

PEDIATRIC TETHERING

Jaren Riley, MD

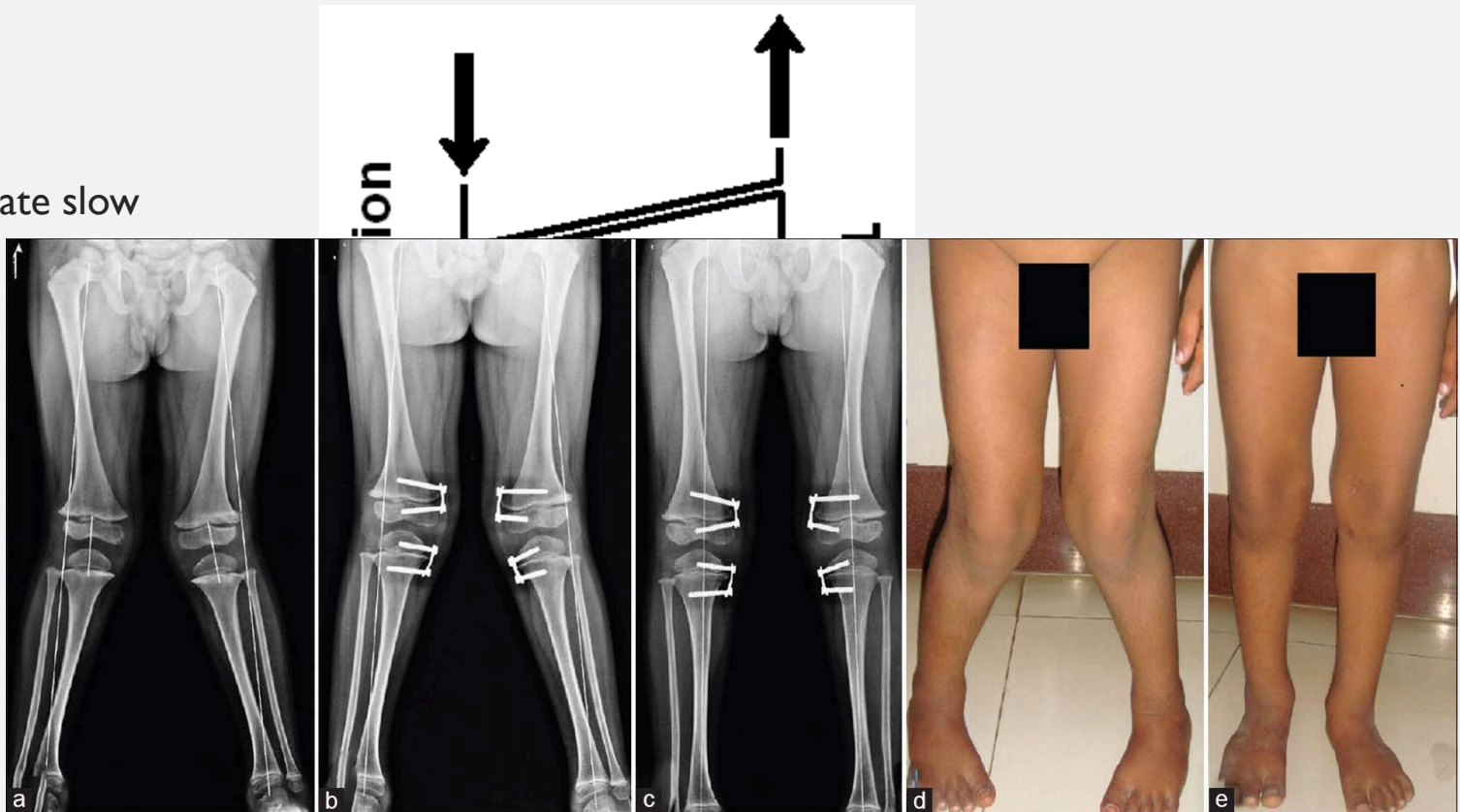
Rocky Mountain Pediatric Orthopedics

OBJECTIVES

- Understand principle of guided growth for osseous structures
- History of guided growth for the spine
- Indications for vertebral body tethering
- Technique
- Outcomes

GUIDED GROWTH

- Heuter-Volkman Law
 - Compression across a growth plate slow growth
 - Distraction accelerates growth



GUIDED GROWTH IN THE SPINE: PROOF OF CONCEPT



- Newton et al 2002
 - Bovine model
 - Placed lateral tether
 - 3 months of growth
 - Straight spines became curved

- Newton et al 2008
 - Bovine model
 - Lateral tether x6 months
 - Flexibility of discs maintained
 - No signs of disc degeneration

c.



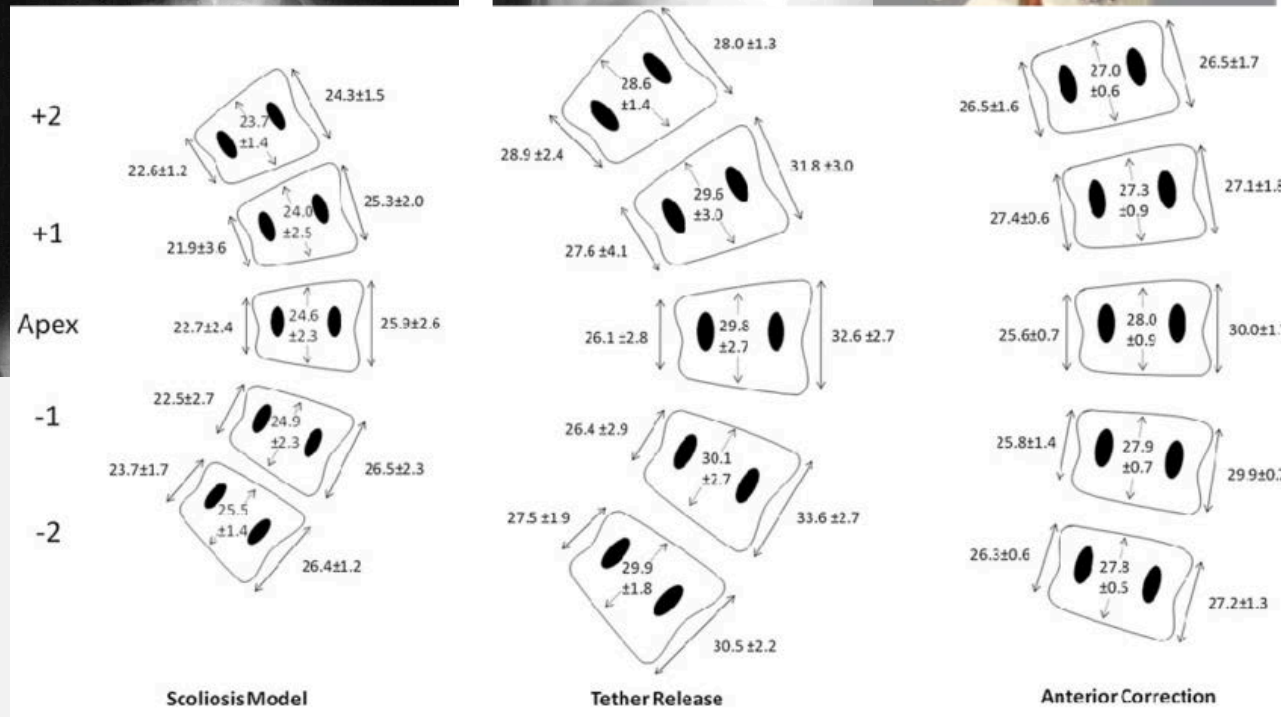
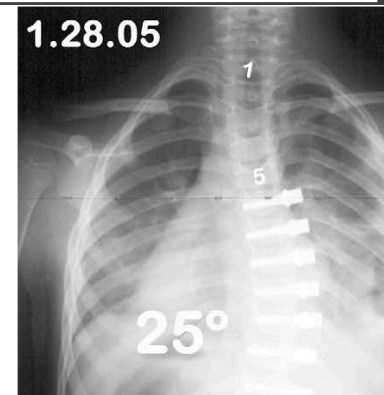
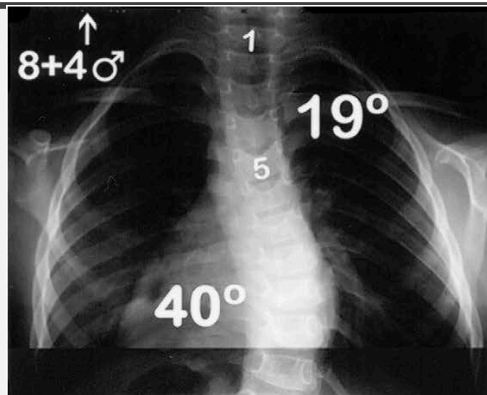
EARLY ATTEMPTS

- Vertebral body stapling
 - Short term outcomes reported in 2010, 2011, 2013, 2018
 - Success defined as avoidance of fusion, improvement of $>10^\circ$
 - Success correlated with
 - Smaller curves (20°)
 - Flexible curves
 - Curves ≥ 35 consistently failed
 - My issues with VBS
 - Did these curves need surgery?



FURTHER INNOVATION

- Lenke 2010
 - Vertebral tether with polypropylene rope across mobile segment
- Newton
 - Also showed that discs maintained hydration
 - Vertebral bodies returned to normal shape
 - This is the key to MAINTAINING the correction!!!



INDICATIONS

- Growth
 - Must have enough growth remaining to correct the curve
 - Shouldn't have too much growth or curve will overcorrect
- Curve size
 - Curve should be large enough to predictably need surgical intervention in the future
 - Curves too big will not correct
 - Tether will break
 - Mechanics too powerful for overpower

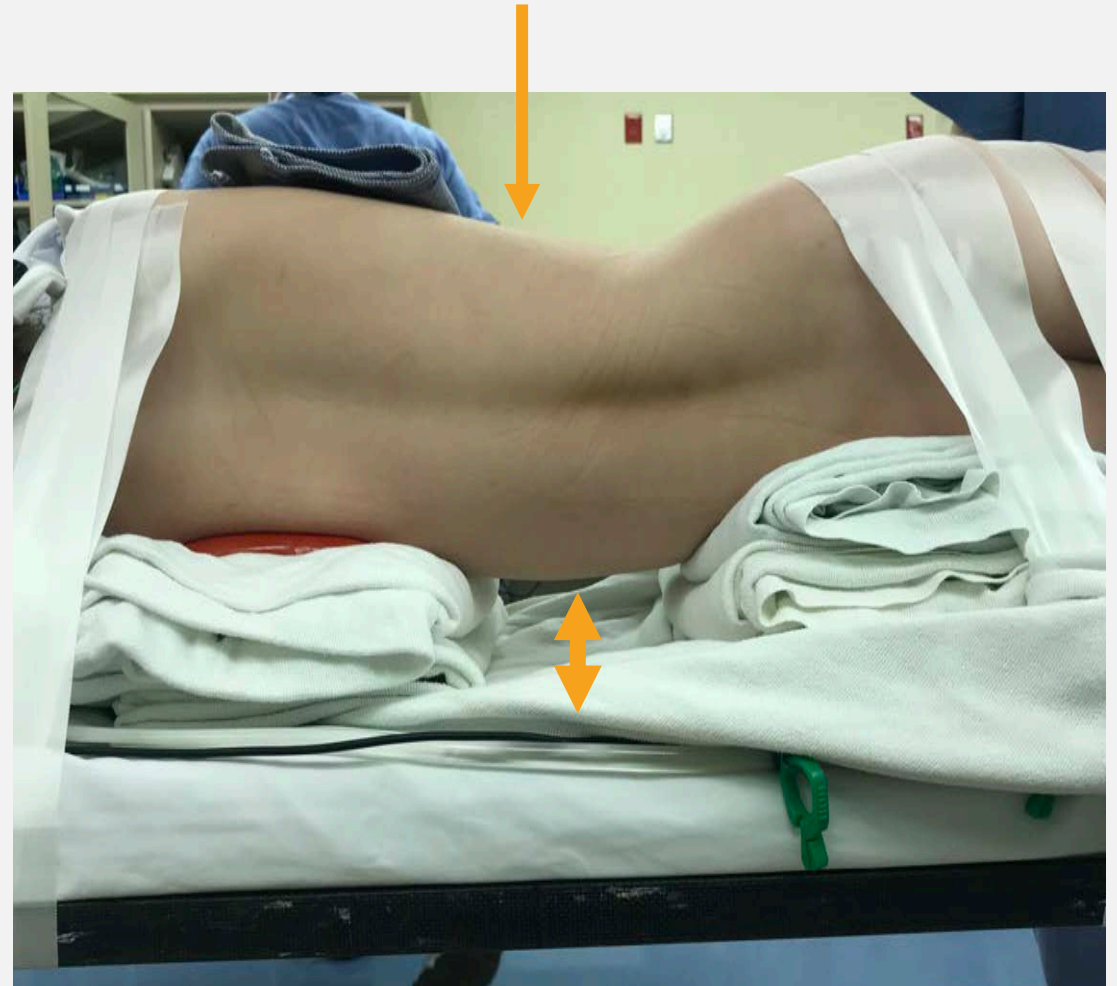
Curve	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7, 8
10°	2% (0% to 40%)	0% (0% to 15%)	0% (0% to 0%)	0% (0% to 0%)	0% (0% to 0%)	0% (0% to 0%)	0% (0% to 1%)
15°	23% (4% to 69%)	11% (1% to 58%)	0% (0% to 2%)	0% (0% to 0%)	0% (0% to 0%)	0% (0% to 0%)	0% (0% to 7%)
20°	84% (40% to 98%)	92% (56% to 99%)	0% (0% to 14%)	0% (0% to 1%)	0% (0% to 1%)	0% (0% to 1%)	0% (0% to 26%)
25°	99% (68% to 100%)	100% (92% to 100%)	29% (3% to 84%)	0% (0% to 5%)	0% (0% to 5%)	0% (0% to 2%)	0% (0% to 64%)
30°	100% (83% to 100%)	100% (98% to 100%)	100% (47% to 100%)	0% (0% to 27%)	0% (0% to 22%)	0% (0% to 11%)	0% (0% to 91%)
35°	100% (91% to 100%)	100% (100% to 100%)	100% (89% to 100%)	0% (0% to 79%)	0% (0% to 65%)	0% (0% to 41%)	0% (0% to 98%)
40°	100% (95% to 100%)	100% (100% to 100%)	100% (98% to 100%)	15% (0% to 99%)	0% (0% to 94%)	0% (0% to 83%)	0% (0% to 100%)
45°	100% (98% to 100%)	100% (100% to 100%)	100% (100% to 100%)	88% (2% to 100%)	1% (0% to 99%)	0% (0% to 98%)	0% (0% to 100%)

INDICATIONS

- Must be able to tolerate single lung ventilation
 - Screen for risk factors pre op
 - ALWAYS tell parents, we don't know until we know
 - Any risk factors
 - Pre op nebulizer treatment
 - All patients
 - Ketamine
 - No longer use double lumen ET tube
- Flexible curve
- Rotation
 - Doesn't remodel well
 - Rotation must either be small, or family must understand it may not improve
 - T4 may be upper limit for instrumentation
 - L4 may be lower limit (iliac crest gets in the way)

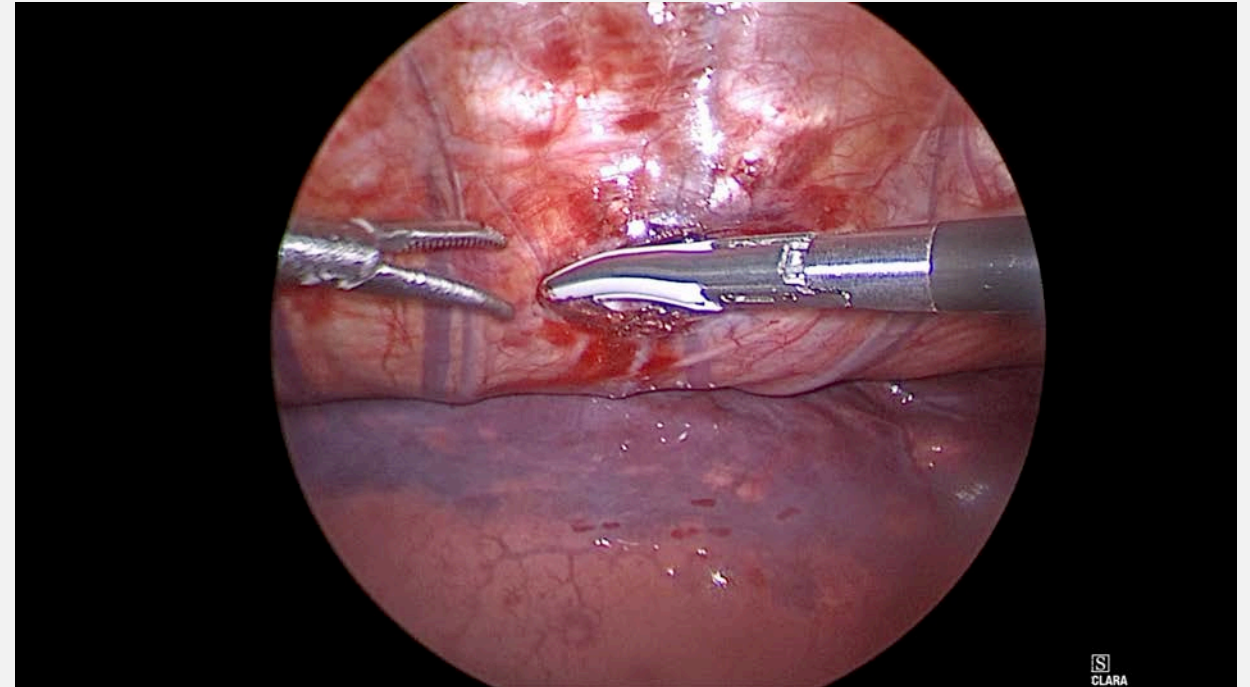
TECHNIQUE

- Lateral decubitus
 - Convexity up
 - Arrange padding to allow for curve manipulation



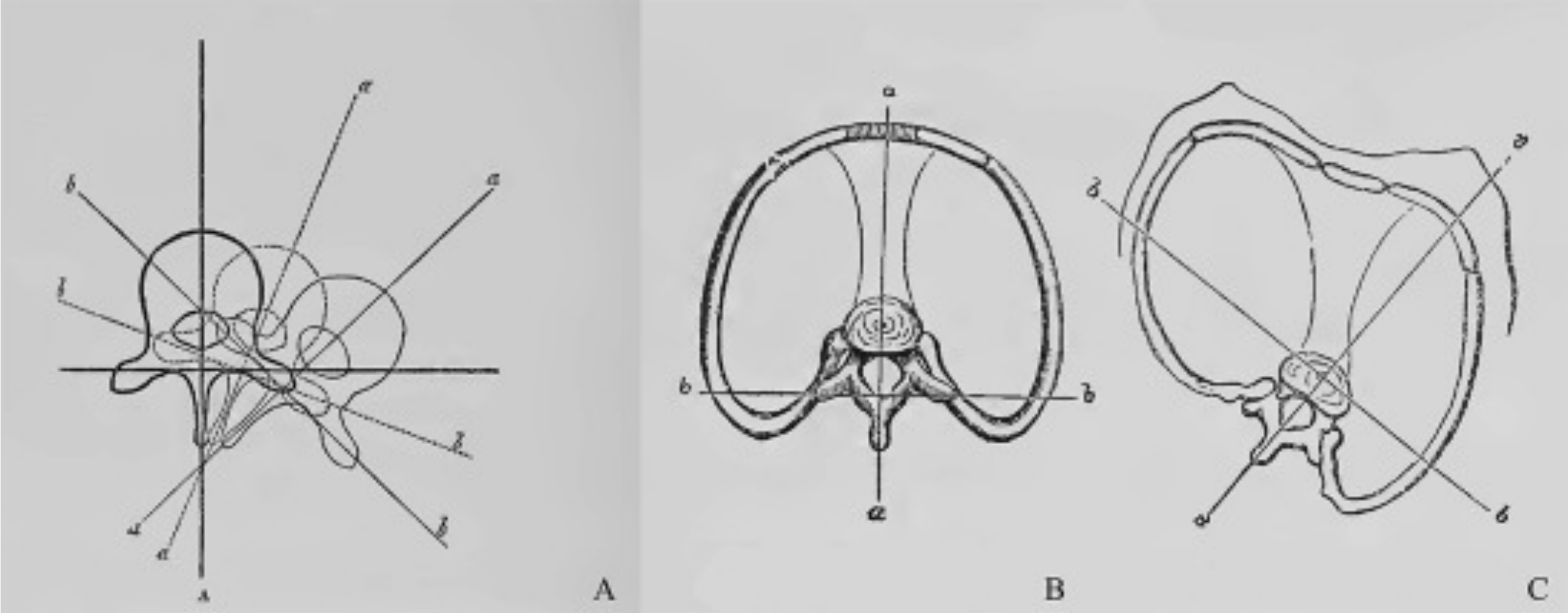
TECHNIQUE

- Thoracoscopic access
 - 3-4 incisions (15mm portals)
 - MUST create portals more posterior than normal to accommodate the rotation of the spine
 - Elevate periosteum, take down segmentals
 - If instrumenting both sides of a vertebral body, spare a segmental artery on one side



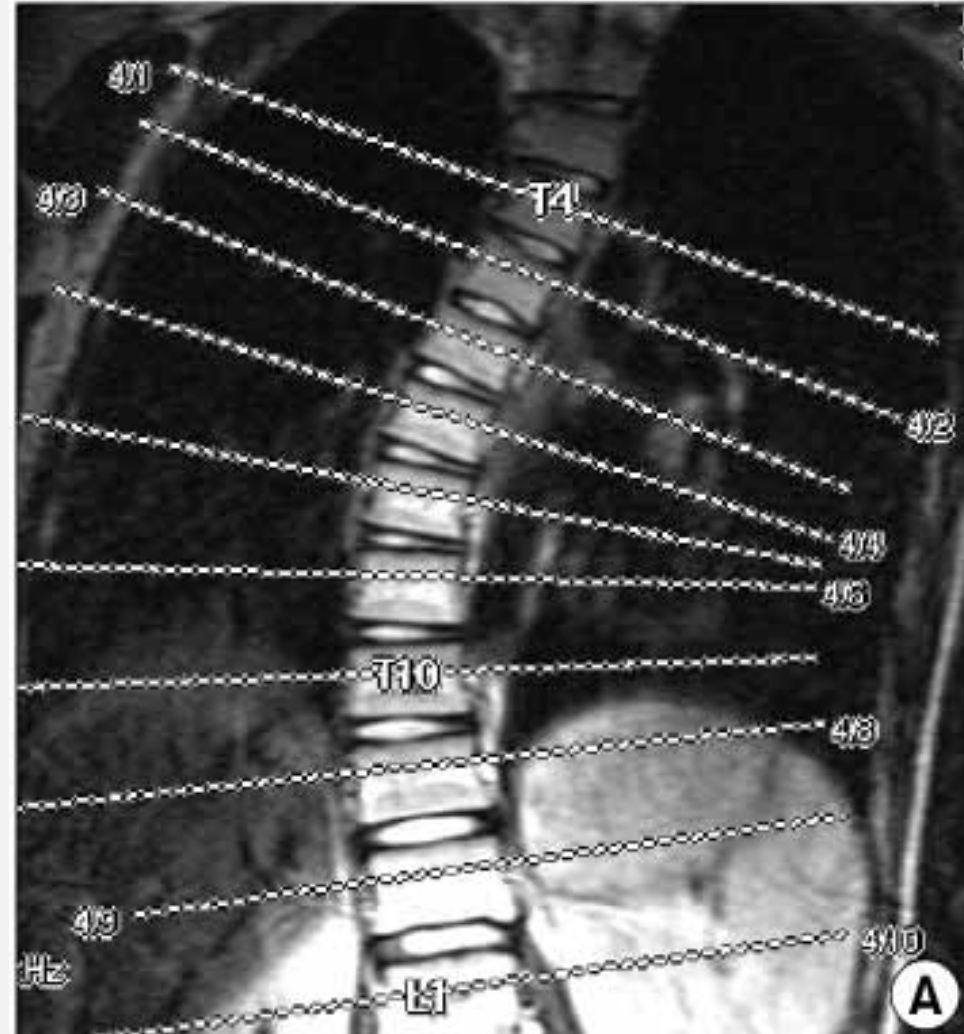
TECHNIQUE

- Why posteriorly placed portals?



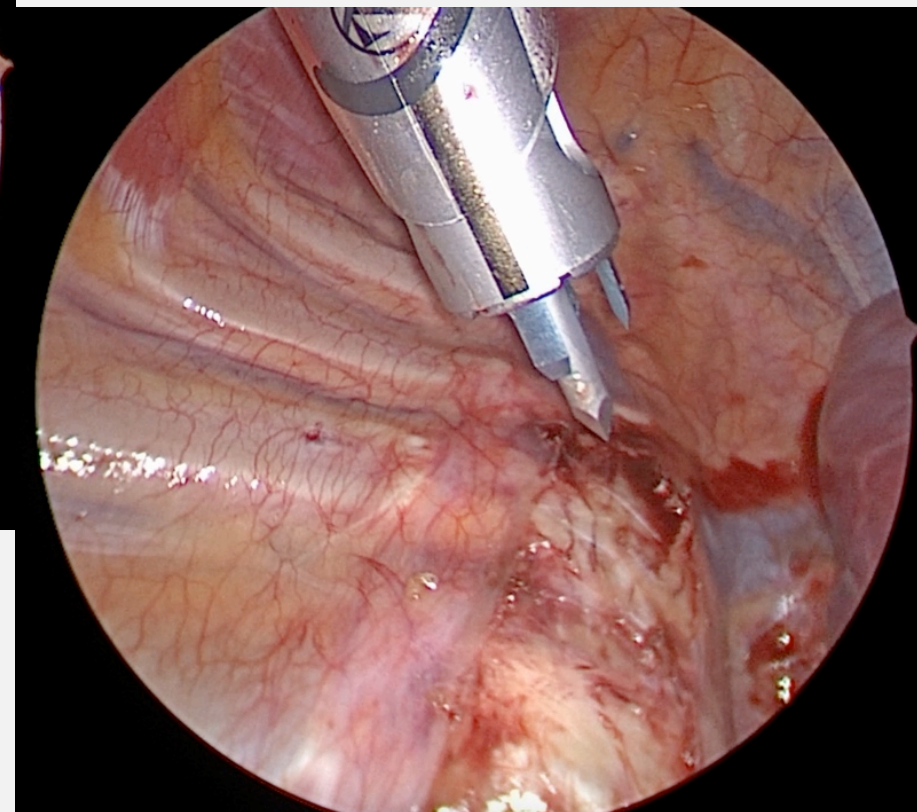
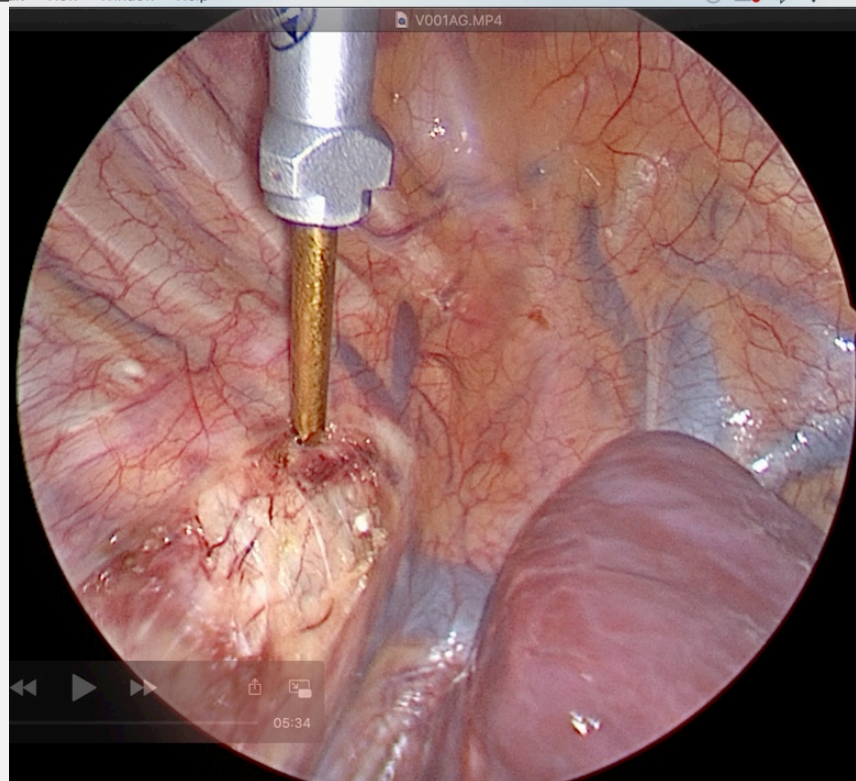
TECHNIQUE

- How many portals?
- 2-3 levels/ portal
 - No need to create a new incision for each rib space
 - Shift current incision to next rib space



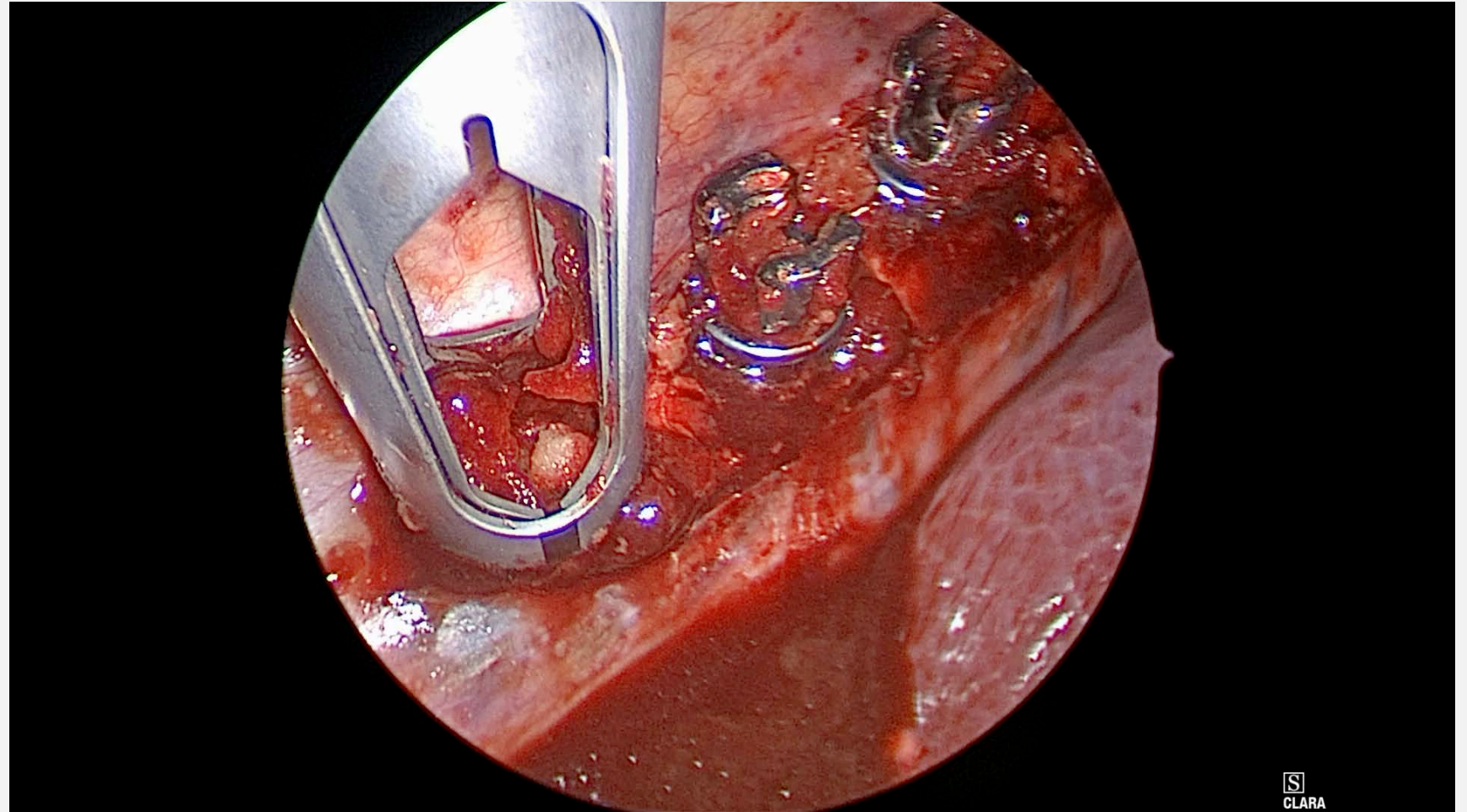
TECHNIQUE

- Starter awl
- Staple



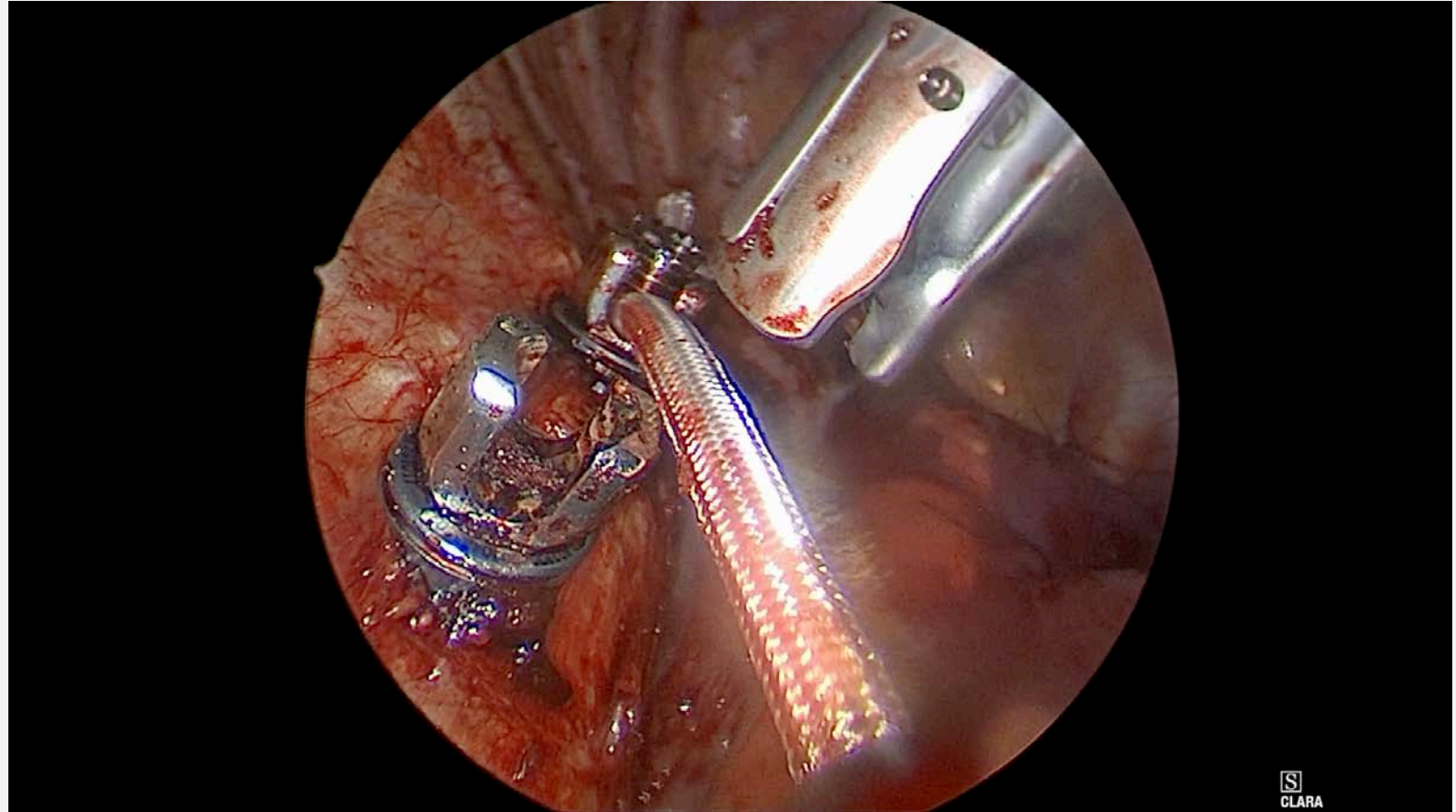
TECHNIQUE

- Tap
- Screw



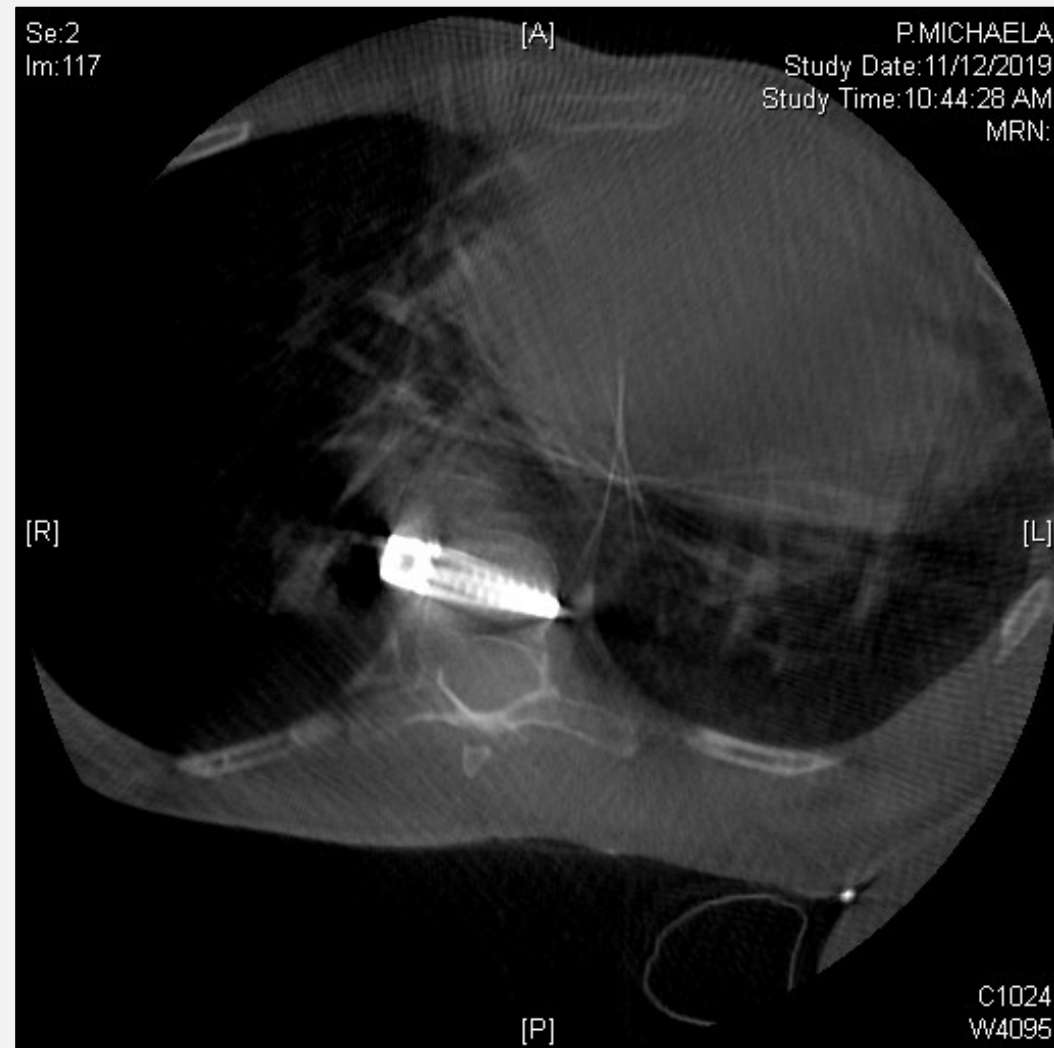
TECHNIQUE

- Place and tension tether



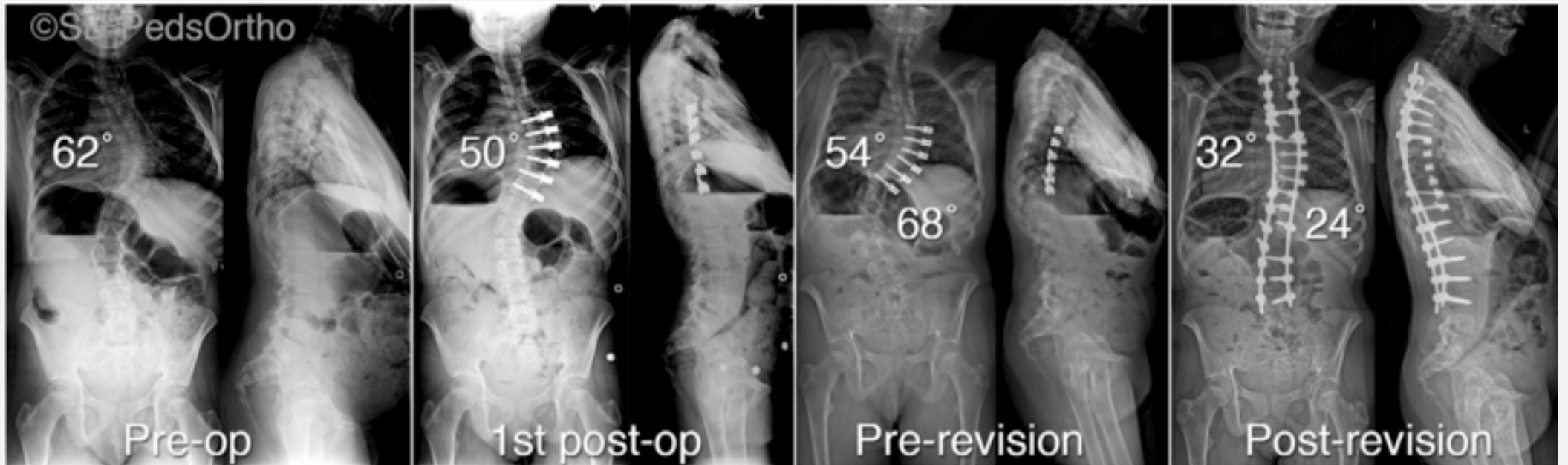
TECHNIQUE

- Check screw location, orientation, and length with O-arm



OUTCOMES

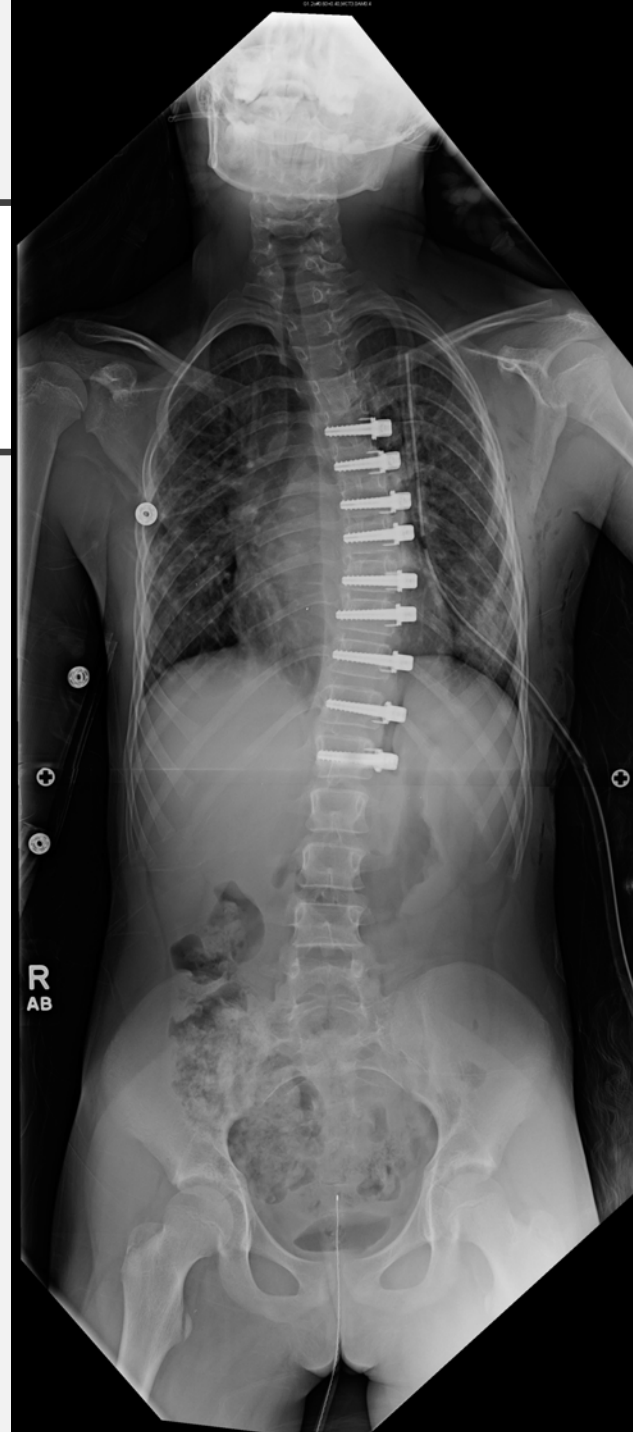
- **Samdani** (n=11)
 - 2 returned to OR to loosen tether (overcorrection)
 - Good curve correction in coronal, sagittal and axial planes
- **Newton** (n=17)
 - 41% revision rate
 - Complications
 - Tether breakage
 - Overcorrection
 - Curve progression



OUTCOMES

- Number of cases: 8
- Avg inpatient stay: 3.5 days
- Avg time with chest tube: 2 days
- No neurologic deficits
- No infections
- One gymnastics state champion (6 months postop)
- Follow up too short





FUTURE DIRECTIONS

- Refine indications
 - Algorithms for curve magnitude, growth remaining, flexibility, and how much correction to shoot for in surgery
- Better instrumentation
- Reliable tether
- Smaller implants

