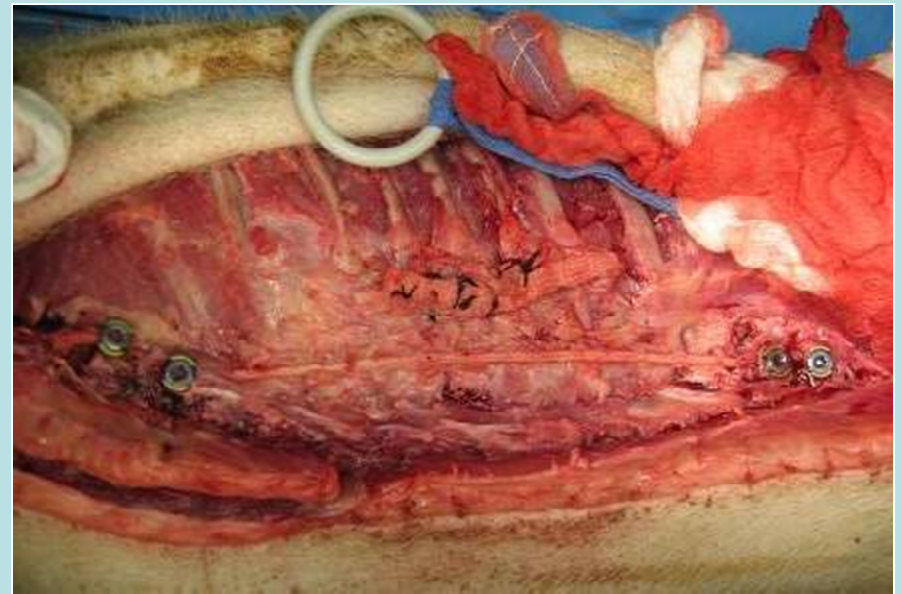
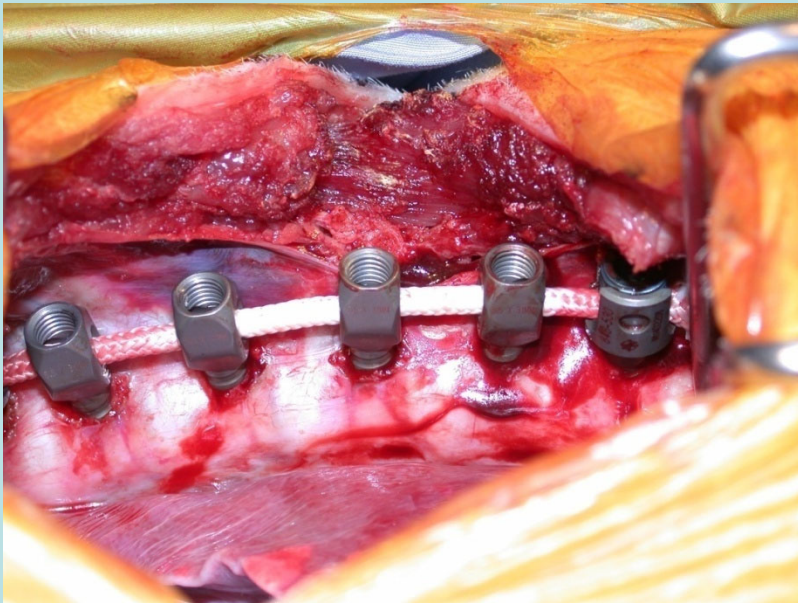


GROWTH MODULATION ...OTHER THAN STAPLES



Charles E Johnston MD
ICEOS DUBLIN
Disclosures - Medtronic a,e

Why modulate ?

- Decrease morbidity of multiple, serial interventions
- Gradual correction/stablization of spine prevents or improves extrinsic chest wall deformity (windswept thorax)
- Preserve motion/disc+facet function

- **BIG RESEARCH QUESTION**

Ability to create deformity =
ability to correct deformity ??

History - "Thoracogenic" theory

- Growth of Th spine and ribs inter-related
 - Disturb growth of one → disturbs the other, especially in proximal Th area
1. Canavese / prox. thor. fusion → hypoplasia of ribs, sternum, thorax, decreased lung volume
 2. Carpintero / asymmetric tether T1-3 → larger curve > mid thor. tether
 3. Mehta&Snyder / asymmetric rib tether → larger curve > spine tether at same level
 4. Sevastik, Agadir / rib elongation → concavity of scoliosis
 5. Langenskiold, Sevastik, Deguchi / rib resection → larger curves > rib shortening

BIG RESEARCH INTEREST

Ability to create deformity =
ability to correct deformity ??



FIG. 1

FIG. 2

FIG. 3

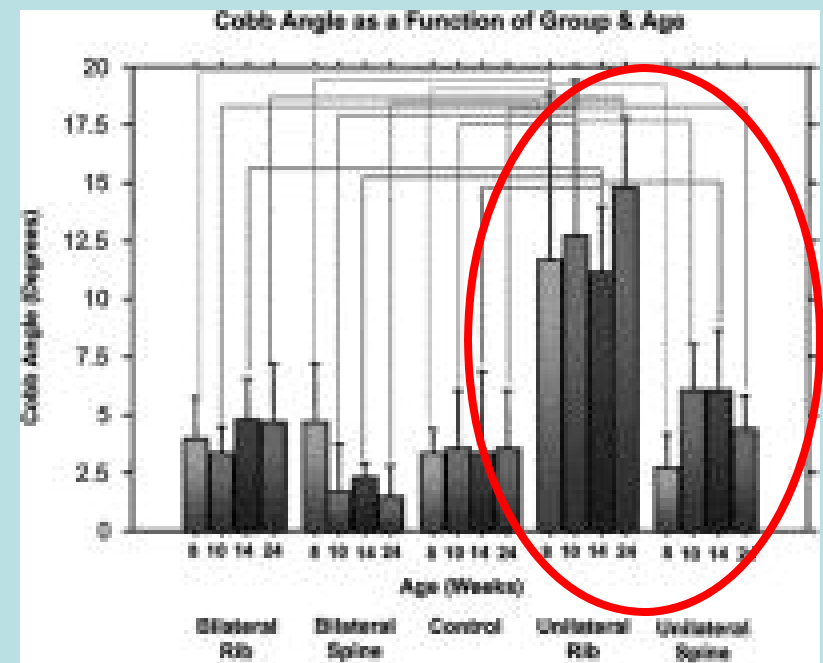
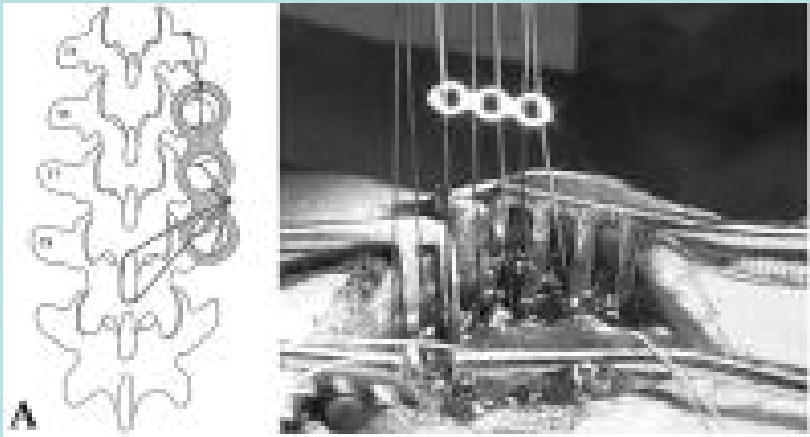
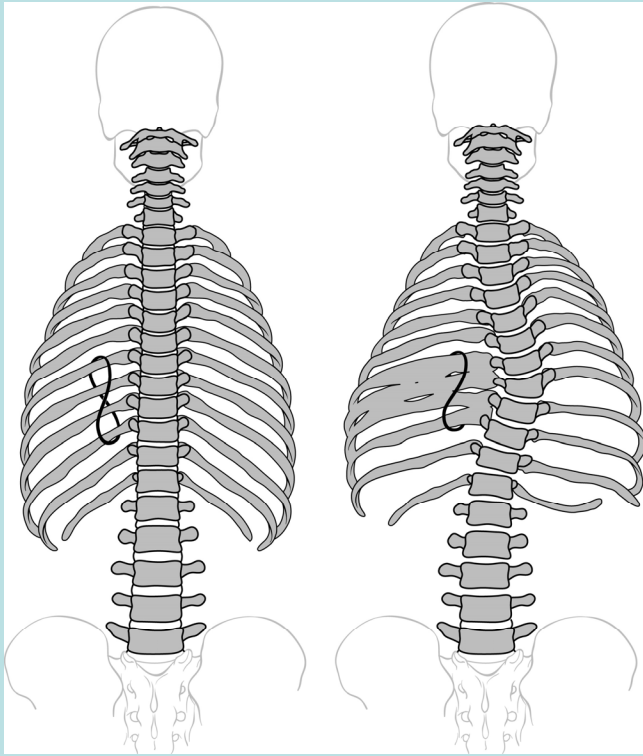
Rib resection
1960's

Langenskiold et al

-Not currently
utilized clinically

Rib vs. Spine Effect (Mehta/Snyder)

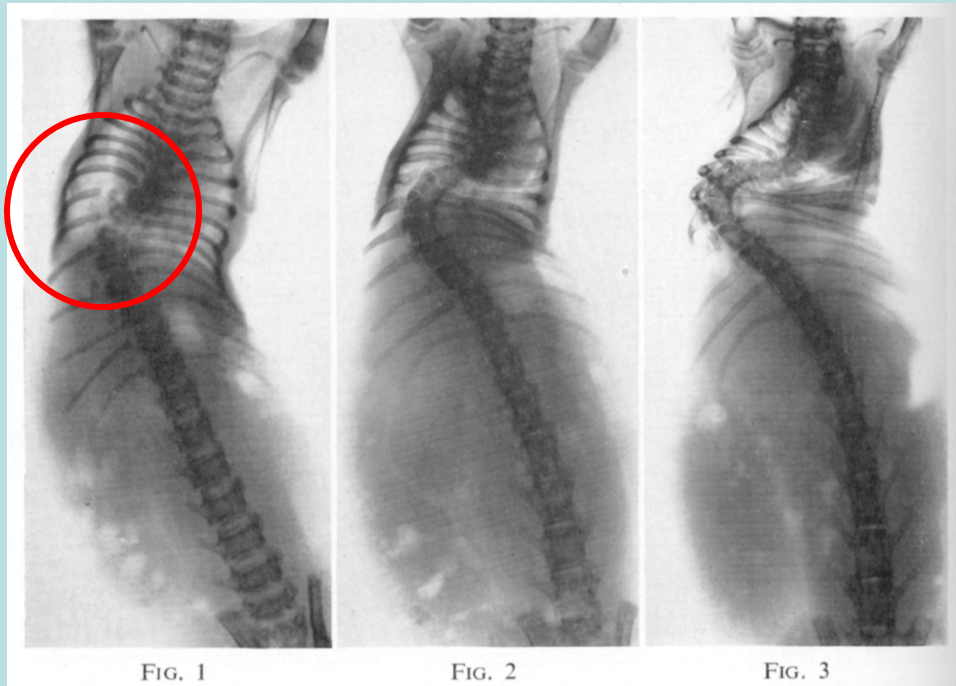
Rib tether \rightarrow longer
moment arm $>$ t.p.
tether = larger curves



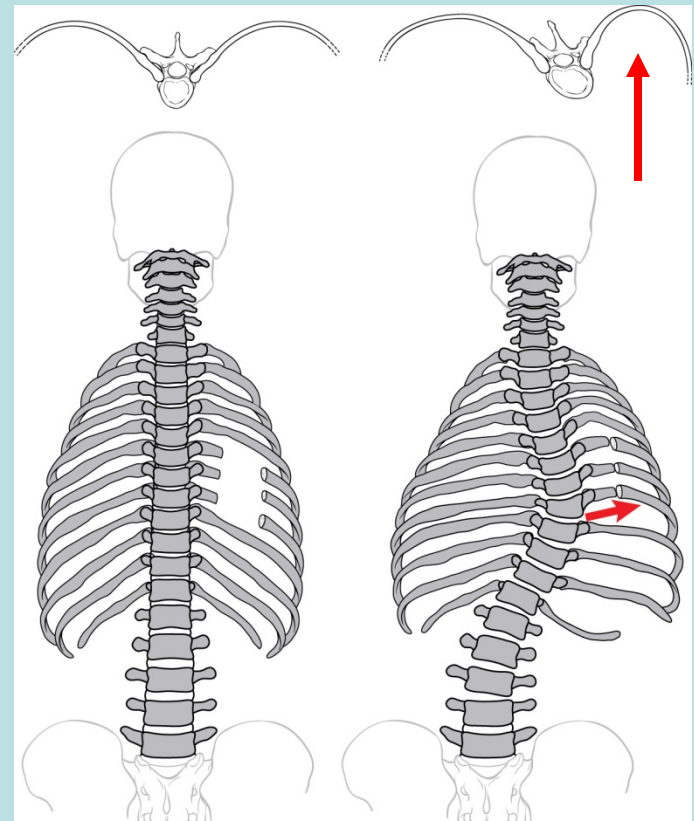
Classic animal model

Langenskiold ('60's)

- Rib resection (=shortening) → severe scoliosis



Destabilize convexity +
concave ribs elongate



Rib Modulation Model

Pinealectomized Chickens

(Deguchi et al '90s)

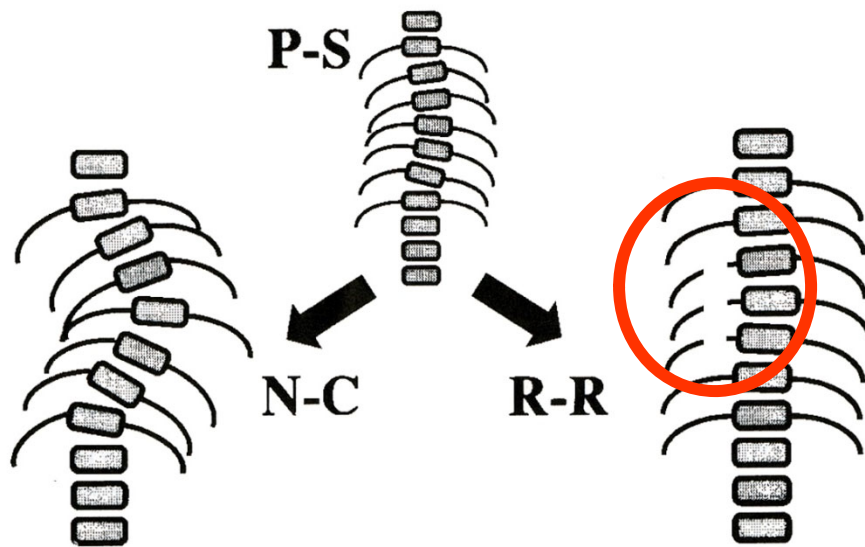


FIG. 1. Hypothesis: Rib resection may suppress the progression of scoliosis or reduce curvature when it is done on the concave side of the curve at an early stage of the growth period. R-R, rib resection; P-S, progressive scoliosis; N-C, natural course.

- Pinealectomy-produced curves = "systemic" effect
- **Concave** apical rib resection @ 2 or 4 wk. (depending on curve reaching $>20^\circ$) = "local" effect
- Curve control / suppression observed

Curve Suppression (Deguchi)



FIG. 2. Severe scoliosis in subgroup A1.



Chicken in subgroup B1 at 20 weeks of age. Curve was reduced by rib resection done at 2 weeks of age. A curve of 24° was present. The resected ribs showed healing of 16 weeks.

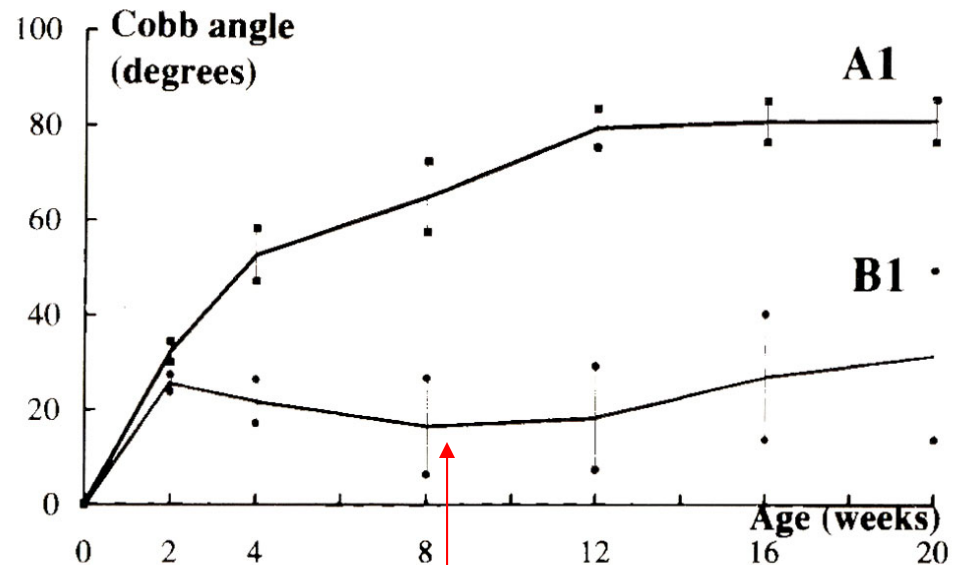
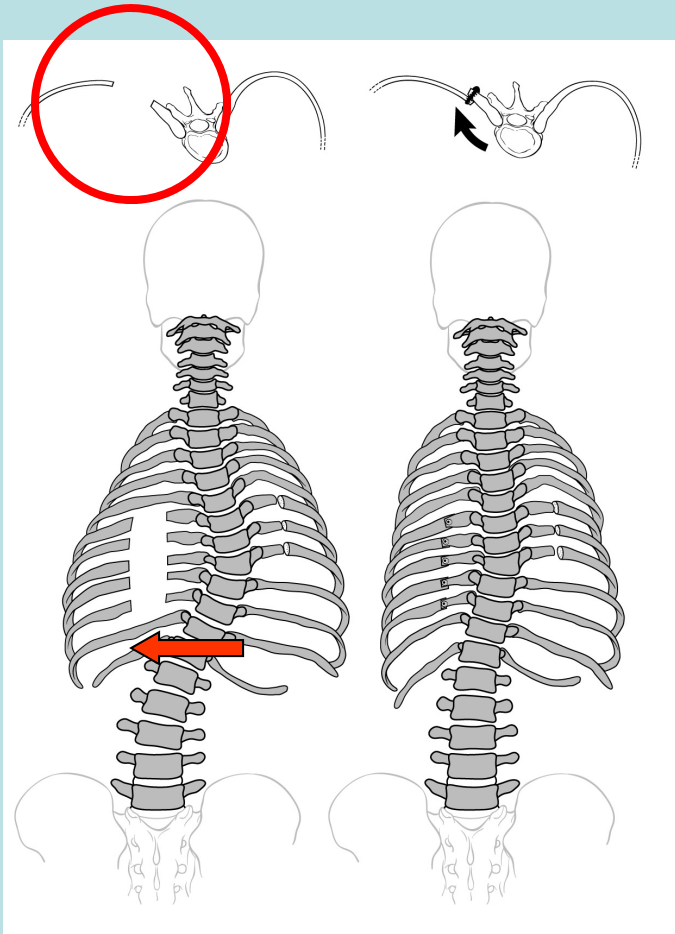


FIG. 3. Course of progression of scoliosis in subgroups A1 and B1. Mean value and standard deviation in each subgroup was shown. Note that subgroup A1 chickens developed scoliosis rapidly until 12 weeks of age and gradually after that, whereas progression of the scoliosis in subgroup B1 chickens was suppressed after 2 weeks of age. Repression of the curvature occurred after 8 weeks of age.

Ribs healed after 8 weeks - thorax "stable" allowing re-progression

Rib Shortening vs. Lengthening

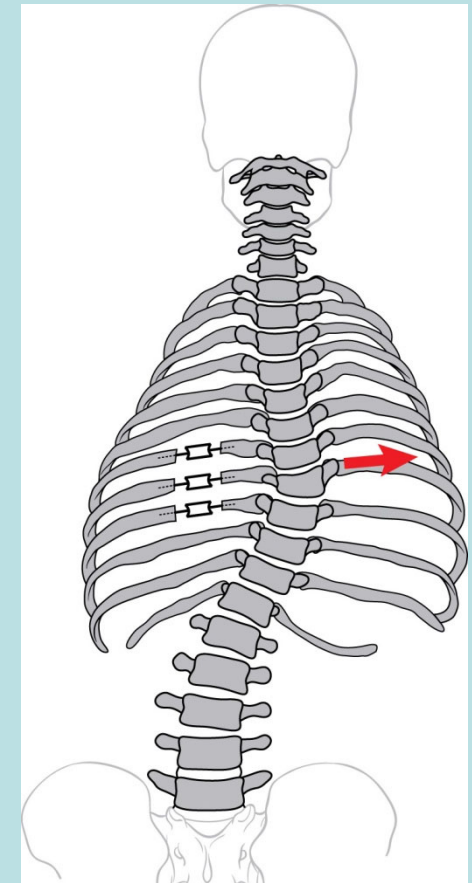
Sevastik et al '90



Limited effect after initial acute changes in coronal plane (rib continuity restored)

(10% correction predicted by Montreal simulation C-E Aubin)

Not as "effective" as resection



Concave Rib Resection for IIS

Piggott ROH Birm (53-B:663, 1971)

- Mean curve 64°
- 6 ribs/heads, postop not specified
- 23/25 $<10^\circ$ prgrsn @ 29 mo (6-57) f/u
- 7 improved $>10^\circ$

Barnes RNOH (61-B:31, 1979)

- Mean curve 80°
- Apical 4 ribs, cast x 2 mo, then MB
- 23/48 $<10^\circ$ prgrsn @ 6 yr (3-9 $\frac{1}{2}$) f/u
vs. 5/19 cast/brace only $<10^\circ$ prgrsn

Rib resection - Discussion

- Piggott - "several curves have shown significant regression...operation has had a favourable influence...at a relatively early attempt at assessment. ...therapeutically worthwhile....especially in children under five years old
- Barnes - "...no significant differences in either change of angle or rate of change of angle between patients of the two groups."

Clinical Application - Rib

Eur Spine J (1998) 7:505-508
© Springer-Verlag 1998

CASE REPORT

B. Xiong
J. A. Sevastik

**A physiological approach
to surgical treatment of progressive
early idiopathic scoliosis**

3 apical concave ribs shortened 2 cm



7 y.o. 46°



15 mo p.o. 30°



27 mo p.o. 21°

Rib Rx for EOS

- Abandoned - prematurely?
- Active research in deformity creation
- Clinical trial - again ?

THE NEW YORK TIMES, WEDNESDAY, JUNE 27, 2007

BASEBALL

Chiropractor Puts Four of Damon's Ribs Back in Place

By TYLER KEPNER

BALTIMORE, June 26 — The fastest way for Johnny Damon to feel better, it seems, is to visit his chiropractor in Orlando, Fla. That is what he did Monday, after an earlier appointment to see a dentist, and the results had him feeling rejuvenated.

"We've definitely got to get him on the payroll," Damon said of the chiropractor, Dr. Gerry Mattia. "The guy's magic."

Damon, who started only once in Colorado and San Francisco because of a sore rib cage, said Mattia discovered immediately that four ribs on his right side were out of place. Mattia fixed the problem over two visits — one Monday, another Tuesday morning — and Damon was back in the lineup Tuesday night, leading off at designated hitter.

"I feel like a different person," Damon said, adding later: "Just after he did it, I was like, 'Wow, how come I'm feeling so much better?' I'll take it."

Damon, who has also been bothered by problems with his calves and back this season, has embraced the role of designated hitter. But he said Tuesday that he hoped to return to center field.

"I actually want to worry about the field," he said. "I can still go get it. It's just unfortunate how the season started with the strained calf. But that feels pretty good. I want that



Johnny Damon said he felt rejuvenated yesterday after visiting his chiropractor on Monday in Orlando, Fla. Barton Silverman/The New York Times

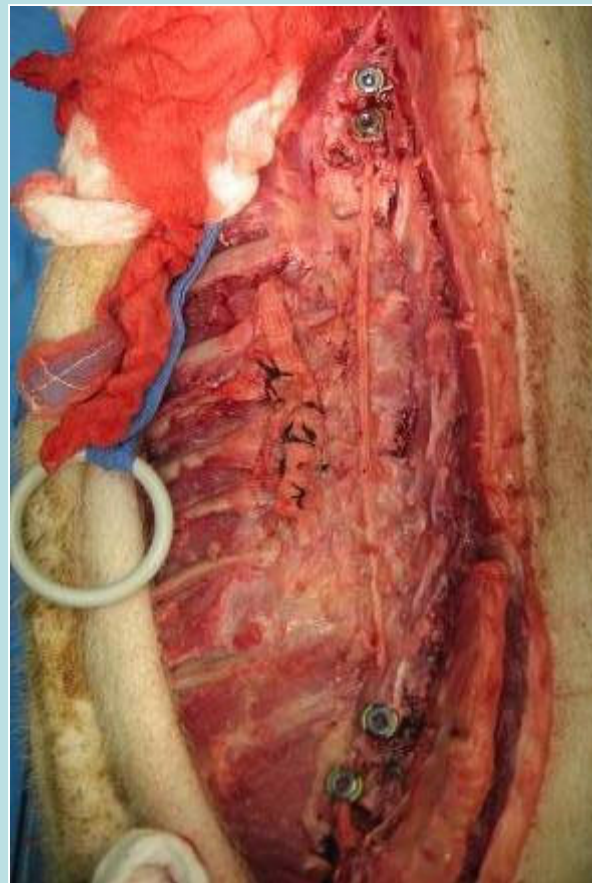
Newer Methods for Curve Creation

- Spine +/- rib tethers (staples, cables)

Lafage/Schwab, Braun, Mehta/Snyder, Newton

Unilateral rib
+ spine only

No
contralateral
rib resection



G.S.
age 10 + 6

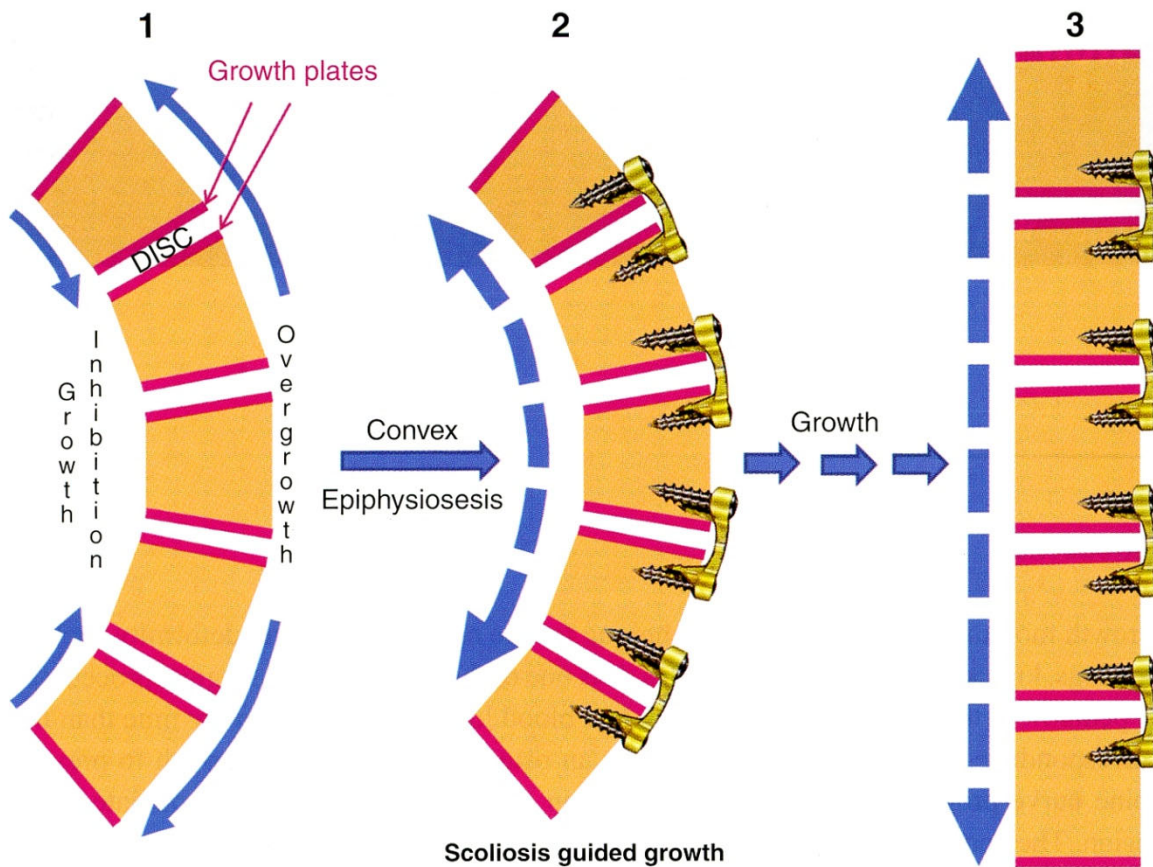
Stapling

G.S.
11+10
Age X 16 mos.

15°

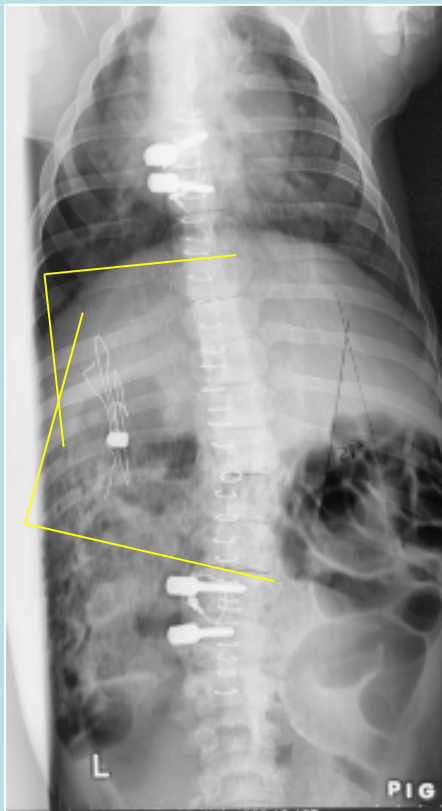
134

E.J. Wall and D.I. Bylski-Austrow

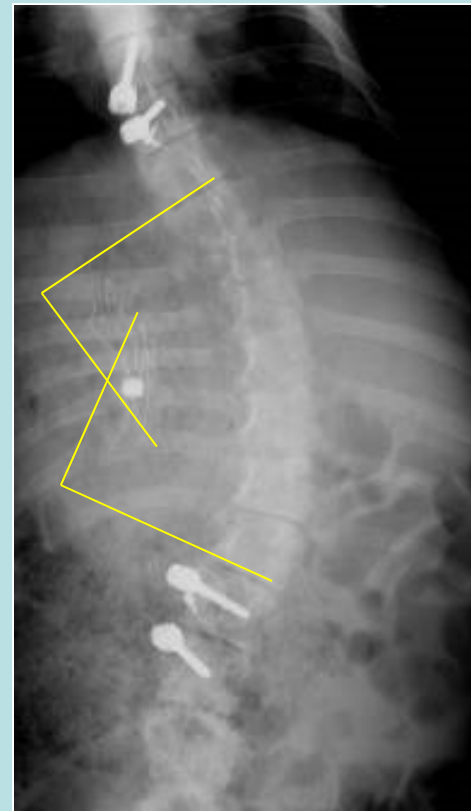


Curves progression: 11 animals

Coronal Curve Progression



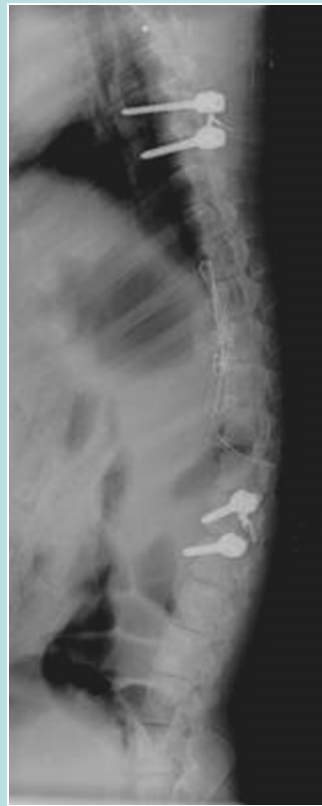
Immediate Post-Op
26 degrees



Last Follow-up
52 degrees

Curves progression: 11 animals

Sagittal Curve Progression



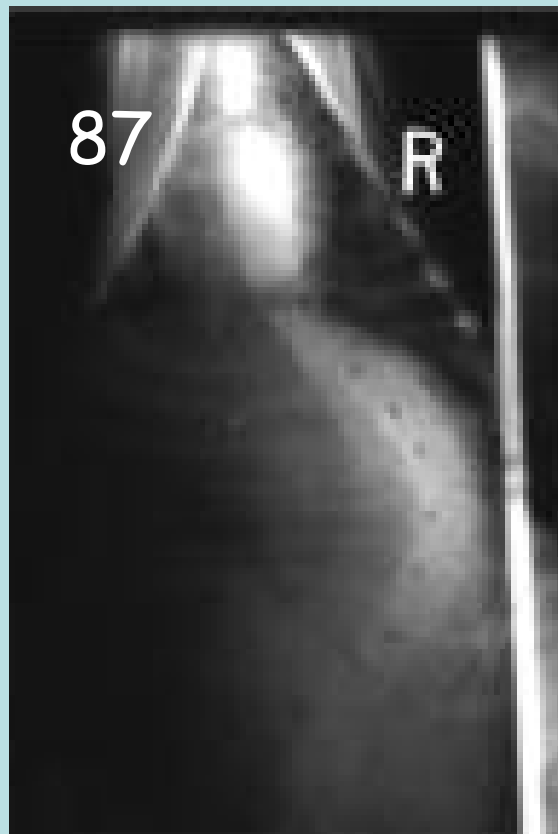
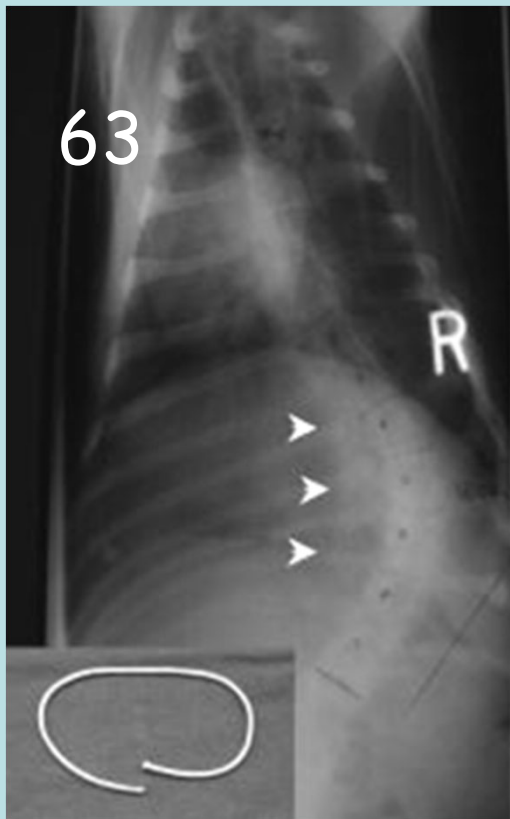
Immediate Post-Op
7 degrees



Last Follow-up
27 degrees

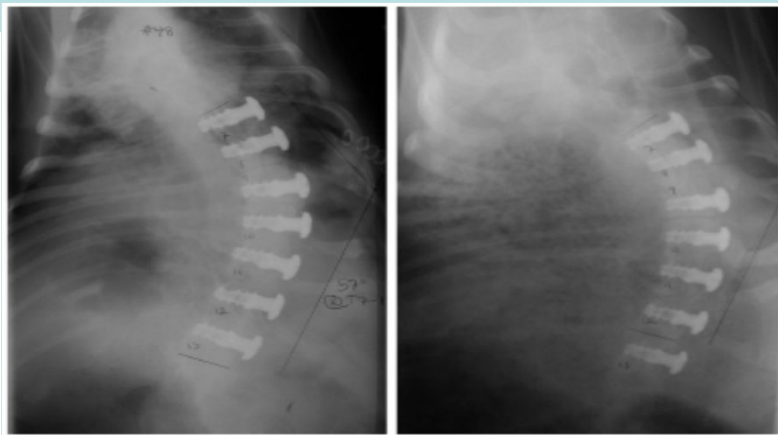
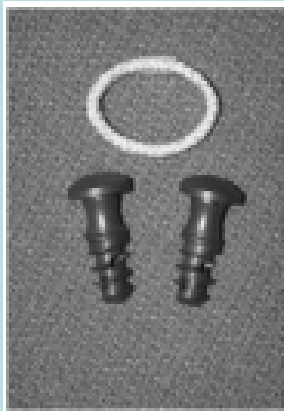
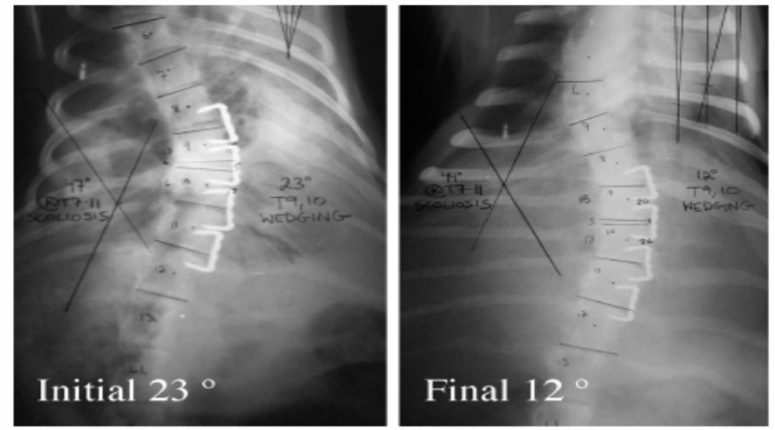
Newer Methods - Spine + Ribs (Braun)

- Flexible tether of spine with **rib resection** (immediate big curve + progression)



Lordosis

Correct/suppress (Braun)



Not enough
growth
remaining
following curve
development to
fully assess
corrective
efficiency ???

Deformity Creation - tethers

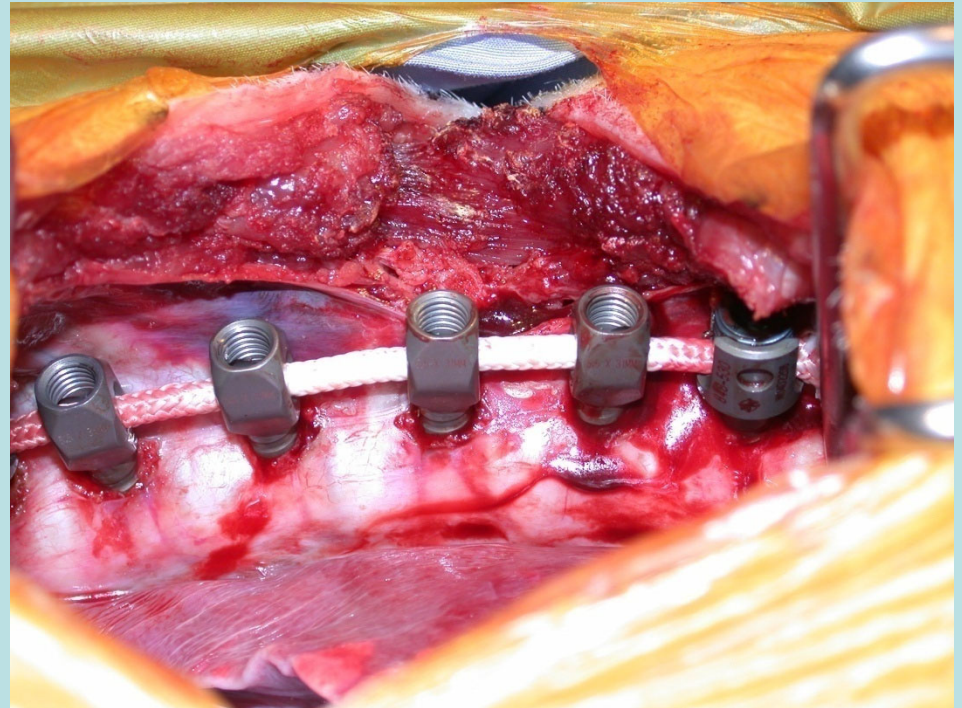
Multiple authors

(Newton et al, Hunt/Braun,
Johnston/Zhang

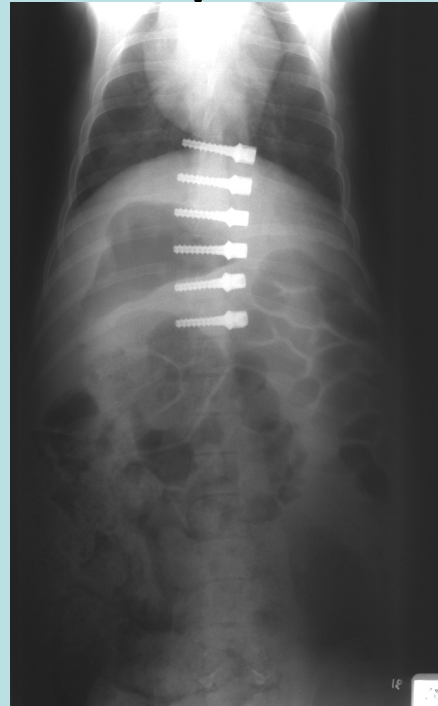
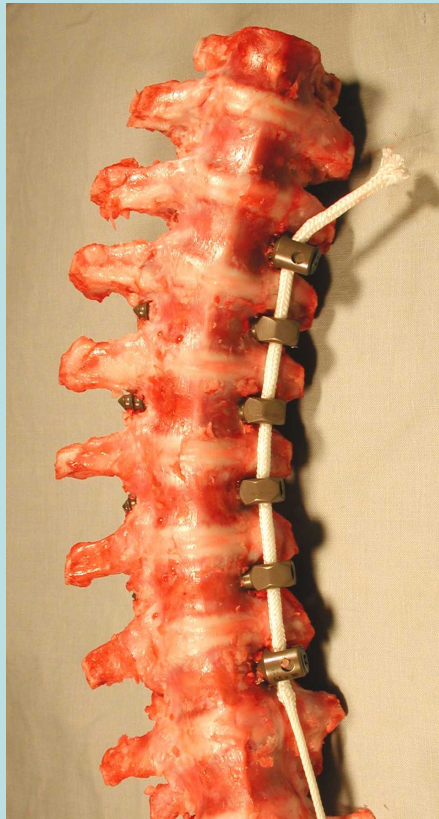
6-10°/seg.

segments,
immaturity, time
implant in place

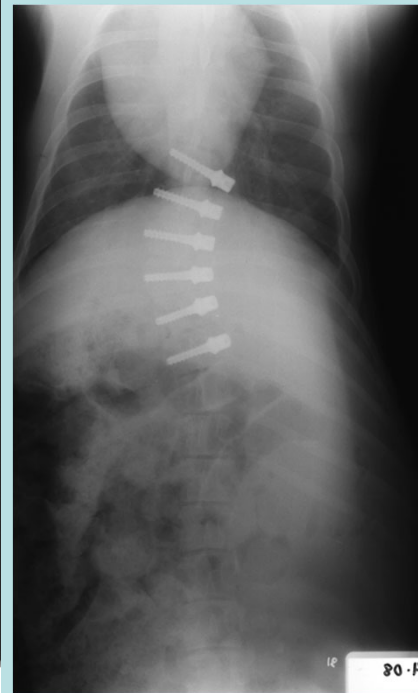
Main issue screw
plowing



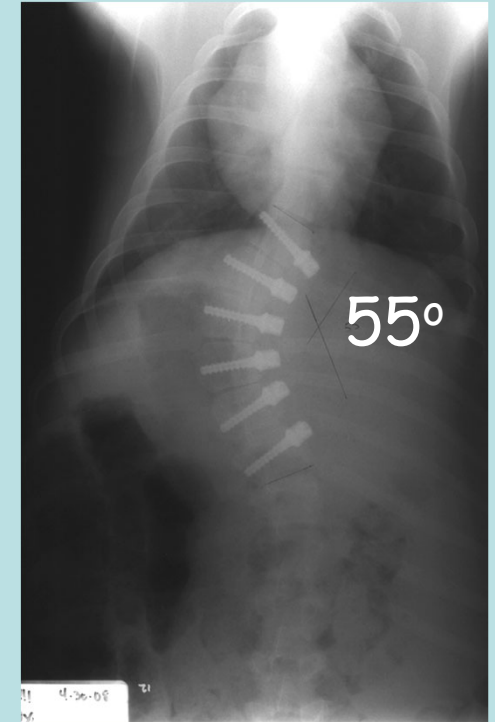
Screw + cable - increased moment arm
(vs. staple or NCS screw) to produce
asymmetric tether



1 mo



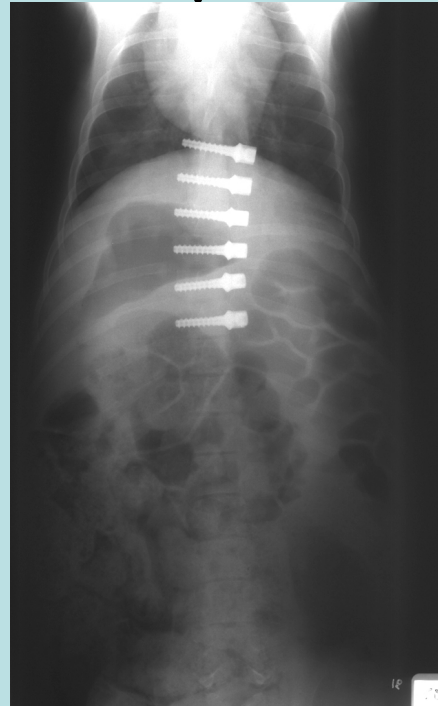
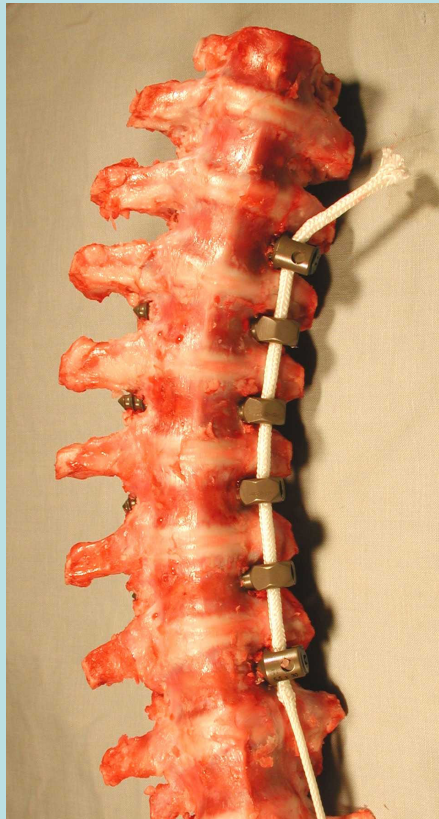
3 mo



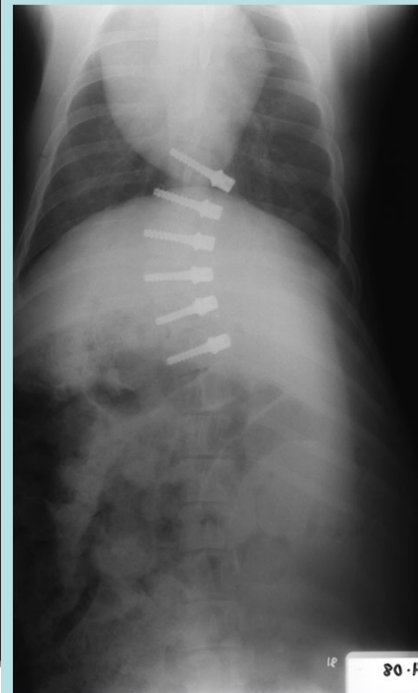
6 mo

Deformity evenly distributed
among several segments
(note screw obliquity)

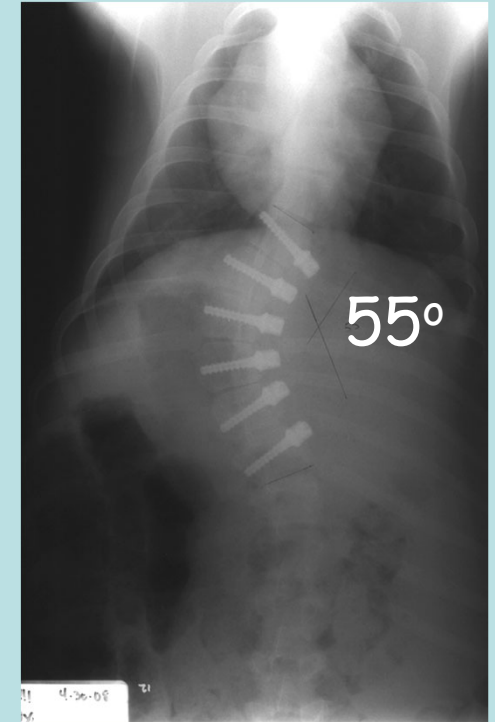
Screw + cable - increased moment arm (vs. staple or NCS screw) to produce asymmetric tether



1 mo



3 mo

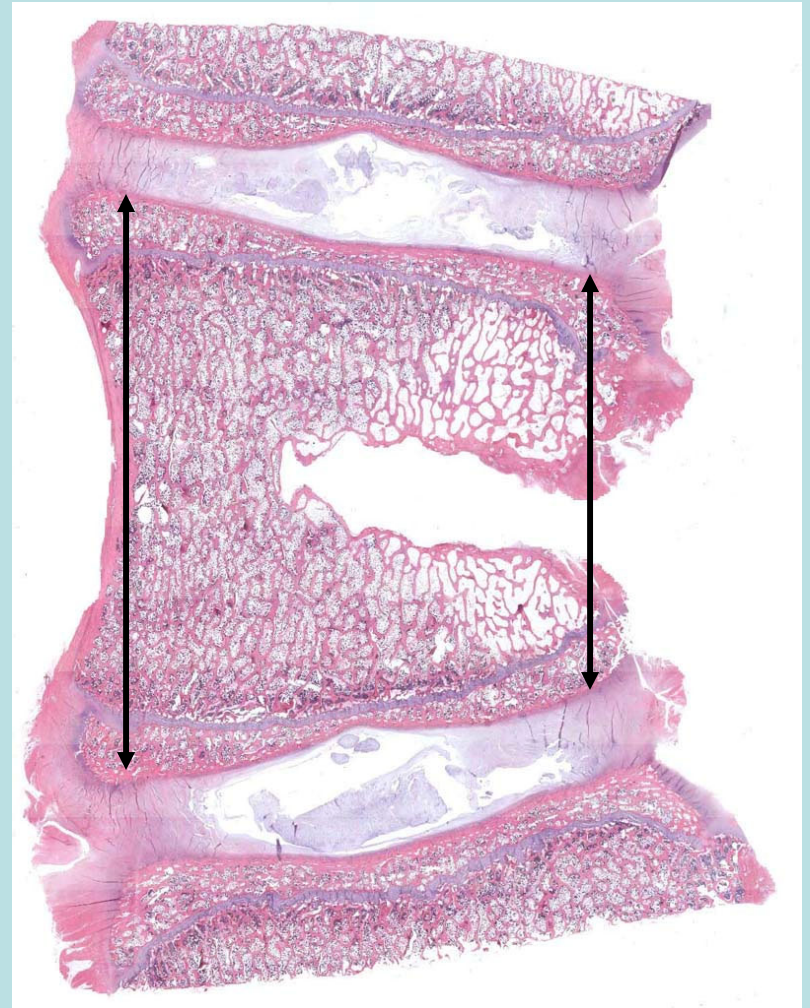


6 mo

Deformity evenly distributed
among several segments
(note screw obliquity)

Vertebral wedging by asymmetric compression (heuter-volkman)

(see Newton et al, Spine '08)



Flexible Anterior Tether

2 cases, 5 & 6 yr f/u

(Crawford 2010 JBJS-A, Lenke AAOS 2012)

- infantile / young juvenile idiopathic; also syndromic, neuromuscular (??)
- 25-40°, hypokyphotic
- apex mid-lower Th levels
- “custom implant” (FDA)

1st Case

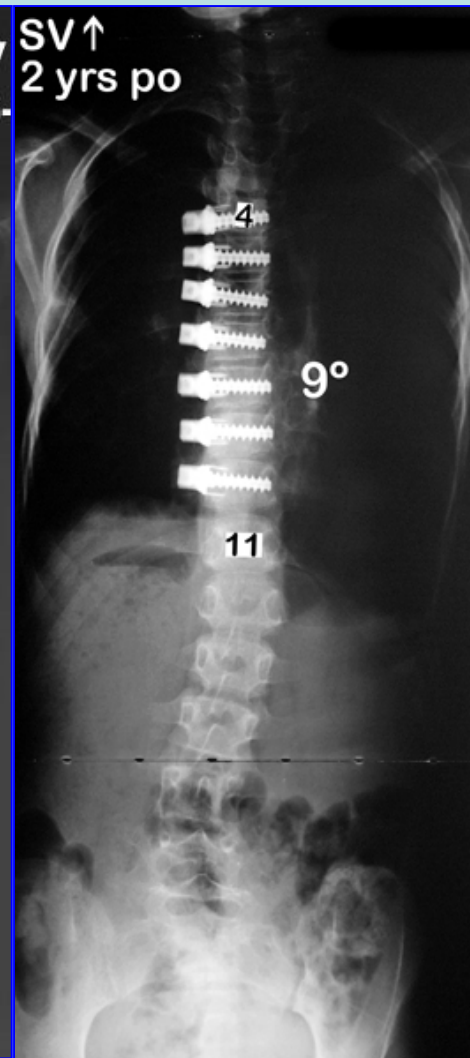
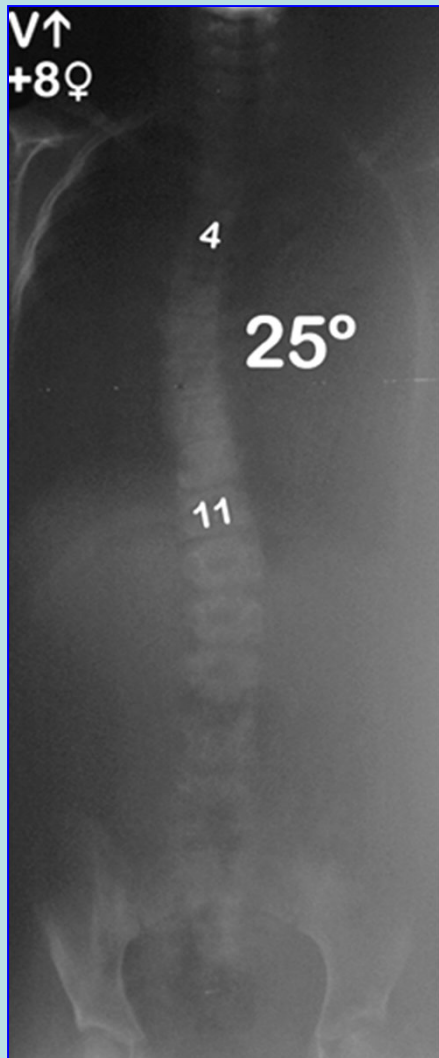
- 8 yo male, progressive curve to 40° despite bracing
-> anterior T6-12 flexible tether -> ipo 25°
-> gradual correction to -6° over 5 yr, no change in sagittal alignment

8+8 yo F

i.p.o.

2 yr

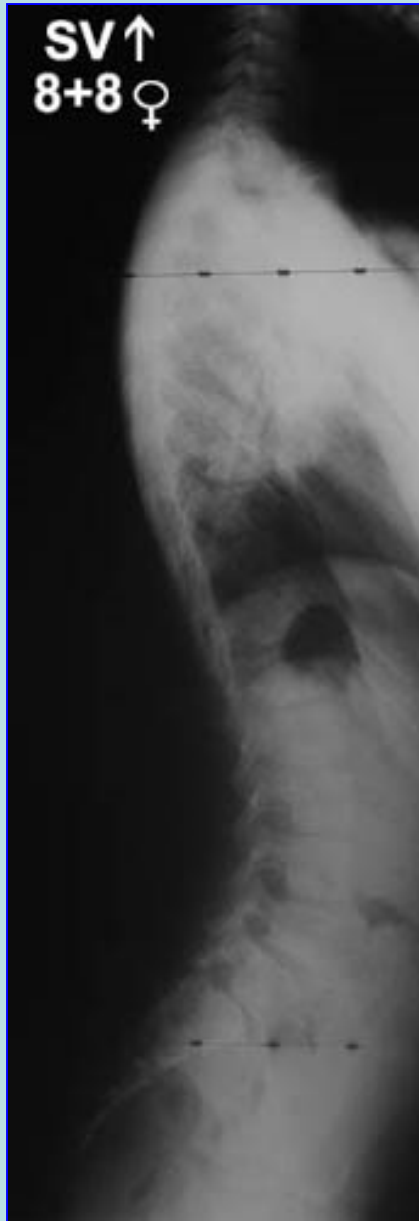
6 yr

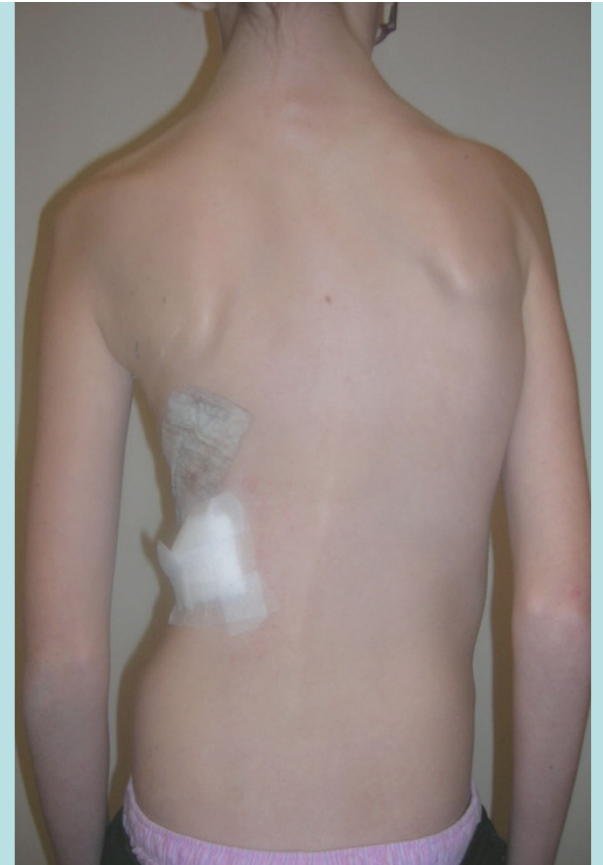


Courtesy L. Lenke M.D.

Curve reversal
True modulation !!!

Sagittal plane WNL - not kyphogenic



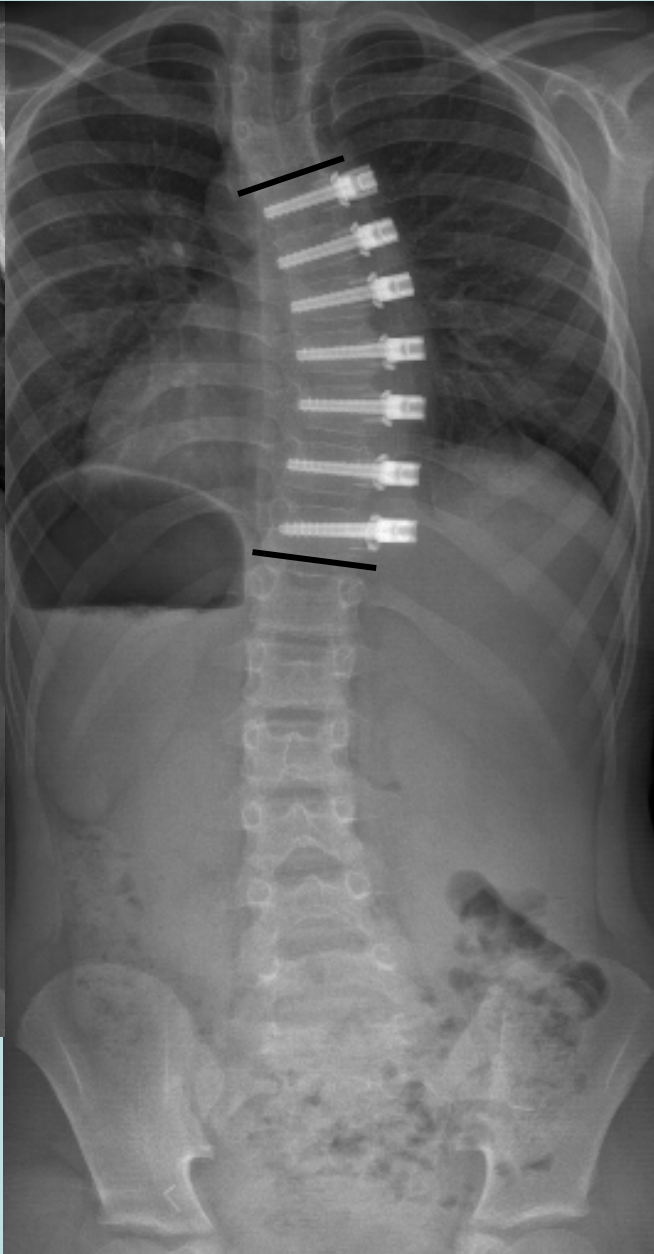


Tether +
screw
removal

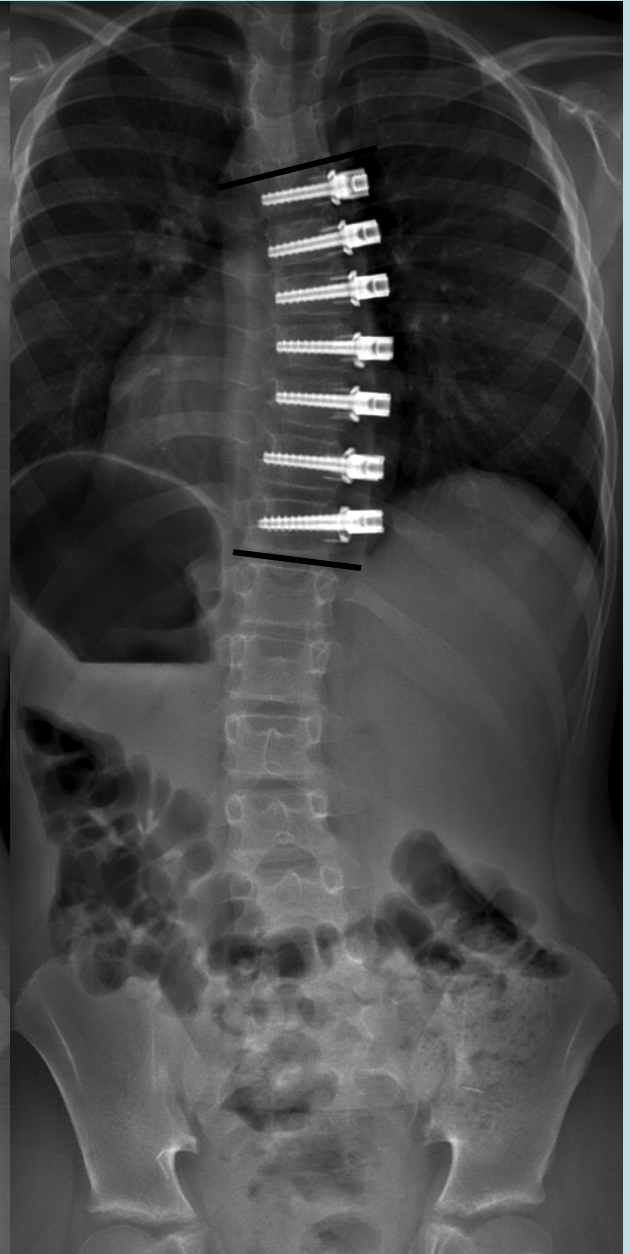
Preop



Postop



1 year Postop



10 year male, 44°
Courtesy P. Newton MD

Staple vs. tether - clinical

- Staples useful for smaller curves (< 30-35°) in juvenile (<age 10)Same curves treatable non operatively
- Fixation across disc → no experimental evidence of disc or physcal injury, motion maintained (short experimental implantation time)
- Tethers may be more effective corrective constructs (lever arm ?)

"Time Tested"

- Nitinol VBS's - 3.2 yr (max 5.3)
- Flex anterior tether - 5/6 yr
- Shilla - 5 yr. (2012 SRS/ICEOS)
- "Modern" trolley - 4.5 yr. (2012 SRS)

Coming next ?

Flexible tether - Singapore

Dynesis - in use, off label

Magnetic lengthening GR

Screw-staple device - Cincinnati



T E X A S
SCOTTISH RITE HOSPITAL
FOR CHILDREN

Ribs and Spine Tethers
More to come - soon?

