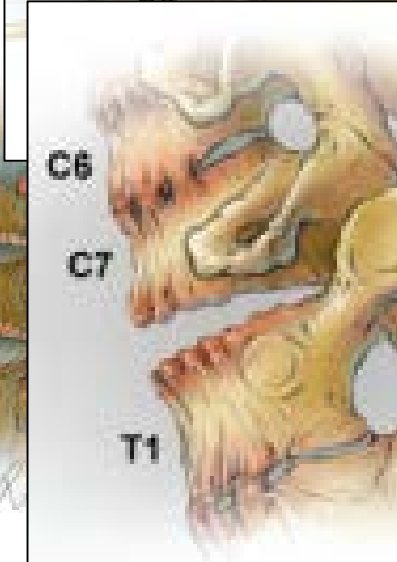
Clinical article

**CHRISTOPHER P. AMES, M.D.,¹ JUSTIN S. SMITH, M.D., Ph.D.,² JUSTIN K. SCHEER, B.S.,³
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AND THE INTERNATIONAL SPINE STUDY GROUP**

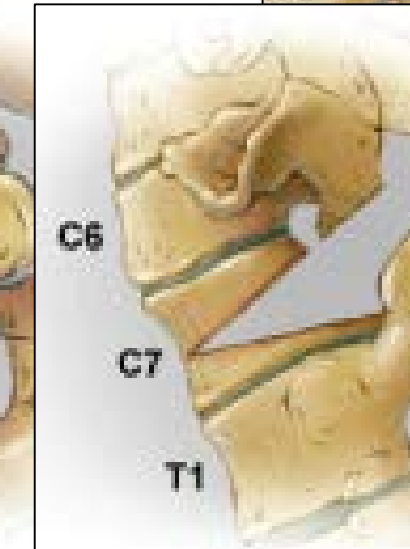
AMES ISSG OSTEOTOMY GRADING



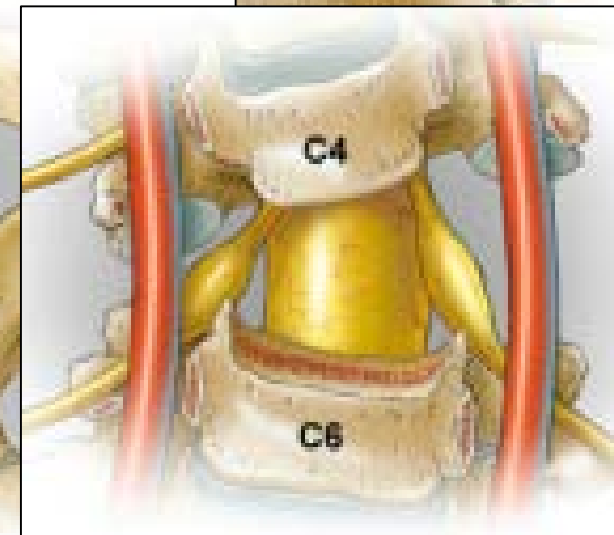
Grade-1



Grade-5



Grade-6



Grade-7

Case

Partially-Flexible Chin-On-Chest

Deformity

CHIN-ON CHEST DEFORMITY



CERVICAL PARAMETERS: CBVA



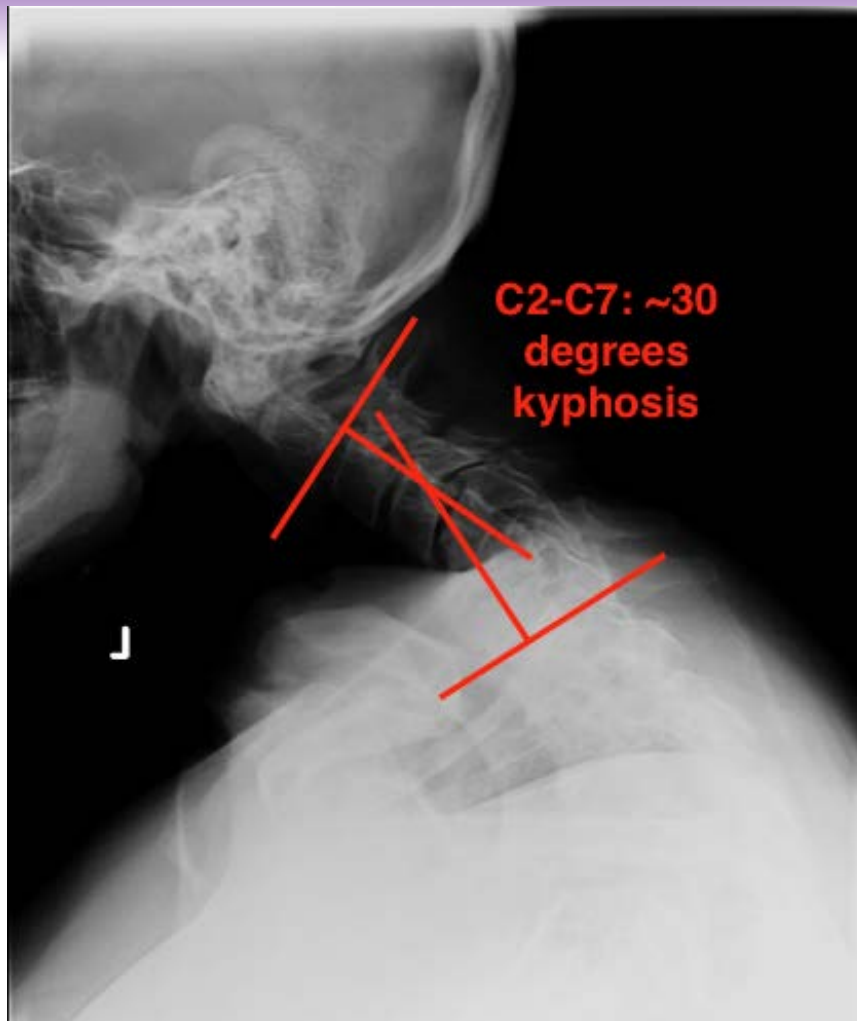
CBVA: $\sim 30^\circ$

Normal: $0-10^\circ$



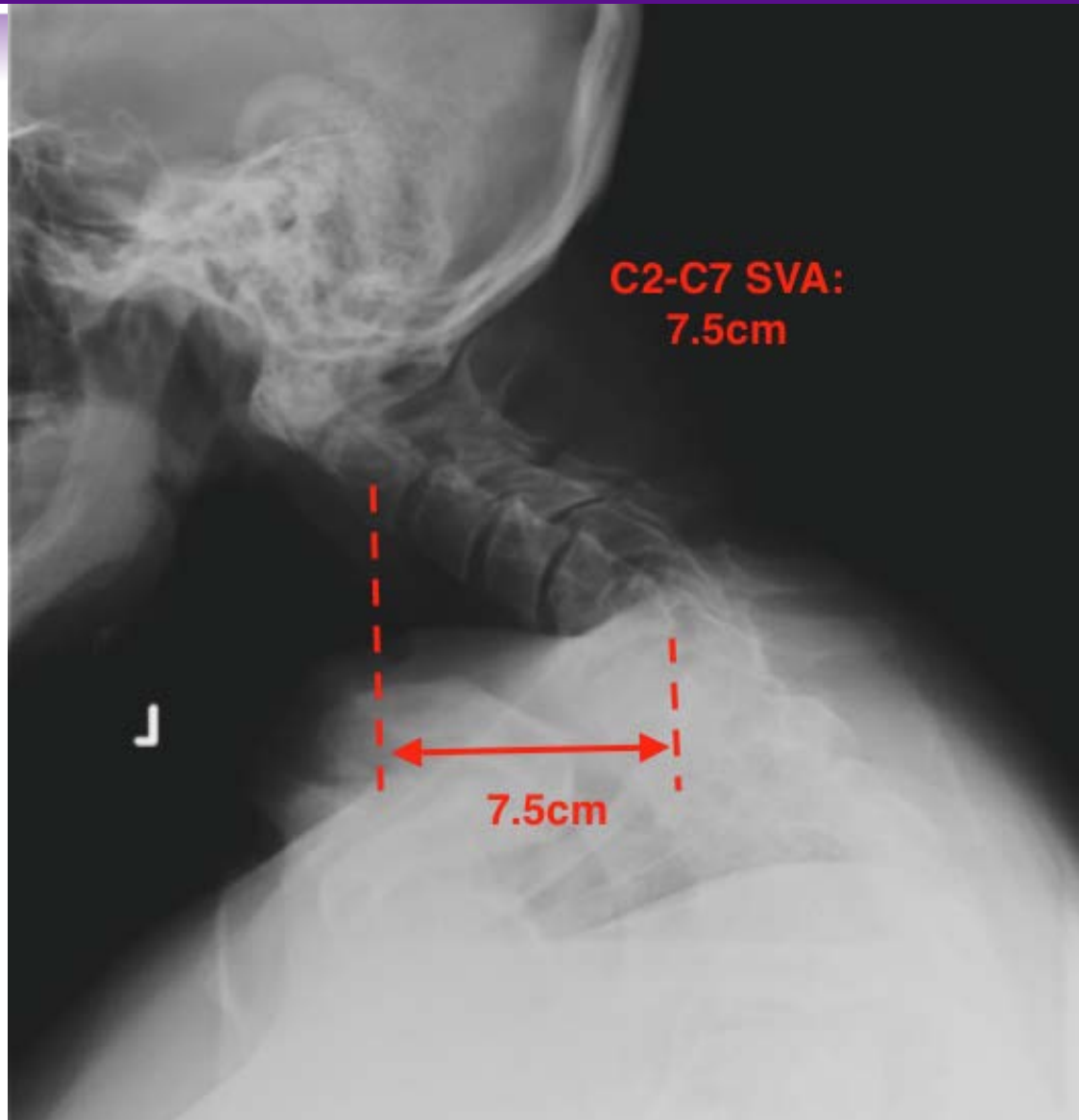


CERVICAL PARAMETERS: C2-C7 CURVATURE



C2-C7A: ~30° kyphosis (normal: 4-20° lordosis)

CERVICAL PARAMETERS: C2-C7 SVA



C2-C7 SVA: 7.5cm

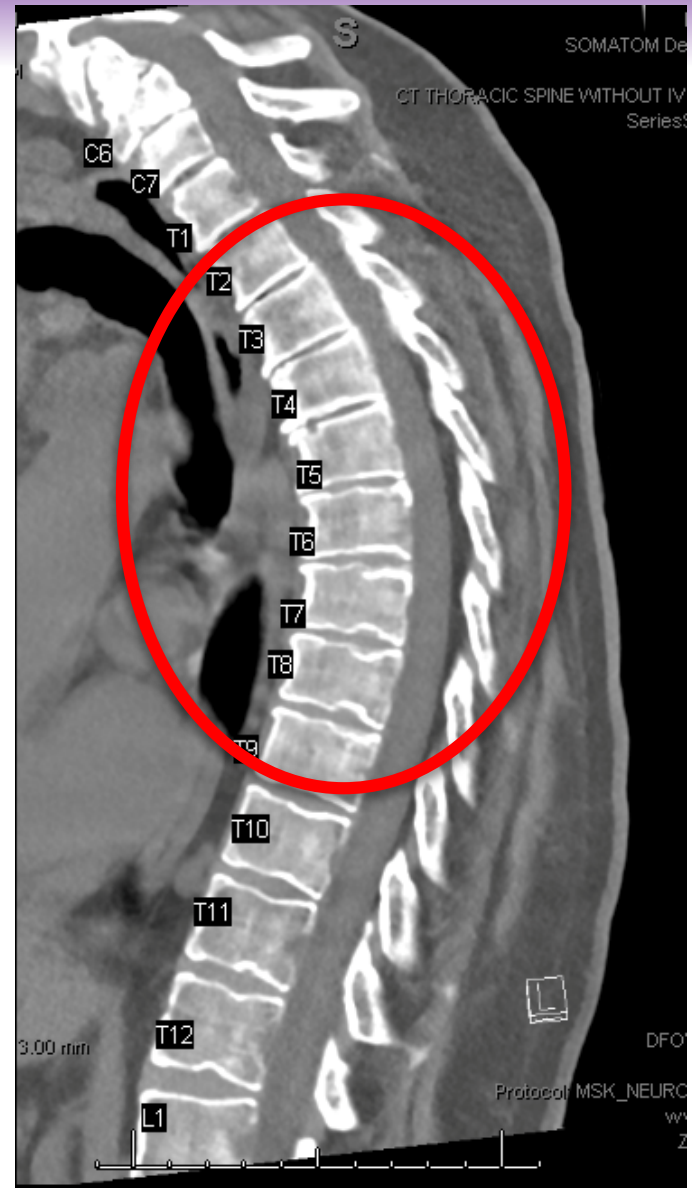
Normal: 1.5cm

**>4cm associated with
poor HRQOL measures
(NDI and SF-36)**

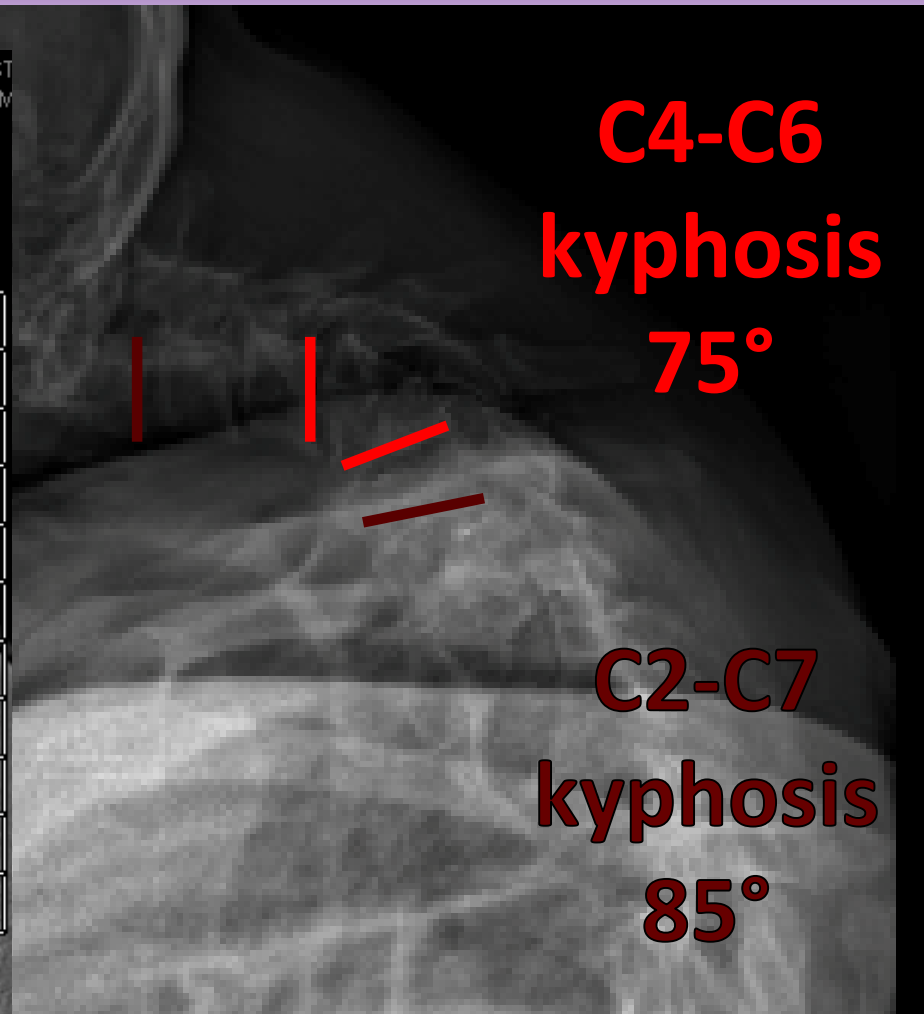
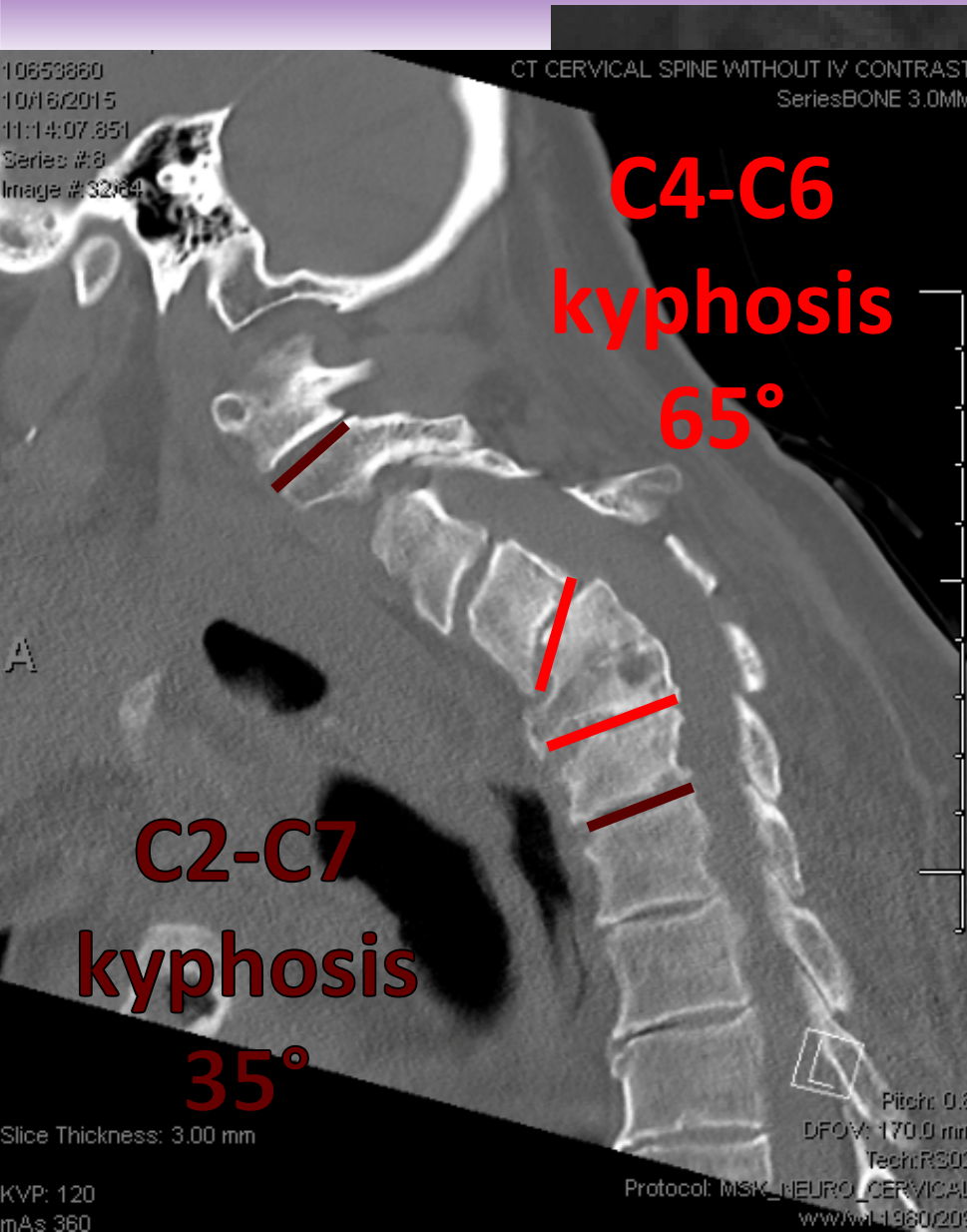


FLEX / EXT STEREORADIOGRAPHS





ASSESS FLEXIBILITY



🎯 **So what to do...**

◎ Traction

◎ C3-C7 Anterior Osteotomies

- ◎ Grade IV: C4-5, C6-7 w/ uncovertebral J. resection
- ◎ Grad I: C3-4
- ◎ Release of sternocleidomastoid

◎ C2-T10 PSF

- ◎ Grade II (Ponte) osteotomy C4-5
 - C4-5 laminectomy

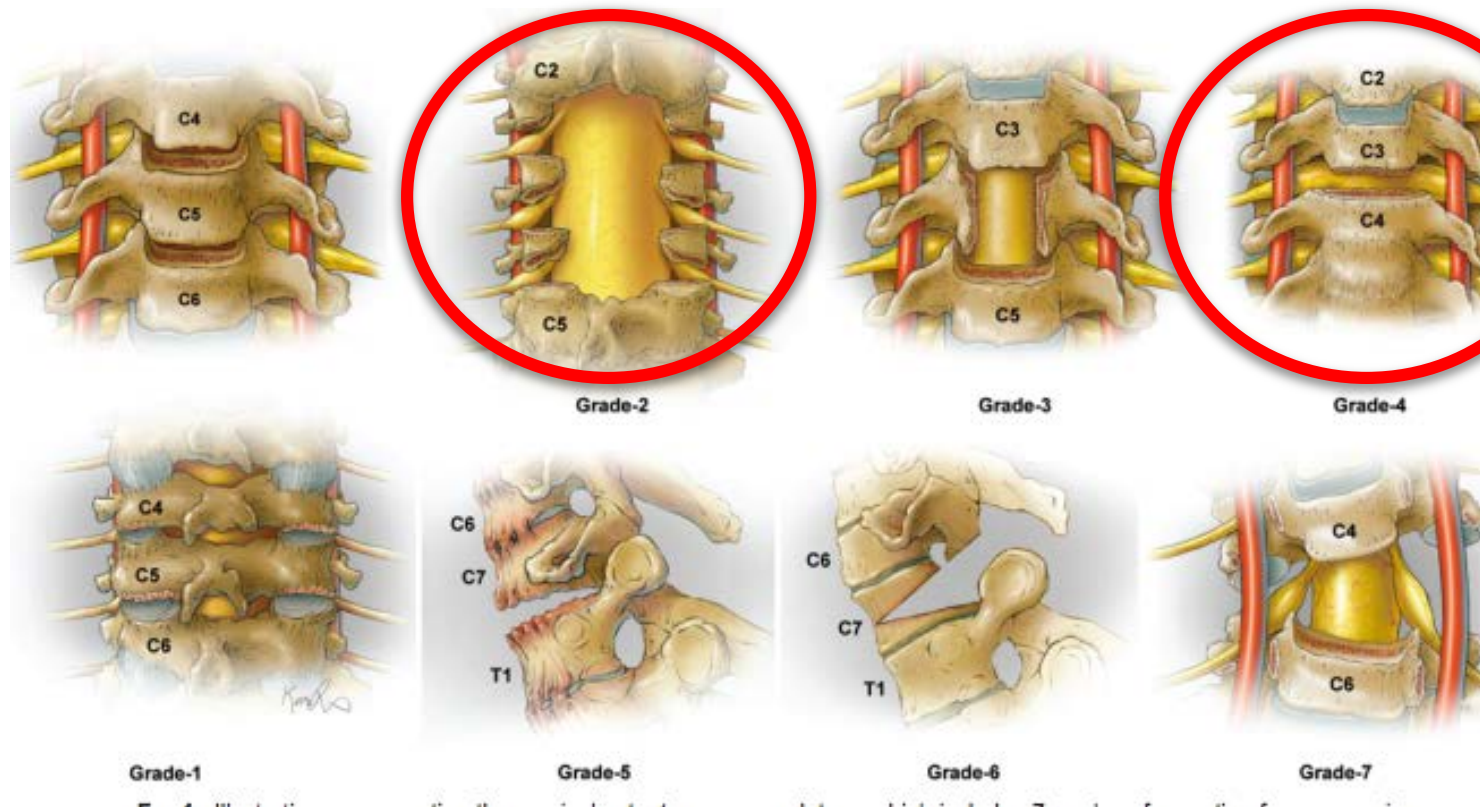


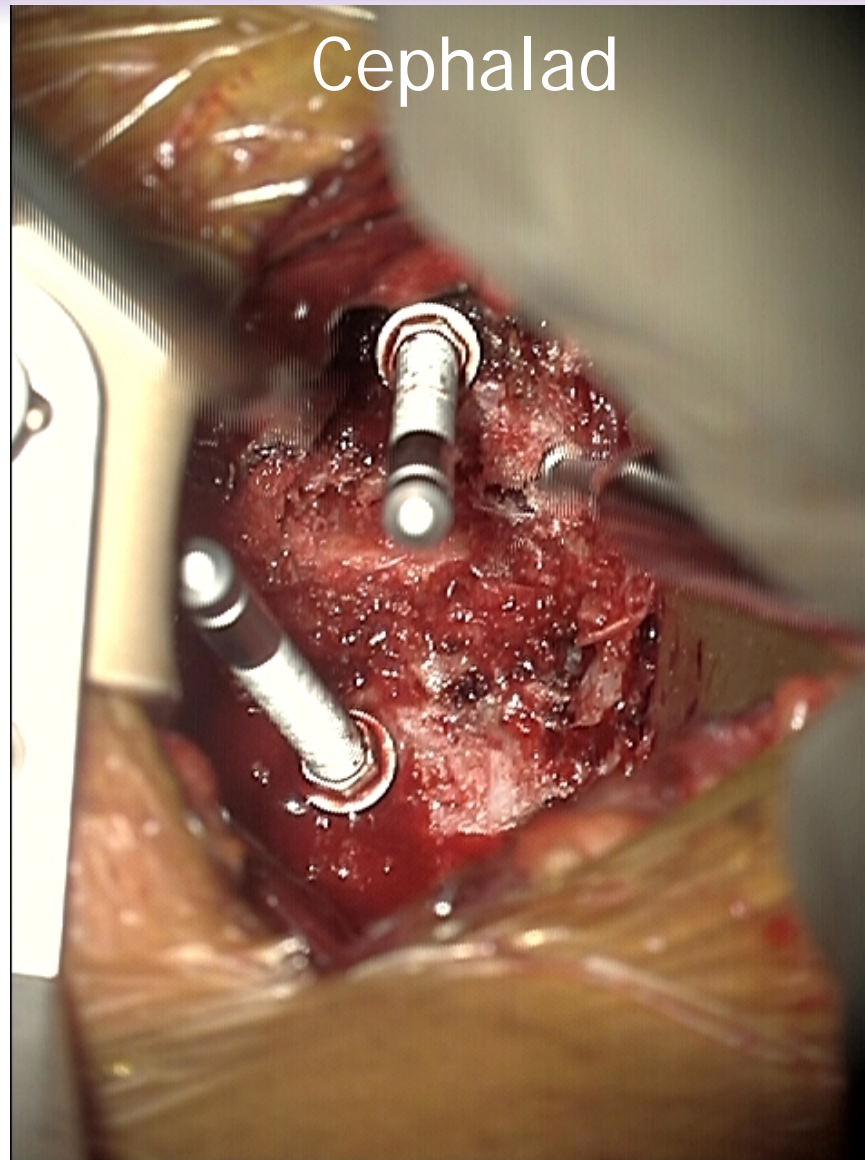


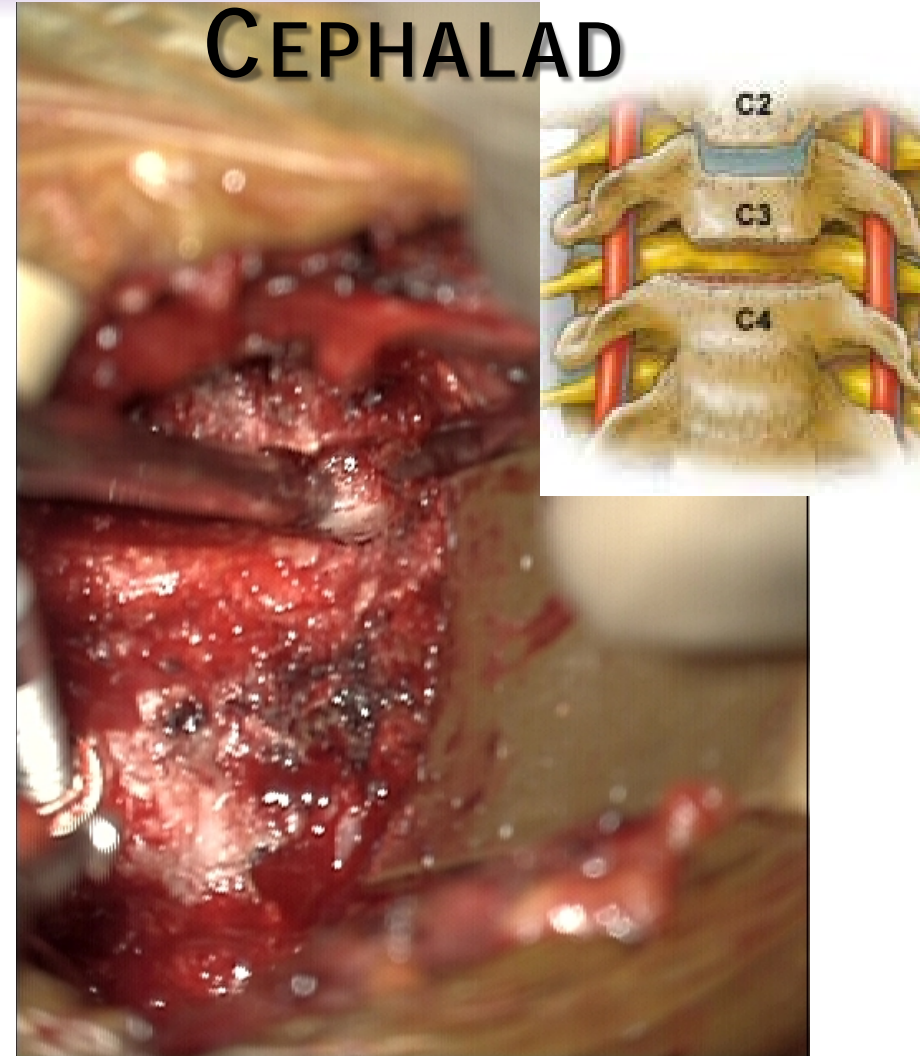
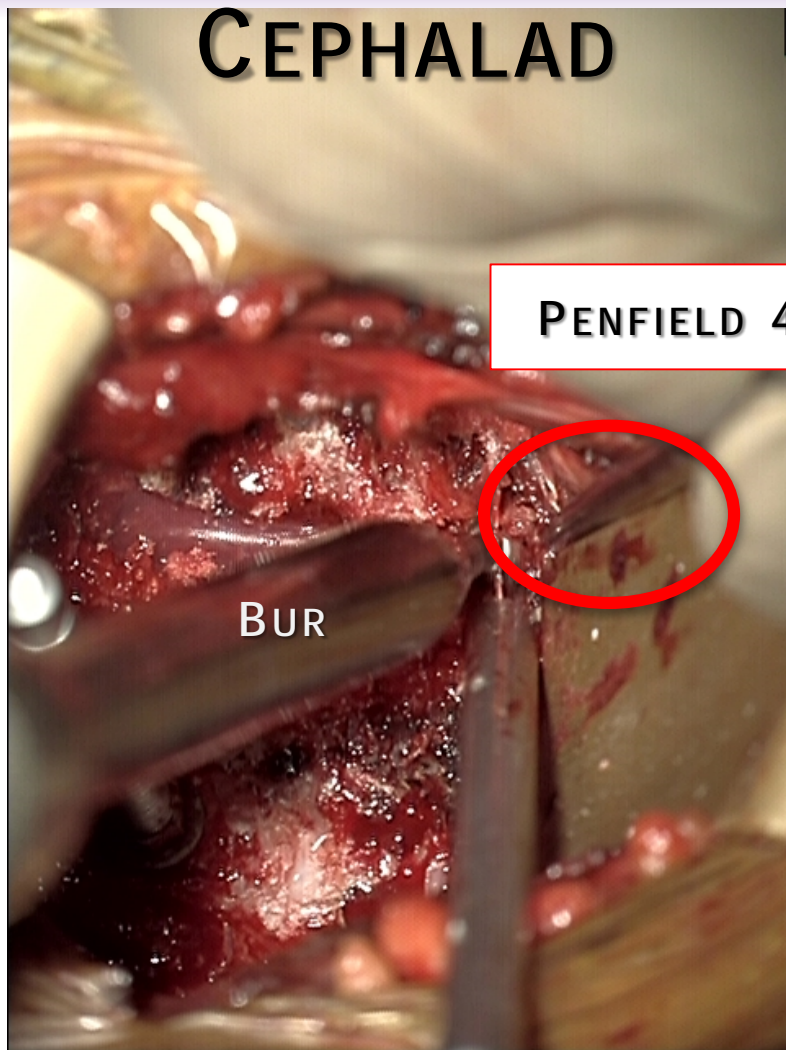
A standardized nomenclature for cervical spine soft-tissue release and osteotomy for deformity correction

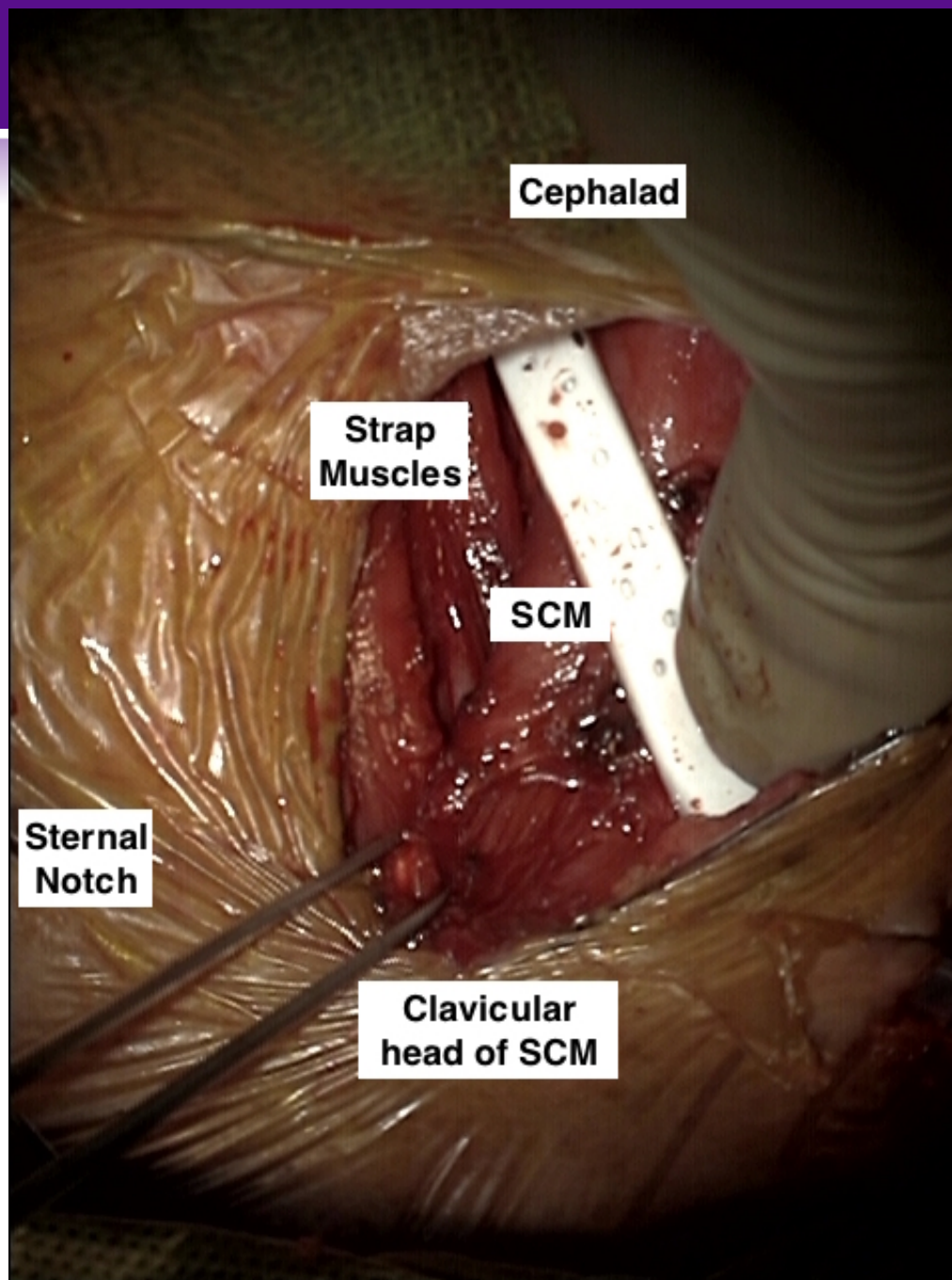
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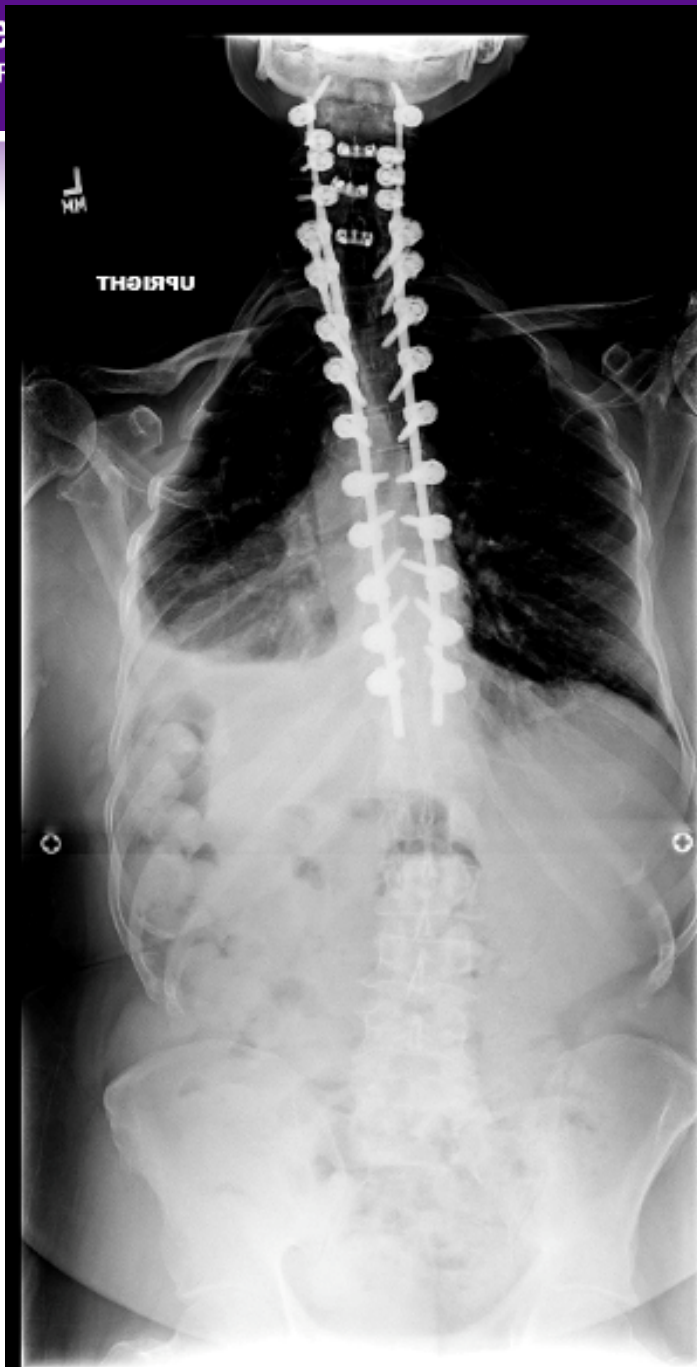


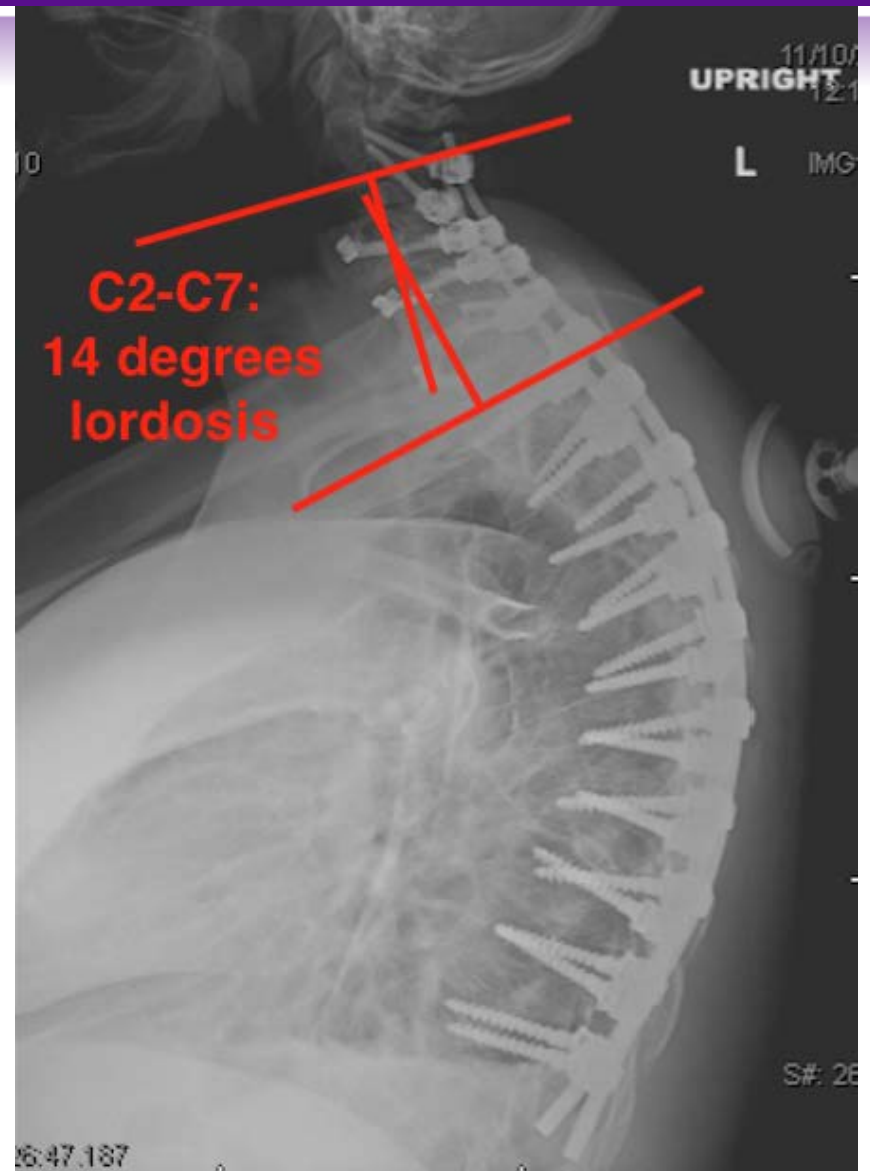
















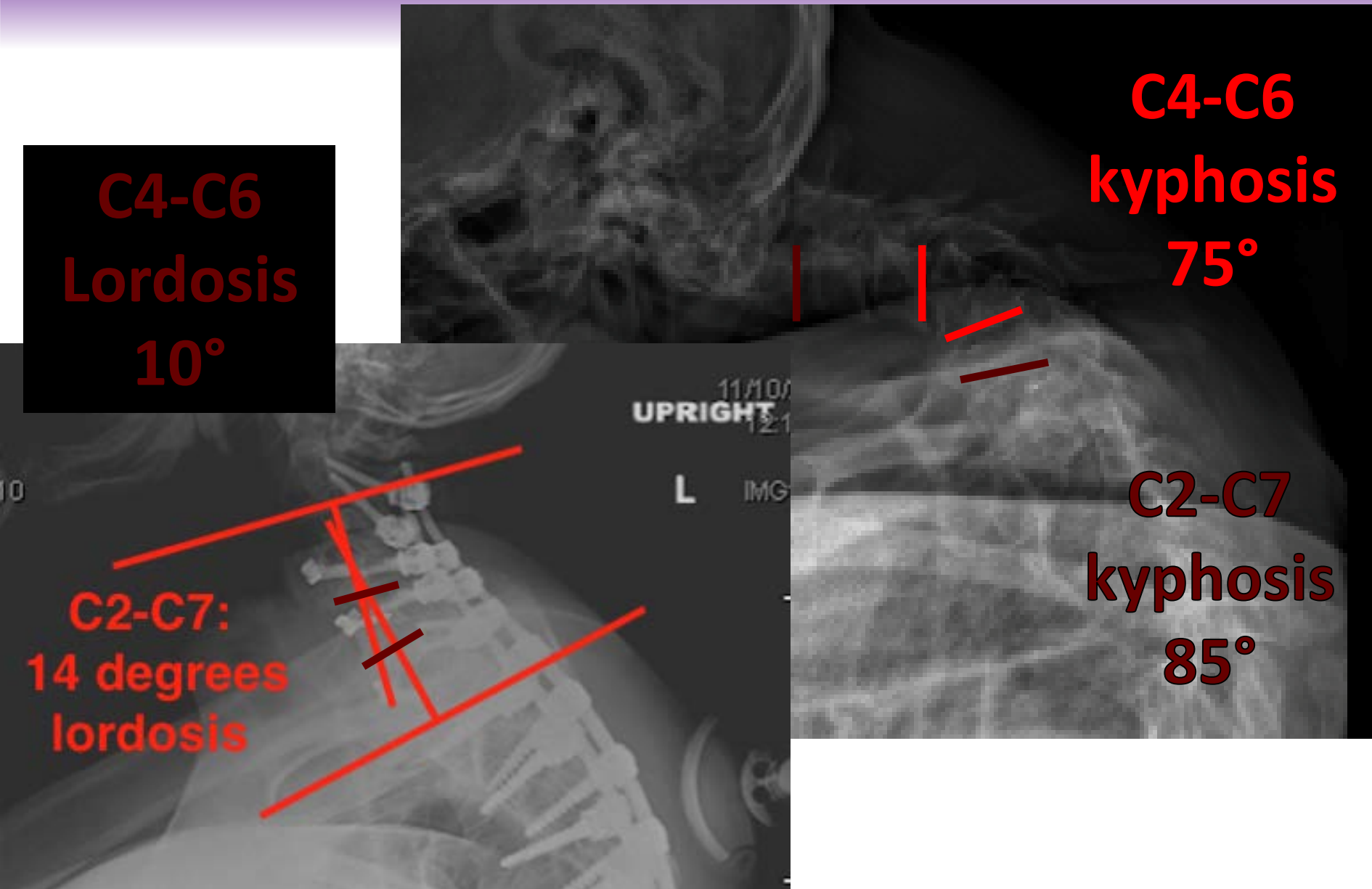
PRE- TO POST-OP ALIGNMENT

**C4-C6
Lordosis
10°**

**C4-C6
kyphosis
75°**

**C2-C7:
14 degrees
lordosis**

**C2-C7
kyphosis
85°**











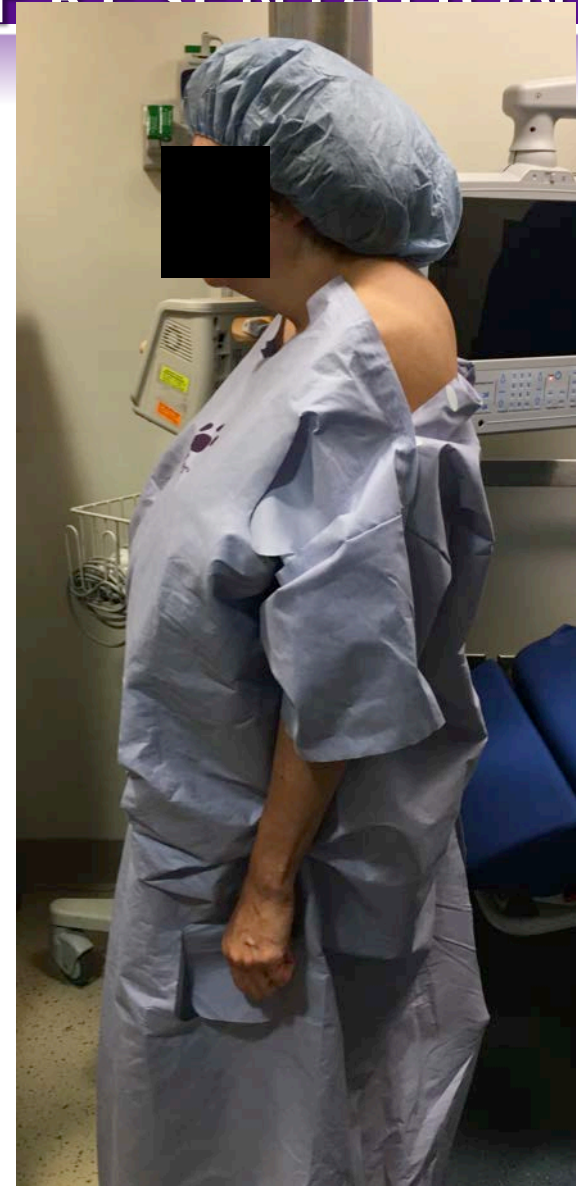
Case:

Fixed Cervical Sagittal

Deformity

CASE PRESENTATION

- ⊙ **57F who had a scoliosis correction as a child, complicated by PJK. As an adult, she underwent a T4 PSO and PSF from T1-T10 but she developed a PJK at C7-T1 post-operatively.**
- ⊙ **progressive deformity**
- ⊙ **her head is falling forward.**
- ⊙ **By the end of the day, her chin is at her chest**
- ⊙ **complains of an upper thoracic prominence and her appearance embarrasses her.**
- ⊙ **She failed conservative treatments including PT and bracing.**



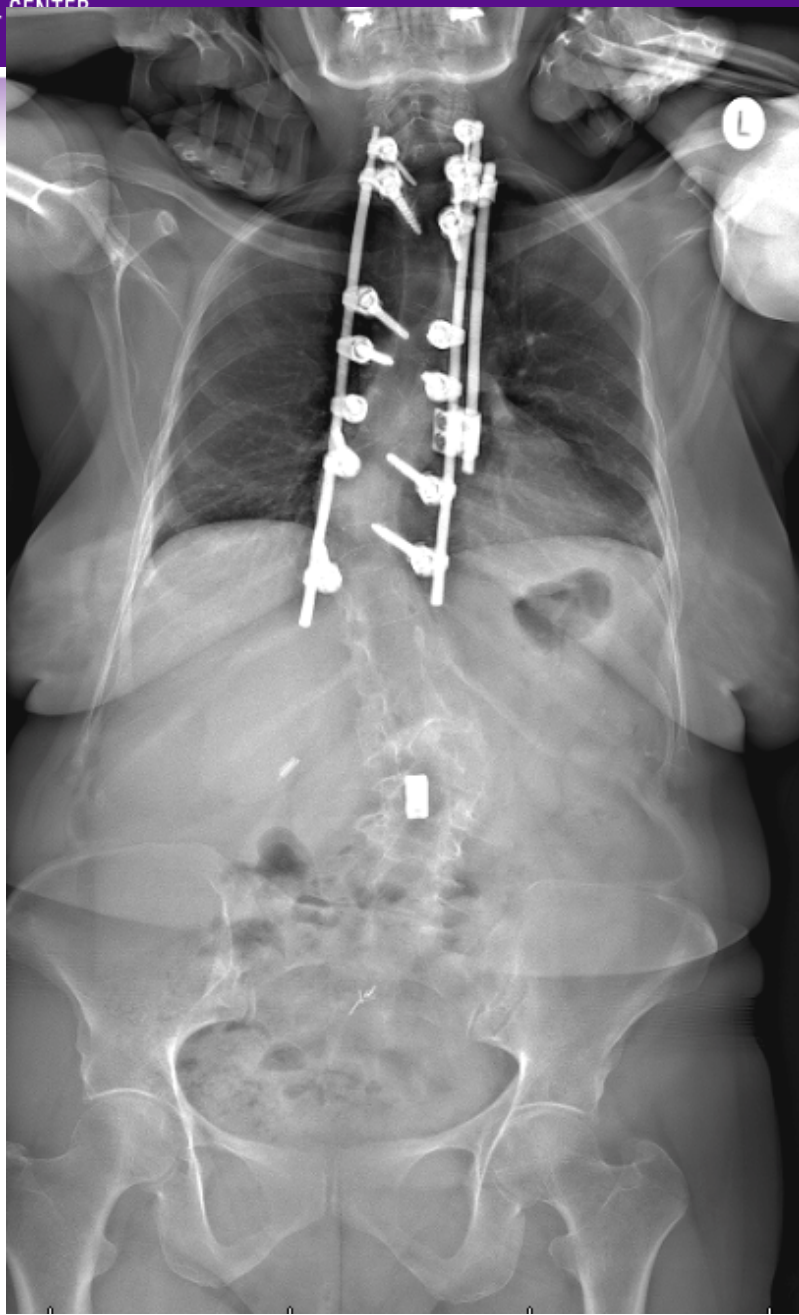
PRE-OP CLINICAL PHOTOS



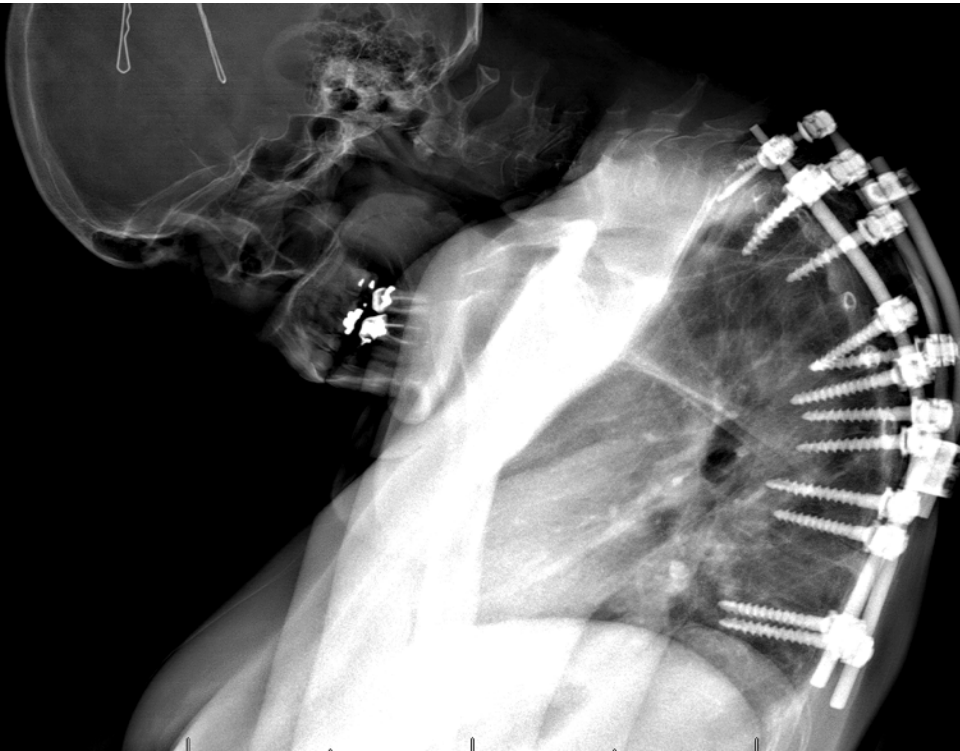
PRE-OP IMAGING



PRE-OP IMAGING

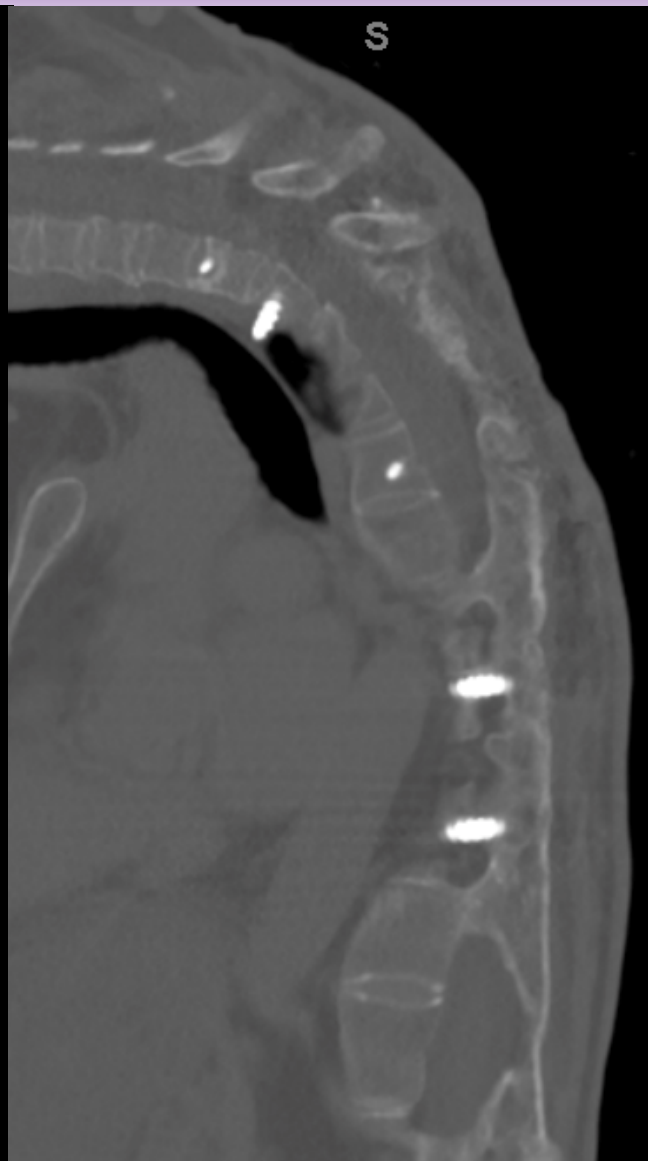
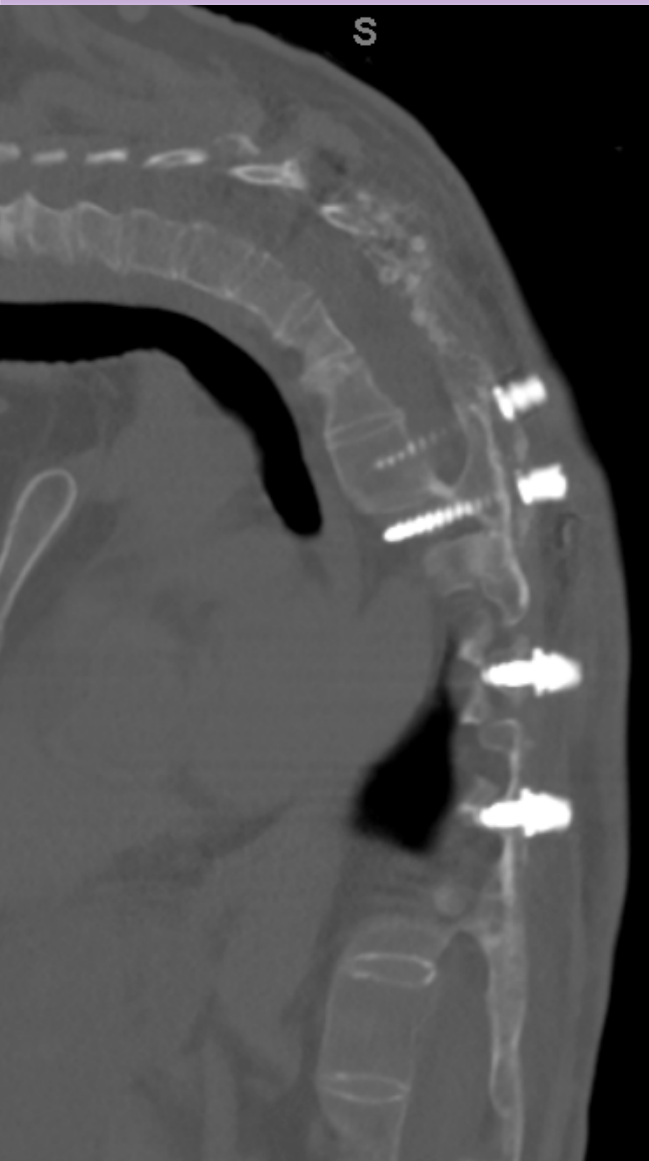


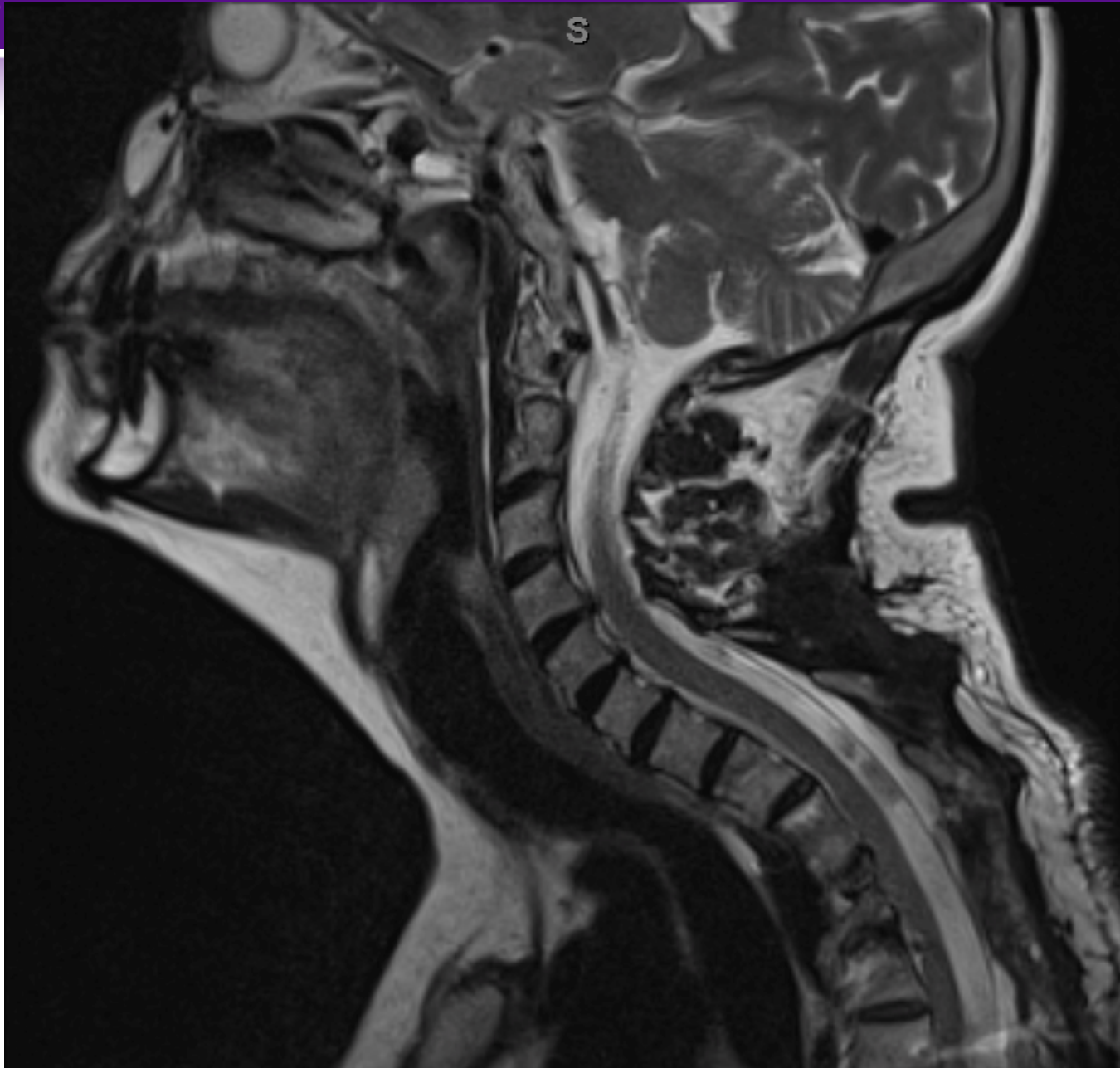
Flexion

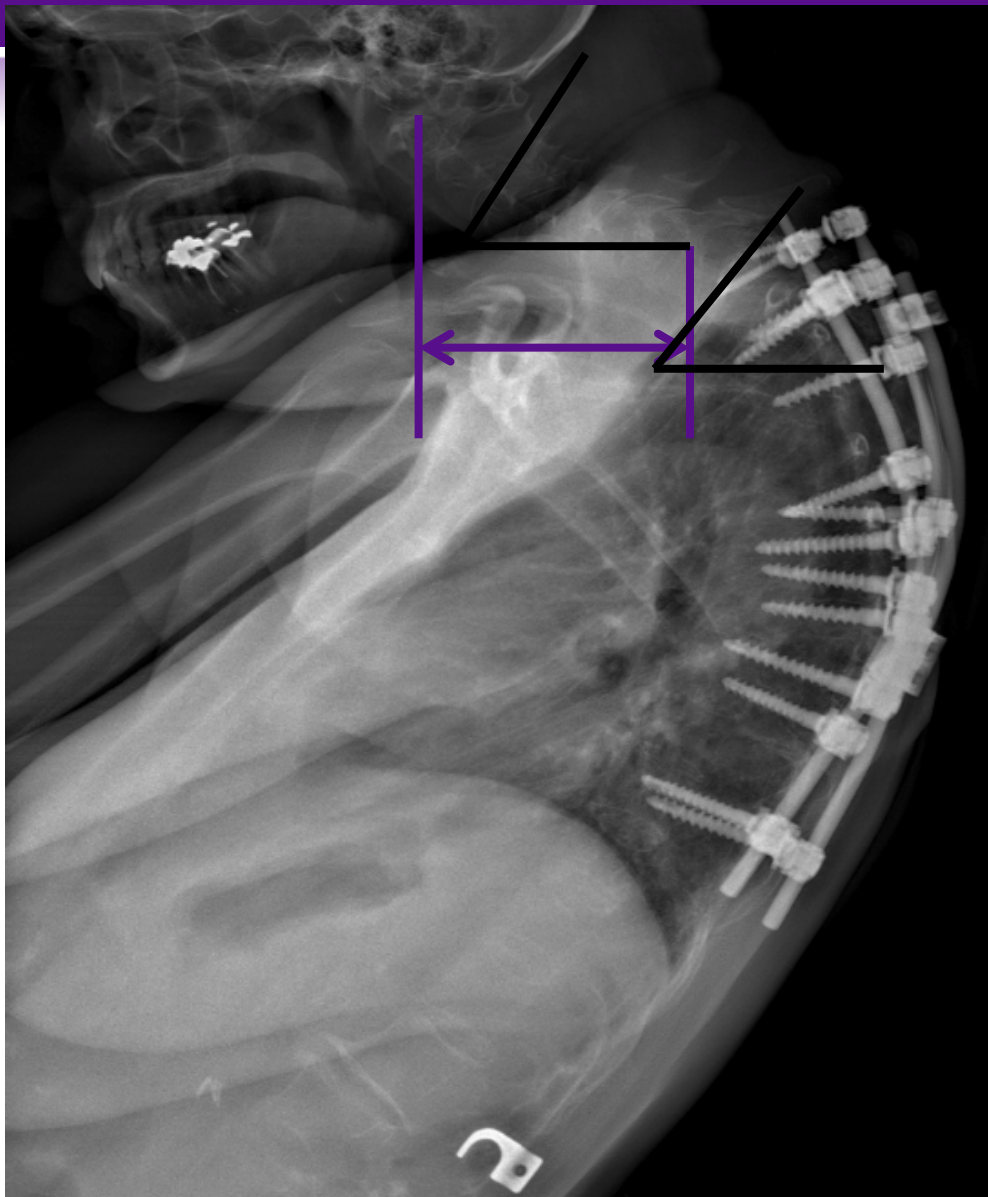


Extension







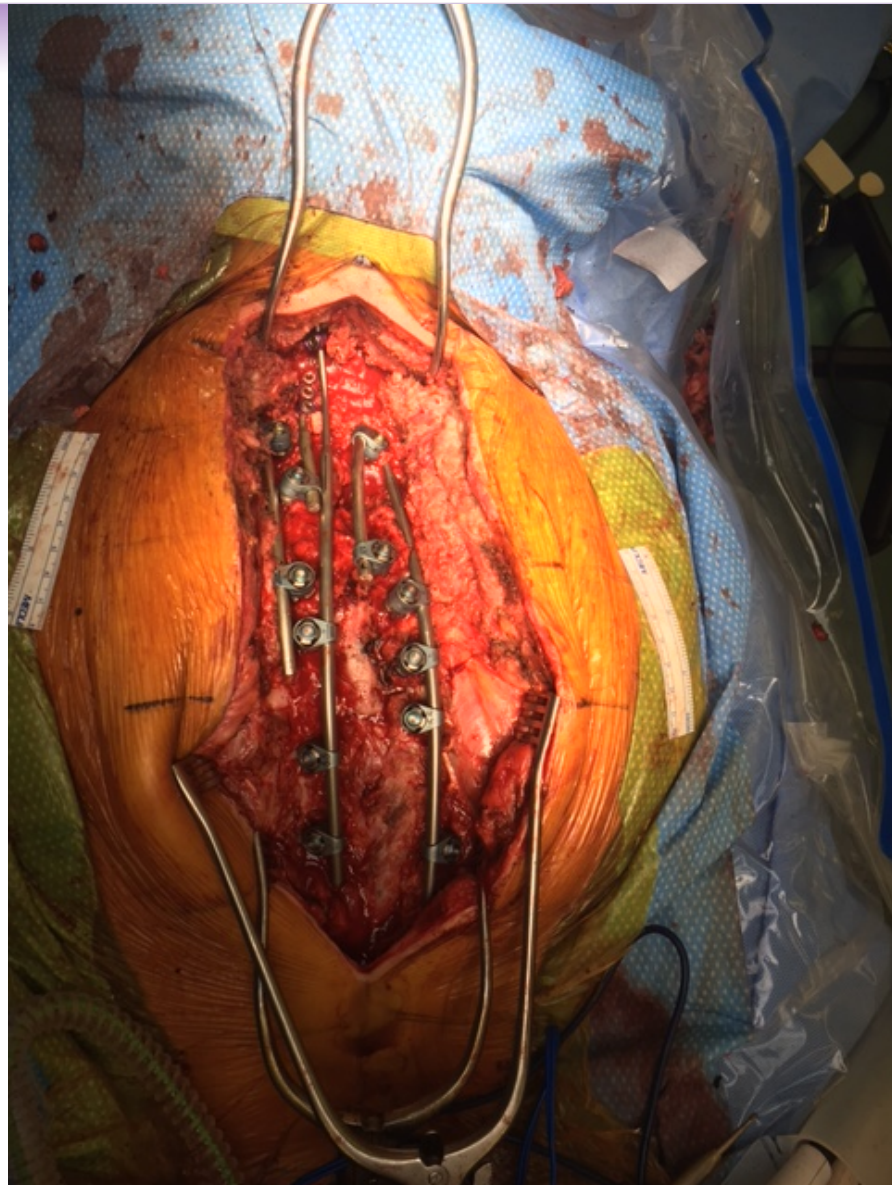


C2-C7 SVA 7.8 cm

C2 Slope 53°

T1 Slope 60°

- ◎ **VCR T2 with expandable cage**
- ◎ **C2 to T10 instrumentation**

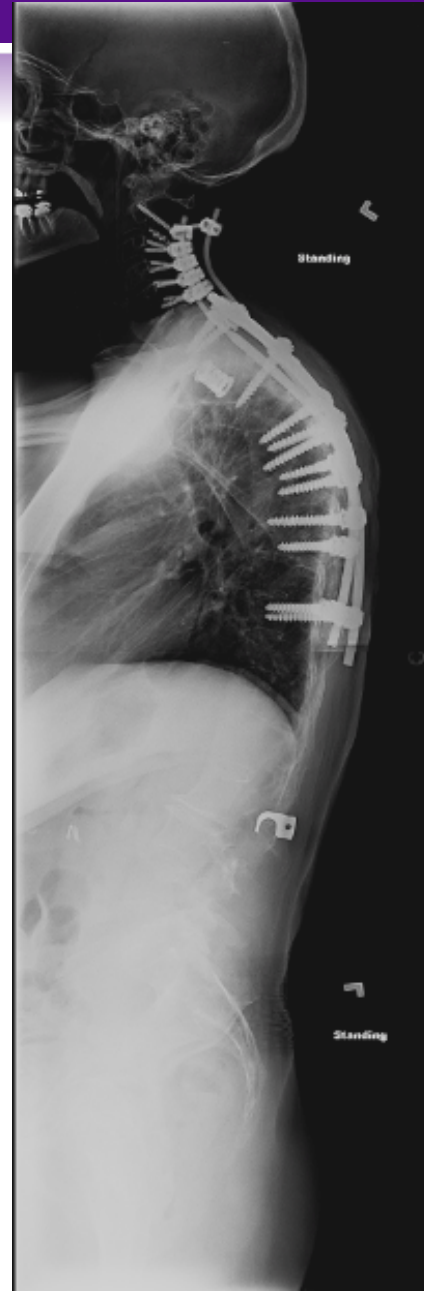


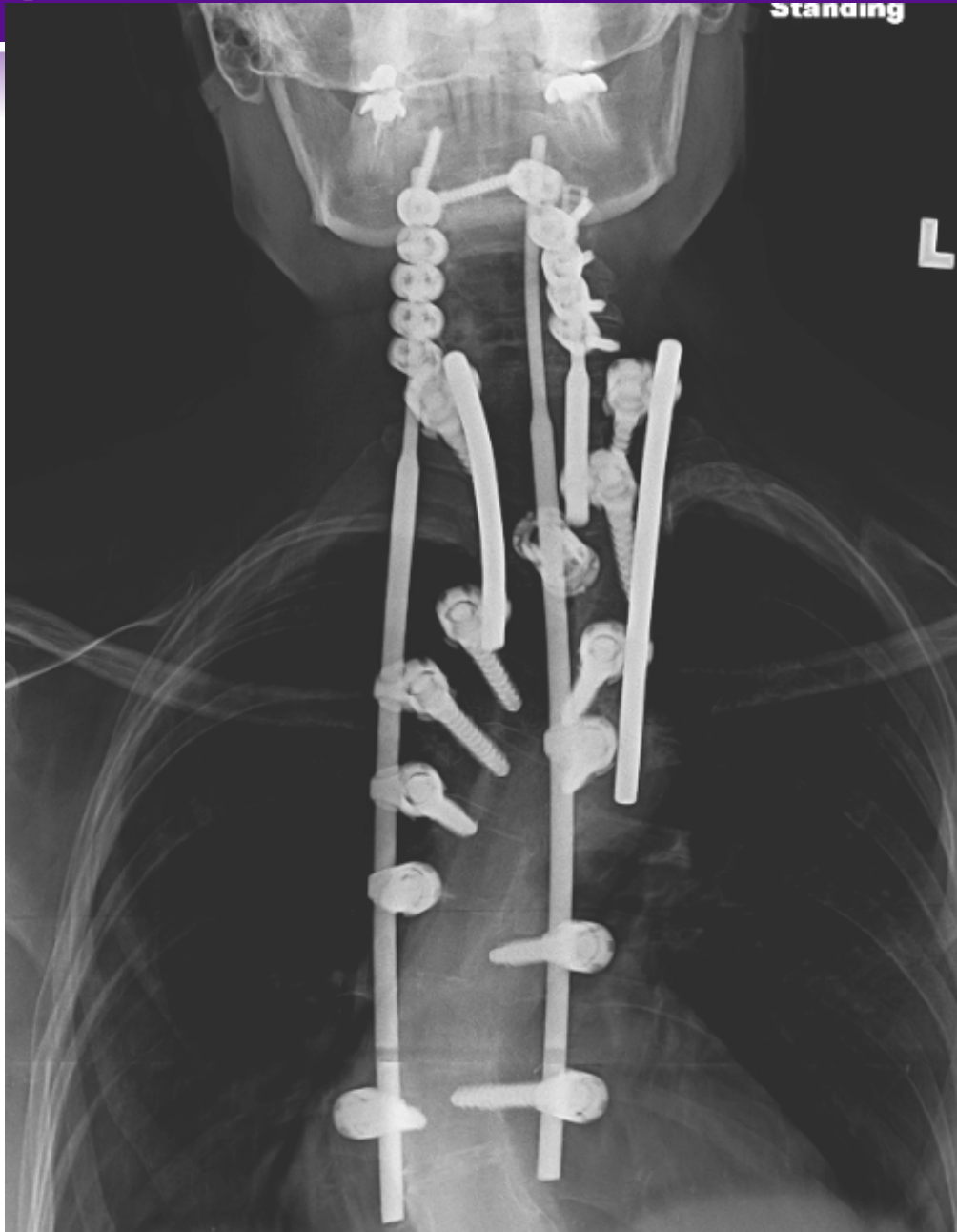
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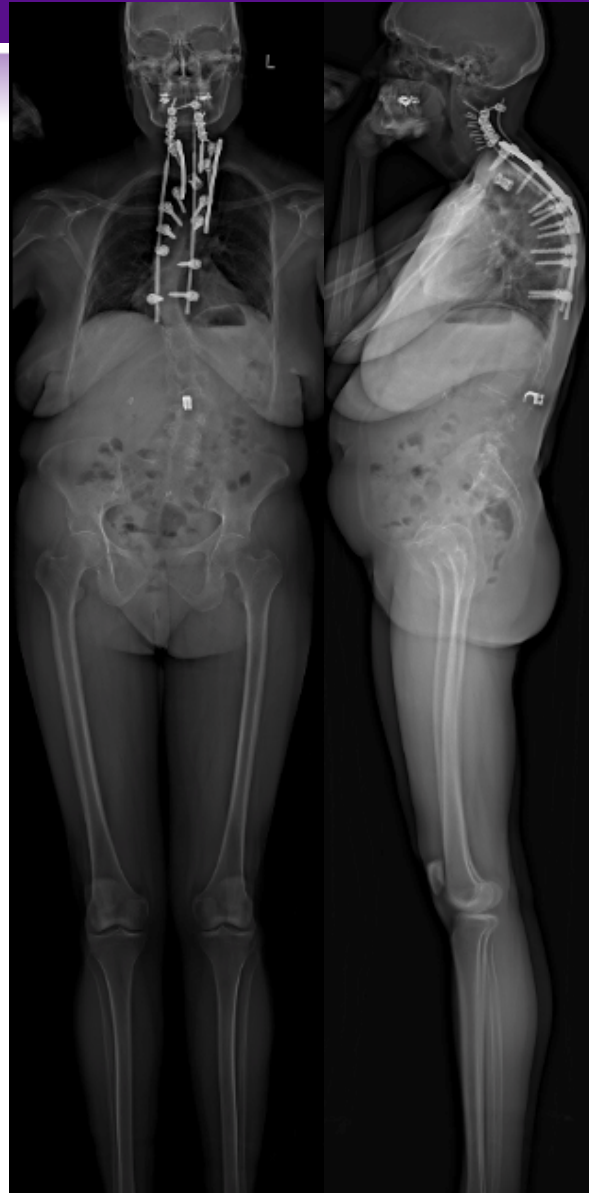


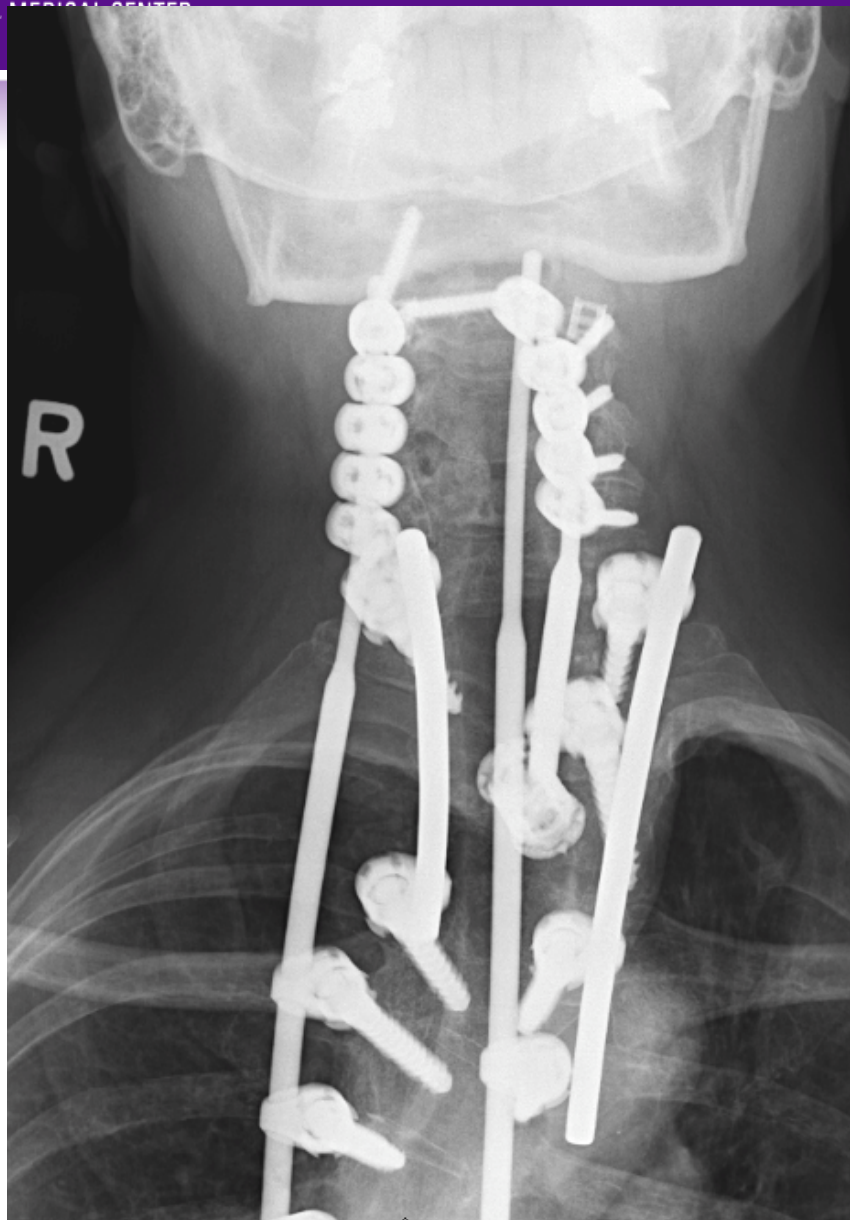


1 MONTH POST-OP

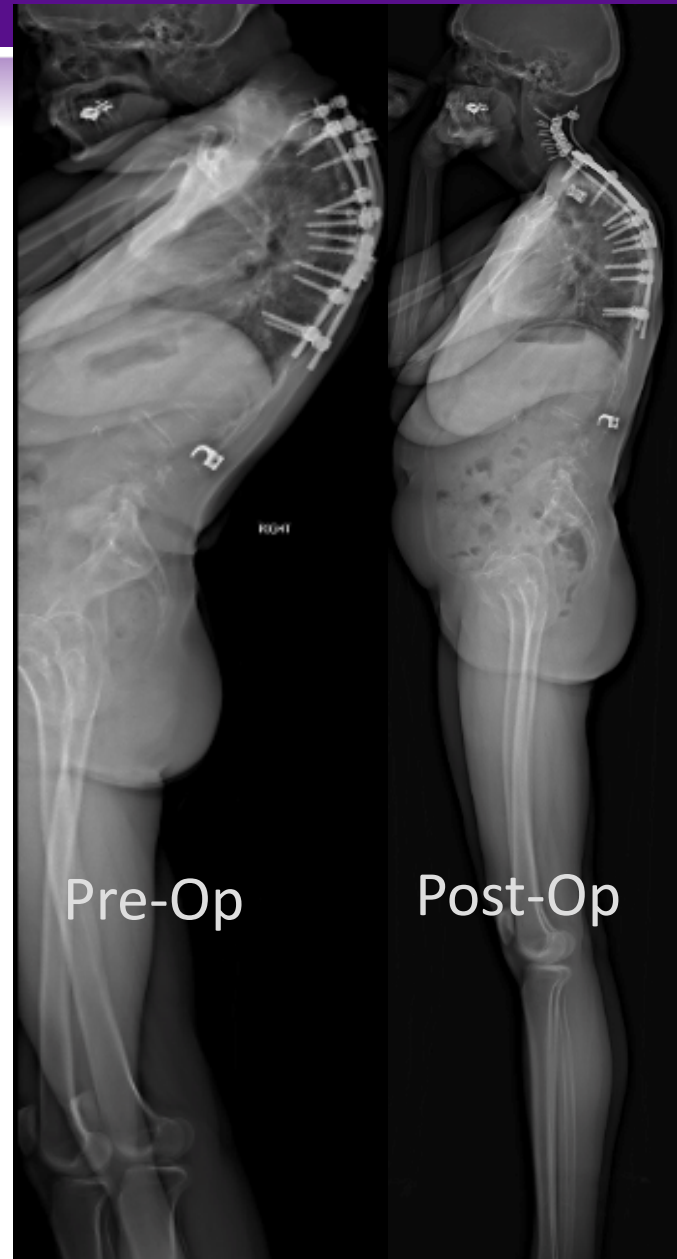
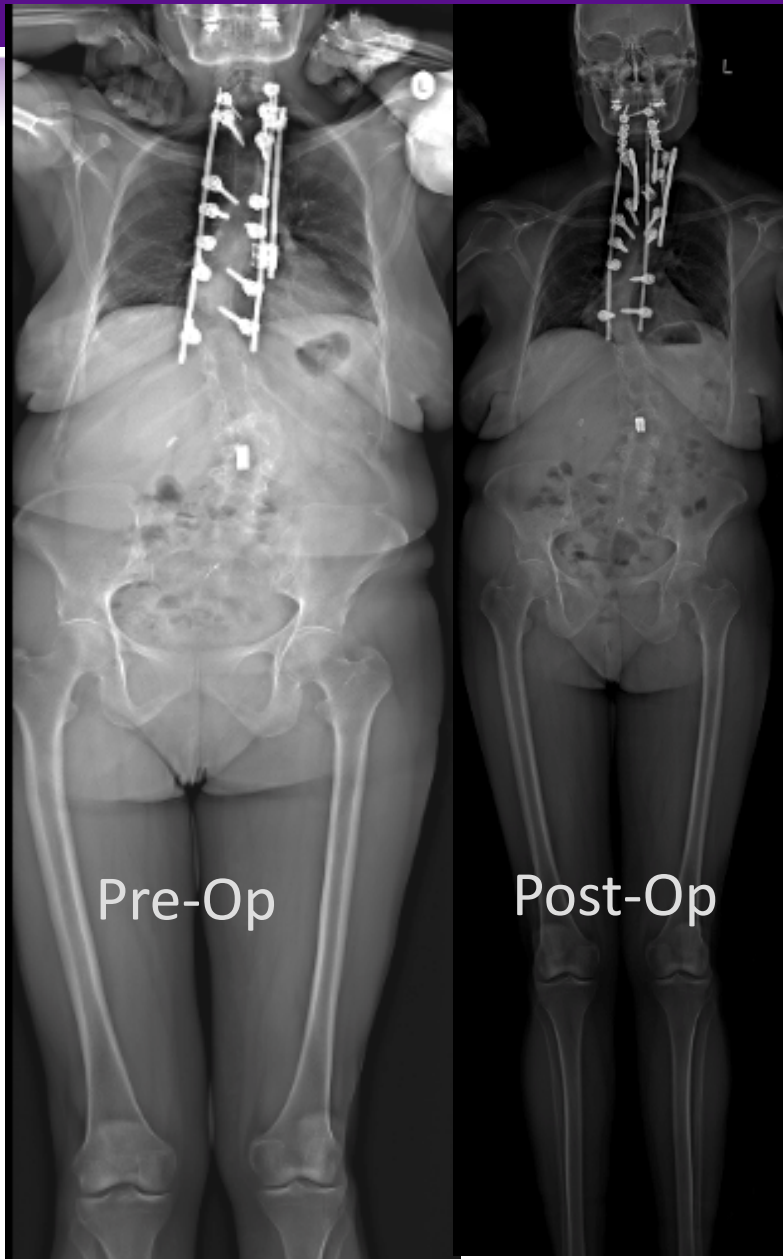




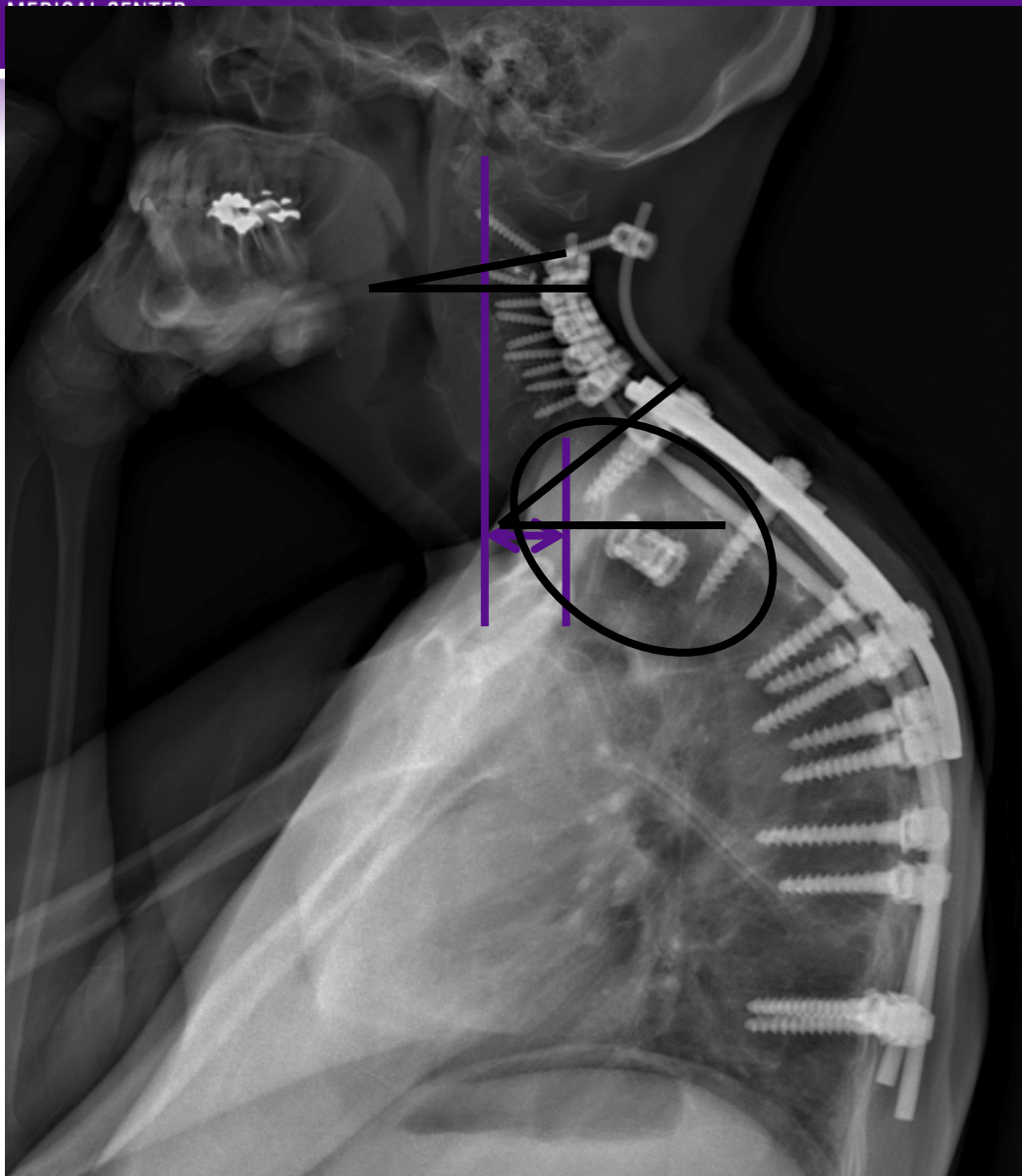




PRE-OP VS POST-OP IMAGING



POST-OP MEASUREMENTS



C2-C7 SVA

Pre-op: 7.8 cm

Post-op: 2.2 cm

C2 Slope

Pre-op: 53°

Post-op: 6°

T1 Slope

Pre-op: 60°

Post-op: 49°

T1-T3 Correction 45°

Pre-Op



Post-Op



Pre-Op



Post-Op



Case:

Partially-Flexible Cervical Sagittal Deformity

PARTIALLY FLEXIBLE CERVICAL DEFORMITY



PARTIALLY FLEXIBLE CERVICAL DEFORMITY



**70 yo F s/p C3-C6
lami/fusion for CSM**

**c/o forward thrust
to neck and
difficulty with
horizontal and
upward gaze**



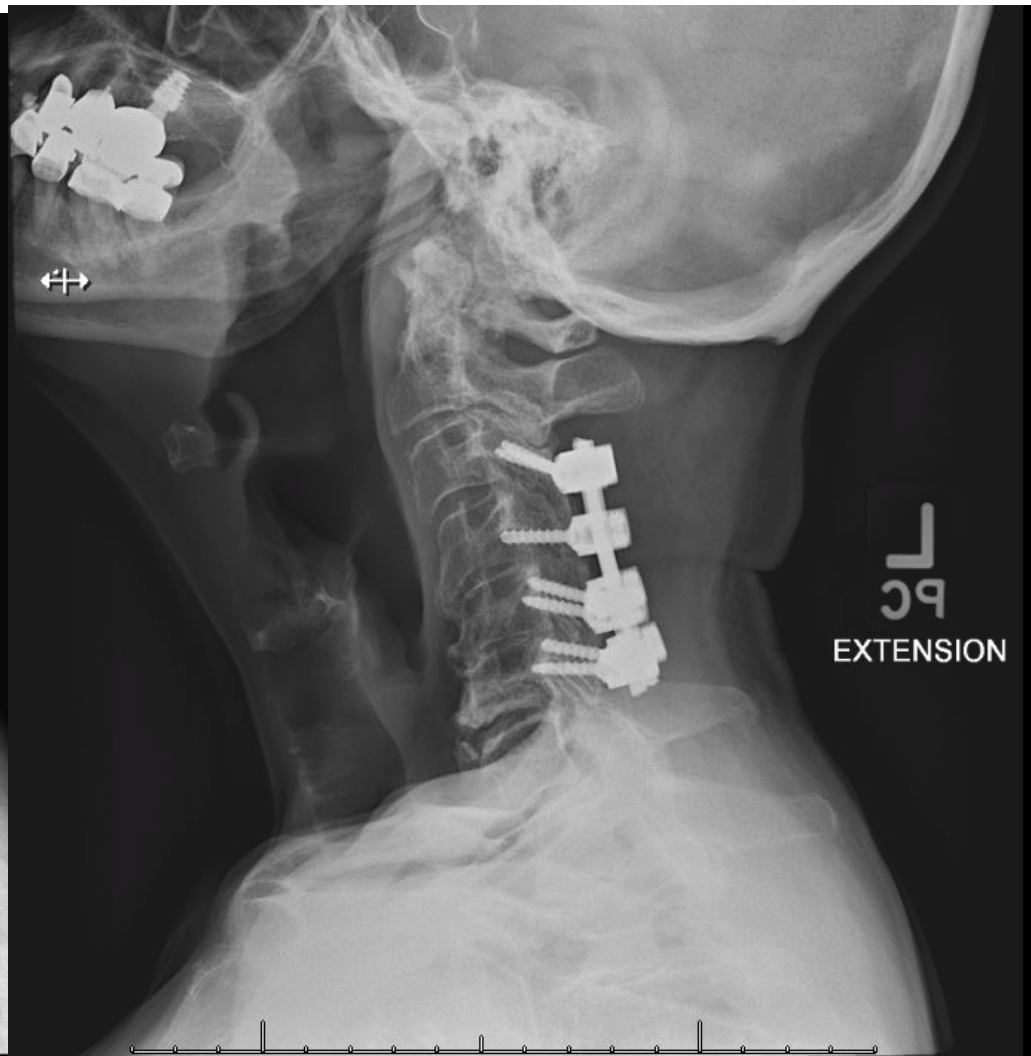
C2-C7 SVA = 4.9 cm

CL = -2°

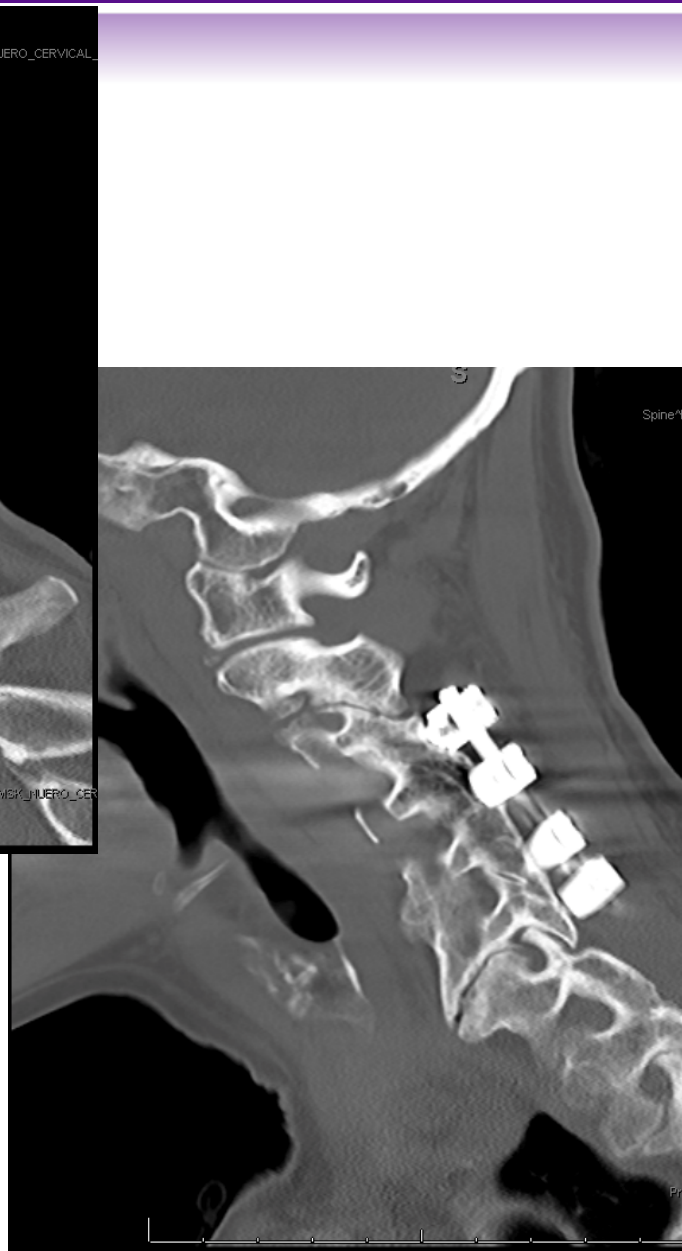
T1 Slope = 35°

TS-CL = 37°

PARTIALLY FLEXIBLE CERVICAL DEFORMITY



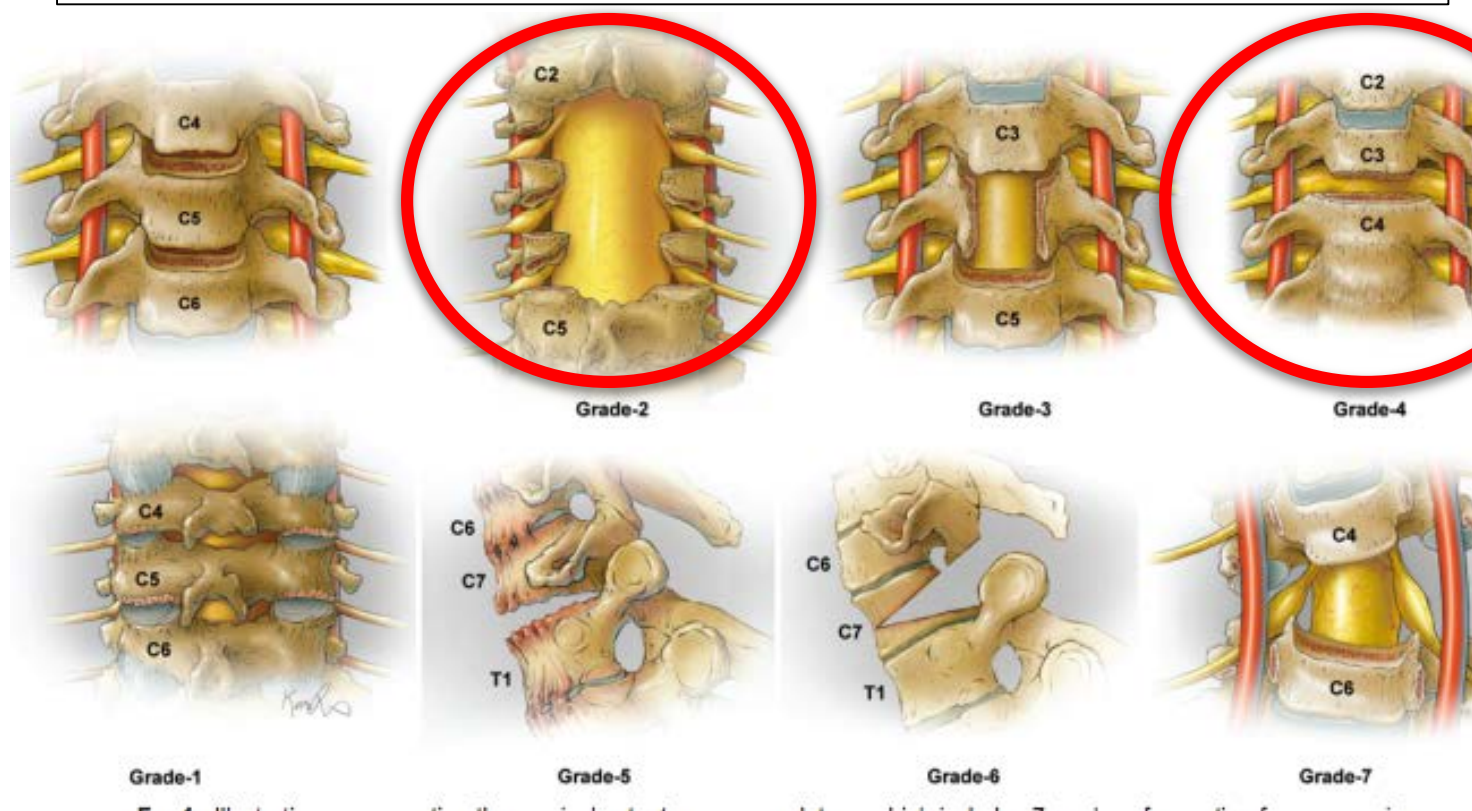
PARTIALLY FLEXIBLE CERVICAL DEFORMITY



A standardized nomenclature for cervical spine soft-tissue release and osteotomy for deformity correction

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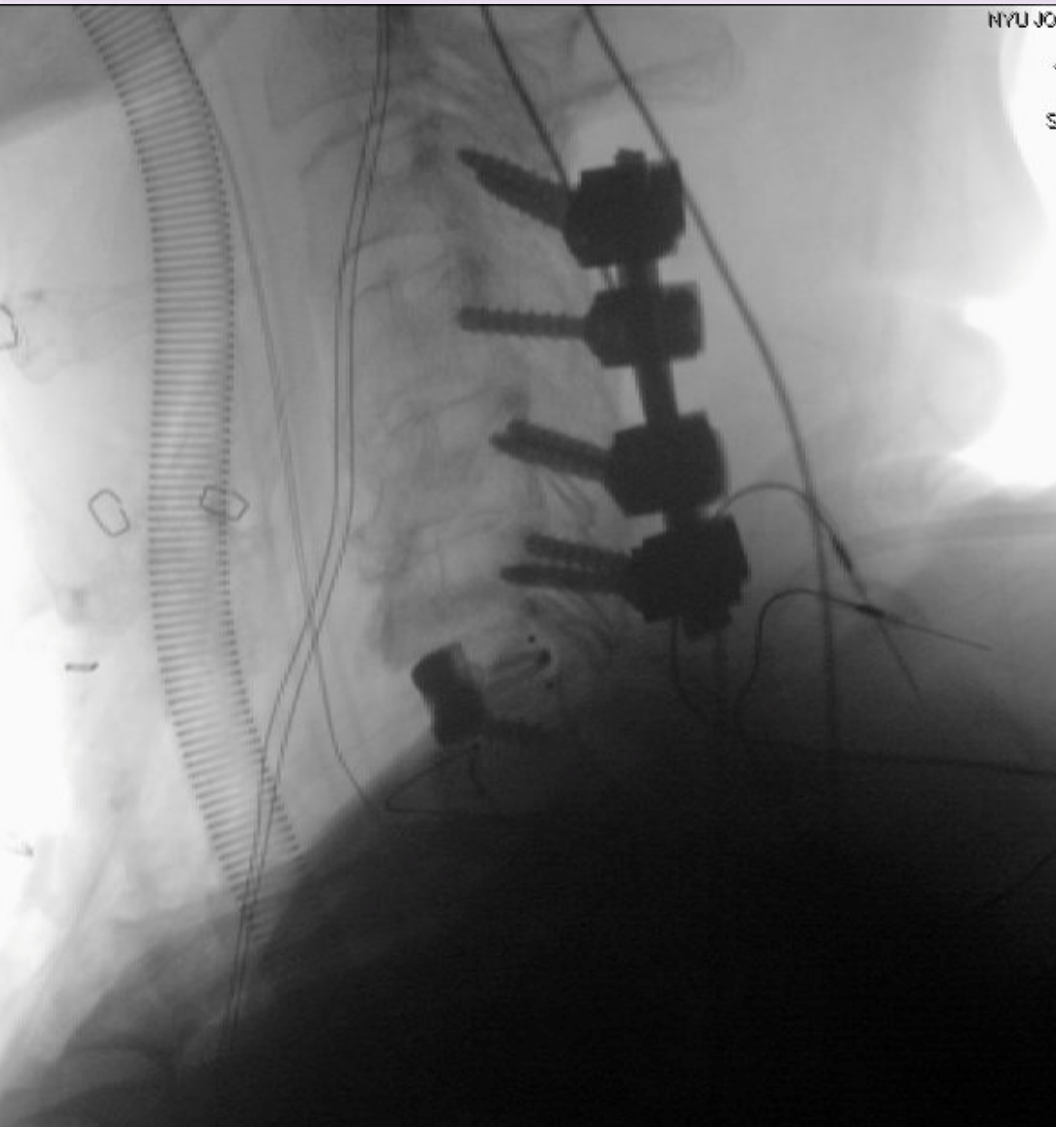
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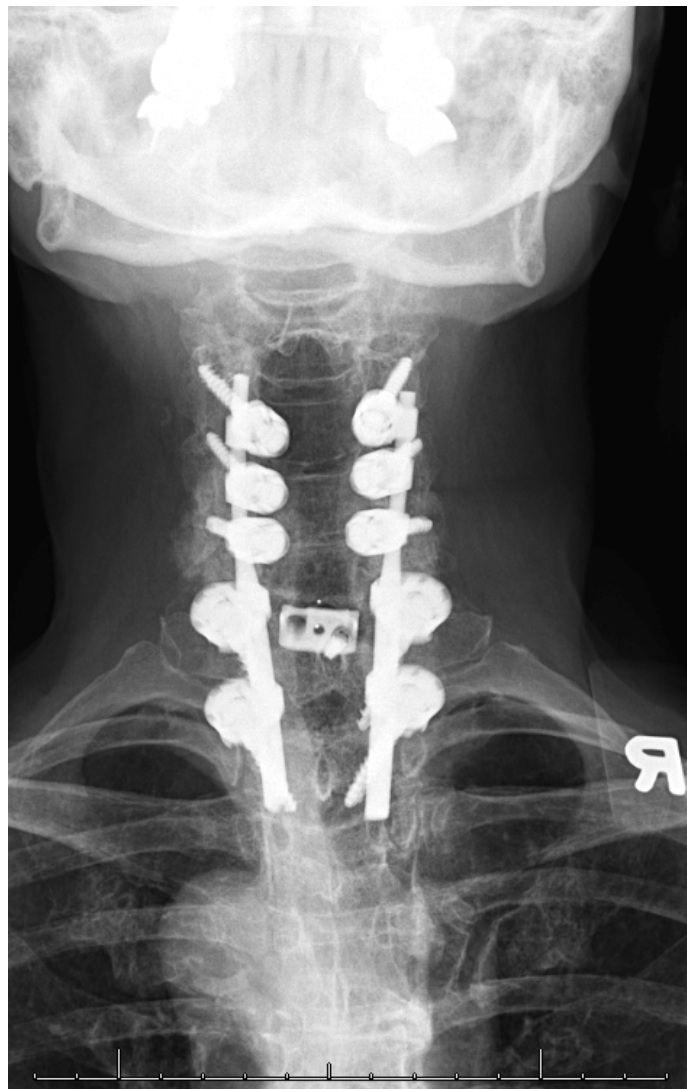
PARTIALLY FLEXIBLE CERVICAL DEFORMITY



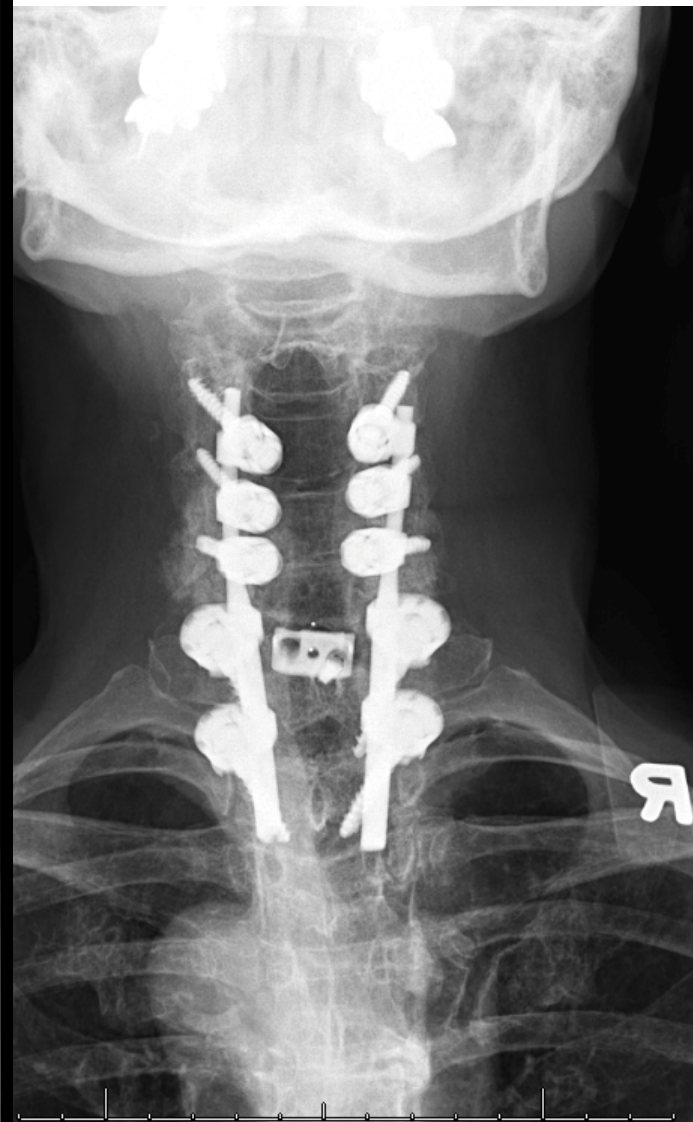
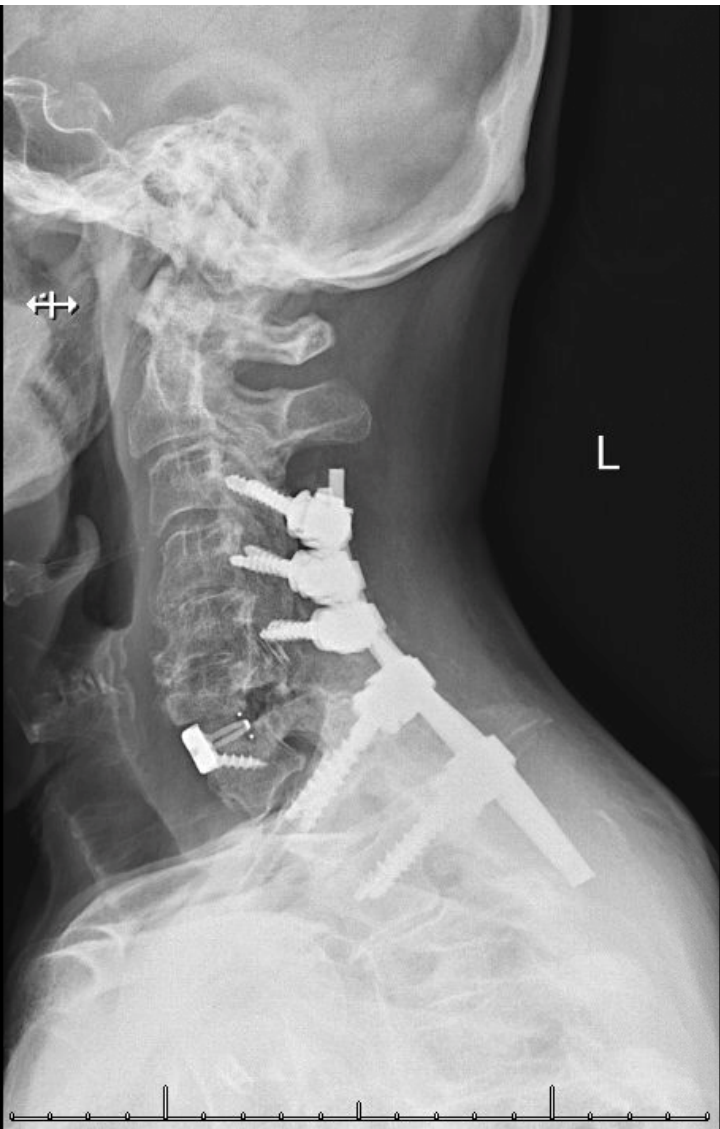
A/P SF&I C3 to T2

**Anterior: C6-7
Grade IV osteotomy
with zero profile
device/one screw**

**Posterior: C6-7
Grade II Ponte
osteotomy C3-T2
PSF&I**









C2-C7 SVA = 2.1 cm

CL = 36°

T1 Slope = 43°

TS-CL = 7°



PRE- TO POST-OP ALIGNMENT

Correction: cSVA = 2.8 cm
CL = 38°

Preop



Postop



Preop



Postop

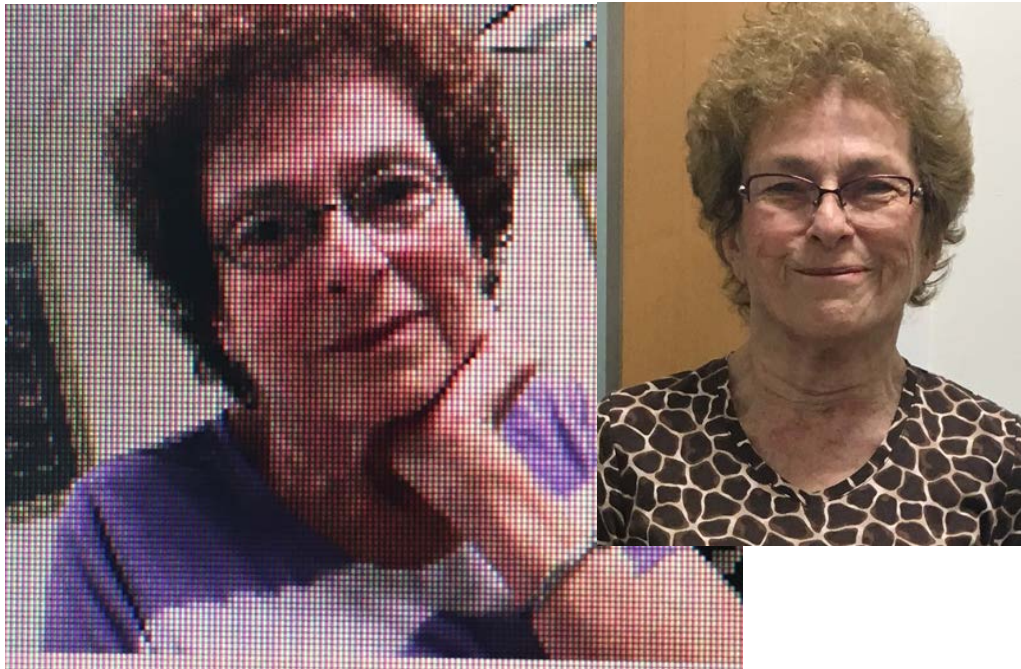


PRE- TO POST-OP ALIGNMENT

Correction: cSVA = 2.8 cm
CL = 38°

Preop

Postop



Preop

Postop



Case:

Fixed Cervical Sagittal

Deformity

FIXED CERVICAL DEFORMITY



**55 yo F s/p C4-T3
lami/fusion for C7
burst Fx**

**c/o forward thrust
to neck and
difficulty with
horizontal and
upward gaze**

FIXED CERVICAL DEFORMITY



cSVA = 6.3 cm

CL = -9°

T1 Slope = 26°

TS-CL = 33°

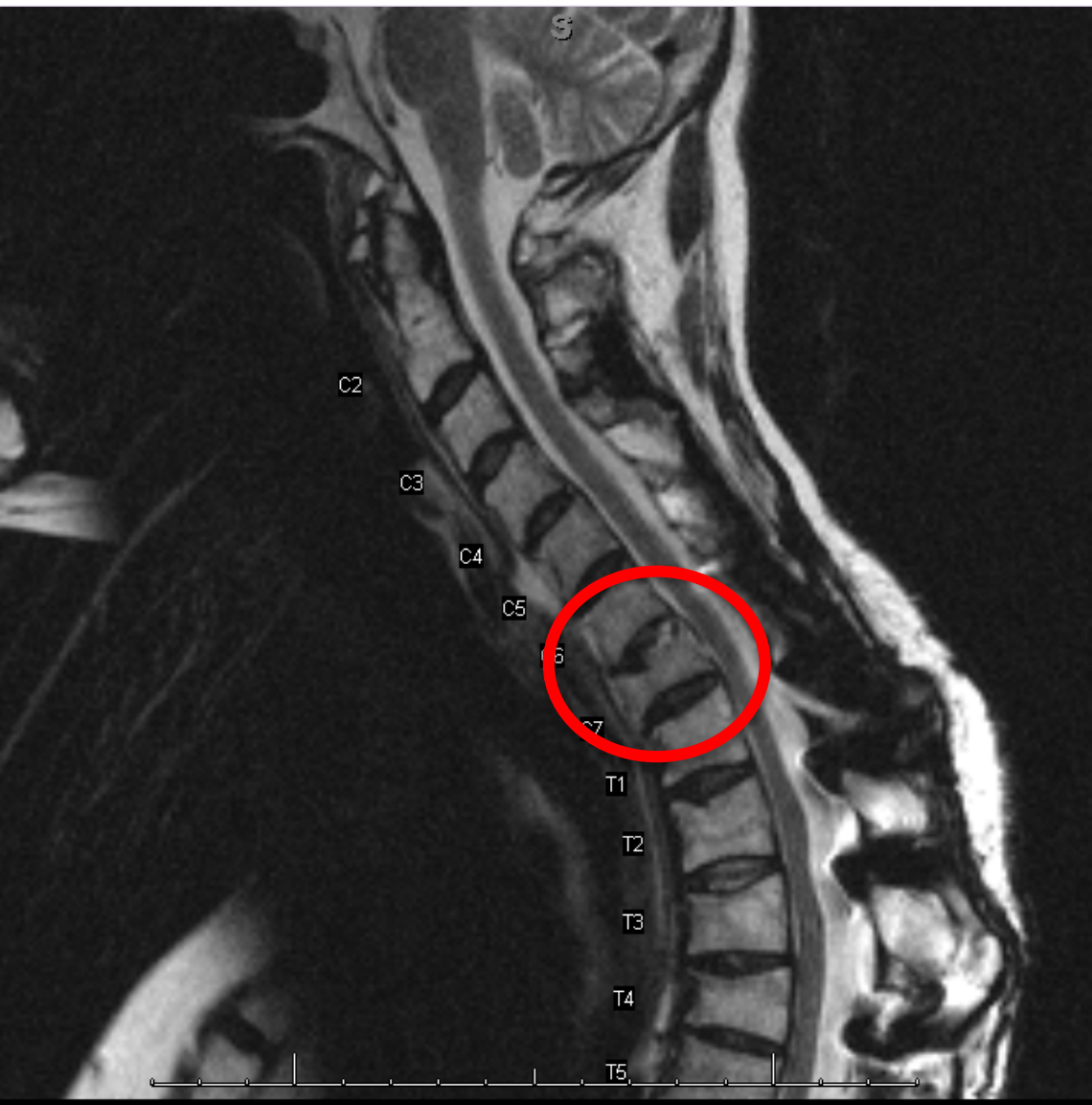
FIXED CERVICAL DEFORMITY

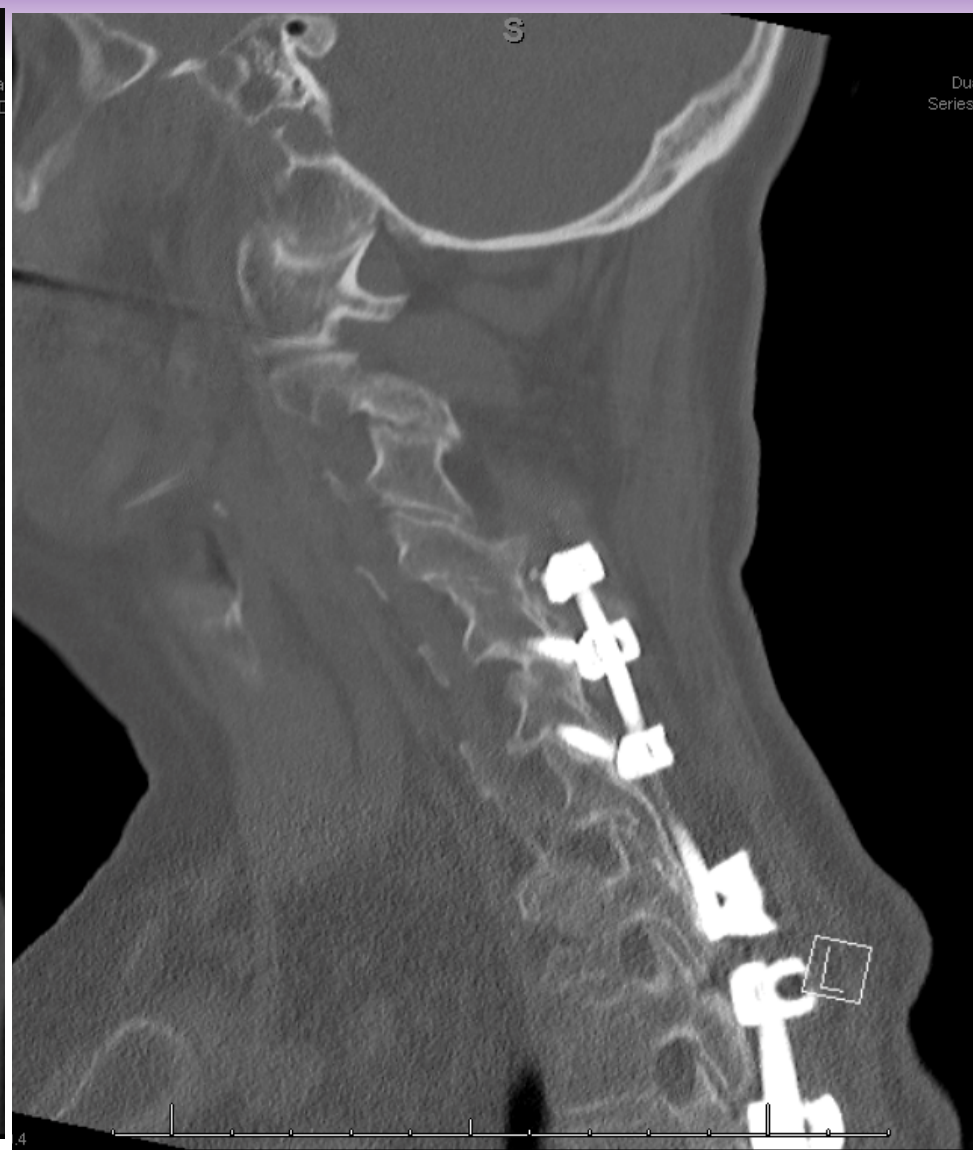
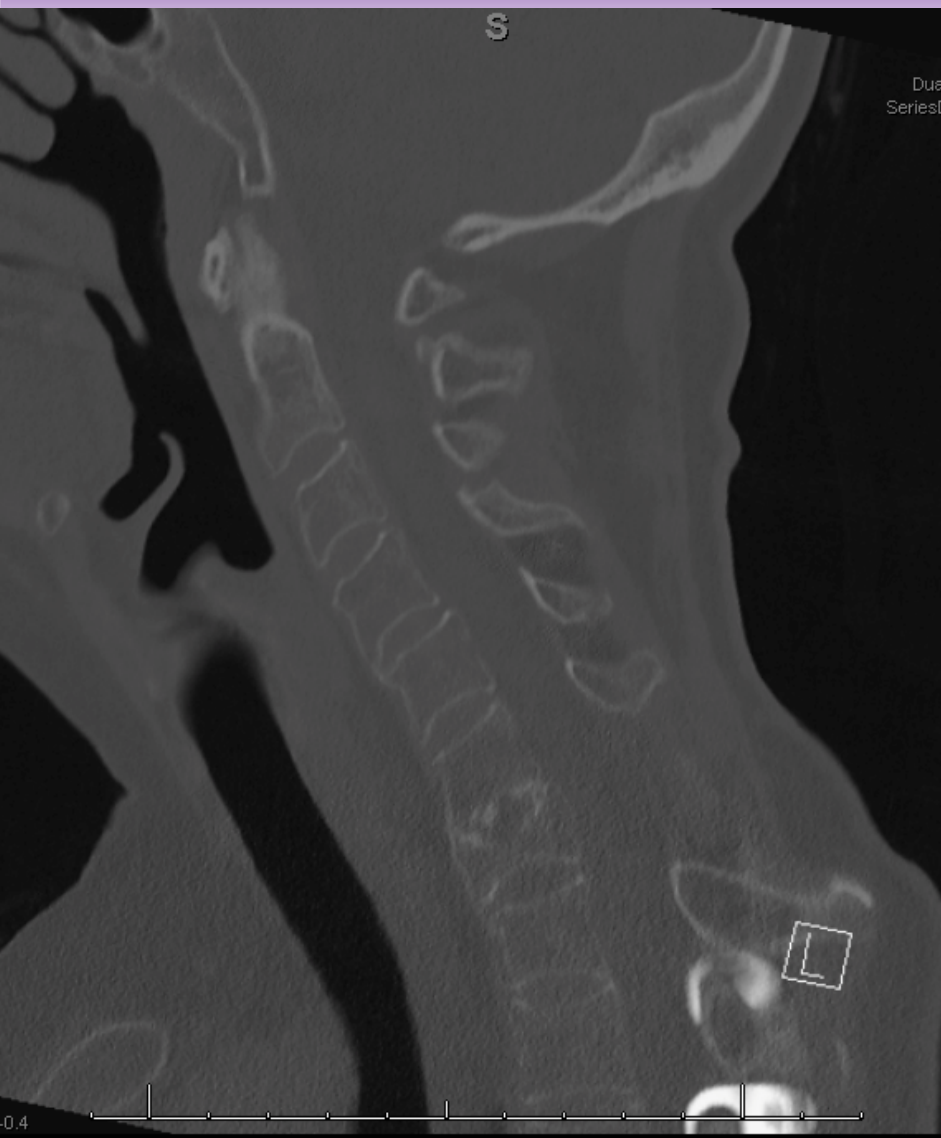


**Neck Flexion /
Extension ROM**

FIXED CERVICAL DEFORMITY



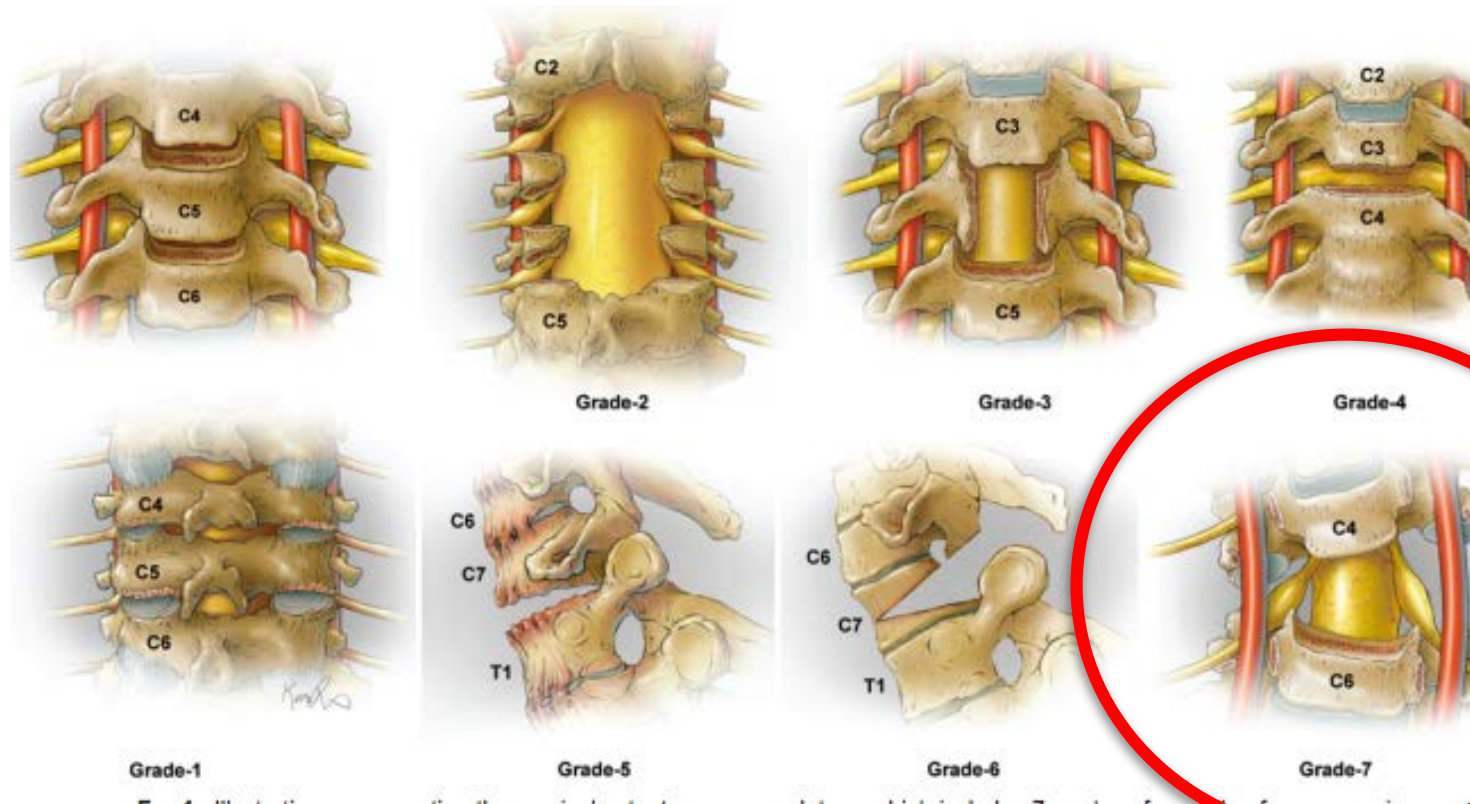




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Technique of cervicothoracic junction pedicle subtraction osteotomy for cervical sagittal imbalance: report of 11 cases

Clinical article

VEDAT DEVIREN, M.D.,¹ JUSTIN K. SCHEER, B.S.,² AND CHRISTOPHER P. AMES, M.D.²

Departments of ¹Orthopaedic Surgery and ²Neurological Surgery, University of California, San Francisco, California

J NS 2011

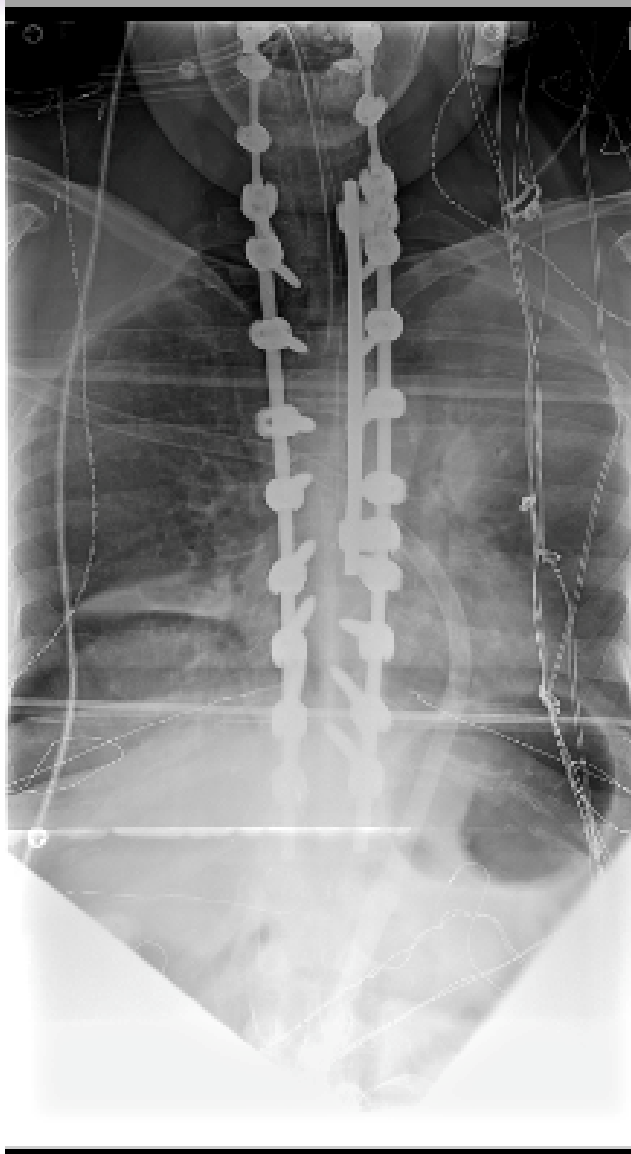


- **11 PSO patients (C6, C7, T1)**
- **19° mean correction**
- **1100 mL mean EBL**
- **4.5 hours mean OR time**



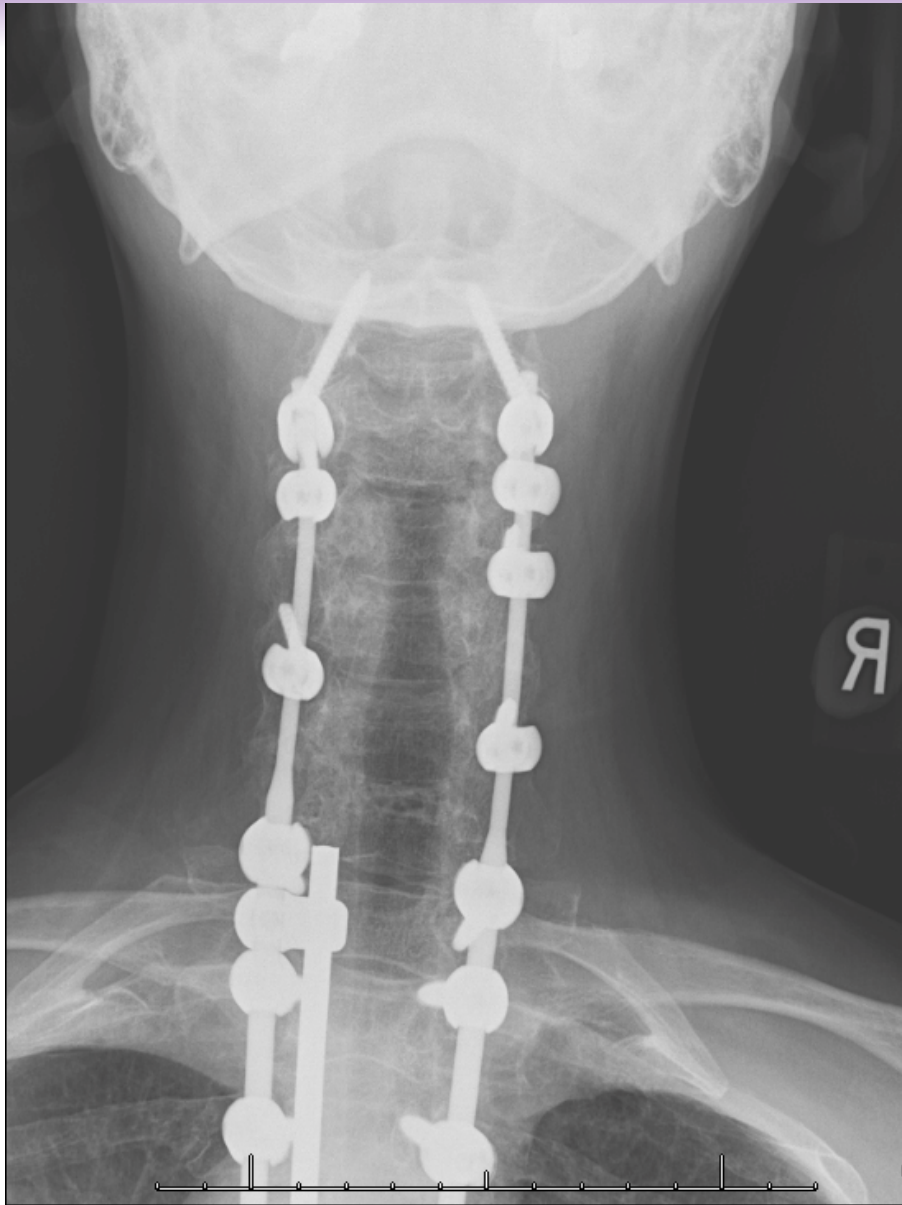
**Grade VII
VCR**

INTRAOP FIXED CERVICAL DEFORMITY



PSF&I C2 to T10

T3 Grade VII VCR





cSVA = 4.3 cm

CL = -4°

T1 Slope = 28°

TS-CL = 32°

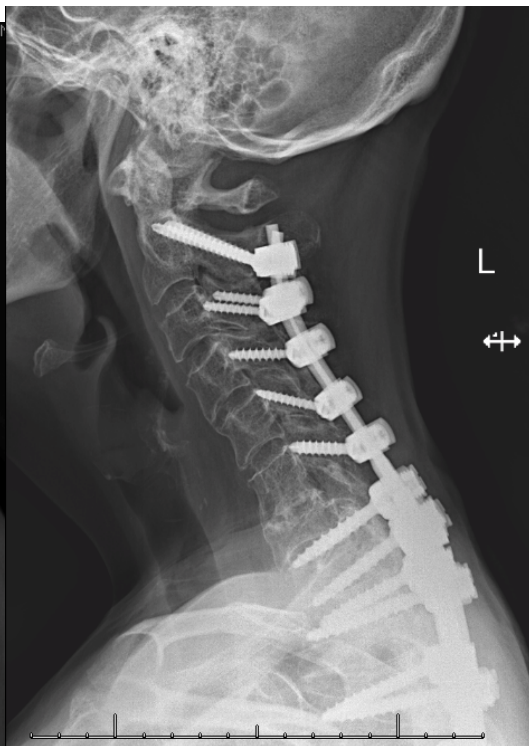
PRE- TO POST-OP ALIGNMENT

Correction: cSVA = 2.0 cm
T2/T4A = 35°

Preop



Postop



Preop



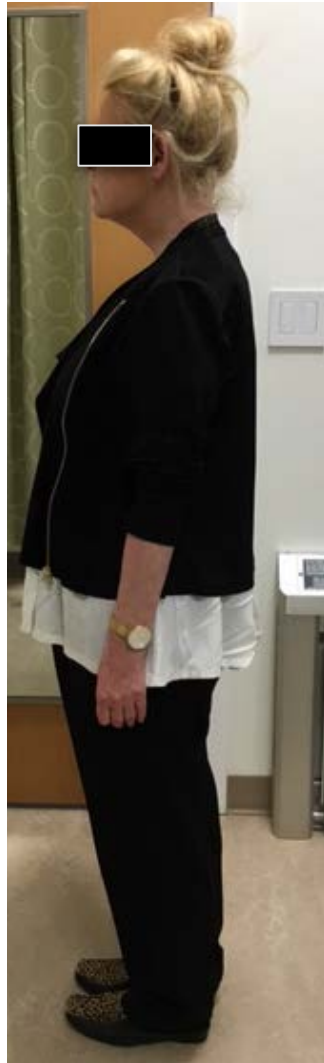
Postop



Preop



Postop



Preop



Postop



THANK YOU

