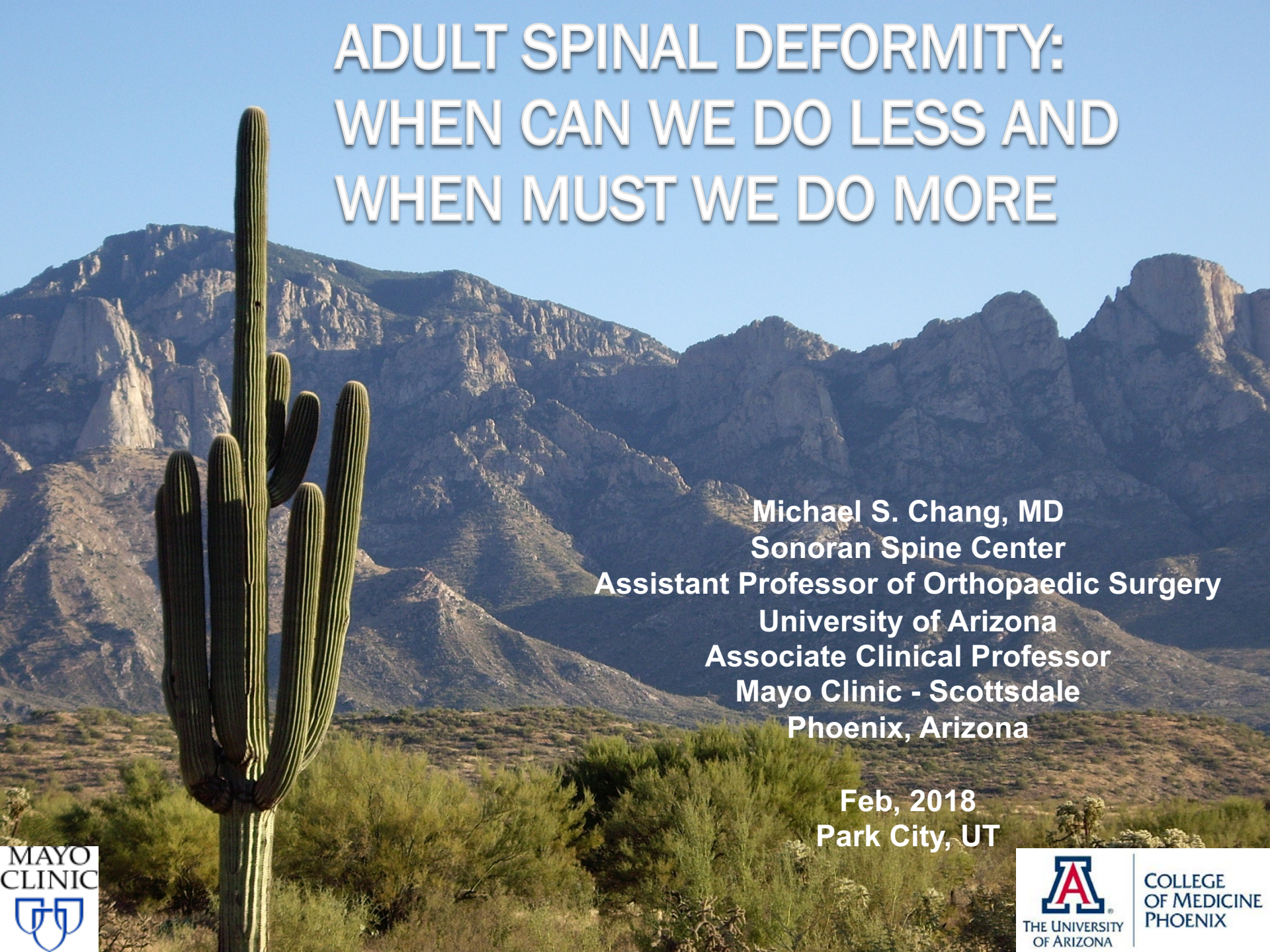
ADULT SPINAL DEFORMITY: WHEN CAN WE DO LESS AND WHEN MUST WE DO MORE



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Phoenix, Arizona

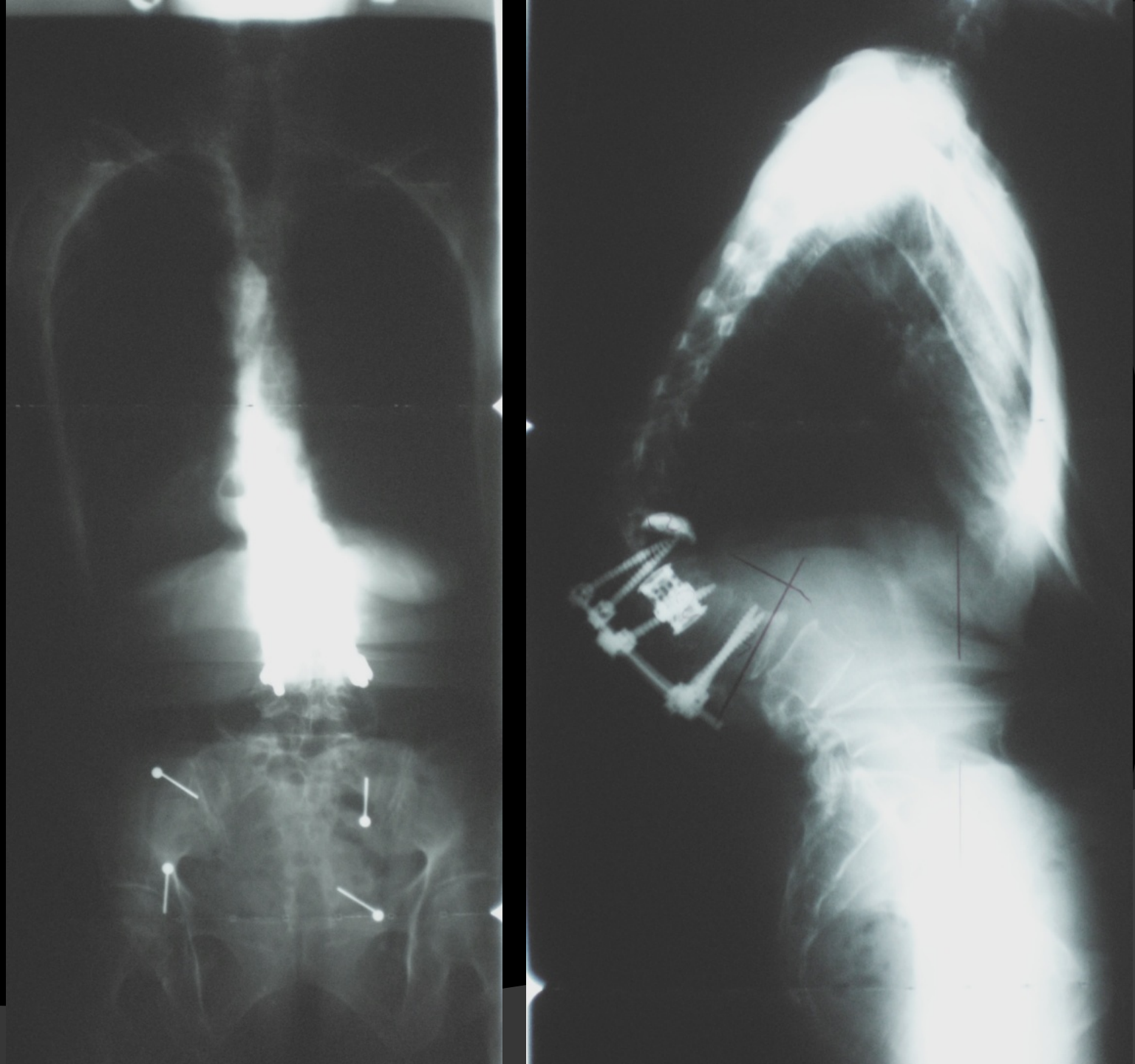
Feb, 2018
Park City, UT

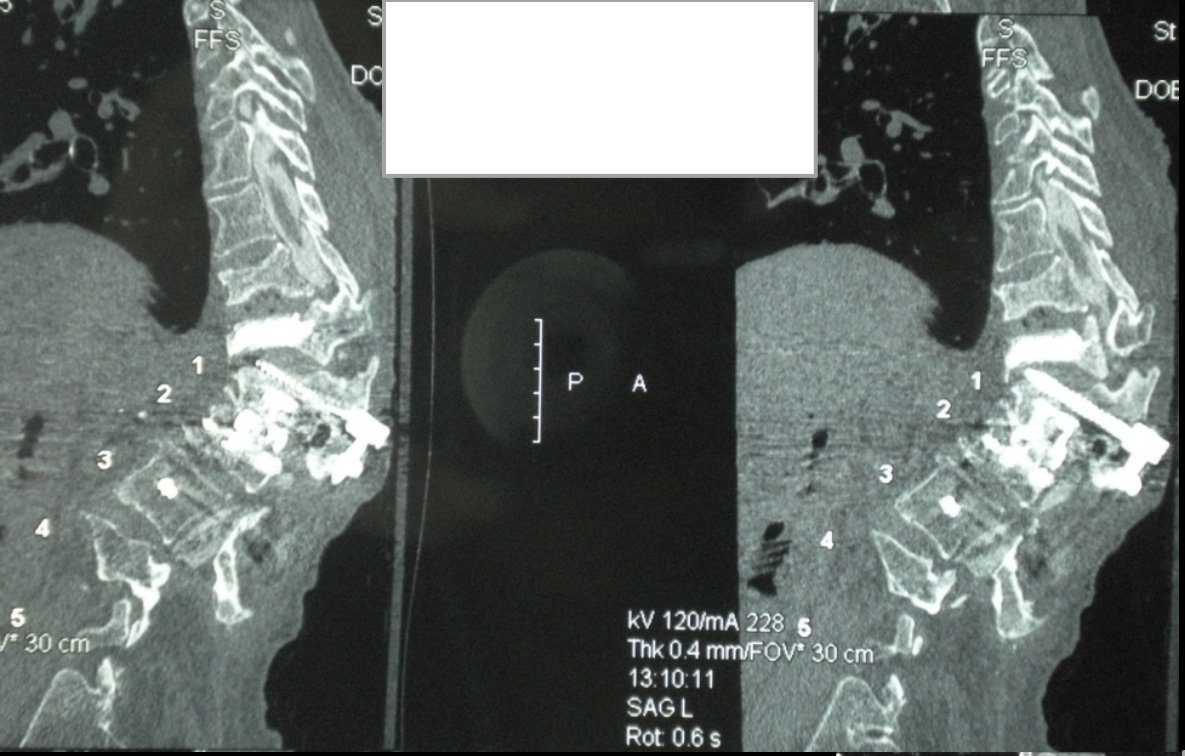
MAYO CLINIC

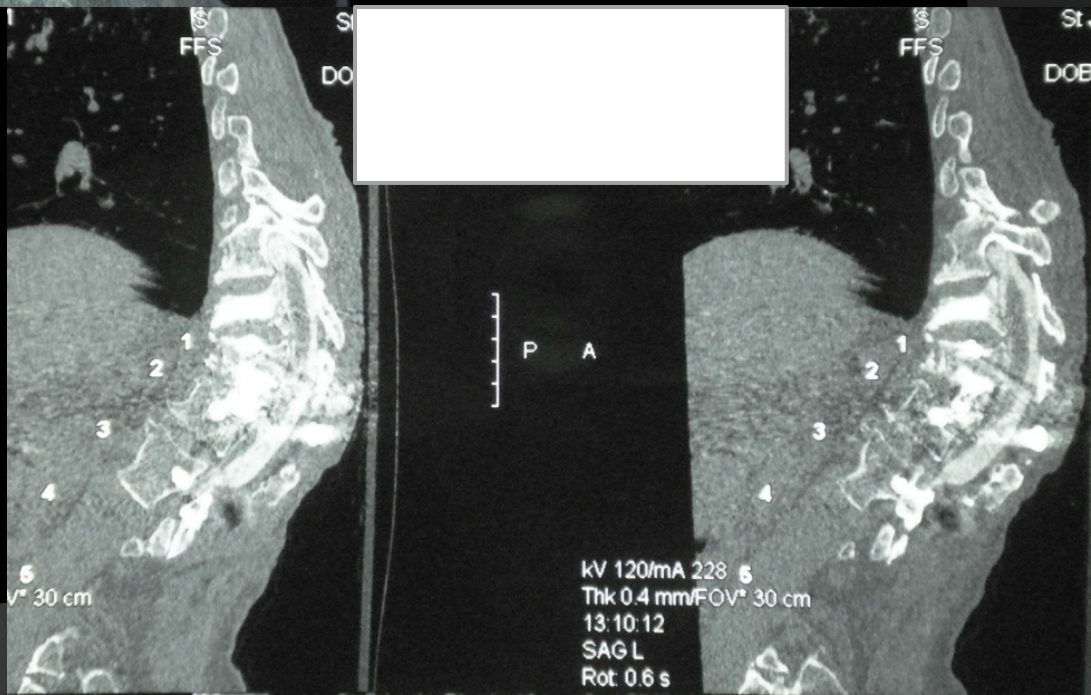
THE UNIVERSITY OF ARIZONA COLLEGE OF MEDICINE PHOENIX

Case: 82 F c/o LBP

2 sx for L2 and T12 comp fx, 80 lbs, T = -2.5




FFS
P A
1
2
3
4
5
kV 120/mA 228
Thk 0.4 mm/FOV* 30 cm
13:10:11
SAG L
Rot 0.6 s


FFS
P A
1
2
3
4
5
kV 120/mA 228
Thk 0.4 mm/FOV* 30 cm
13:10:12
SAG L
Rot 0.6 s

Should I even offer surgery?

- Real challenge is in deciding between which problems to address and who to operate on
- Bigger vs. smaller surgery pros/cons
  - Levels?
  - Osteotomies?

Level Selection

- How do we optimize upper and lower limits of construct?
- How much is necessary?

Upper Instrumented vertebrae

- UIV should be
  - Neutral
  - At or above the upper end vertebra
- Avoiding ending at:
  - Listhesis
  - Rotated spinal segment
  - Region of kyphosis
  - At apex of deformity
  - Junctions (T1, L1)

Bridwell J neurosurg spine 2004

Instrumenting to T10 vs L1

- Benefits
  - Reduces adjacent segment stresses & Junctional kyphosis
  - 10^{th} vertebrae
    - Supported by a true rib
    - Increased ligamentous support
- Disadvantages
  - Greater blood loss
  - Increased surgical times
  - Increased risk of pseudoarthrosis
  - Greater Cost

What about T3 vs. T10?

Complications:

Pseudo?

Op time?

EBL?

Advantages:

less PJK?

Less re-op?

Courtesy Wayne Cheng

PJK

Authors	year	LT (t10)	UT (t3)
Kim et al (ISSG)	2014	16%	19%
Ha et al (UCSF/korea)	2013	34%	27%
O'Shaughnessy (Wash U)	2012	18%	10%

Courtesy Wayne Cheng

Re-operation

Authors	year	LT (t10)	UT (t3)
Kim et al (ISSG)	2014	22%	15%
Ha et al (UCSF/korea)	2013	48%	54%
O'Shaughnessy (Wash U)	2012	10.5%	20%

Courtesy Wayne Cheng

Complication

Authors	year	LT (t10)	UT (t3)
Kim et al (ISSG)	2014	39%	57%
O'Shaughnessy (Wash U)	2012	36.8%	50%

Courtesy Wayne Cheng

Spine
SPINE Volume 37, Number 10, pp 884–890

SURGERY

Does a Long-Fusion "T3-Sacrum" Portend a Worse Outcome Than a Short-Fusion "T10-Sacrum" in Primary Surgery for Adult Scoliosis?

Brian A. O'Shaughnessy, MD, Keith H. Bridwell, MD, Lawrence G. Lenke, MD, Woojin Cho, MD, PhD, Christine Baldus, RN, Michael S. Chang, MD, Joshua D. Auerbach, MD, and Charles H. Crawford, MD

TABLE 6. Complications Data From the Upper Thoracic and Lower Thoracic Groups

Complications	Upper Thoracic	Lower Thoracic	*P*
Overall (%)	50.0	36.8	0.334
Perioperative (%)	30.0	15.8	0.307
Major perioperative (%)	15.0	2.6	0.114
Pseudarthrosis (%)	20.0	5.3	0.168
Total PJK (%)	10.0	18.4	0.476
Surgical PJK (%)	0.0	2.6	1.000
Revision surgery (%)	20.0	10.5	0.428

PJK indicates proximal junctional kyphosis.

Spine
SPINE Volume 39, Number 13, pp E795-E799

DEFORMITY

Upper Thoracic *Versus* Lower Thoracic Upper Instrumented Vertebrae Endpoints Have Similar Outcomes and Complications in Adult Scoliosis

Han Jo Kim, MD,* Oheneba Boachie-Adjei, MD,* Christopher I. Shaffrey, MD,† Frank Schwab, MD,‡ Virginie Lafage, PhD,‡ Shay Bess, MD,§ Munish C. Gupta, MD,¶ Justin S. Smith, MD, PhD,† Vedat Deviren, MD,|| Behrooz Akbarnia, MD,** Greg M. Mundis, MD,** Michael O'Brien, MD,†† Richard Hostin, MD,†† Christopher Ames, MD,‡‡ and the International Spine Study Group

TABLE 4. Complication Data Between the Groups

Complications	UT (n = 91)	LT (n = 107)	*P*
Infection	6	3	0.22
Neurological	13	17	0.62
Cardiopulmonary	15	12	0.29
Vascular	0	0	N/A
Gastrointestinal	6	6	0.77
Operative	25	21	0.26
Renal	1	2	0.65
Wound	5	3	0.35
Radiographical	13	9	0.20
Mortality	1	0	0.32

Instrumenting to T3 vs T10

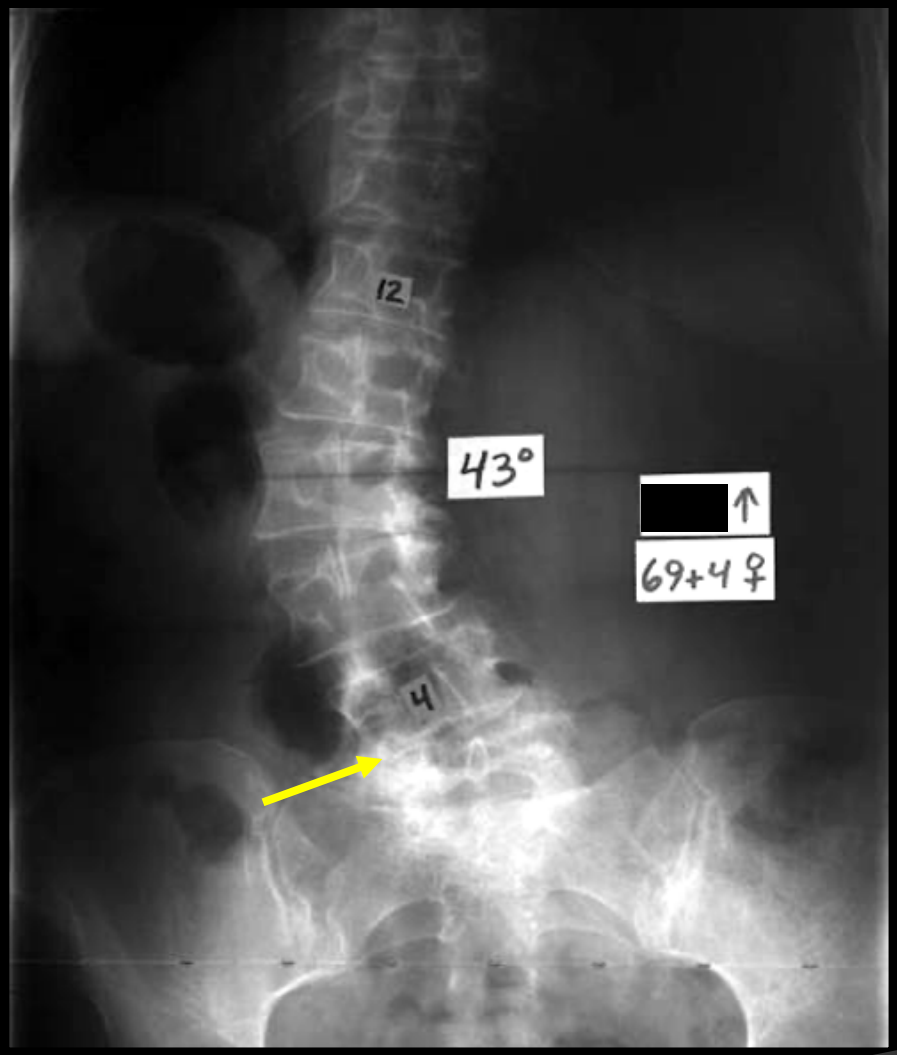
- Tends to:
  - Higher complication
  - Higher reoperation rate
  - Lower PJK risk
- Best indicated for
  - Thoracic pathology
  - TL kyphosis

Lower Instrumented vertebrae

- LIV should be
  - Stable
  - Neutral
  - At or below the lower end vertebra
  - Considerate of spinal stenosis/radiculopathy
- Avoiding ending at:
  - Listhesis
  - Rotated spinal segment
  - Region of kyphosis
  - At apex of deformity
  - Junctions (C7, T12)
  - Degenerated region

Mok & Hu Neuros clinic N Am 2007

Fractional Curves



Left leg radiculopathy- L4 & L5

What if L5-S1 is relatively intact?

- Should lower fusion level end at L5 or S1?

Distal fusion level

- Long fusions stopping at L5 have inferior results
  - 69% had degeneration by 5 years
  - 67% with degeneration had positive sagittal imbalance
  - 19-29% required extension to pelvis

- Sacral/Pelvic fixation
  - Adds substantial OR time and blood loss
  - Increased stiffness
  - Higher risk of non-union
  - Gait changes
  - Better fractional curve control

Edwards et al Spine 2003
Kuhns et al. *Spine*. 2007
Swamy et al Neuros Clinic N Am 2007

Spinal Osteotomies

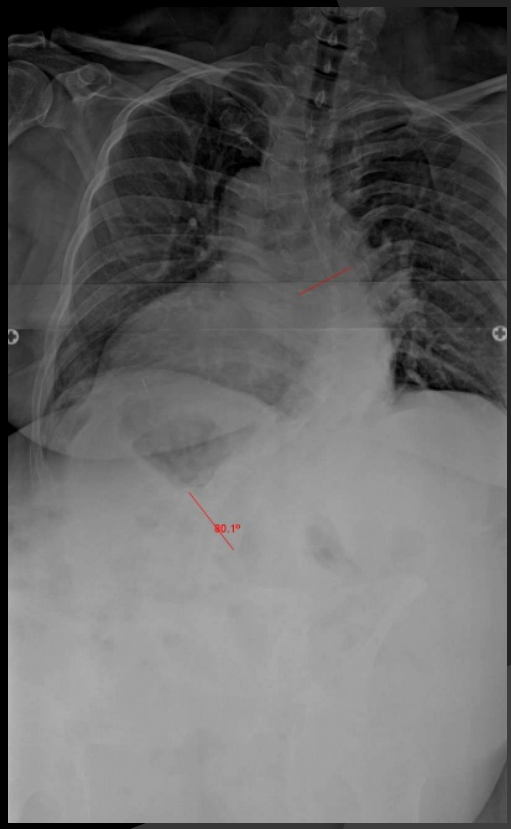
- Rigid deformities
- Decreases strain on bone-screw interface
- Improve overall spinal alignment

1) Smith-Petersen Osteotomy
2) Pedicle Subtraction Osteotomy
3) Vertebral Column Resection

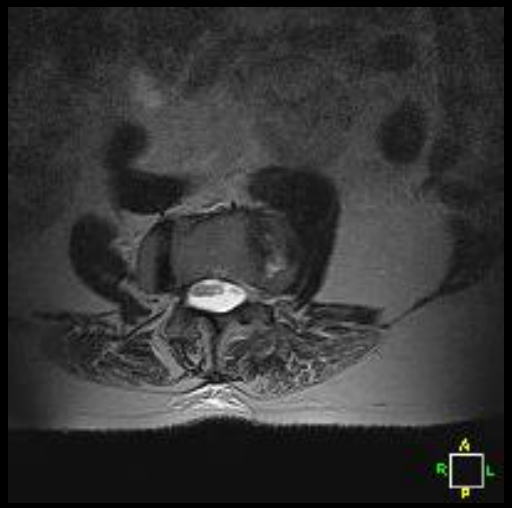
54 F c BP, Deformity

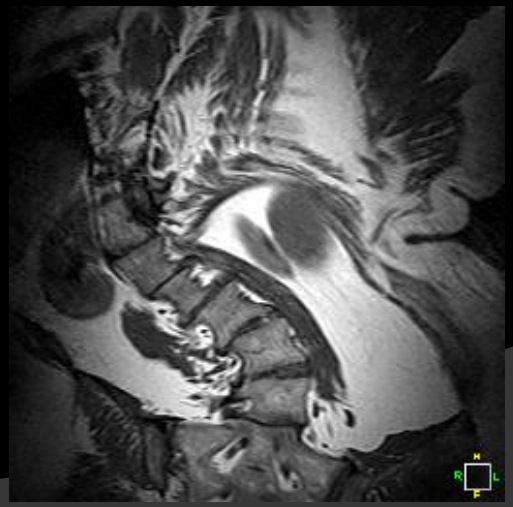
- Pediatrician
- BMI: 50.5
- PMH: Hypothyroid
- NVI

- PI = 48º
- PT = 43º
- LL = 48º Kyph
- SVA = 18.5 cm
- Cobb = 80º
- C7-CSVL = 10.2 cm



Open Discs, Very Rigid





Options

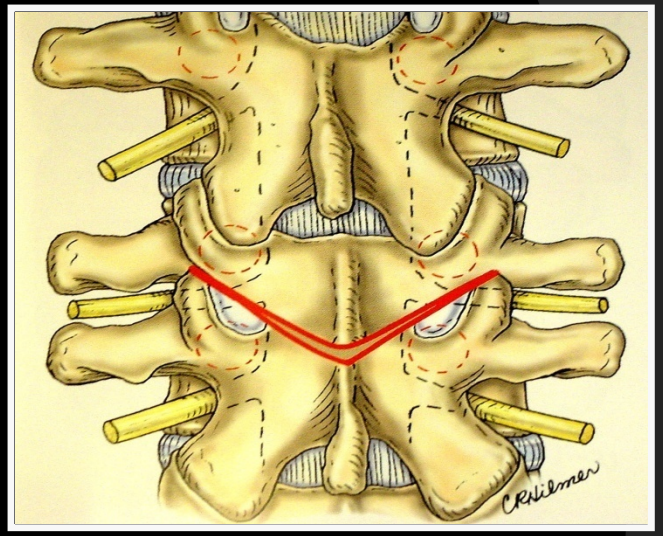
- PCO
- 3-column (PSO)

Smith-Petersen Osteotomy

- Typically used in:
  - Scheuermann's Kyphosis
  - Junctional kyphosis
  - Iatrogenic flatback
  - Stiff adult lumbar scoliotic curves
- Gradual lordotic correction
- Increase spinal flexibility

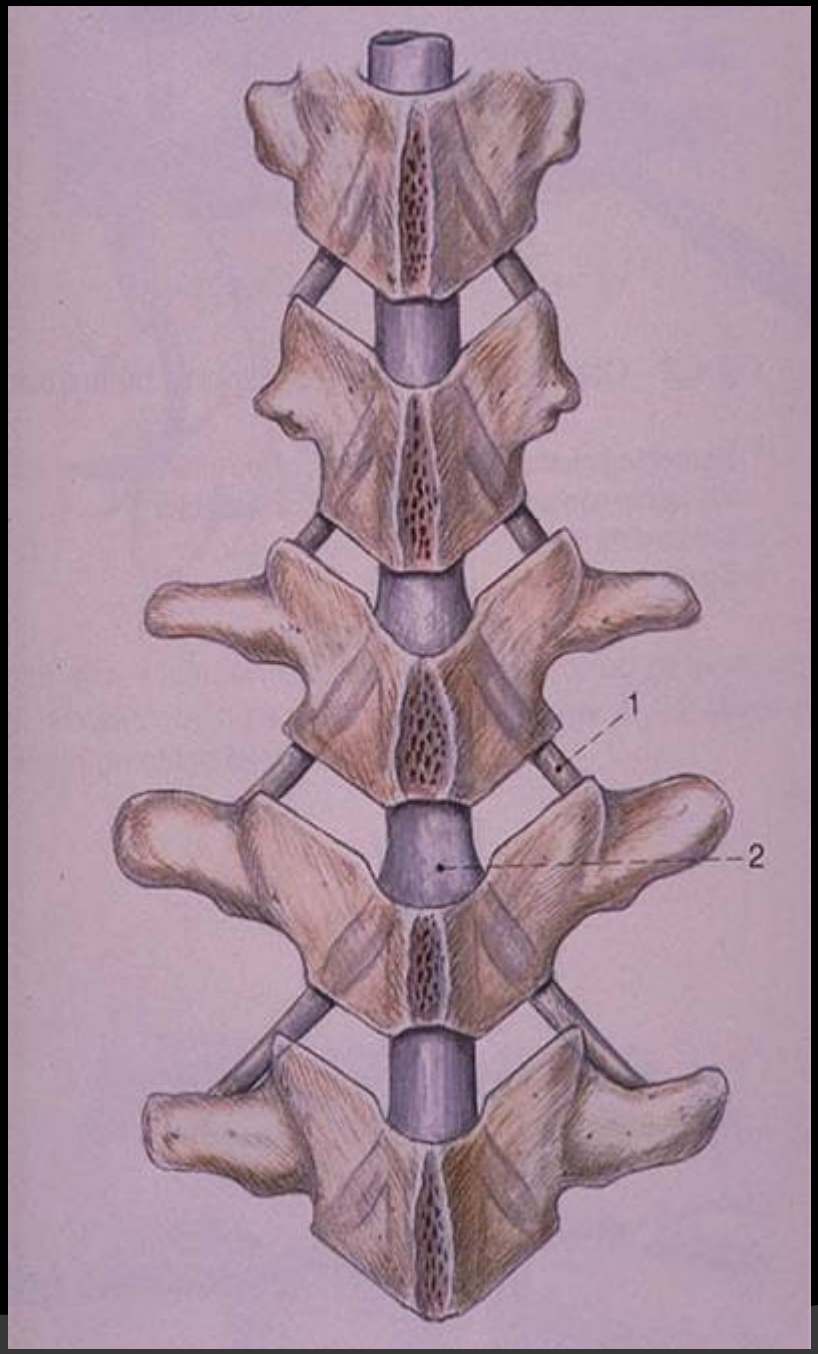
Smith-Petersen Osteotomy

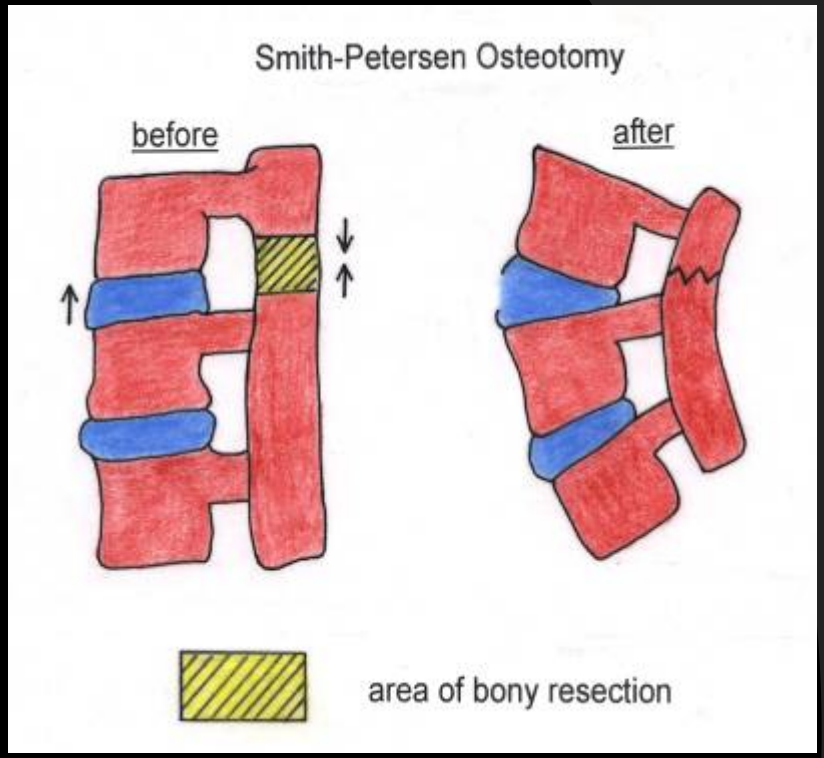
- Posterior facet osteotomies
- Complete removal of ligamentum flavum
- Resection of fusion mass also possible



Smith-Petersen J Bone Joint Surg 1945

Ponte A, Aulo Gaggi, 1984

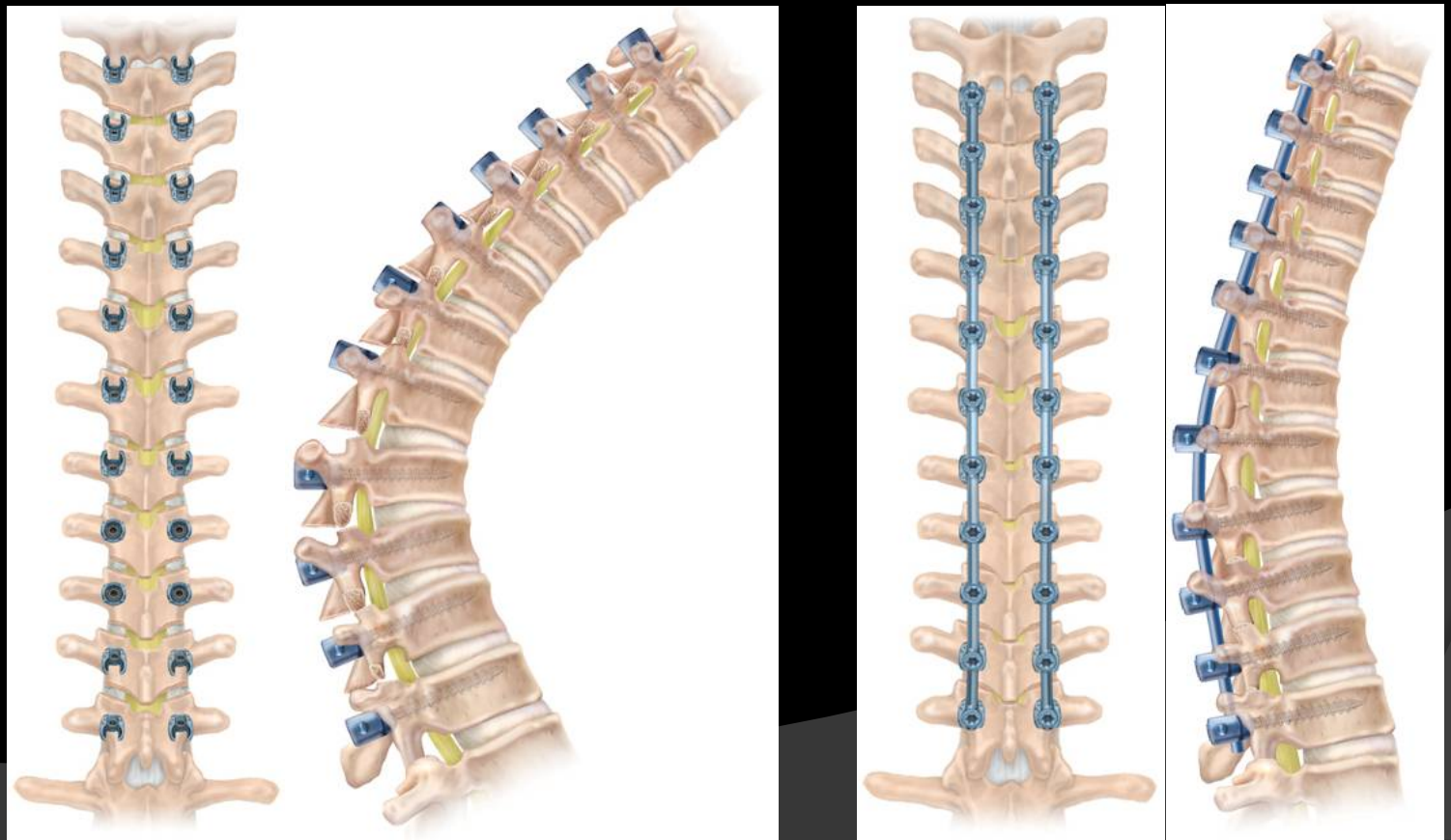




- Shortens the posterior column
- Hinges on the middle column
- Lengthens the anterior column
  - Potentially dangerous
- Mobile/generous discs ideal
- Rigid deformities = anterior release + SPOs (older technique)

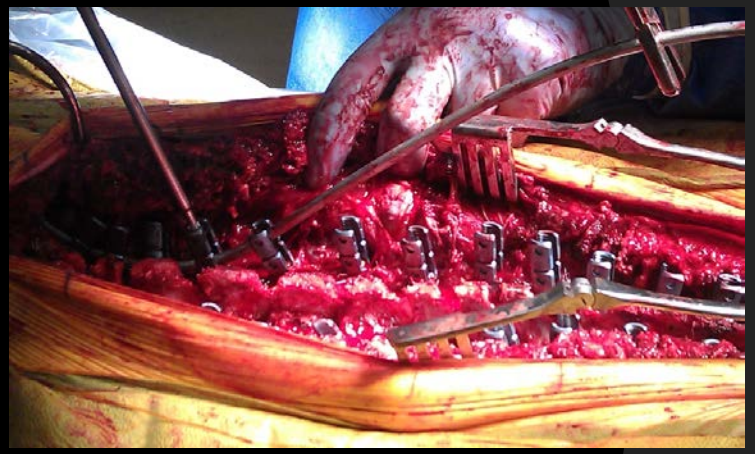
Smith-Petersen Osteotomy

- ~1°/mm = 5-10°/level
- Smooth correction



SPO Common Complications

- Significant bleeding with multiple levels
  - Gelfoam
- Neurologic deficit
  - Probe foramina post closure
  - Neuromonitoring
- Screw cut out
  - Cantilever Reduction



Smith-Petersen Osteotomy

- Considerably safer than PSO
  - 47% less blood loss
  - 3.3% vs. 7.3% neurologic complications
- Similar correction of kyphosis
  - 61% kyphosis reduction
  - Similar fusion rates
  - 49% coronal cobb improvement

Cho KJ et al, Spine, 2005

Geck MJ et al, J Spinal Disord Tech, 2007

Smith-Petersen Osteotomy

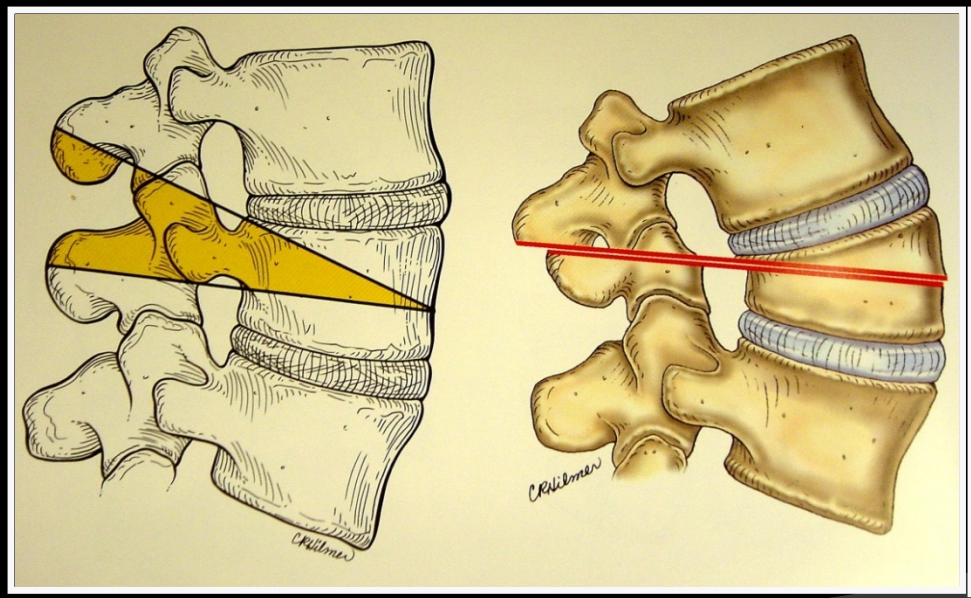
- Inferior correction of sagittal imbalance
  - 5.5 vs. 11.2 cm
- Less focal correction

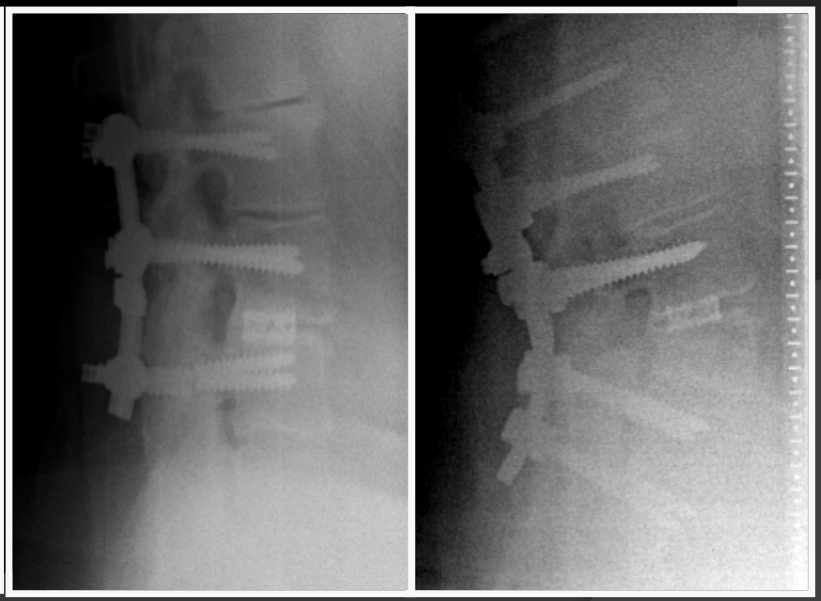
Pedicle Subtraction Osteotomy

- Typically used in:
  - Severe inflexibility
    - Iatrogenic flatback
    - Ankylosing spondylitis
  - Focal kyphotic deformity
    - Congenital Kyphosis
  - Large sagittal imbalance
- Strong sagittal balance correction
- Moderate coronal correction

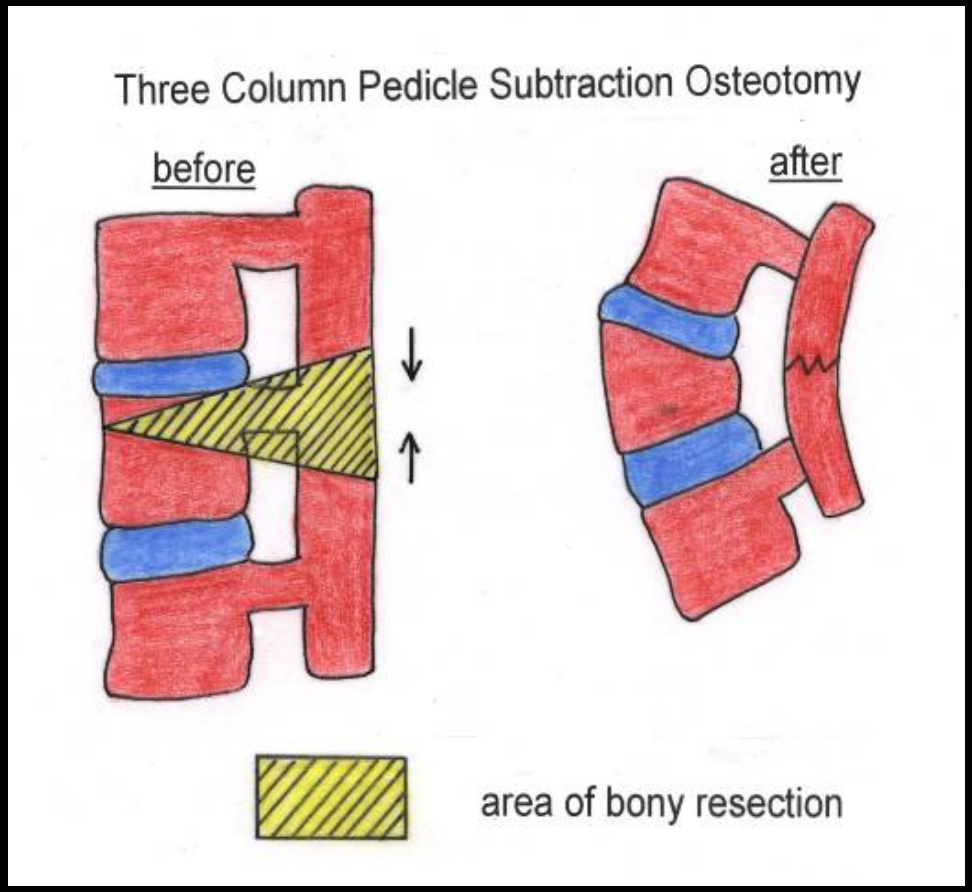
Pedicle Subtraction Osteotomy

- 3-column osteotomy
- Posterior-only correction of fixed sagittal deformity
- Obviates need for anterior release
- Highly focal correction
- Ideal for previous circumferential fusion/AS





Thomasen E: Clin Orthop 1985

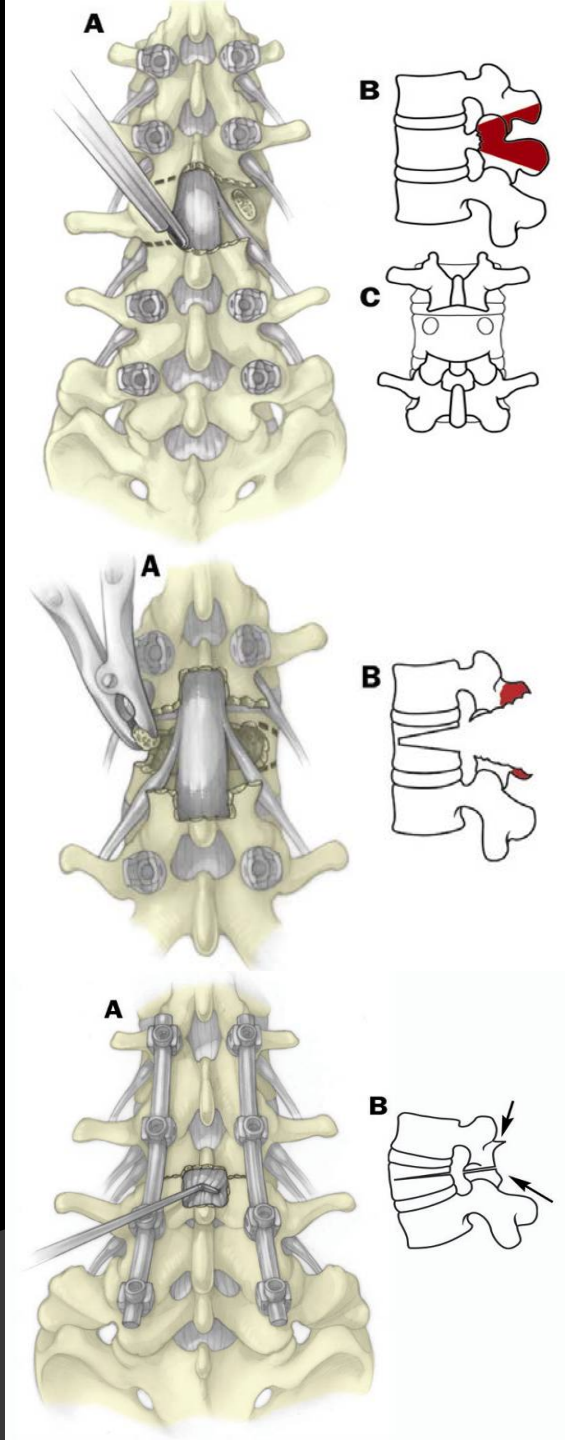


- Shortens the middle and posterior column
- Hinges on the anterior column
- ~ 30° of focal sagittal correction at single segment (~20°/thoracic)
- Safer for certain conditions such as anklyosing sponylitis

Liu et al. Spine. 2015 Apr 15;40(8):570-9

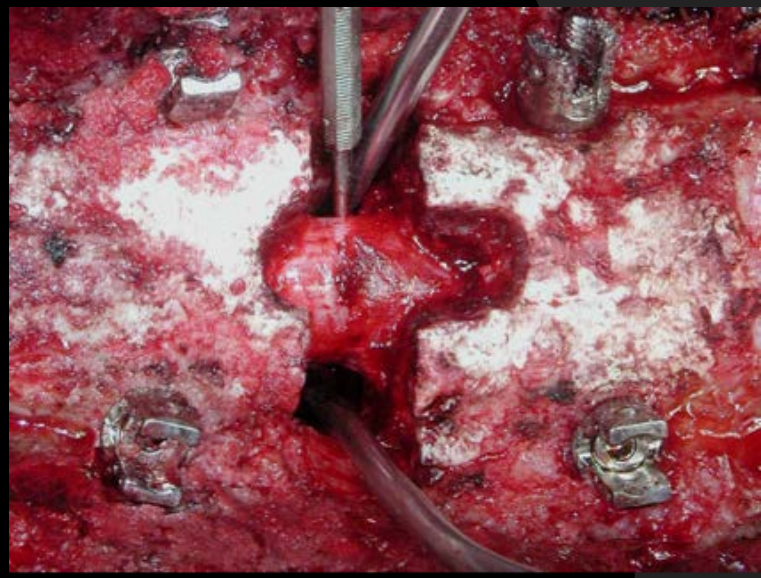
Technique

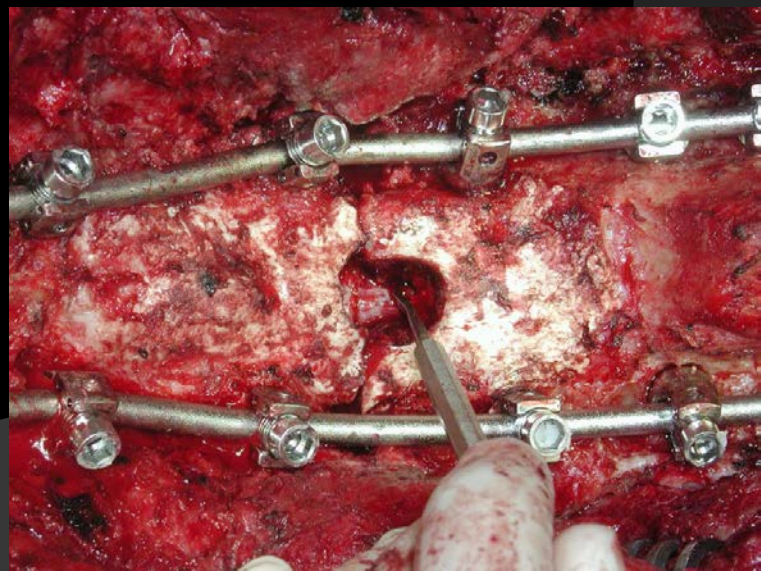
- Laminectomy
- SPOs x 2
- Pedicle resection
  - Rongeur
  - Osteotomes
  - Burr
- Decancellate body
- Remove posterior cortex
- Closure



PSO Common Complications

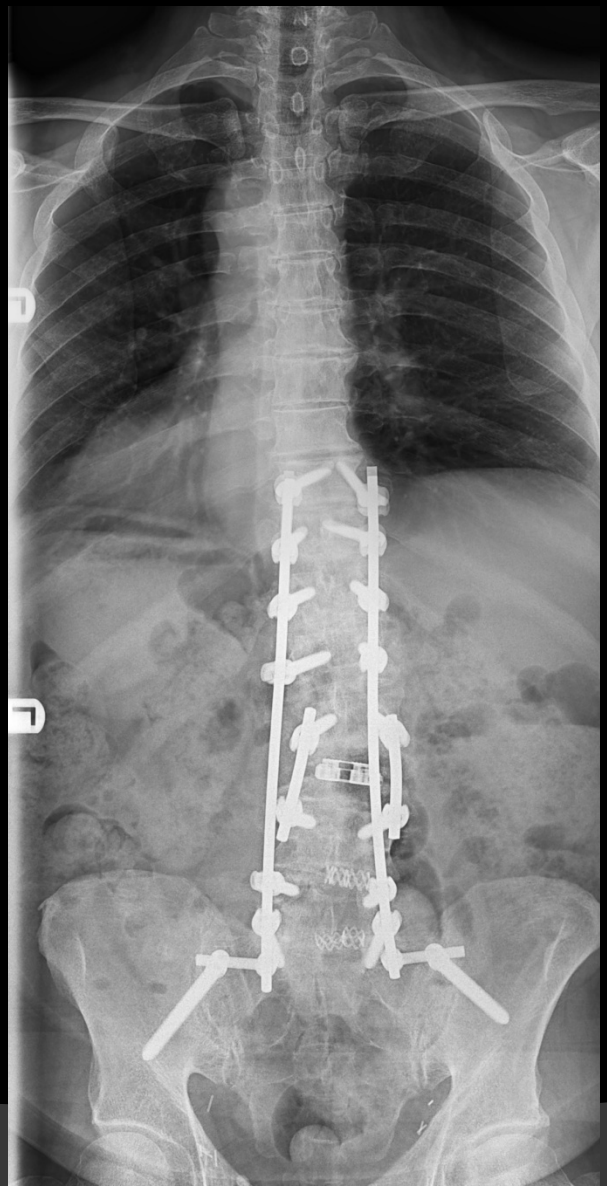
- Neurologic deficit
  - Generous resection
  - Probe foramina post closure
  - Neuromonitoring
- Screw cut out
  - Construct to construct closure





Bridwell KH, Spine, 2003. Sep 15;28(18):2093-101

PSO Common Complications



- Pseudoarthrosis
  - Interbody adjacent discs
  - Accessory/Satellite rods

Gupta. SRS. 2015

Pedicle Subtraction Osteotomy

- Significant correction of sagittal imbalance
  - 7.7-13.5 cm
  - Greatly superior to SPOs
- Significant coronal plane correction
  - 60% correction maintained at >2 years
  - Superior to SPOs

Bao H et al, Spine, 2015 Mar 1;40(5):E293-300
Kim YJ et al, Spine 2007. Sep 15;32(20):2189-97
Berven SH et al, Spine, 2001. Sep 15;26(18):2036-43

Pedicle Subtraction Osteotomy

- Significant complication rate
  - Motor deficits seen in 11.1%, permanent in 2.8%
  - 34% Major complication rate
    - 3.3% permanent medical
    - 2.9% permanent surgical
- Complication did not preclude favorable outcome
- Functional outcome scores maintained at 5 years

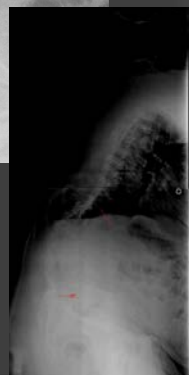
Buchowski et al, Spine. 2007 Sep 15;32(20):2245-52
Auerbach J et al. Spine. 2012 Jun 15;37(14):1198-210

Options

- PCO
  - Smooth correction
  - Lower complications
- PSO
  - Focal correction
  - Better coronal/sagittal alignment
  - Does not require anterior mobility

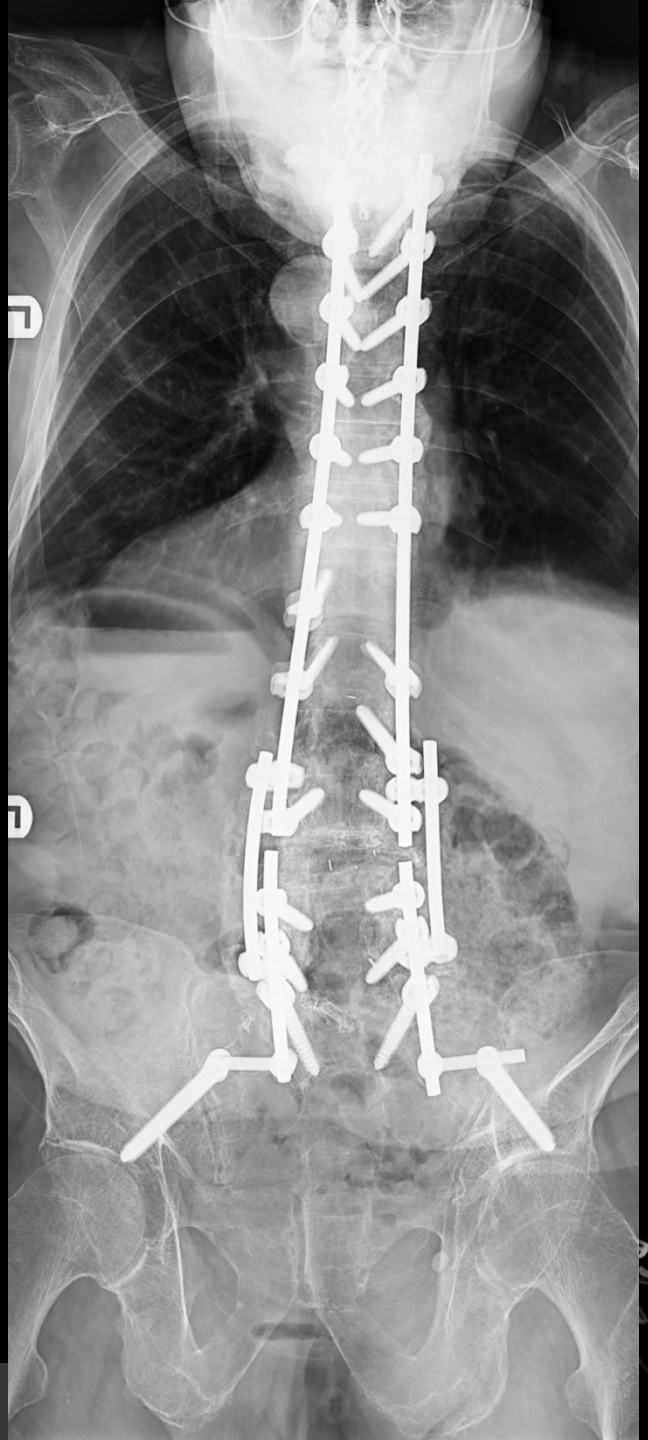
T5-Pelvis, L3 PSO

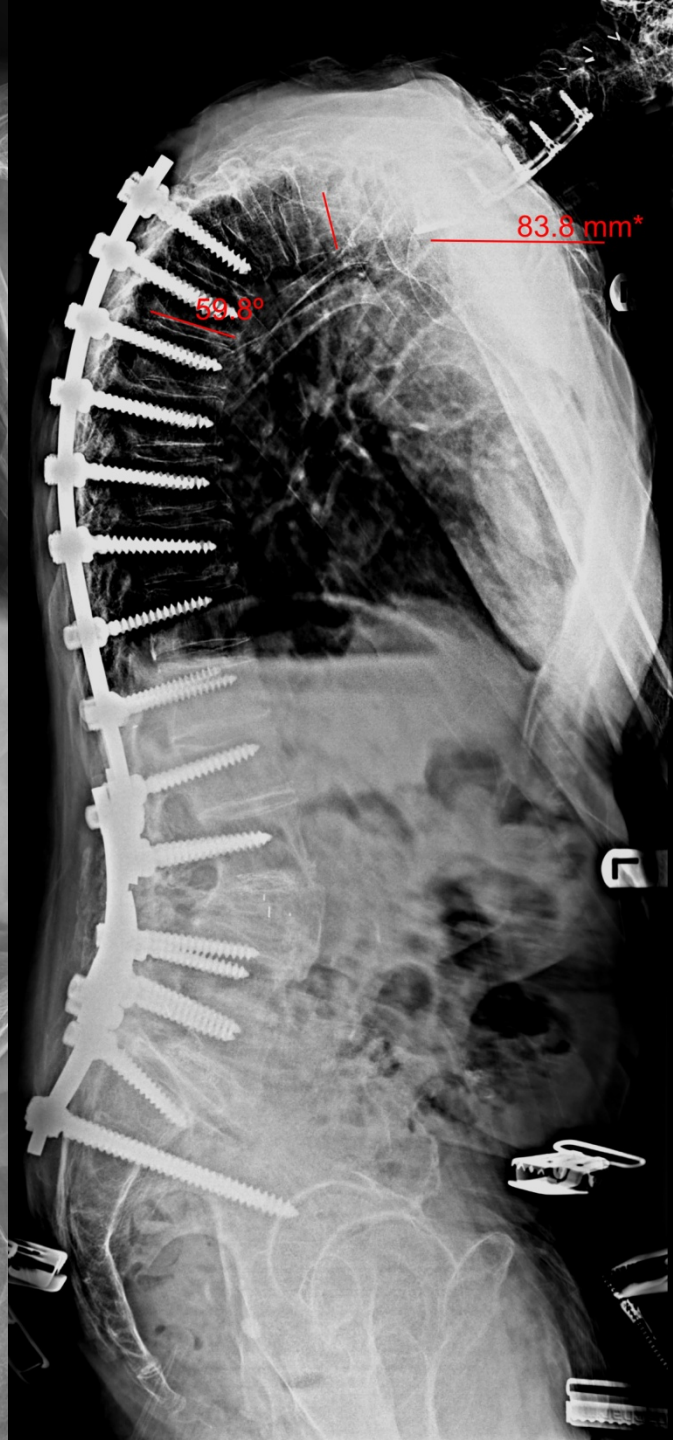
- PI = 48º → 48º
- PT = 43º → 23º
- LL = 48º Kyph → 38º Lord
- SVA = 18.5 cm → 4.4 cm
- Cobb = 80º → 32º
- C7-CSVL = 10.2 cm → 6.2 cm



76 M

- Inability to maintain horizontal gaze, dysphagia, back pain
- 7 yrs s/p cervical, lumbar fusion
- 2 yrs s/p pso + revision
- 5/5 all ext
- T3-6: 60º
- C2-7 SVA: 8.4 cm





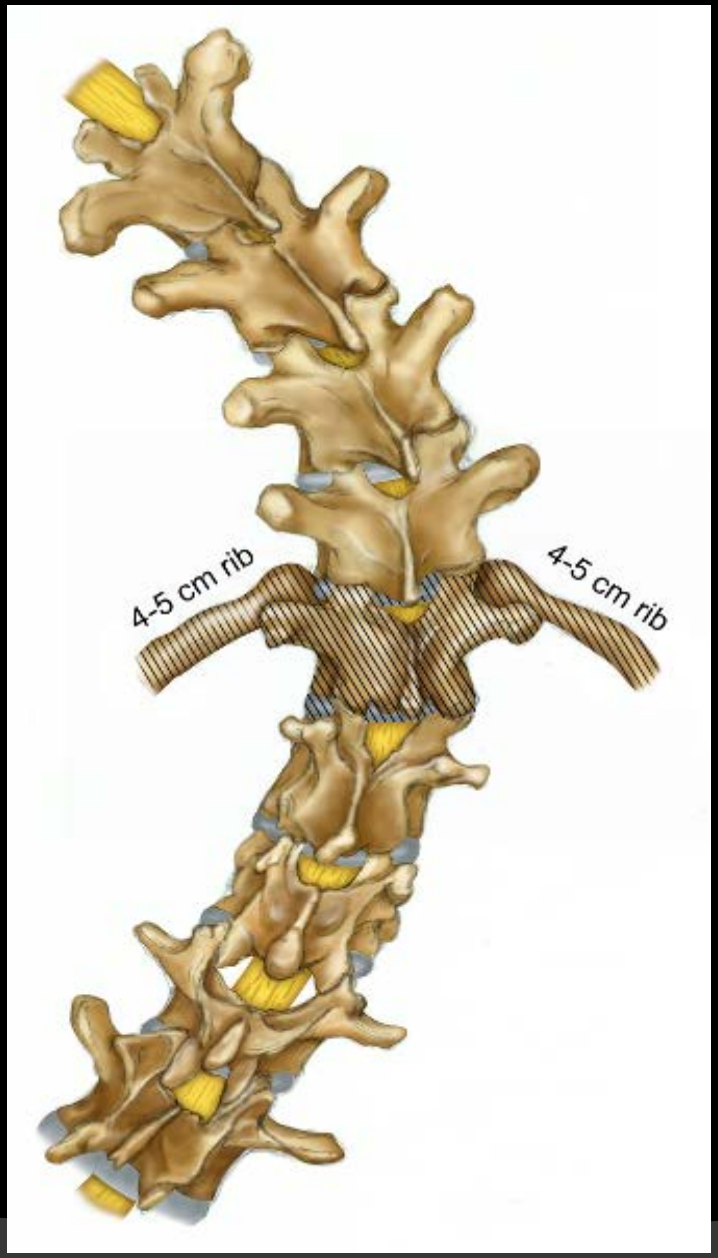
Vertebral Column Resection

- Typically used in:
  - Thoracic anomalies
    - Severe Proximal Junctional Failure
    - Tumor
  - Severe, inflexible deformities
    - Congenital deformities
    - Crankshaft
  - Large sagittal and coronal imbalances
- Strong sagittal balance correction
- Strong coronal correction

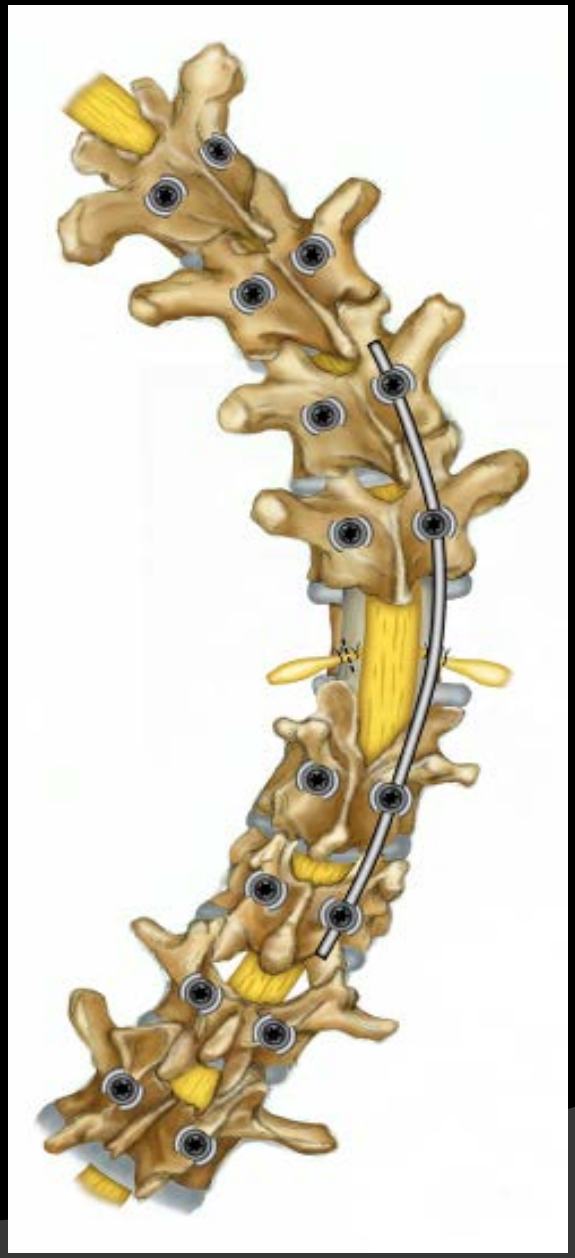
Vertebral Column Resection (VCR)

- Originally A/P (Bradford)
- Now Posterior-only (Lenke, Suk)
- No fixed-angle wedge for osteotomy closure
- Greater correction, typically 40°+
- For sharp, angular kyphosis (T_2–L_1)
- Typically with interbody

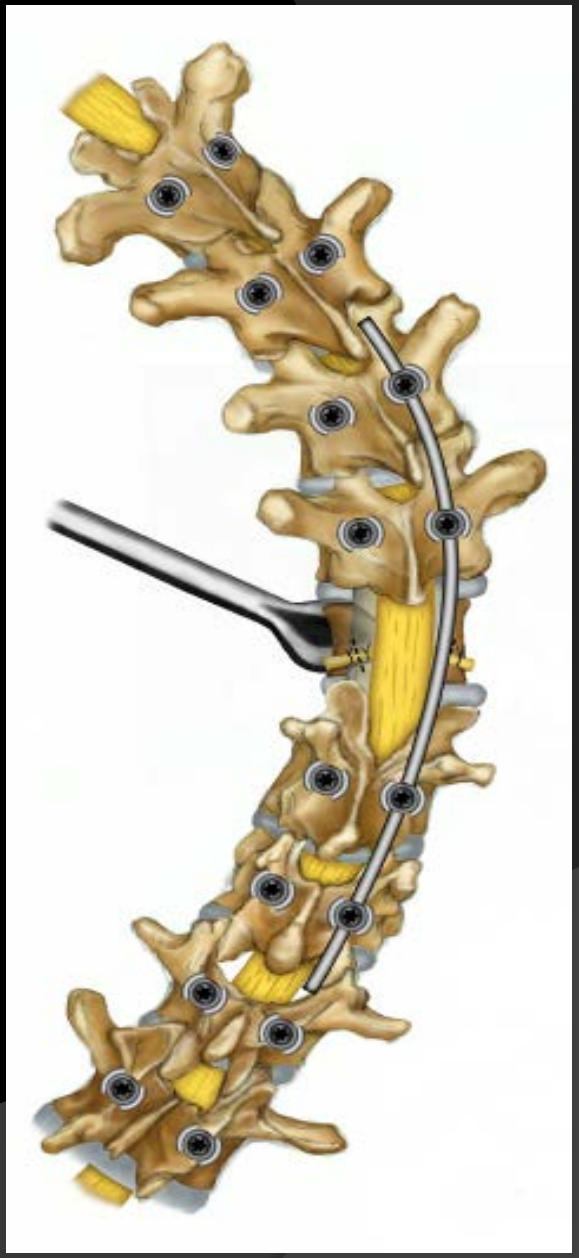
Costotransversectomy



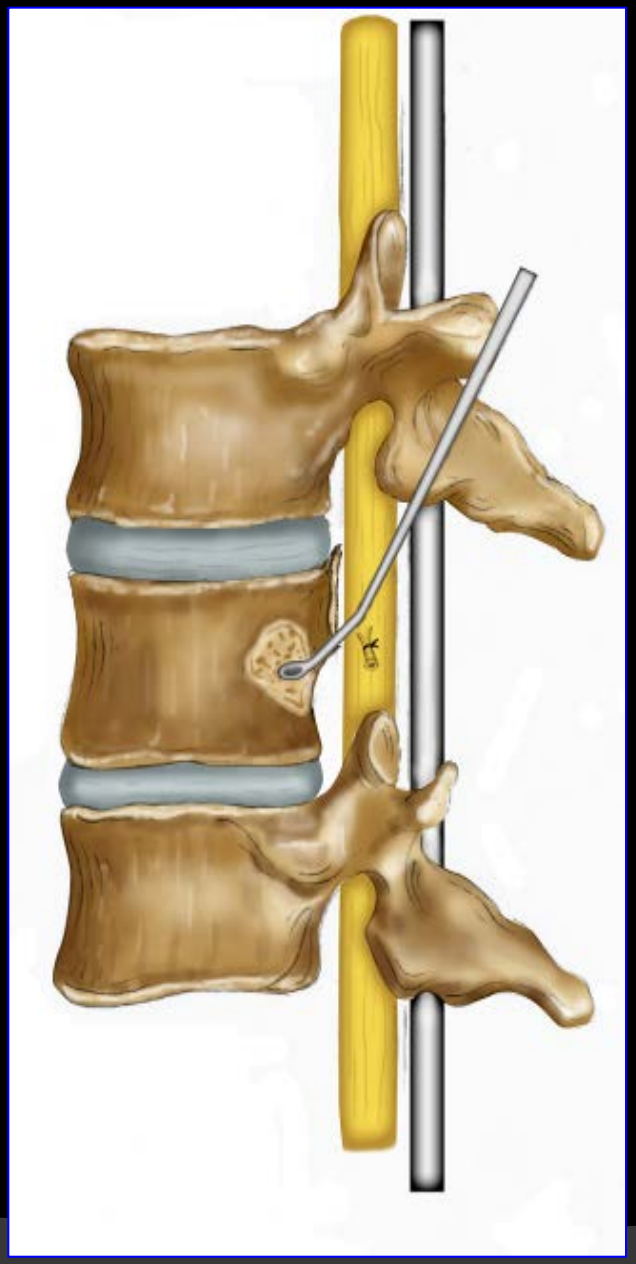
Lami and Rod



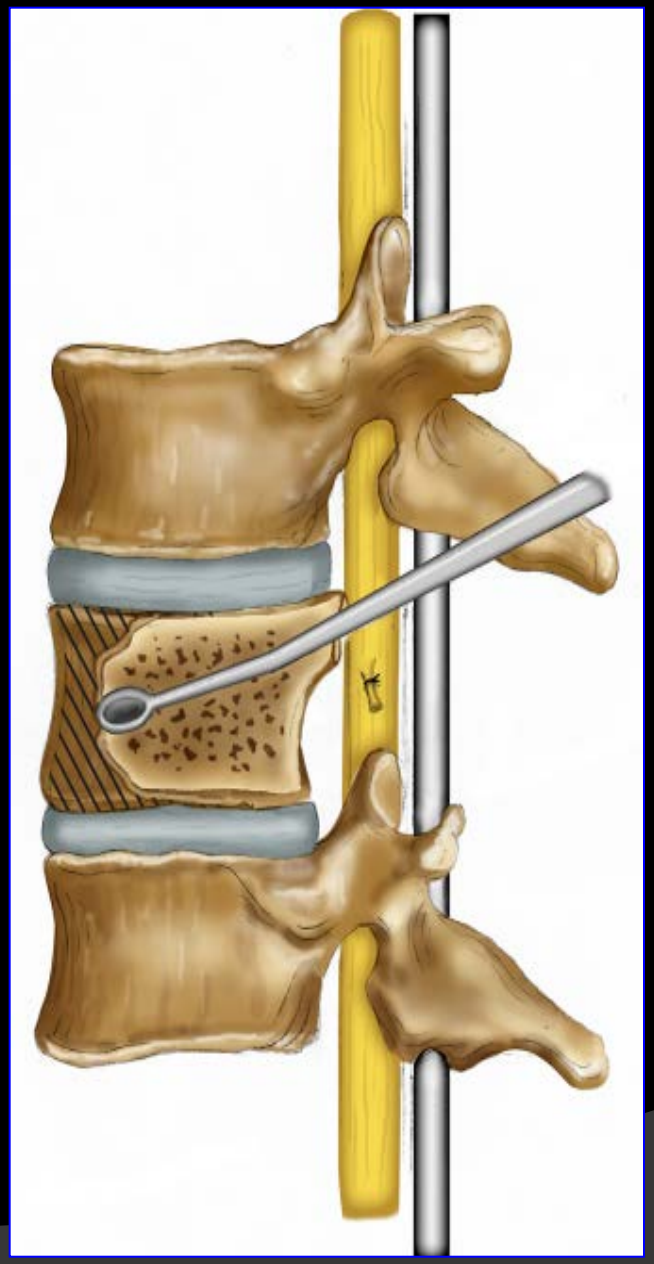
VB Exposure



Access



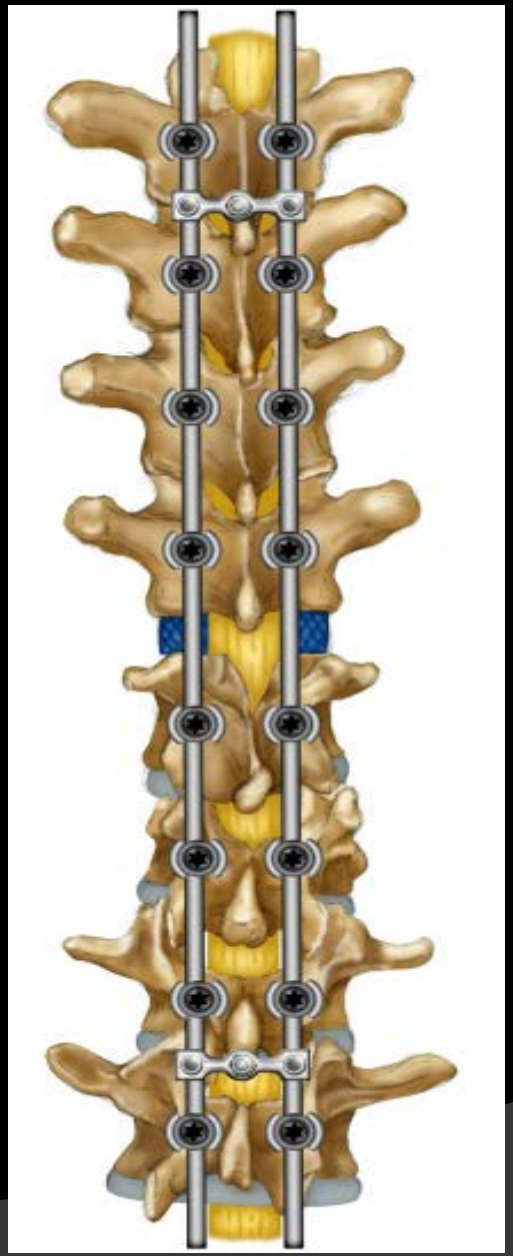
Body Removal



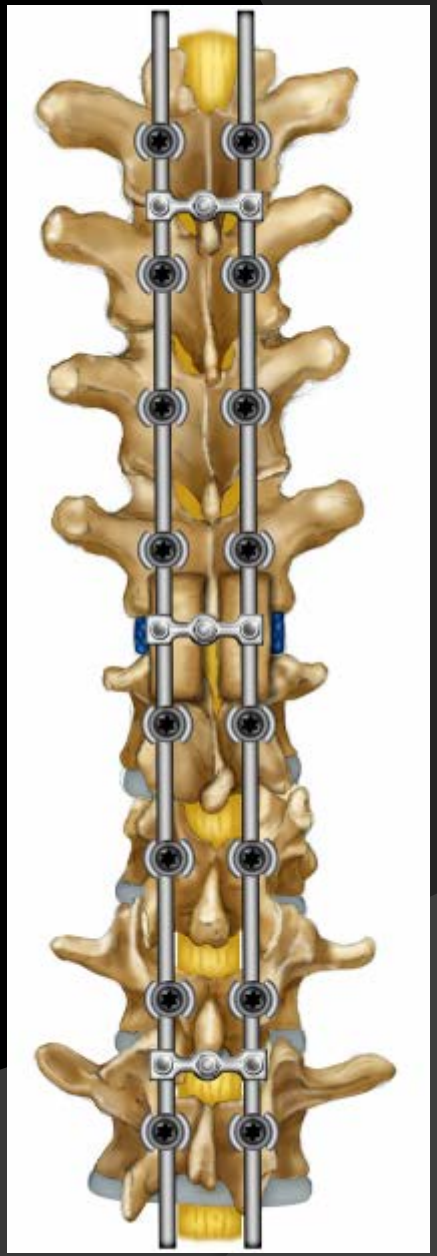
Discectomy

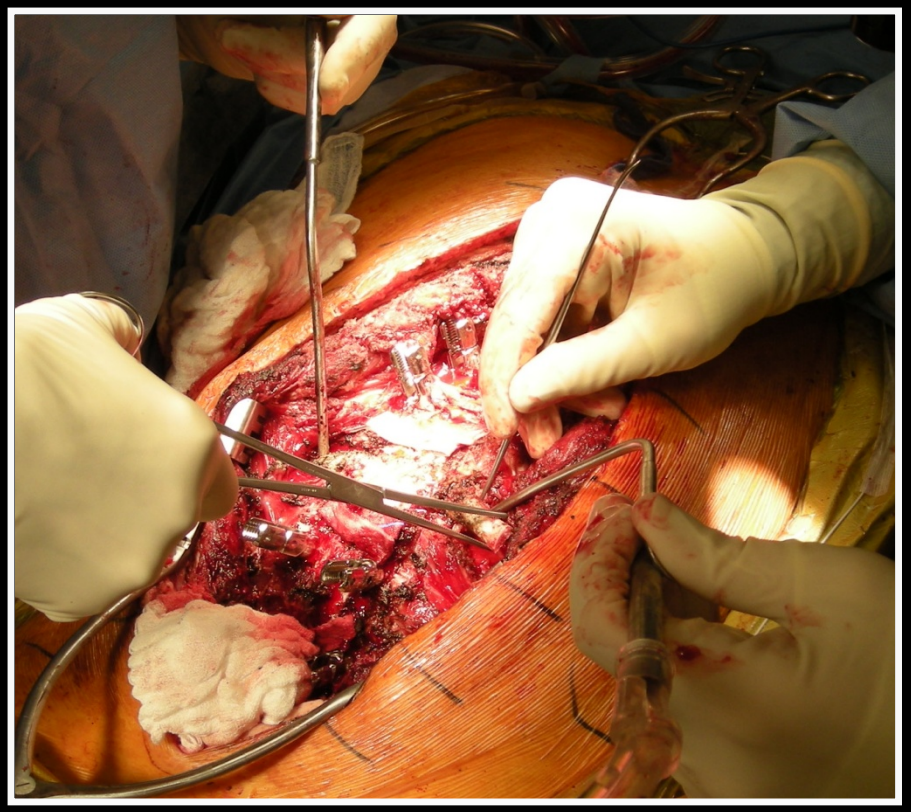
Cage Insertion

Final Correction

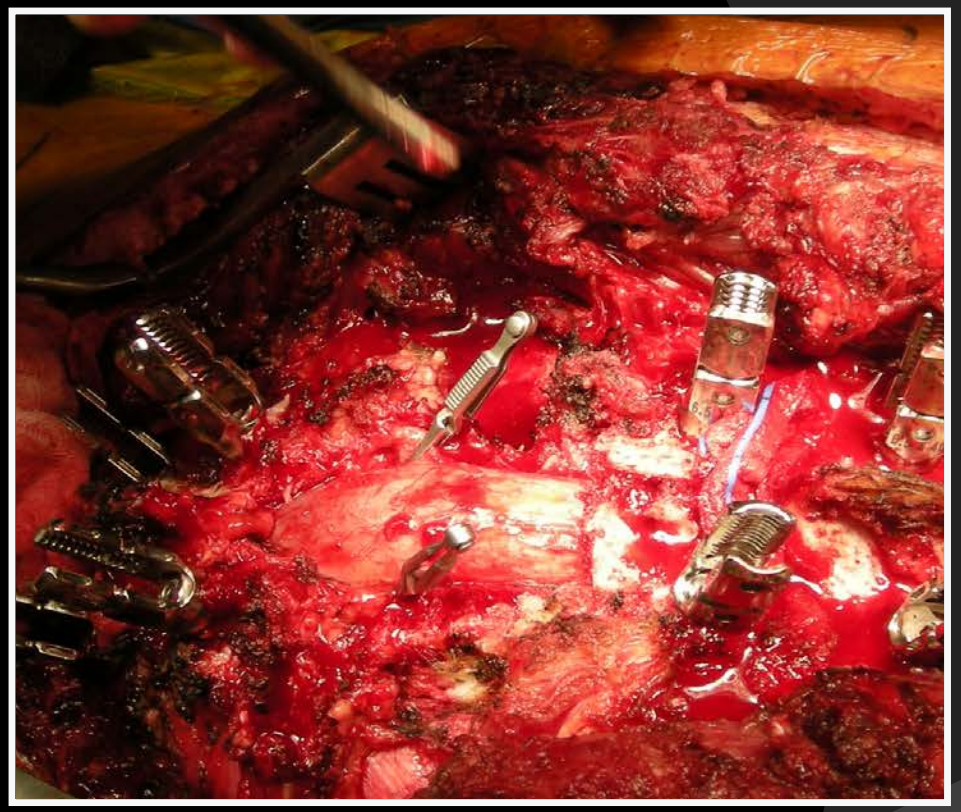


Rib Bridge Graft

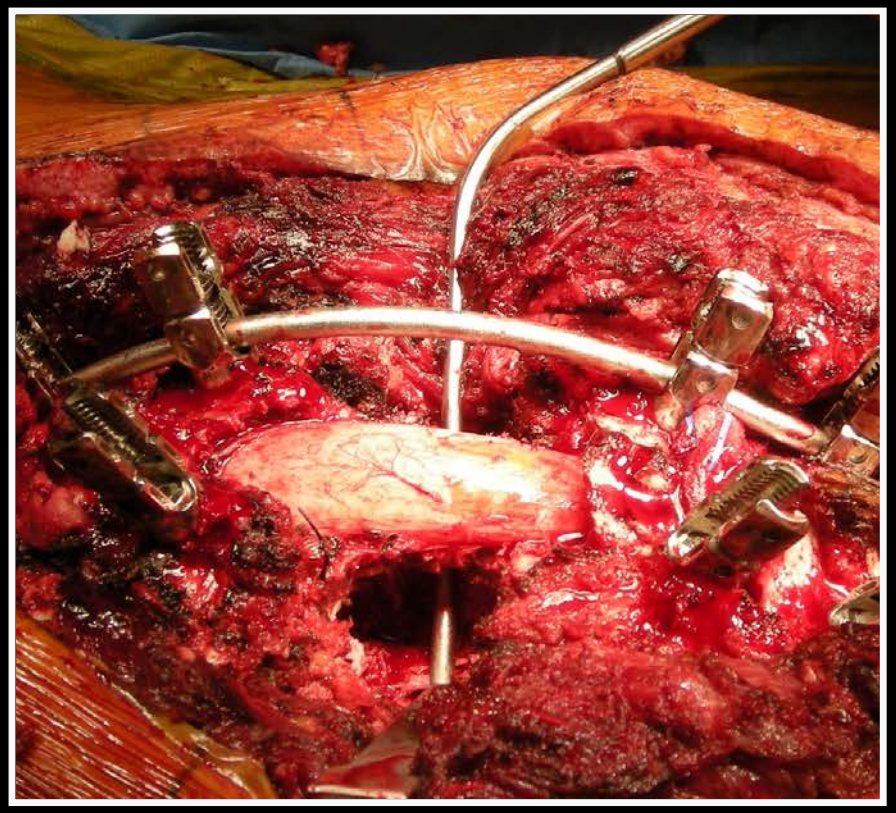




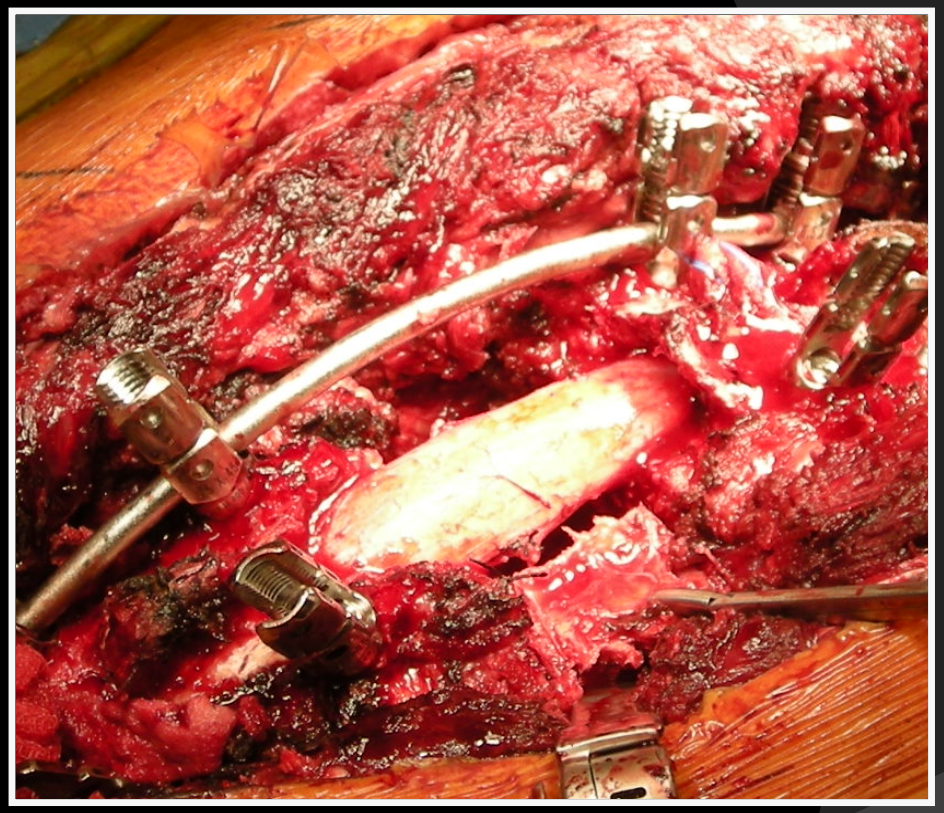
Rib Dissection/Removal



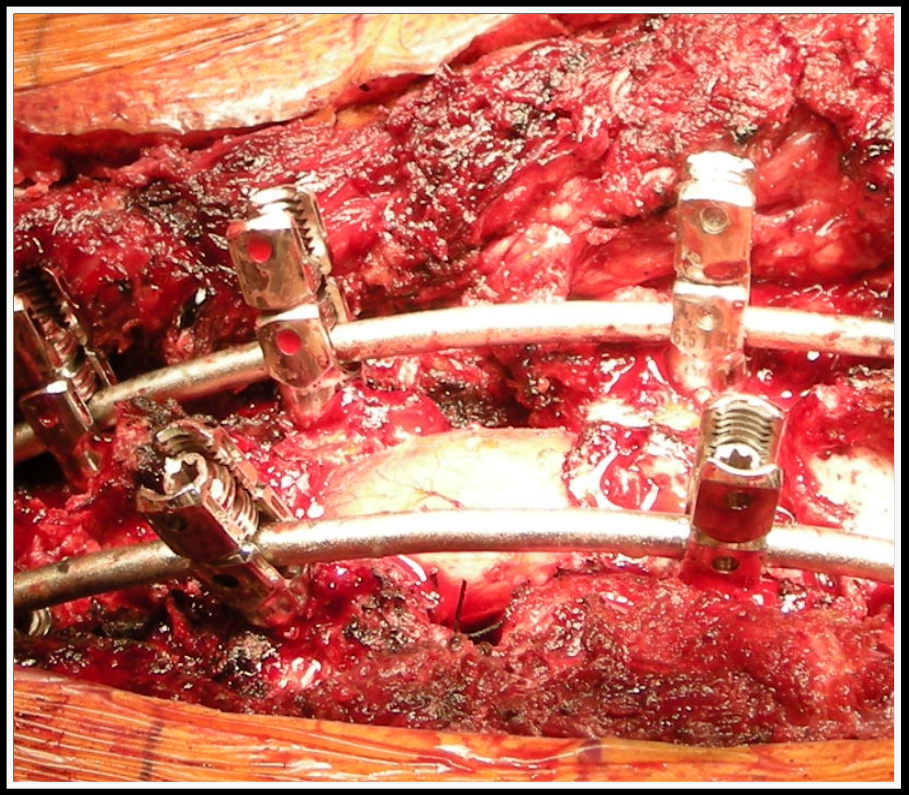
Bull-dog Clamps on Roots



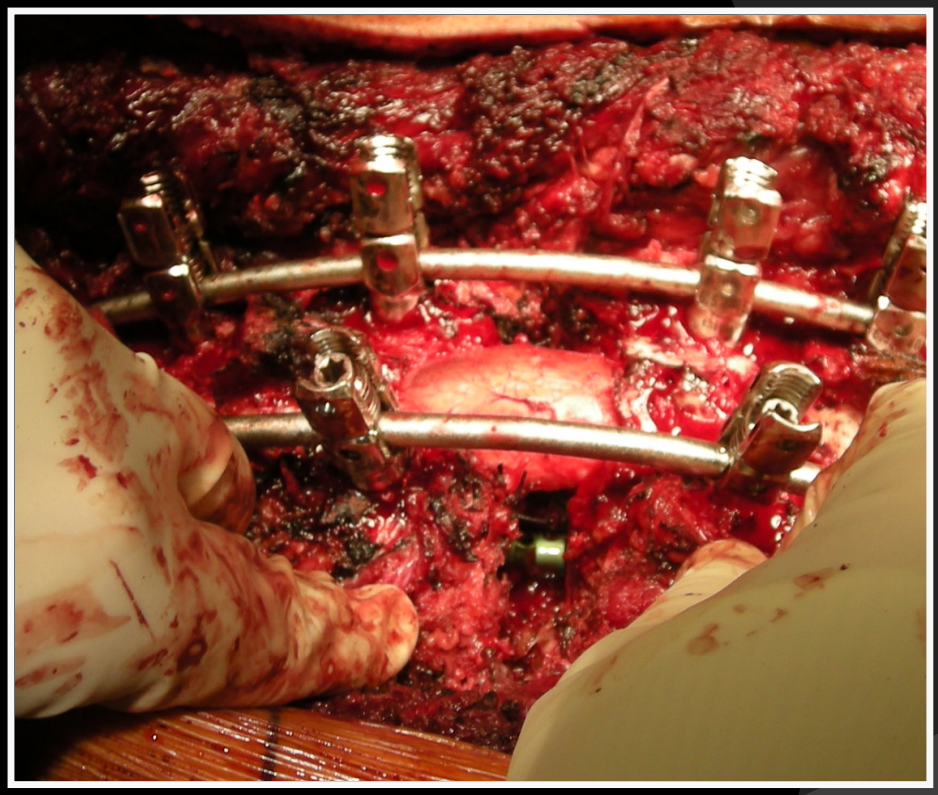
Vertebral Body Resection



Removal of Post VB Wall

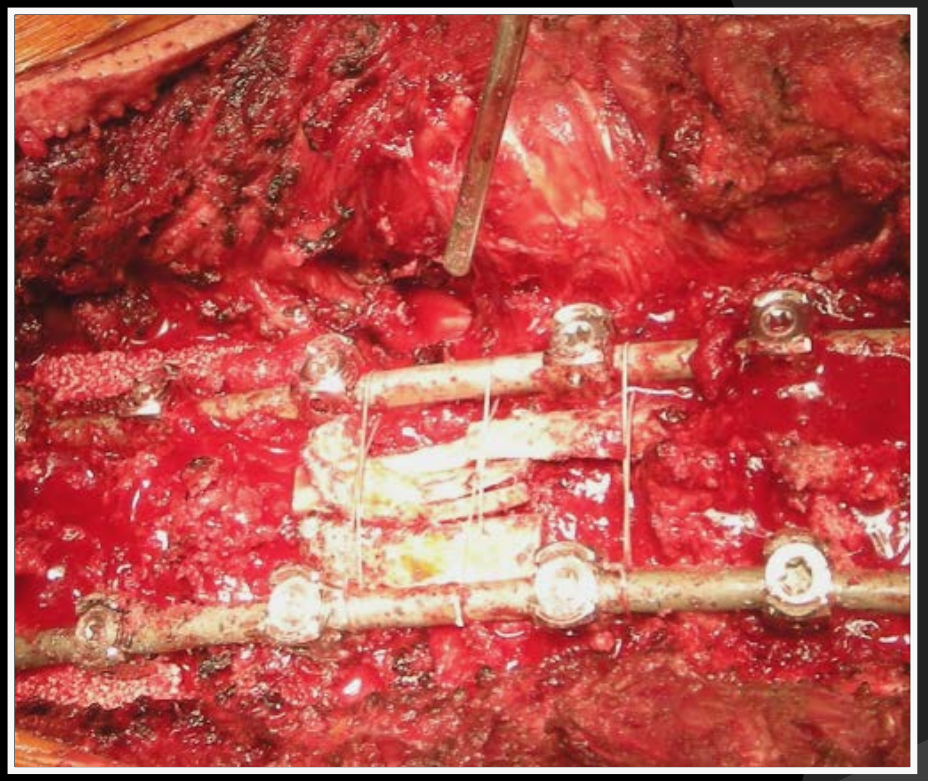


Initial Correction (~50-75%)



Cage Placement & Final Correction

Permanent Rod Placement



Onlay Rib Grafting

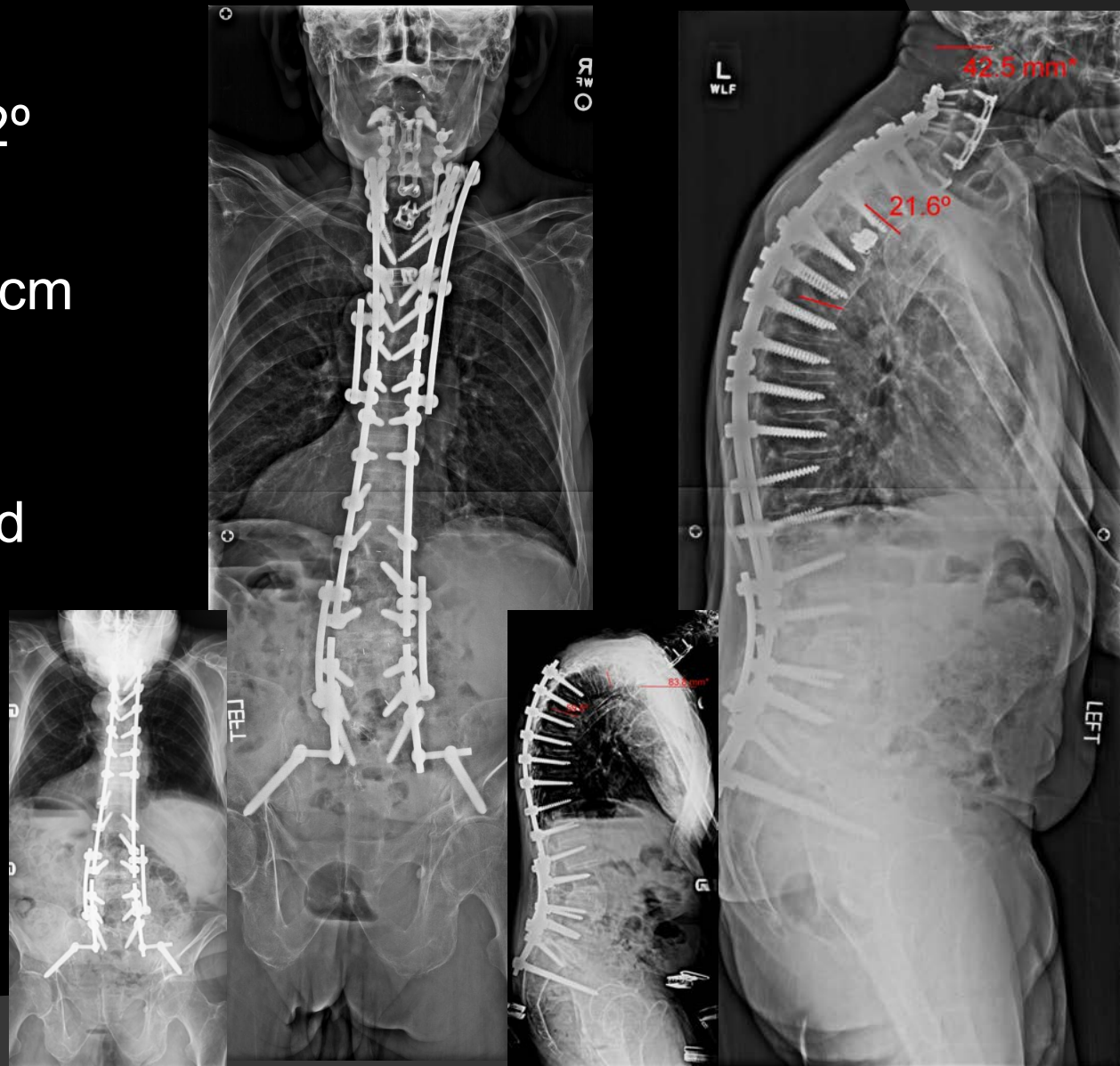
Vertebral Column Resection

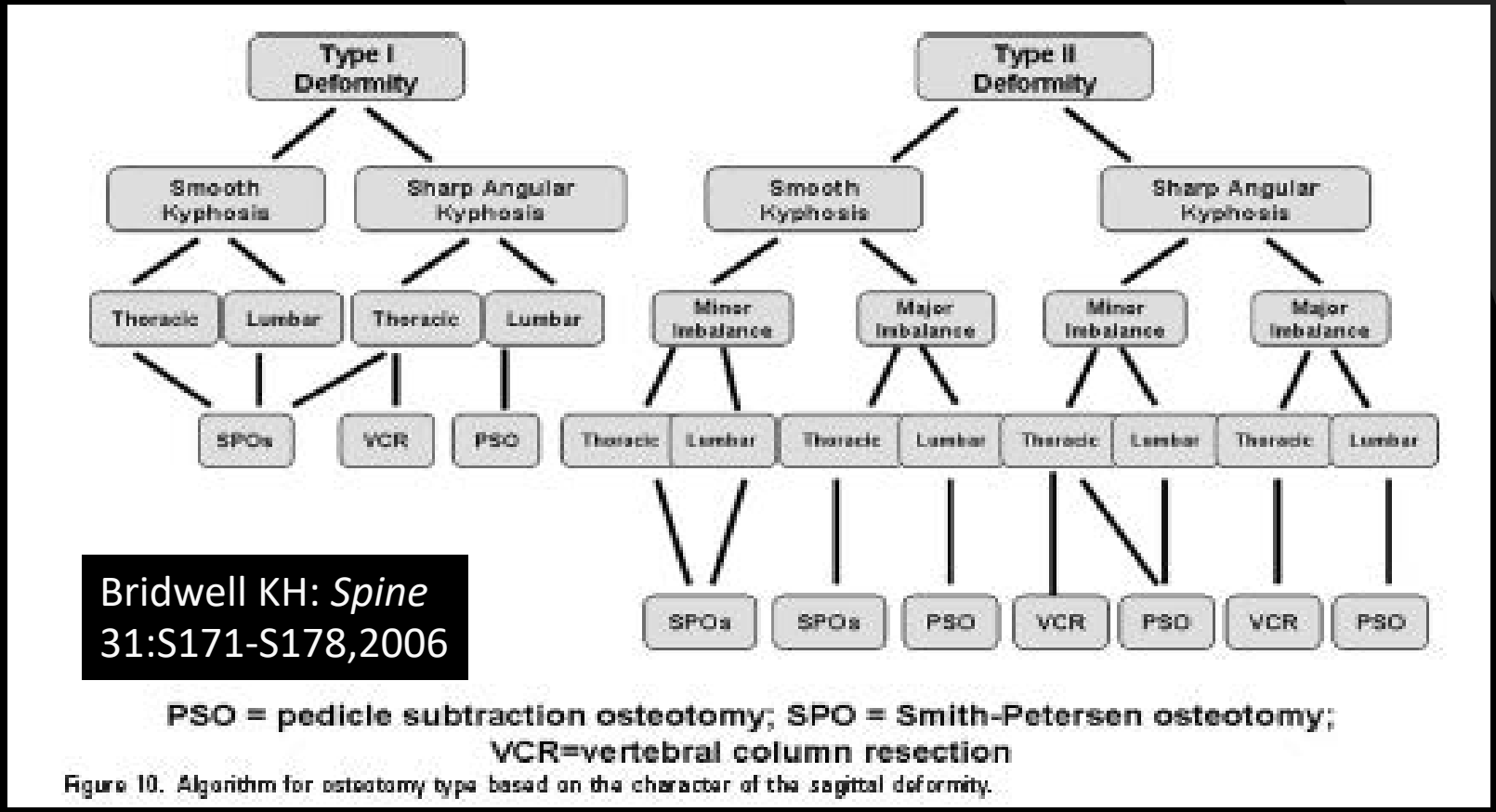
- 61% Complication Rate
- 22% Intraoperative Neuromonitoring Changes
- 7-11% Major Neurologic Deficit
- Non-union less likely than PSO

Papadopoulous et al, *Spine J*. 2013
Smith JS et al, *Spine*, 2011

3mo s/p C3-T10 PSF, T4 VCR

- T3-6 = 60º → 22º
- C2-7 SVA = 8.4 cm → 4.3 cm
- Greatly improved gaze





Bridwell KH: *Spine* 31:S171-S178,2006

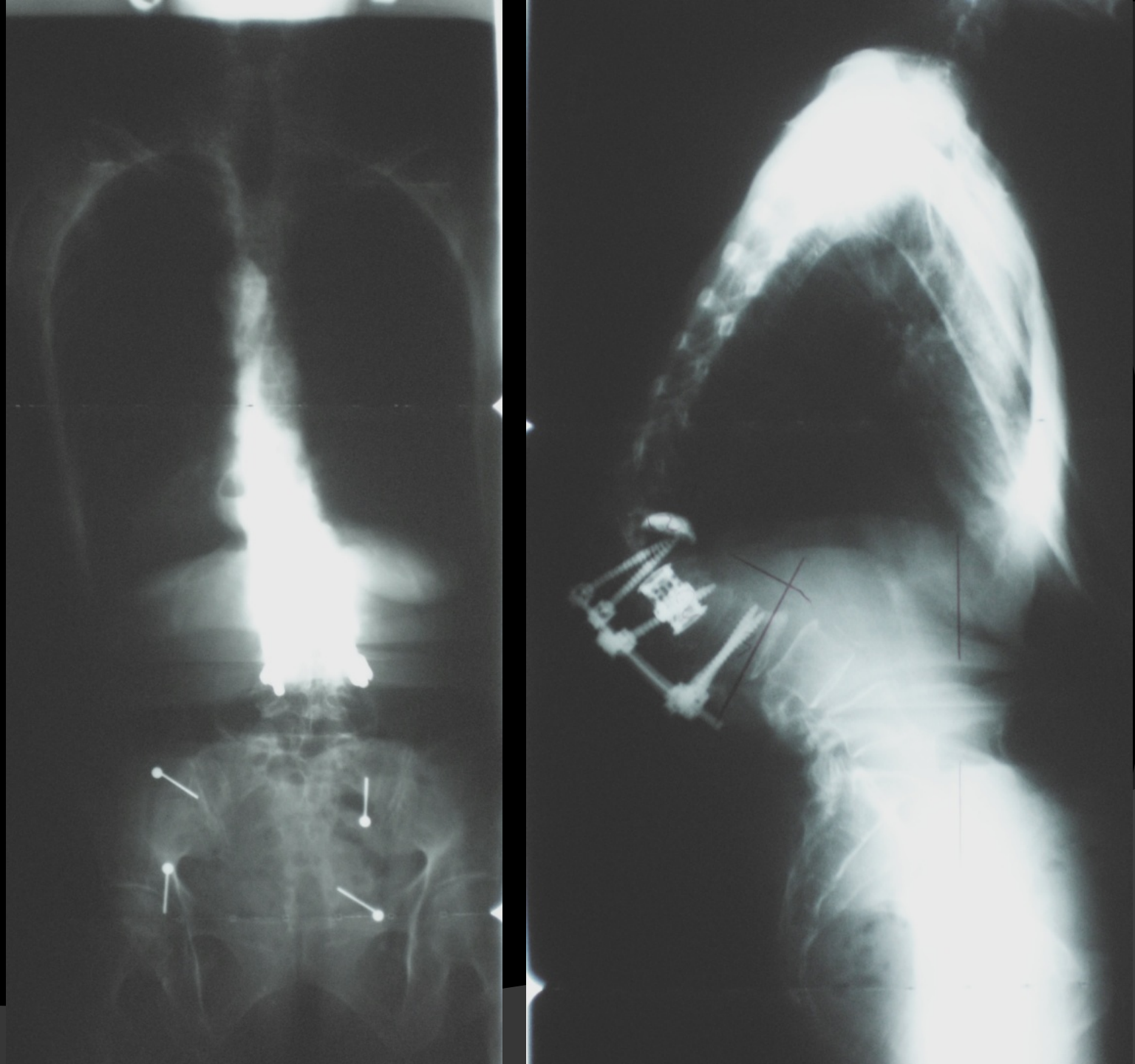
PSO = pedicle subtraction osteotomy; SPO = Smith-Petersen osteotomy; VCR=vertebral column resection

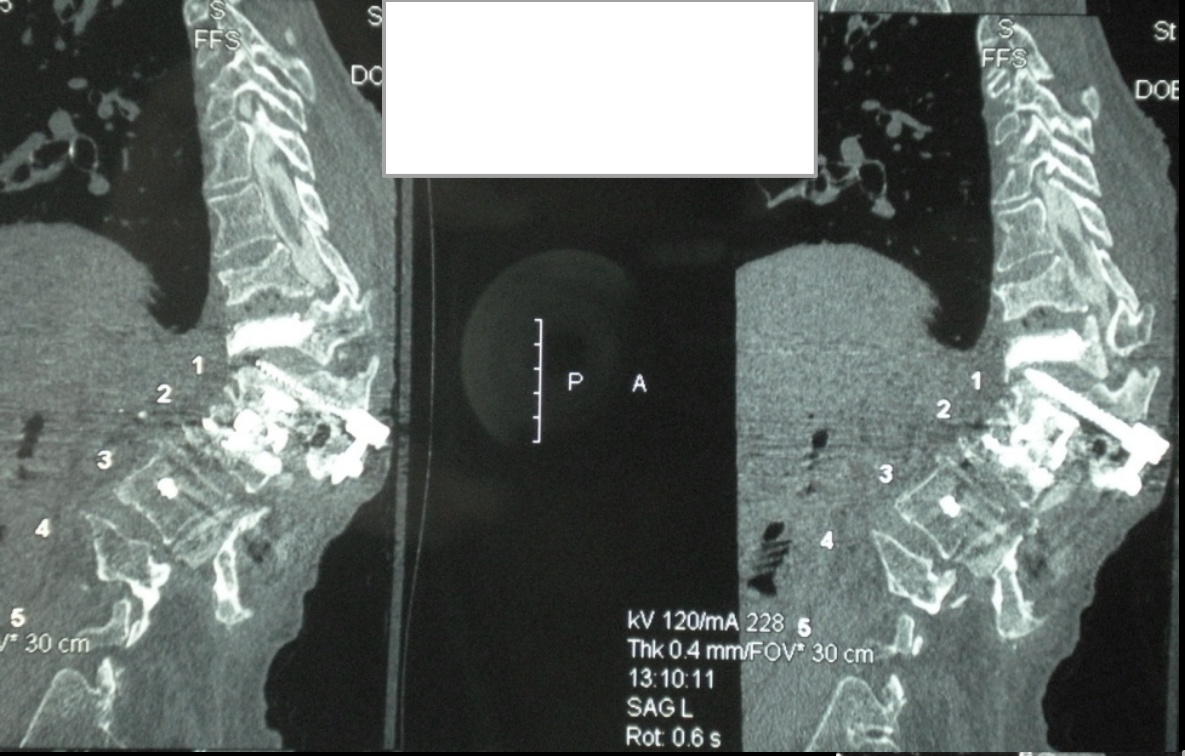
Figure 10. Algorithm for osteotomy type based on the character of the sagittal deformity.

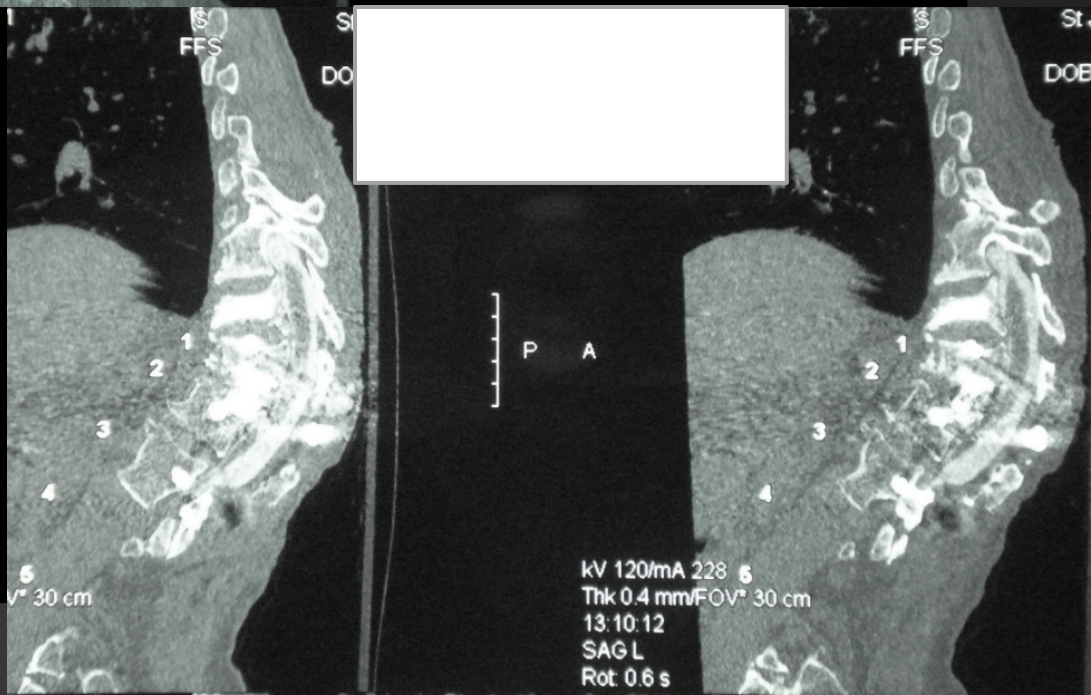
- Smooth deformity, thoracic/lumbar, mobile discs = SPOs
- Sharp deformity, ankylosed discs/posterior fusion = PSO
- Smooth lumbar kyphoscoliosis, major imbalance = PSO
- Sharp angular thoracic deformity = VCR

Case: 82 F c/o LBP

2 sx for L2 and T12 comp fx, 80 lbs, T = -2.5



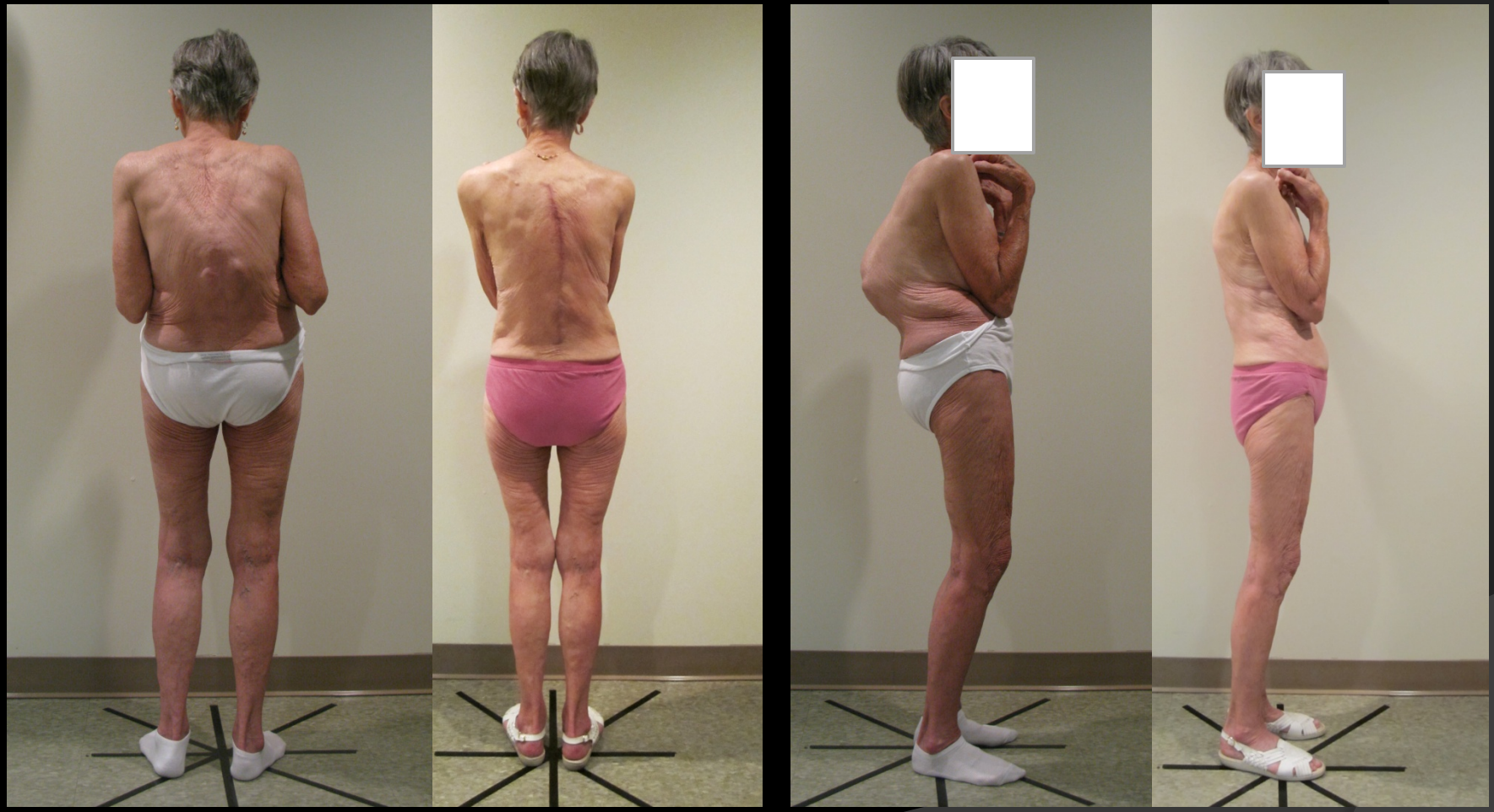

FFS
P A
1
2
3
4
5
kV 120/mA 228
Thk 0.4 mm/FOV* 30 cm
13:10:11
SAG L
Rot 0.6 s


FFS
P A
1
2
3
4
5
kV 120/mA 228
Thk 0.4 mm/FOV* 30 cm
13:10:12
SAG L
Rot 0.6 s

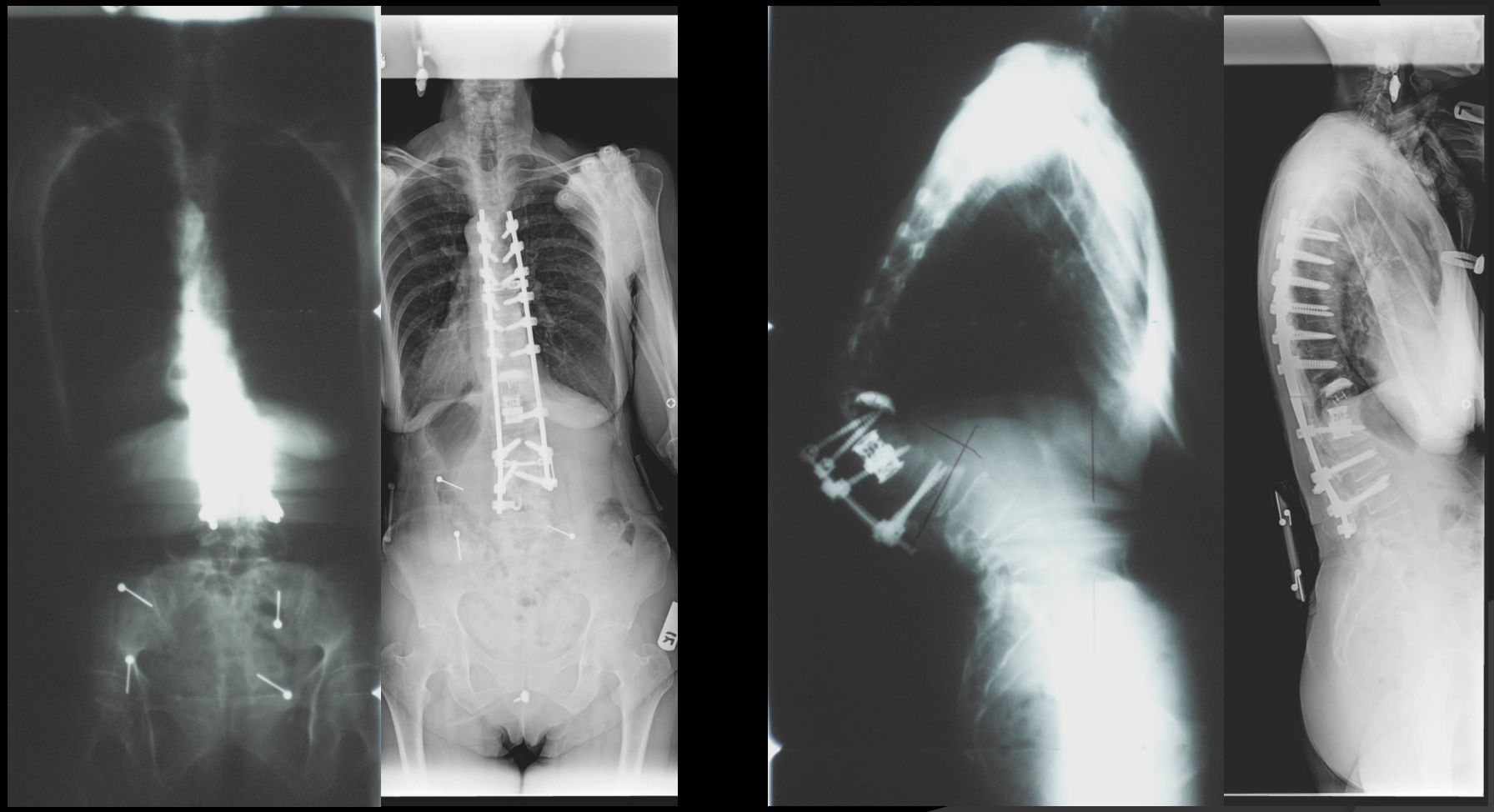
Medical Optimization

- Nutritionist referral
- Placed on Forteo
- Returns 1 year later
  - Now 105 lbs (+25)
  - T-score up to -1.6 (up 0.9)

6 wks s/p T6-L4 PSF, VCR L1



5 yr post op standing



Thank you!

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MAYO CLINIC