

Complications Related to Sagittal Alignment

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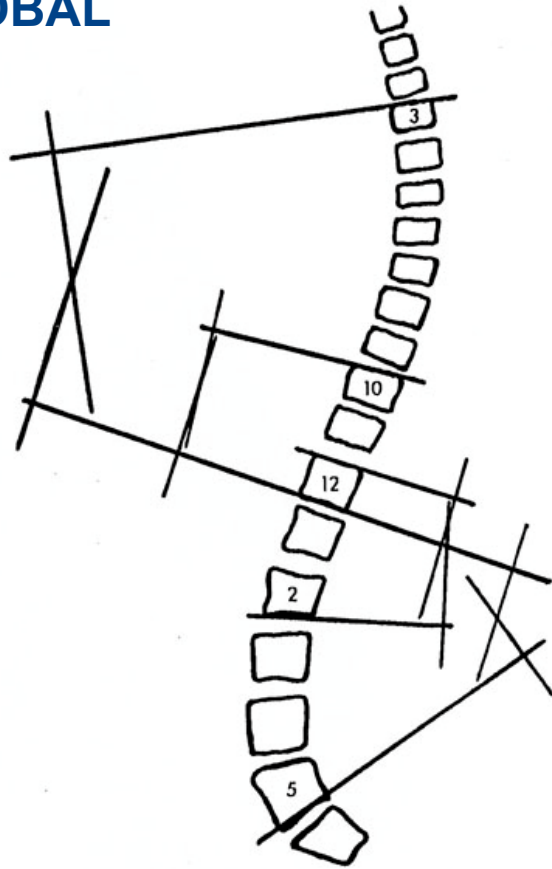


Galen ministering to gladiators wounded in the arena at Pergamon

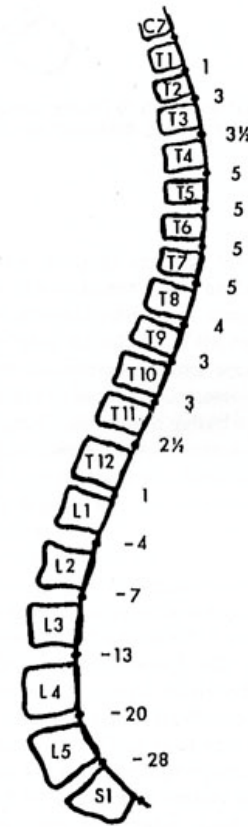


Sagittal Alignment

GLOBAL



SEGMENTAL



- ▶ Global Malalignment

Thoracic Hyperkyphosis (HK)

at onset

during treatment

- ▶ Segmental Malalignment

Proximal Junctional Kyphosis (PJK)



To influence the thoracic
kyphosis you must control it
– the kyphotic (and
potentially kyphotic)
segments must be included
in the construct, and the
anchors must be secure.



There is a well intentioned tendency to minimize the extent of the construct and the number of instrumented segments within the anchors in order to maximize spinal growth-this may be counter-productive. A much longer fused segment may result if the instrumented segment must be extended to control increasing kyphosis or to treat anchor site failure.



Secure anchors are often difficult to obtain in the GR population. There are minimal fixation points, and these are in small, weak bones. The best results will occur when the anchors are stable (3 level staggered hook-claw, ?pedicle screws) and the stresses on them minimized (?pre-op traction, intra-op positioning, anchor site fusion prior to manipulation, delayed corrective forces).



Sagittal Alignment Results Dual GR

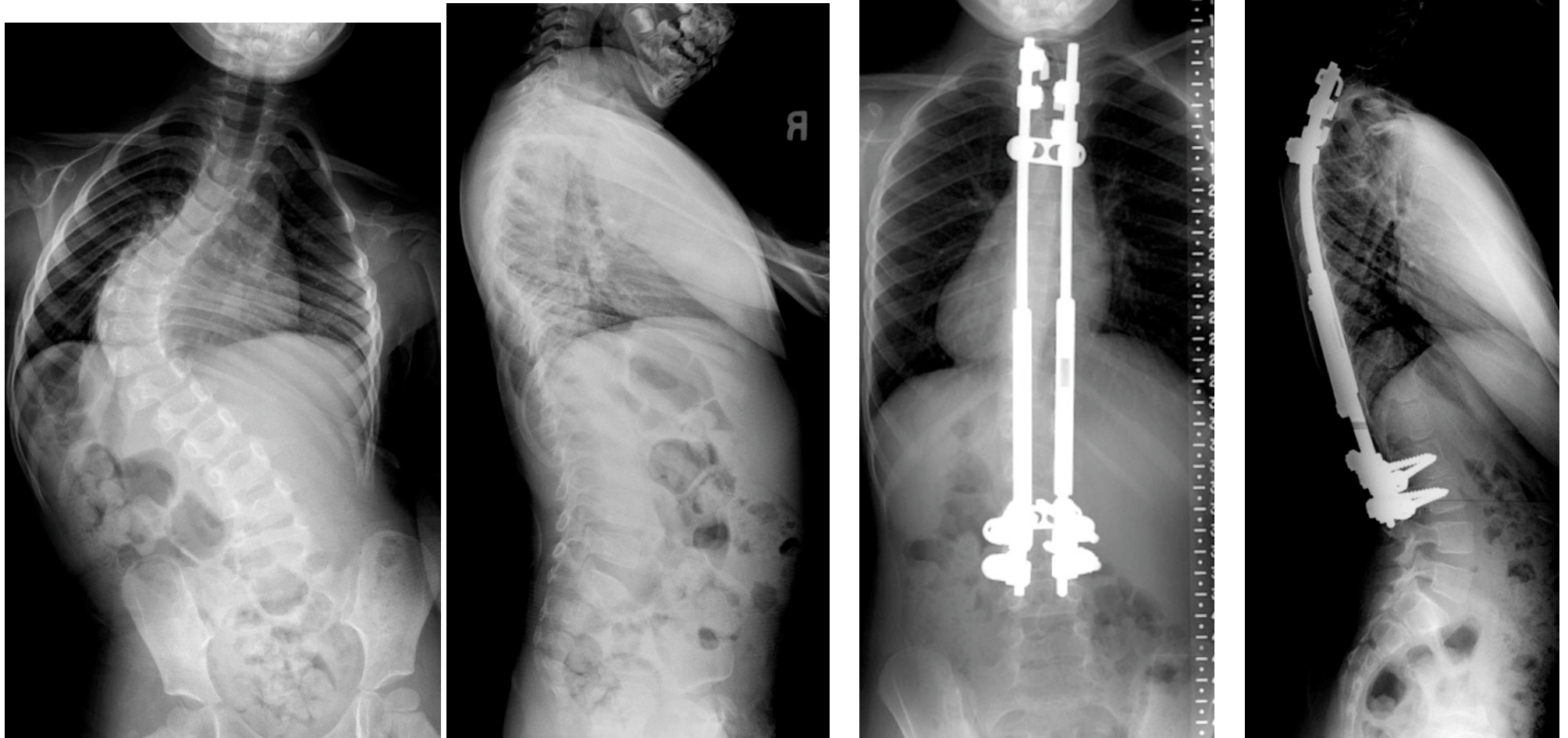
Kyphosis (19/23)

	Pre-Op	Last
Kyphosis	50.3°	44.2°
Kyphosis >50°	8 (73.3°) [56° -95°]	5 (74°) [52° -105°]
Pre-Op HK	8 1 increased 7 decreased 5 - normal	
Post-Op HK		5 2 occurred during tx 50° to 105° 46° to 55°



Clinical Material-Spine Service, CHMC, Boston

John Emans, M. Timothy Hresko, Lawrence
Karlin



Complications of Hyperkyphosis and Proximal Junctional Kyphosis

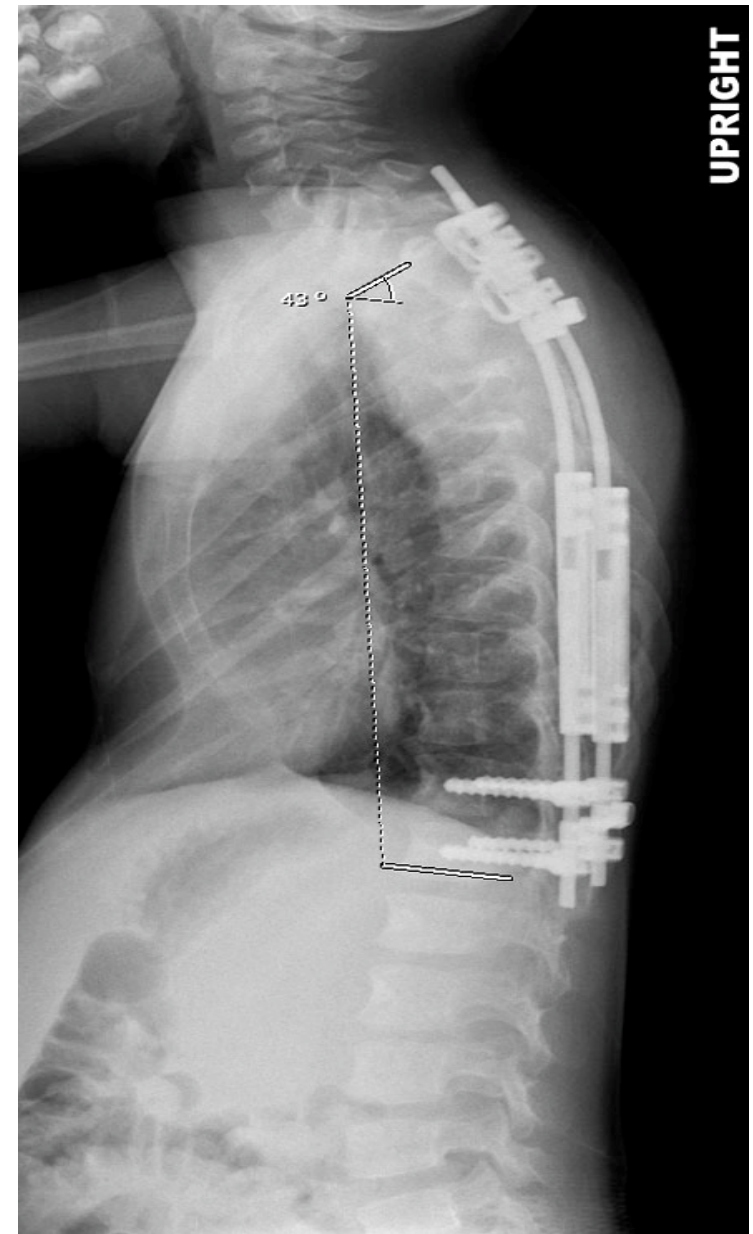
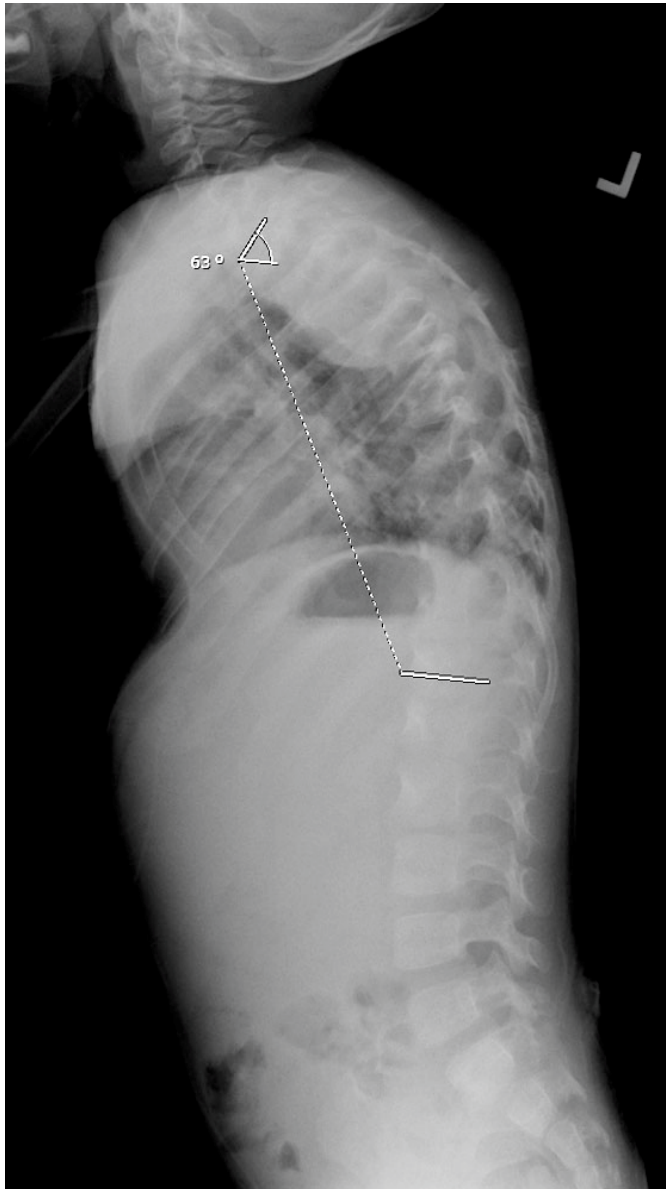
- ▶ Predicted by initial HK

Hyperkyphosis

- ▶ Present at onset -treat it by using
pre-operative strategy, anchor
design, and manipulative timing based
on severity of the deformity, strength of
the bone, biology of the condition
- ▶ Occur during treatment (usually in those
that were initially hyperkyphotic)
correct in timely fashion using similar
principles



HK – Initial Correction

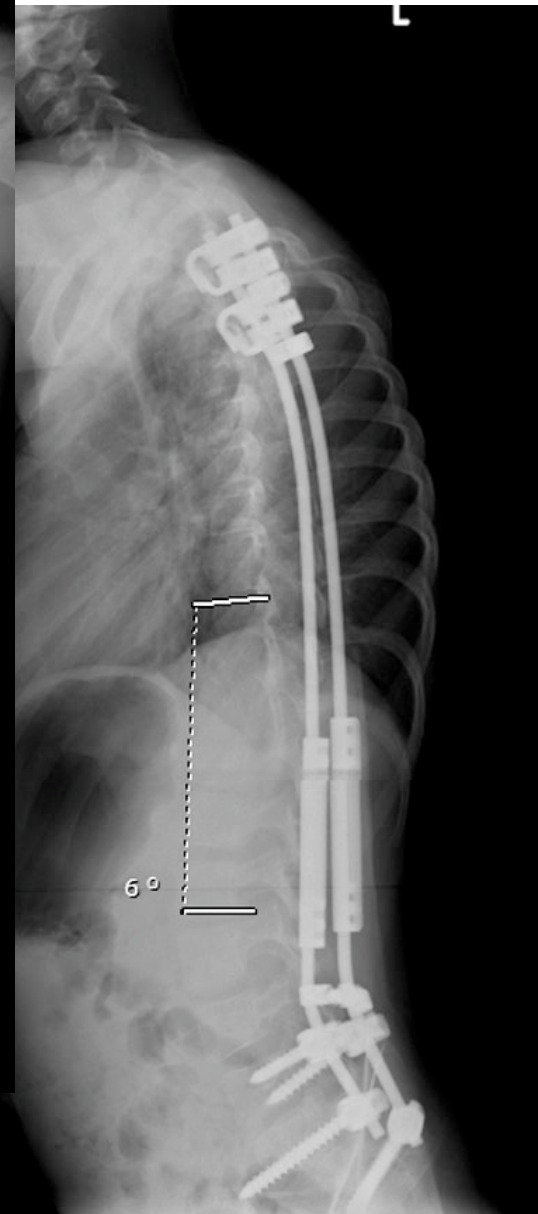
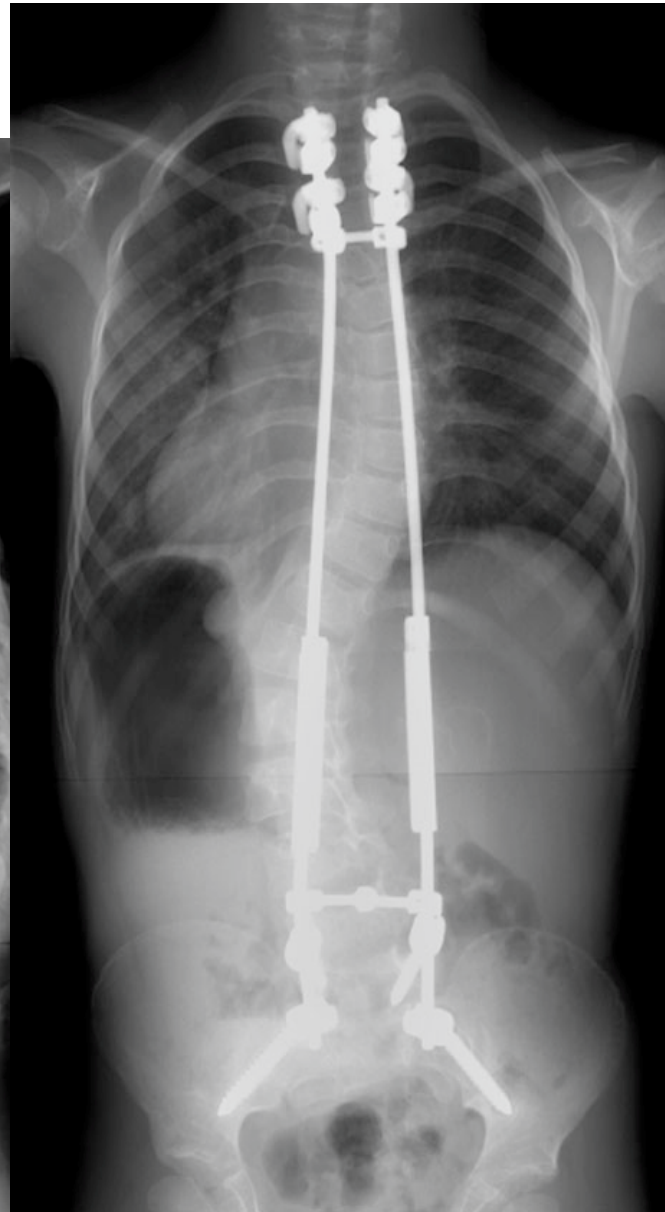
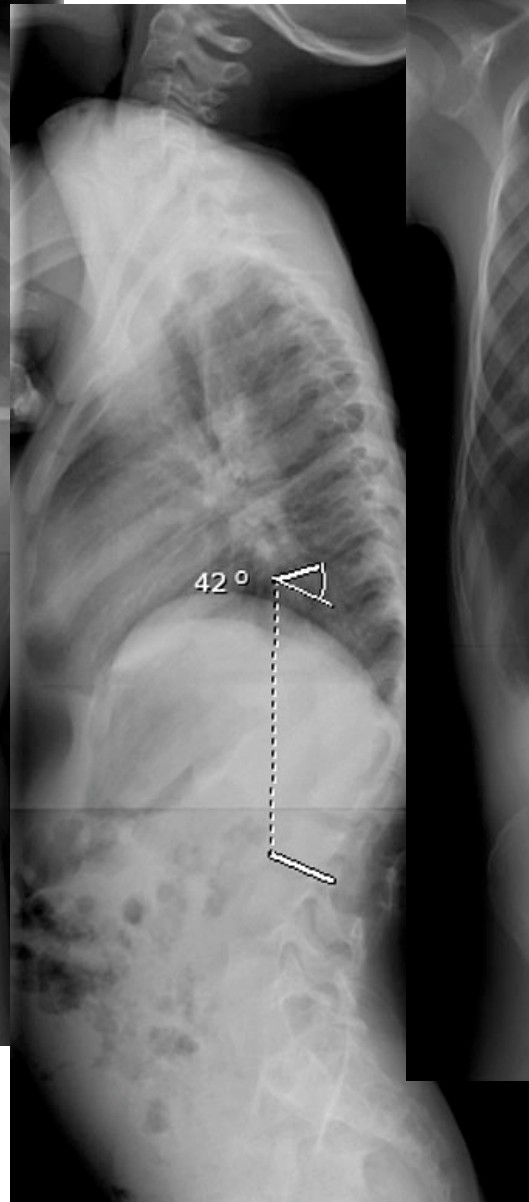
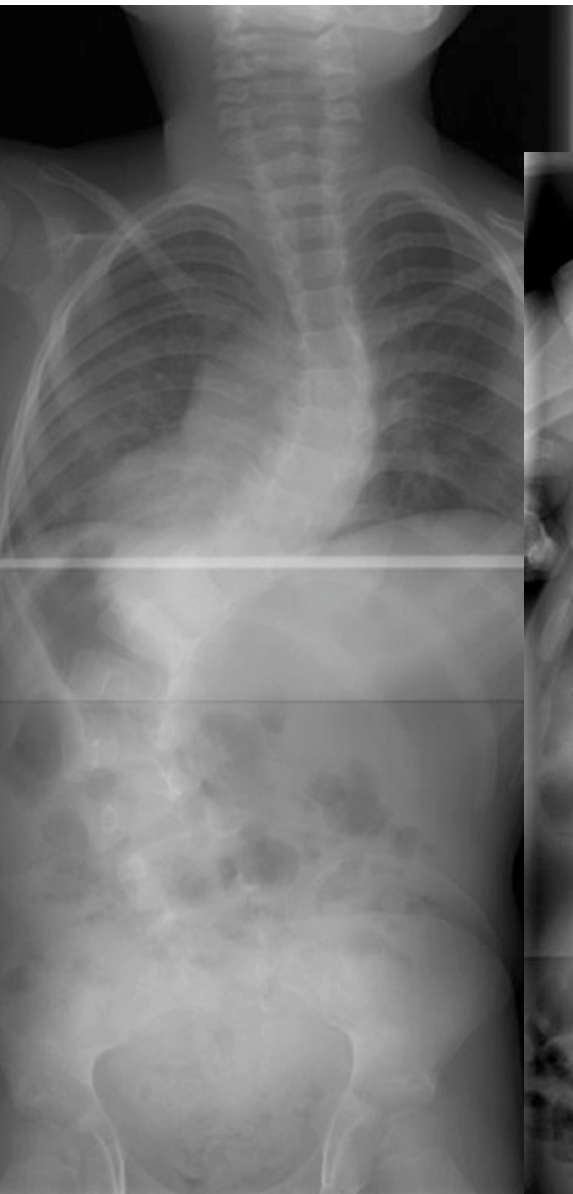


Children's Hospital Boston

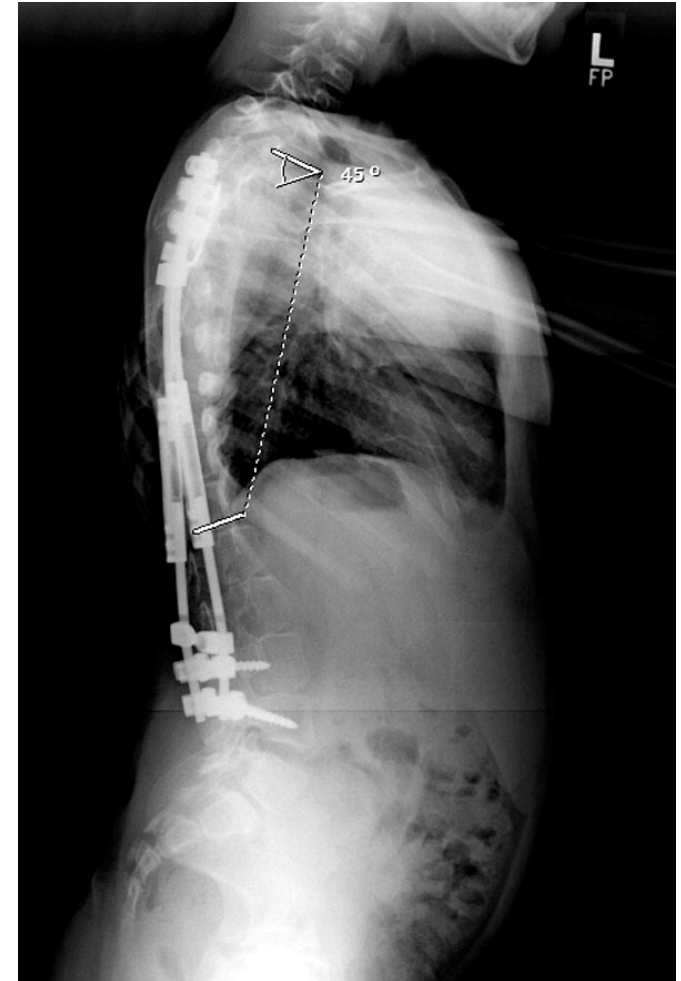


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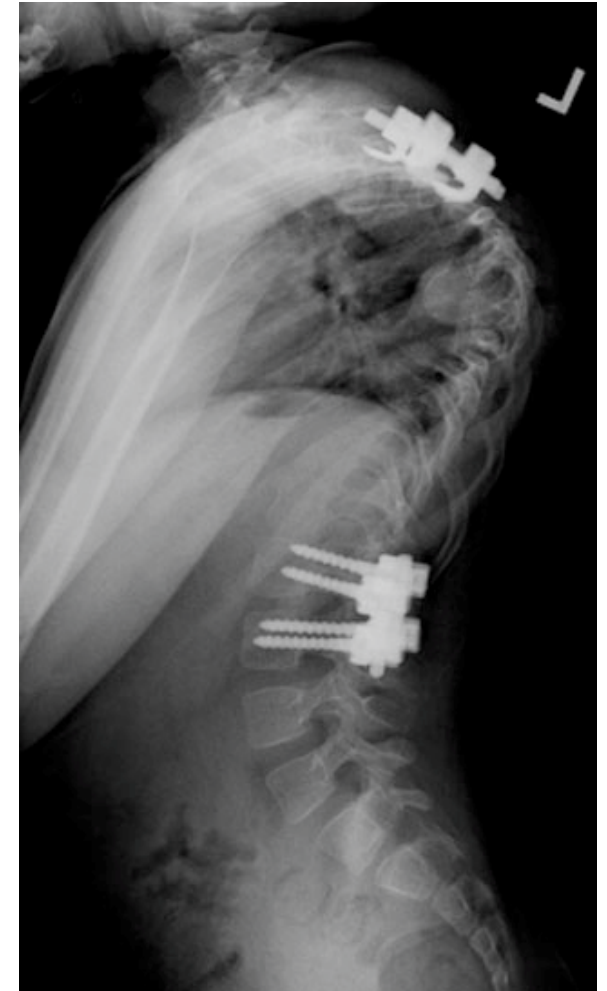
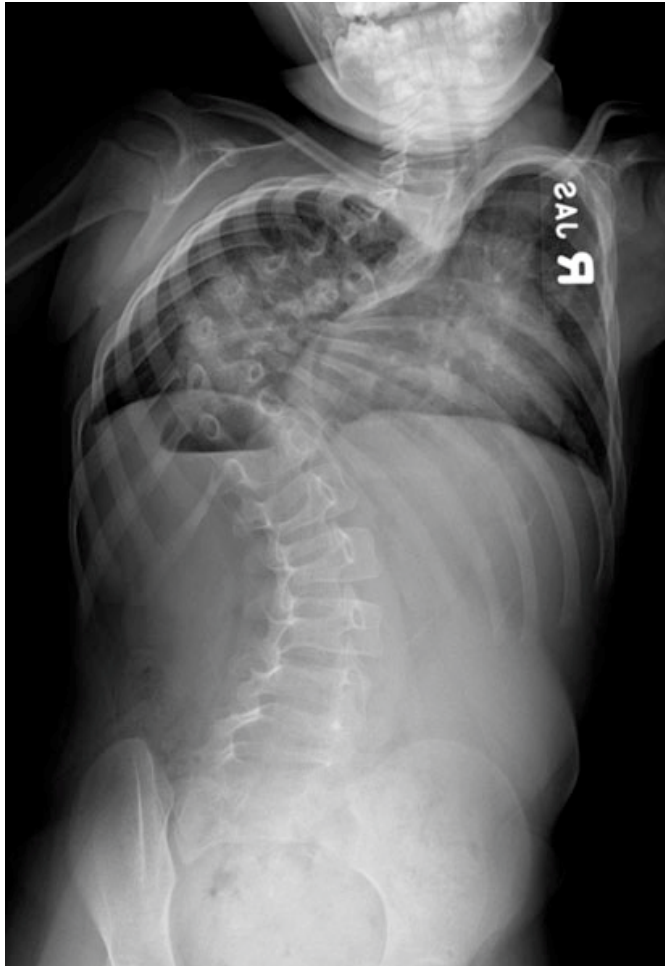
HK- Initial Correction (cong. LS)



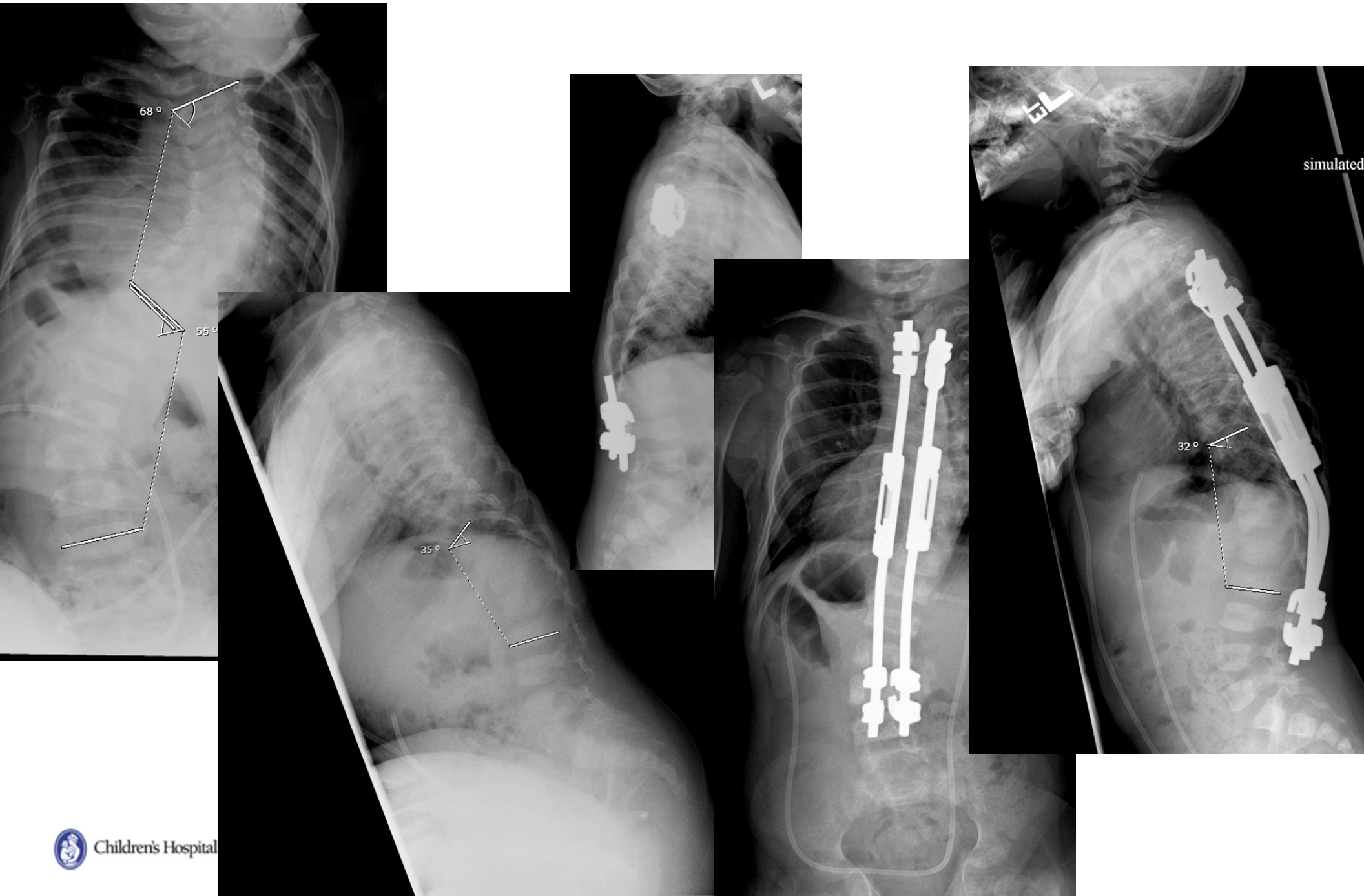
HK – Pre-Op Traction (IIS)



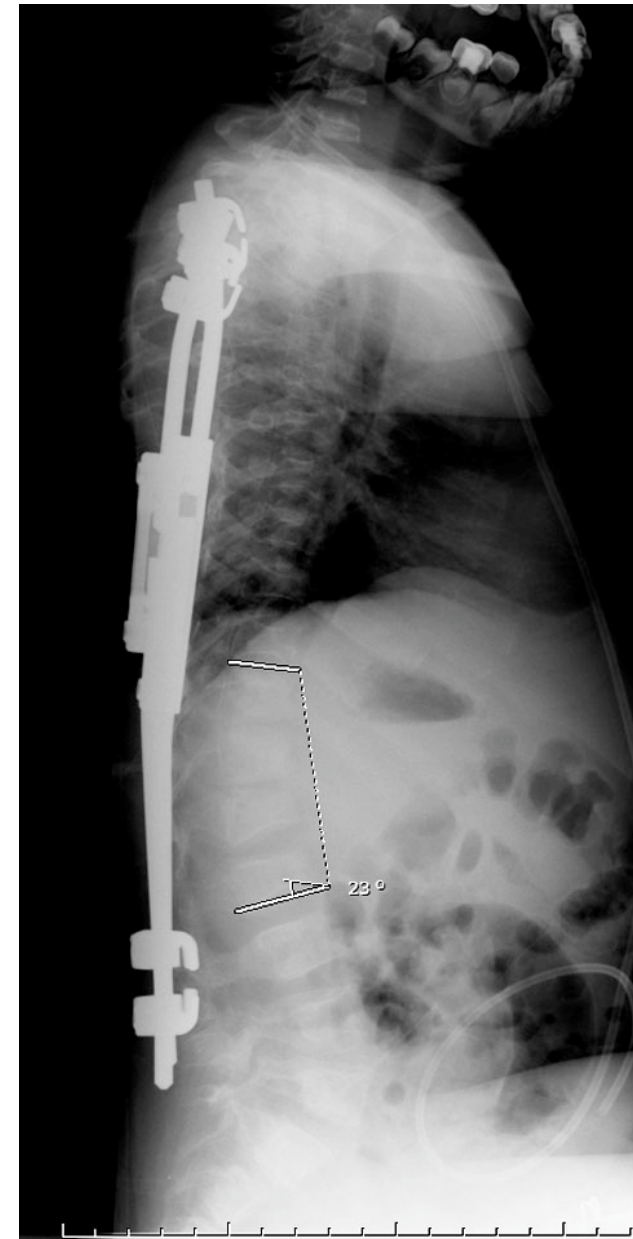
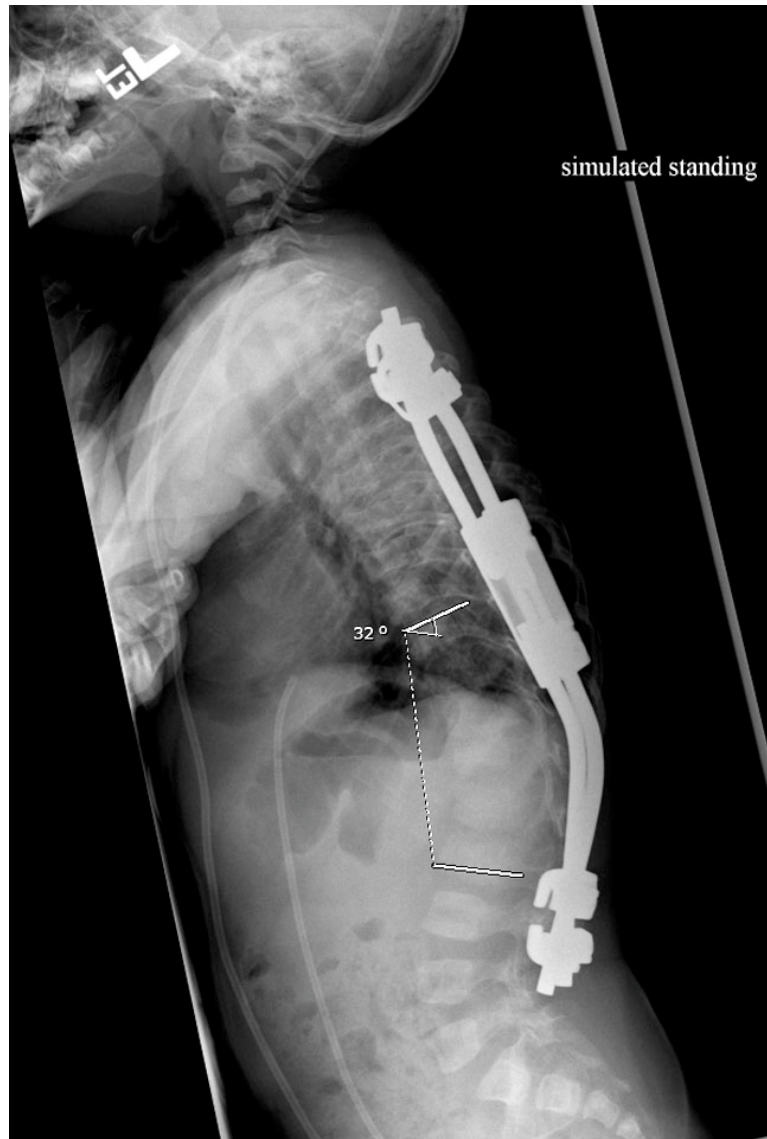
HK – Anchor-alone Fusion (Prader-Willi)



HK-Delayed Correct. (OI)



HK – Delayed Correct. (OI)



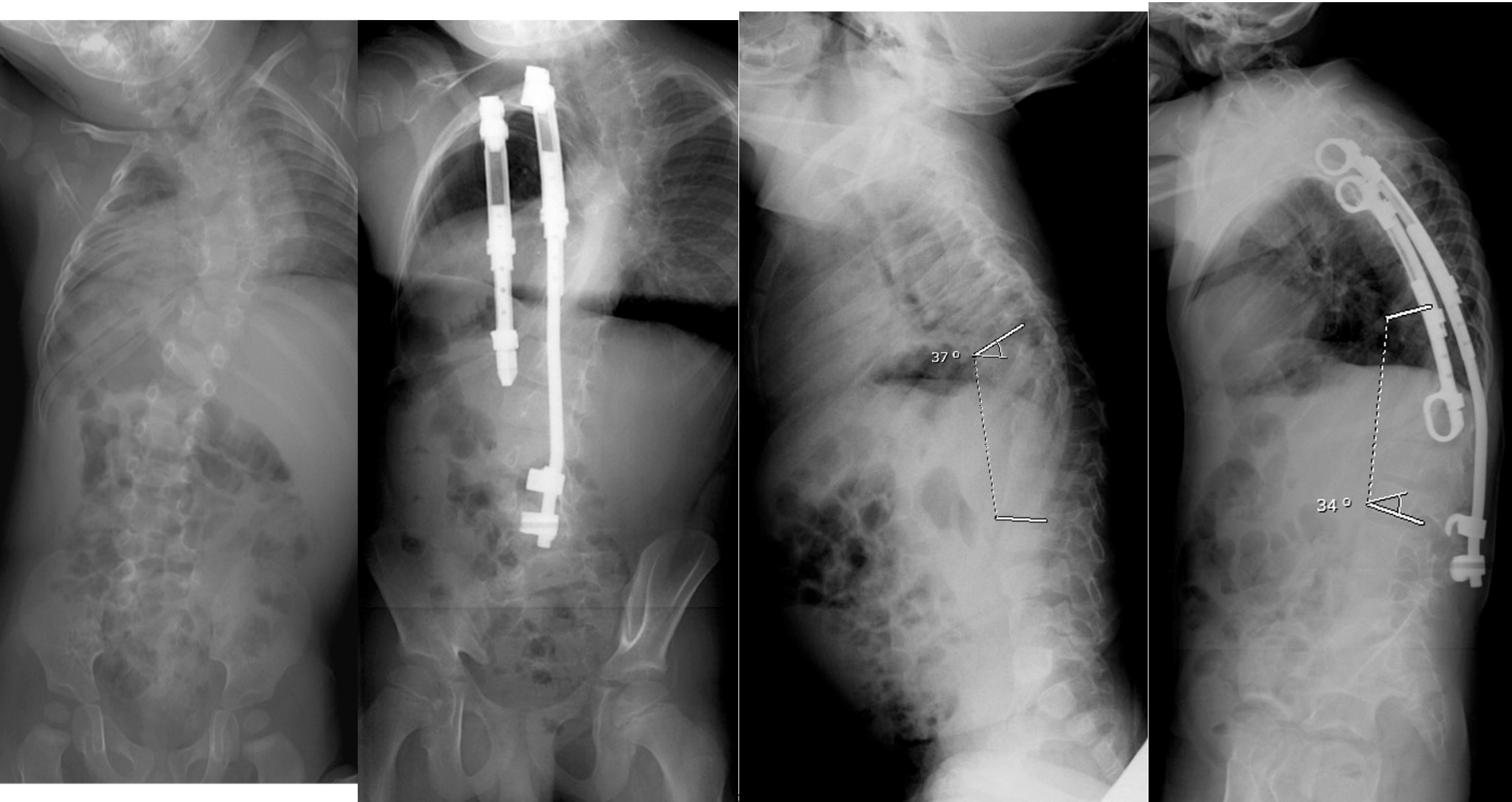
VEPTR

	Pre	Post	Final
K	39° (-10° to 110°)	39° (5° to 110°)	50° (° 20 to 102°)
KI 55° (19)	70° (55° to 110°)	59° (31° to 100°)	75° (42° to 102°)

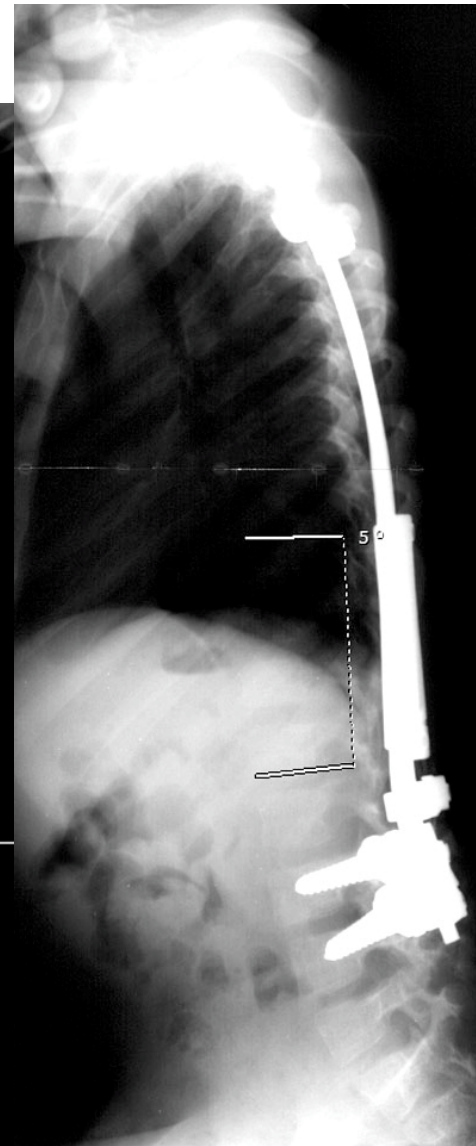
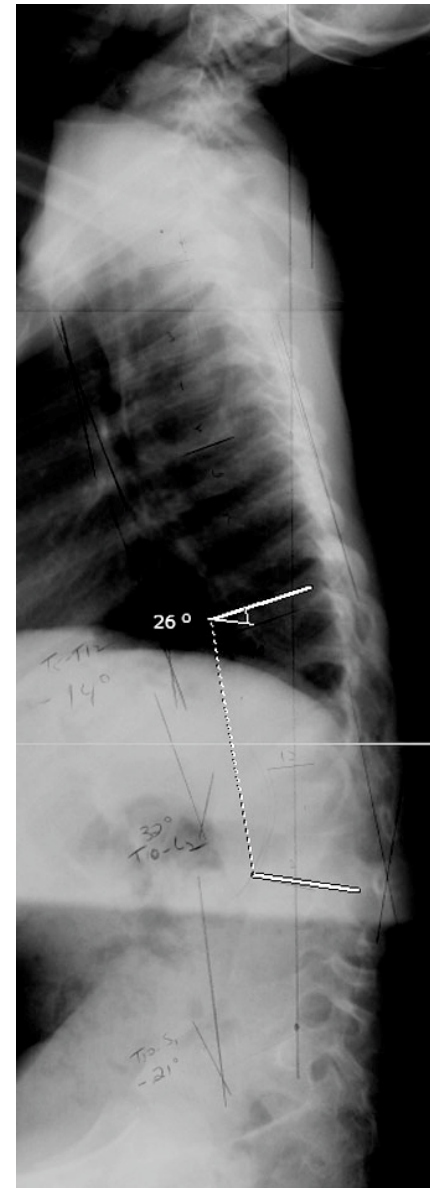
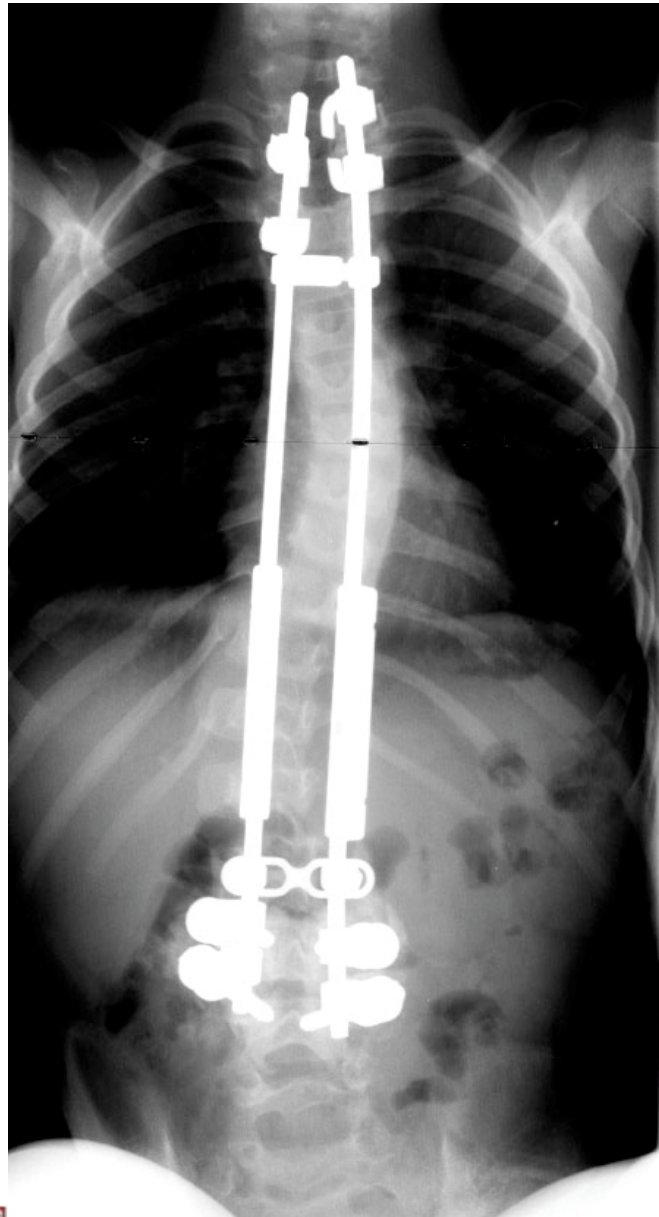
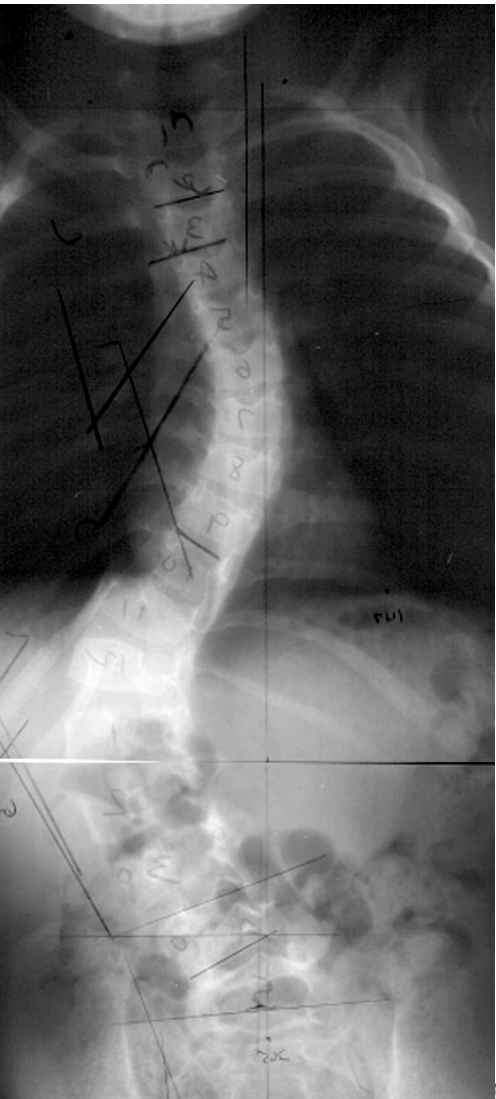
Sturm et al (SRS 2009)



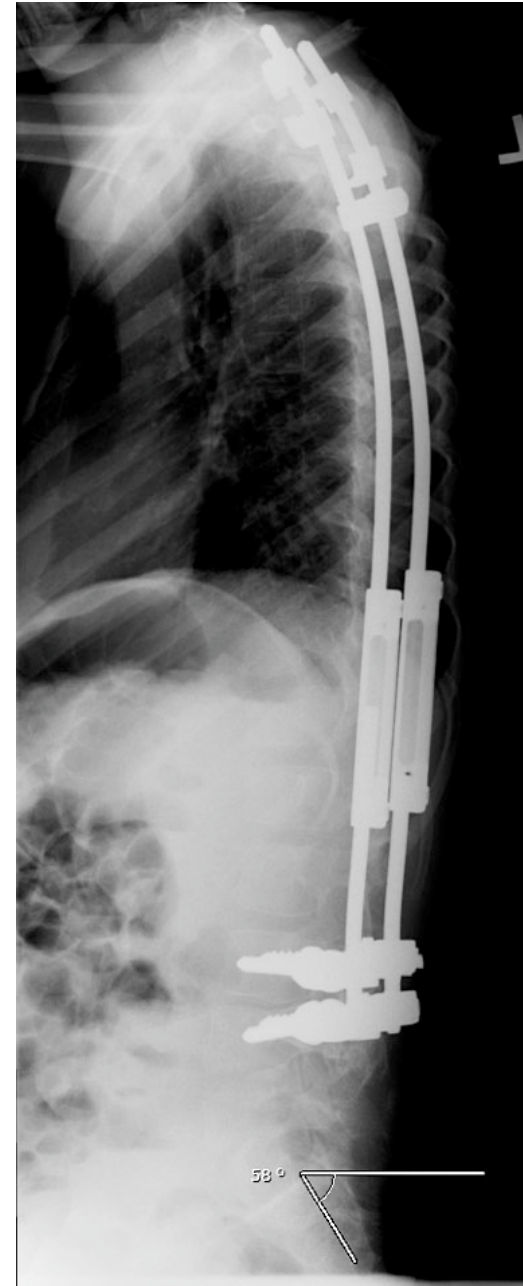
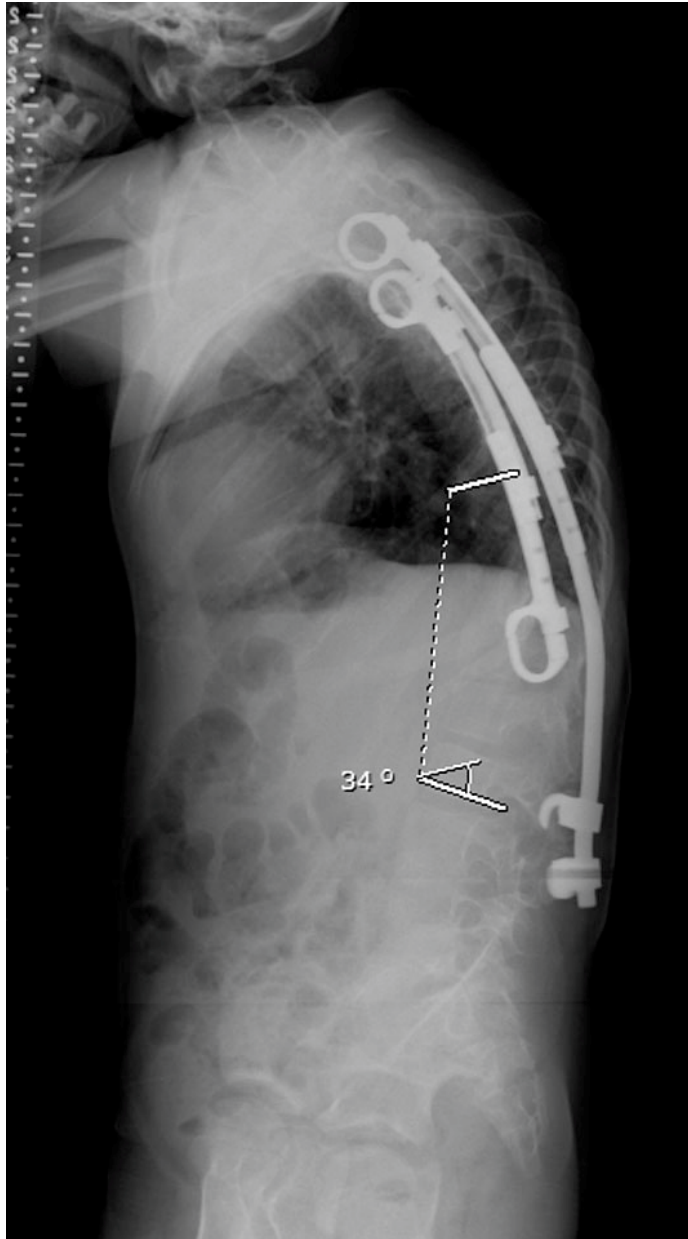
HK- Initial Correction VEPTR (Cong Scoliosis and Rib Fusions)



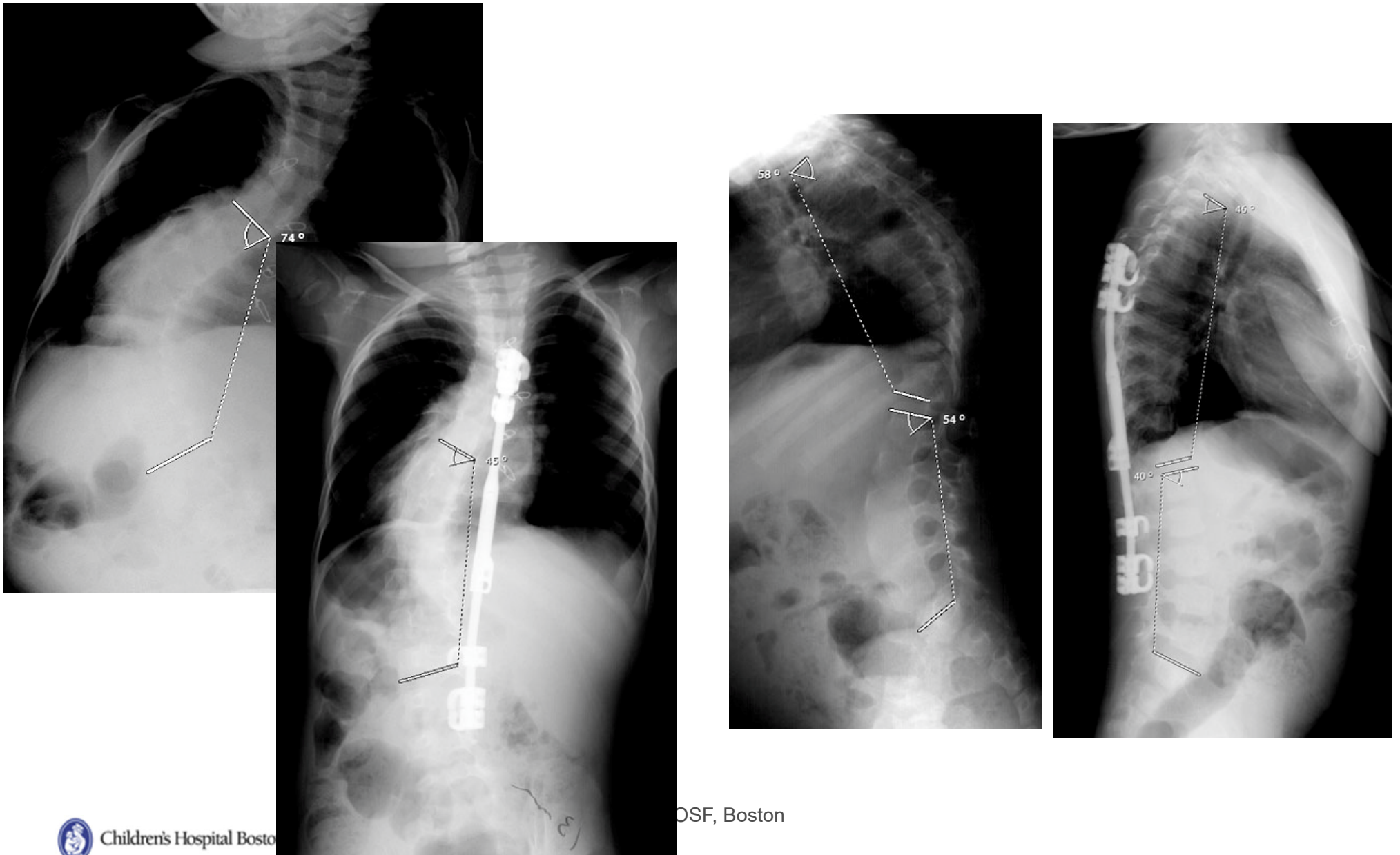
HK- Initial Correction (2Q del.)



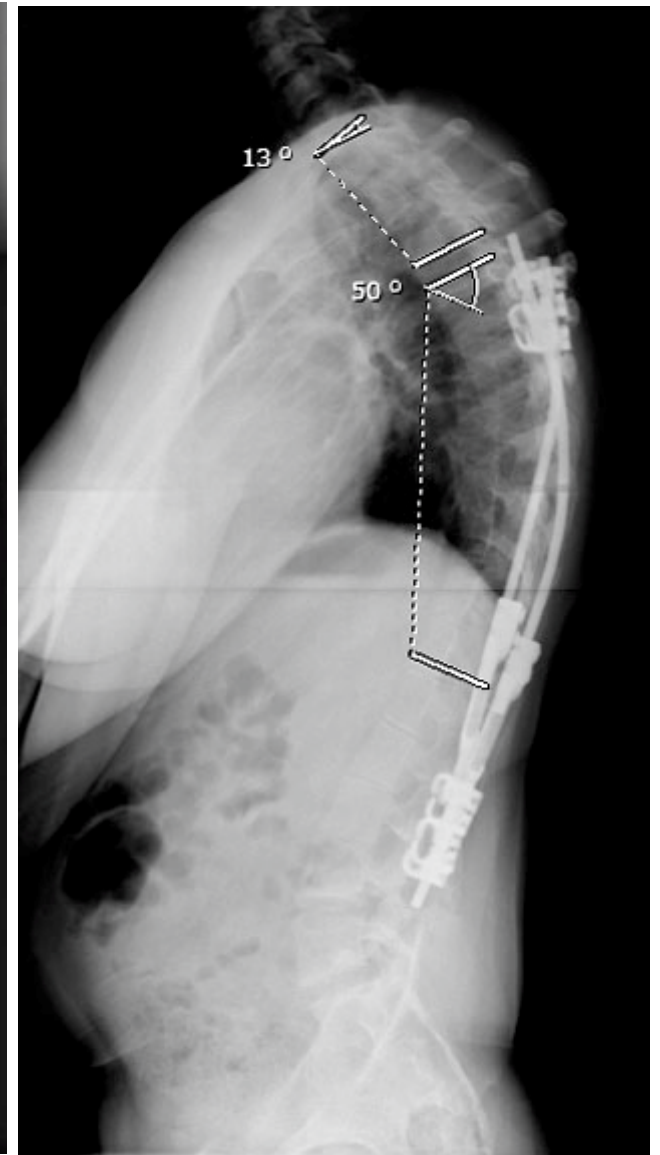
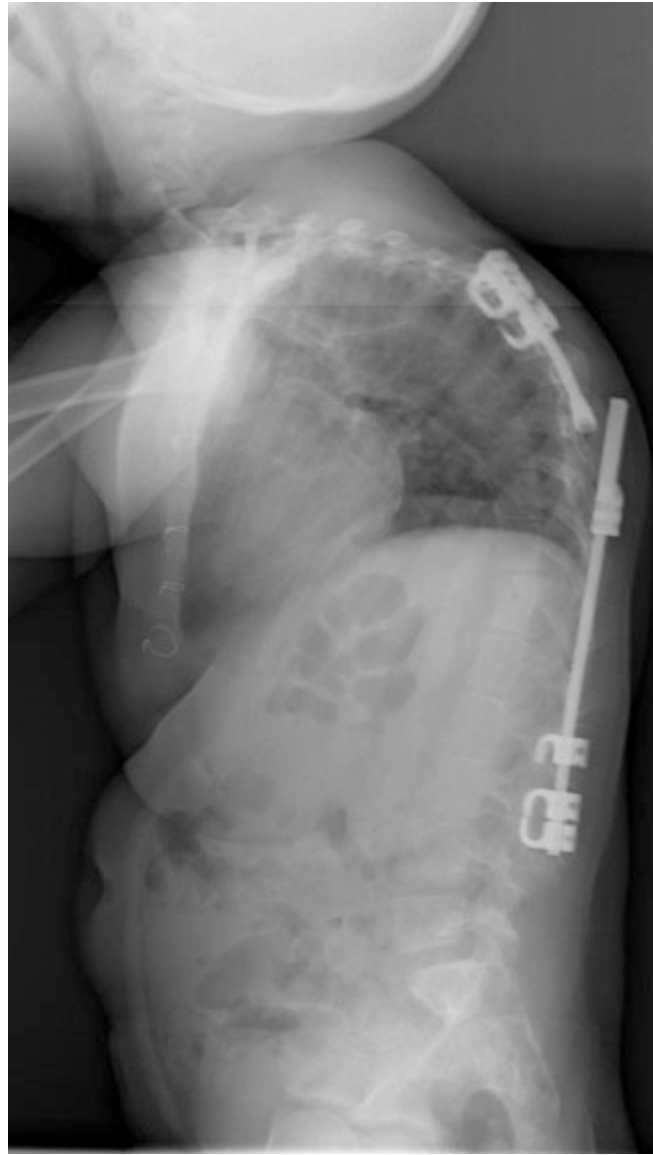
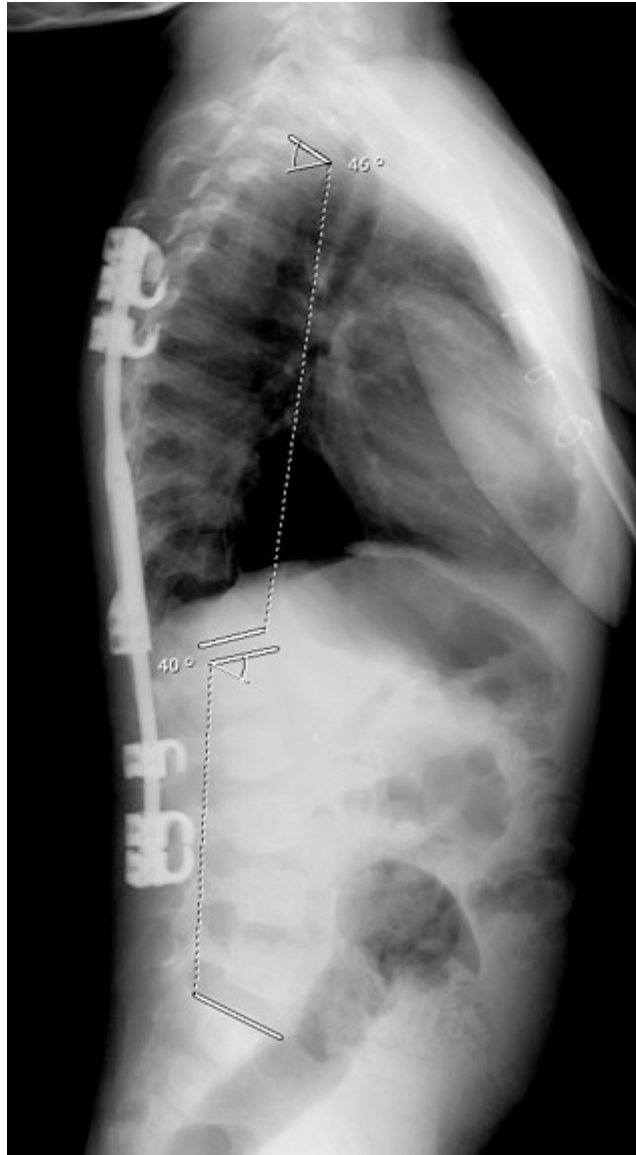
HK – Initial Correction Veptr vs GR



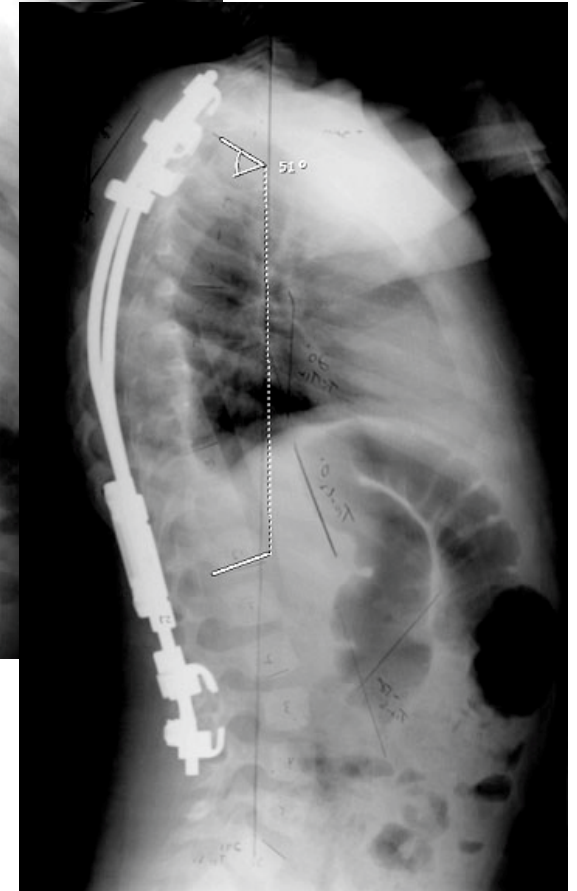
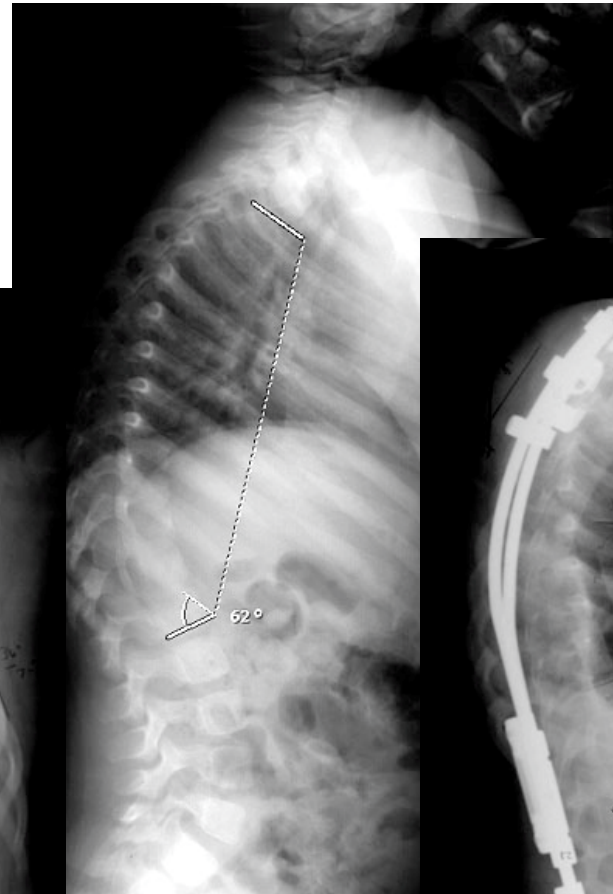
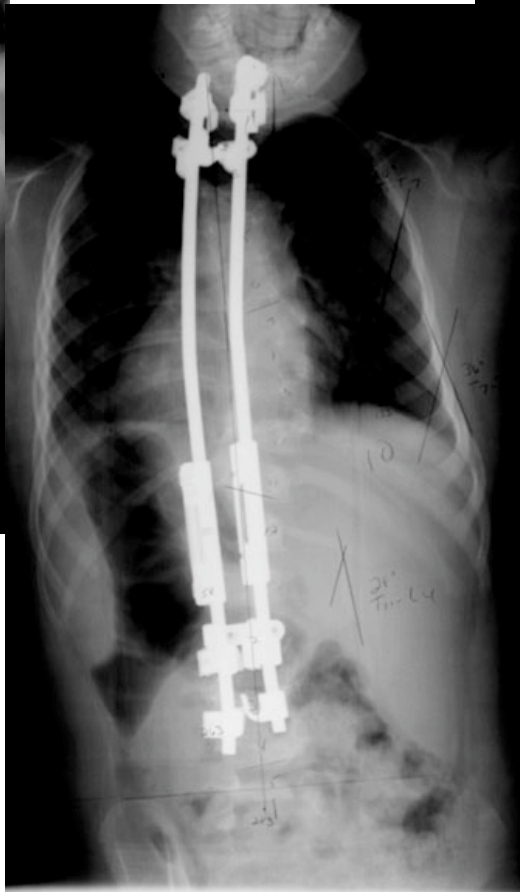
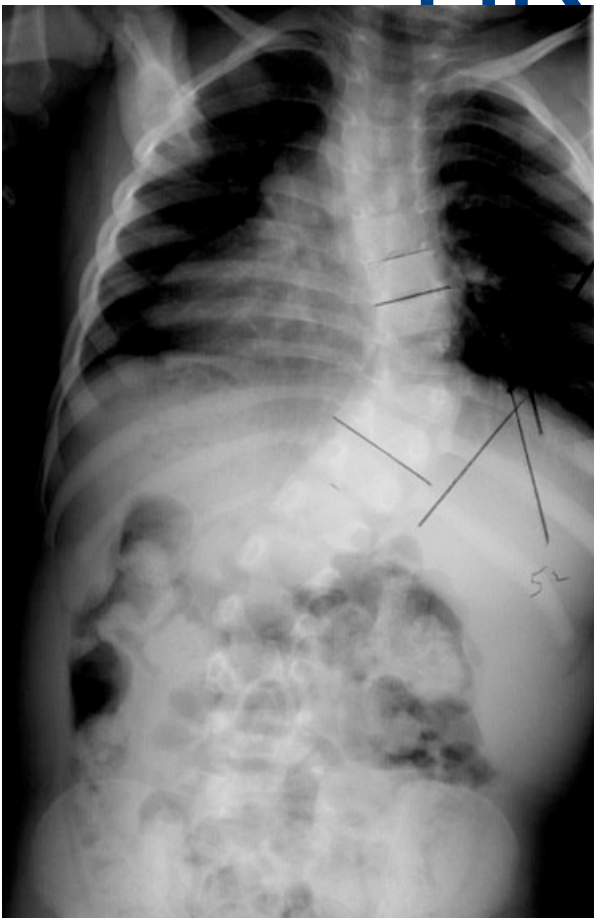
HK – Late (Larsen S.)



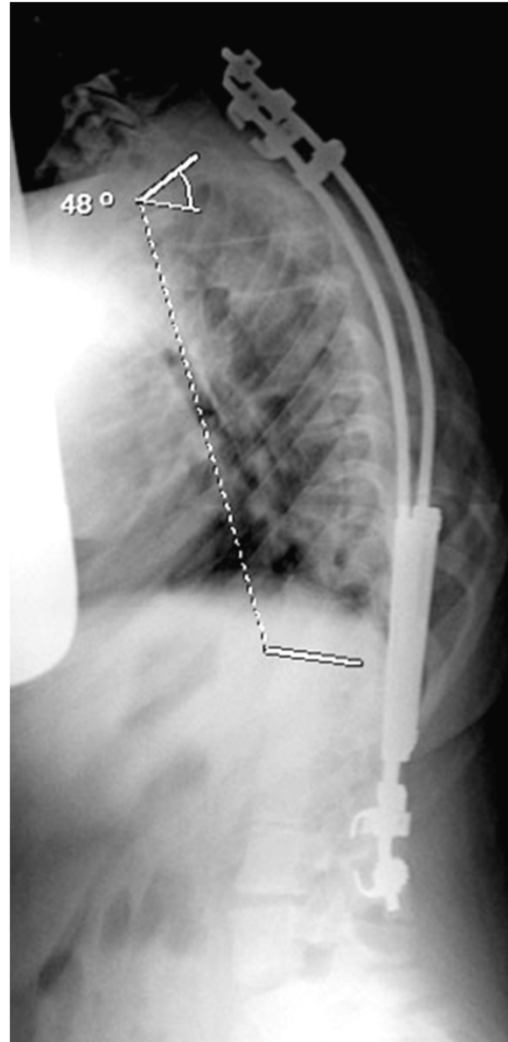
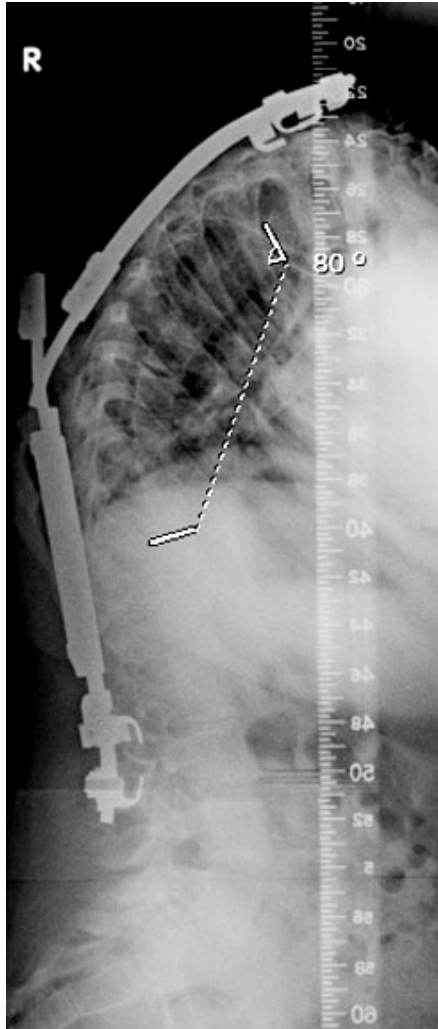
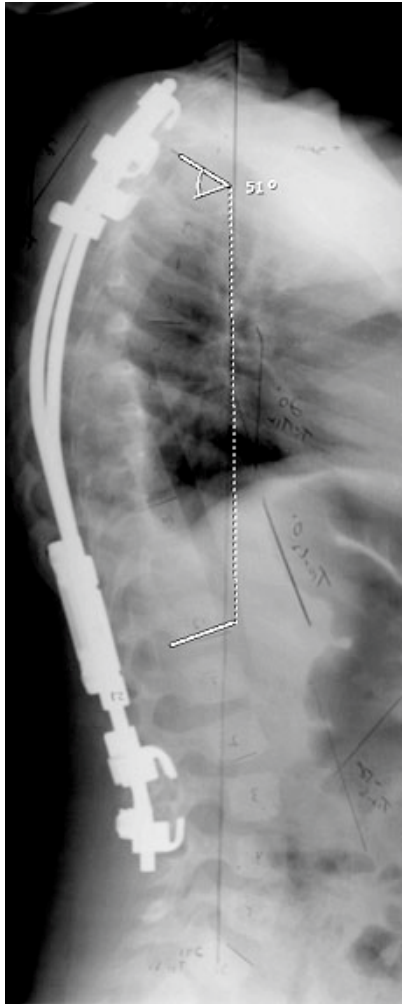
HK- Late : convert to D.R.



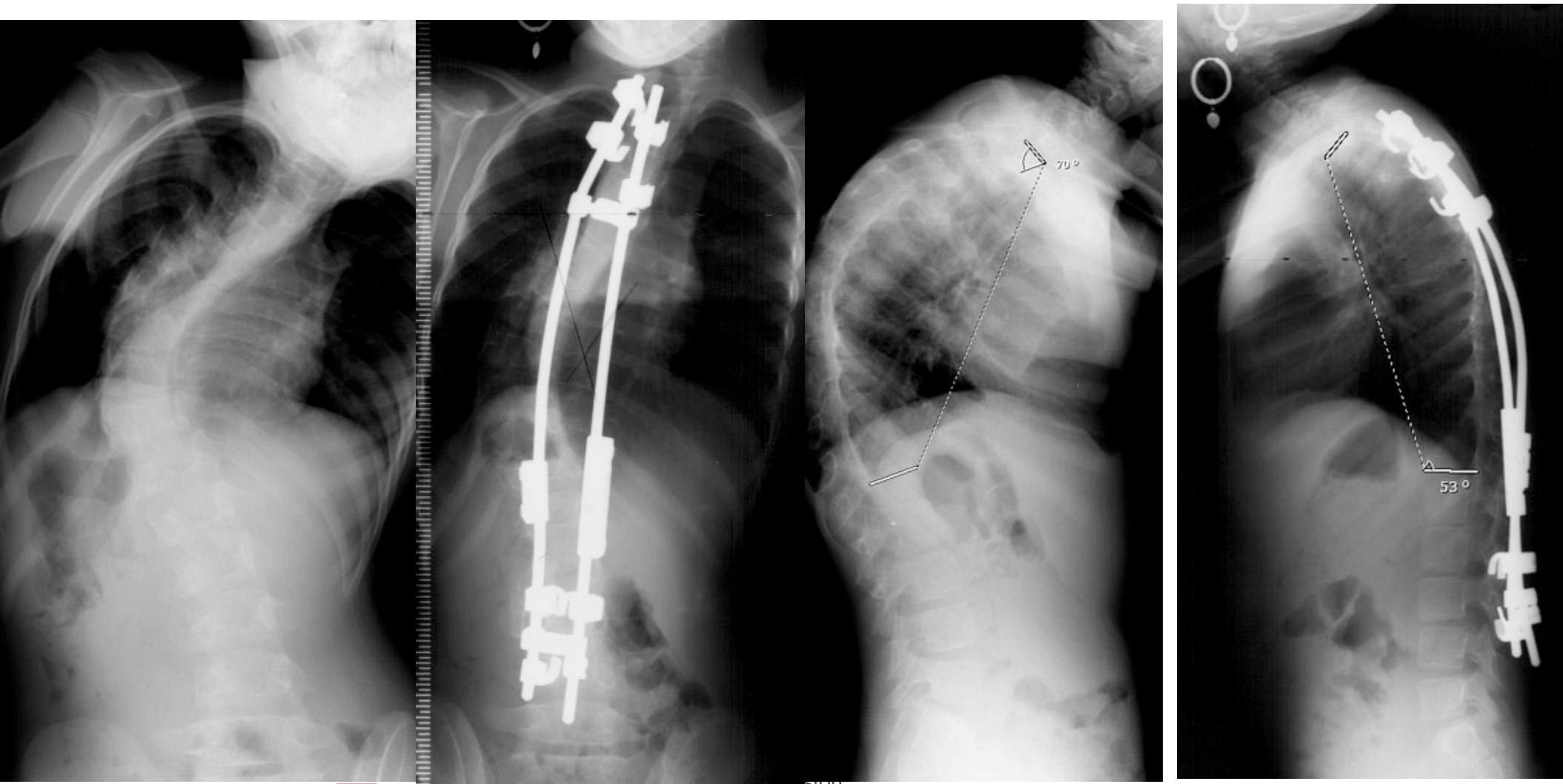
HK – Late (Trisomy 6)



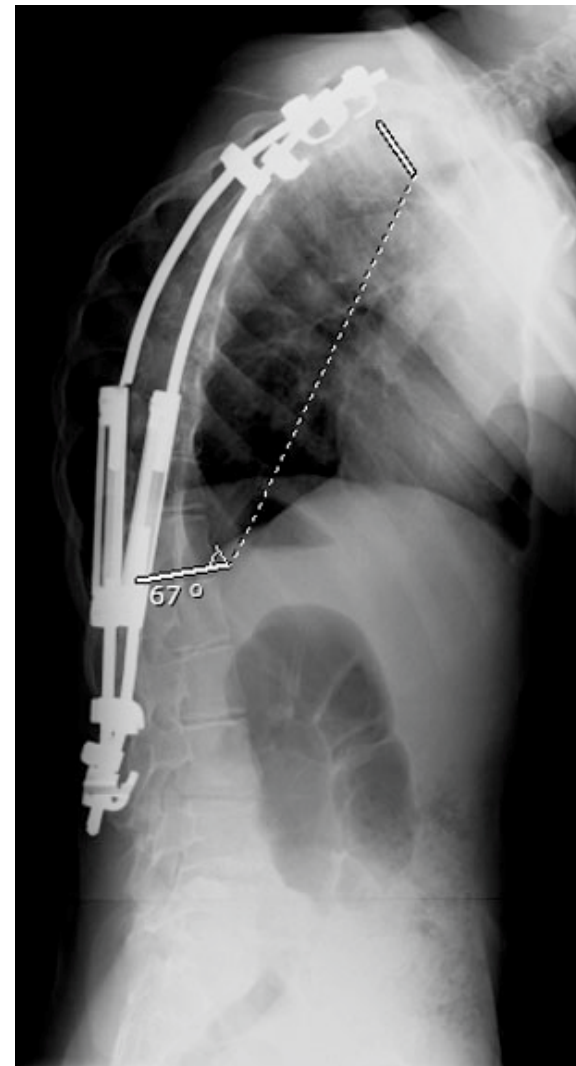
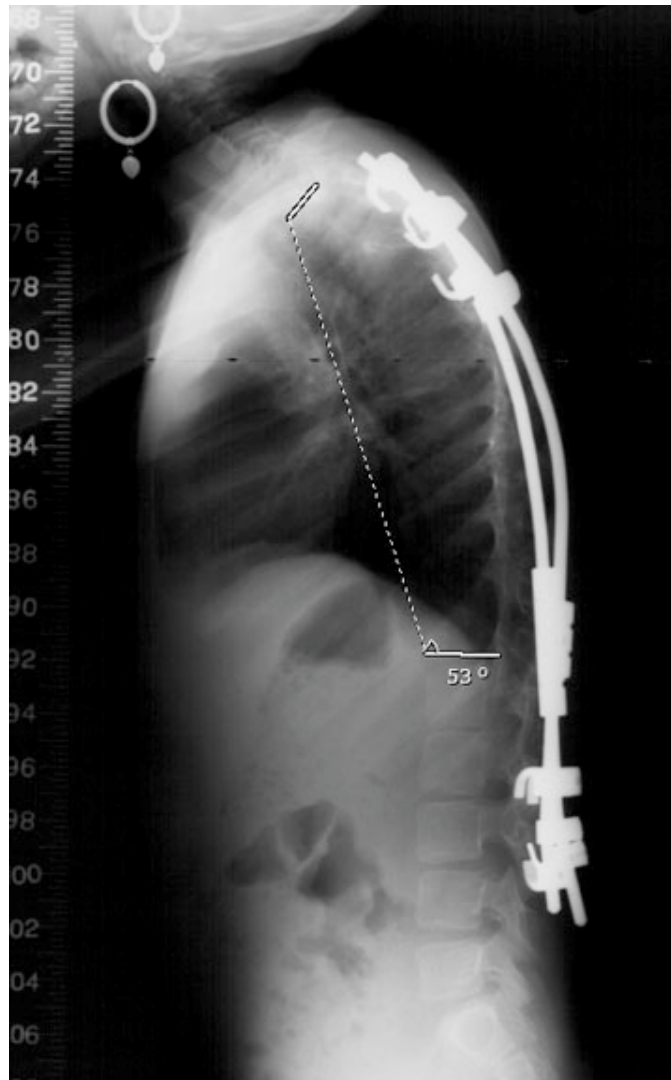
HK – Late (Trisomy 6)



HK – Late (AA) (Tel Hashomar)



HK – Late (AA)



Apical Fusion & GR

	Pre K	Final K	Complication
Single Rod & apical s/p fusion	42°	55°	80%
Single Rod	33°	33°	19%
Dual	49°	42°	19%

Thompson, et al (JPO, 2007)

Increased complications with apical spinal fusion in GR - Farooq (SRS 2009)



Proximal Junctional Kyphosis

Often referred to but, it's exact meaning is ill defined, it's consequences are questionable, and it's mechanism is poorly understood.



Proximal Junctional Kyphosis

Scheuermann's

- ▶ Lowe (1994) UIV to max. kyphotic vert.
- ▶ Lonner (2007) UIV to 1 above $\geq 10^\circ$

Scoliosis

- ▶ Lee (1999) UIV to 1 above $> 5^\circ$
- ▶ Kim (2008) UIV to 2 above $\geq 10^\circ$ and 10° pre-op

Proximal Junctional Kyphosis

Lonner (2007)	32.1%	3/78 revised
Lowe (1994)	30%	-
Lee (1999)	46%	-
Kim (2008) adults	39%	>20° SRS
Kim (2005) adol.	26%	0 SRS



Junctional Kyphosis - Predictors

Lowe (sk)

- ▶ $>50^\circ$ correction
- ▶ UIV below Cobb end vertebra

Kim (s)

- ▶ older age ($>55y$)
- ▶ combined a/p

Lonner (sk)

- ▶ **large kyphosis**
- ▶ too little correction
- ▶ PI?

Kim (s)

- ▶ thoracoplasty
- ▶ hybrid instrumentation
- ▶ **pre-op $T_{5-12} > 40^\circ$**

Lee (s)

- ▶ pre-op PJK $>5^\circ$
- ▶ **increased proximal kyphosis (T_2 -UIV)**



Proximal Junctional Kyphosis in GR

Farooq et al (SRS 2009)

- ▶ Subm G.R. 2/88 early fusion PJK

Debnath (ICEOS 2008)

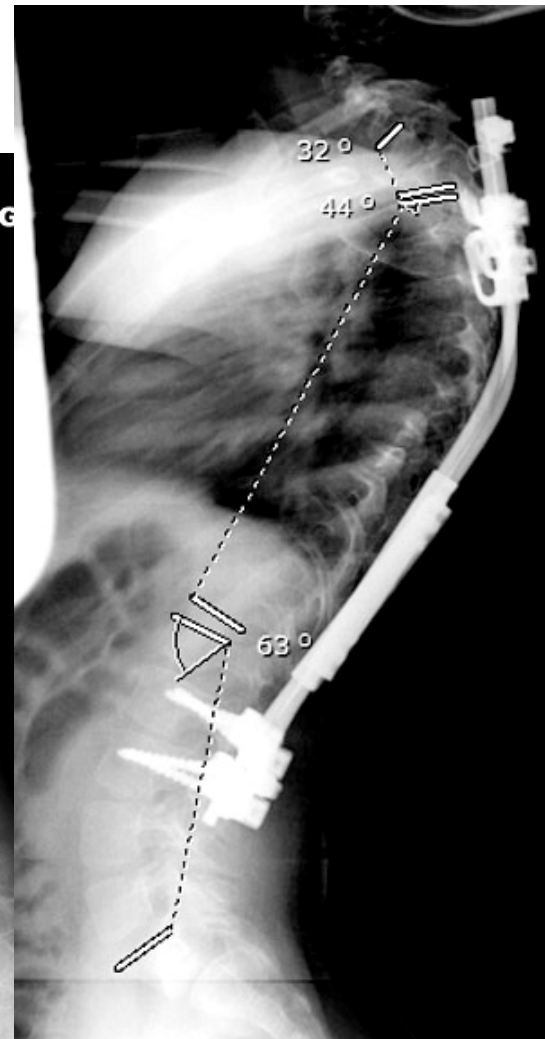
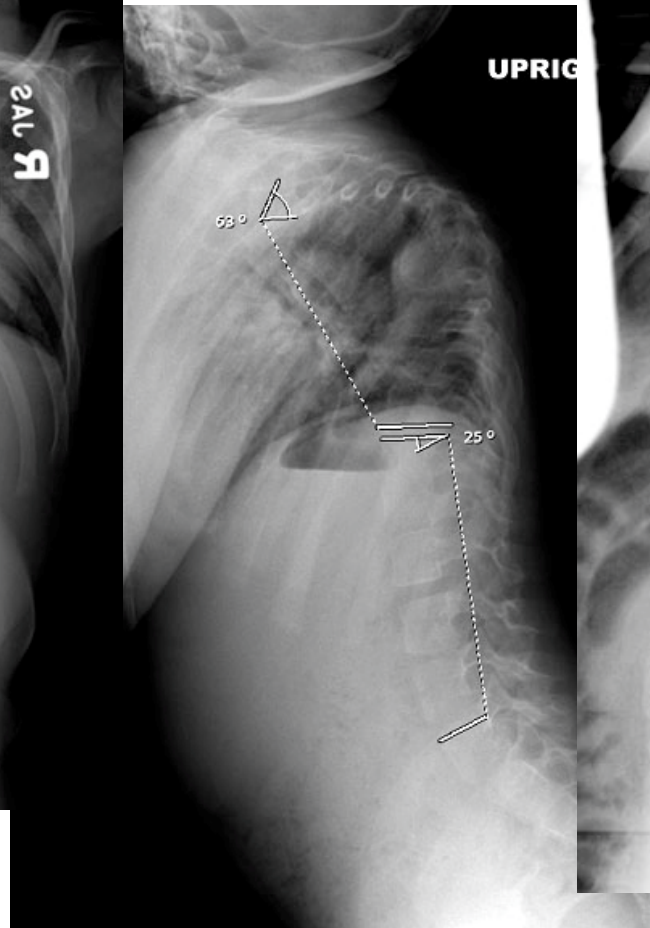
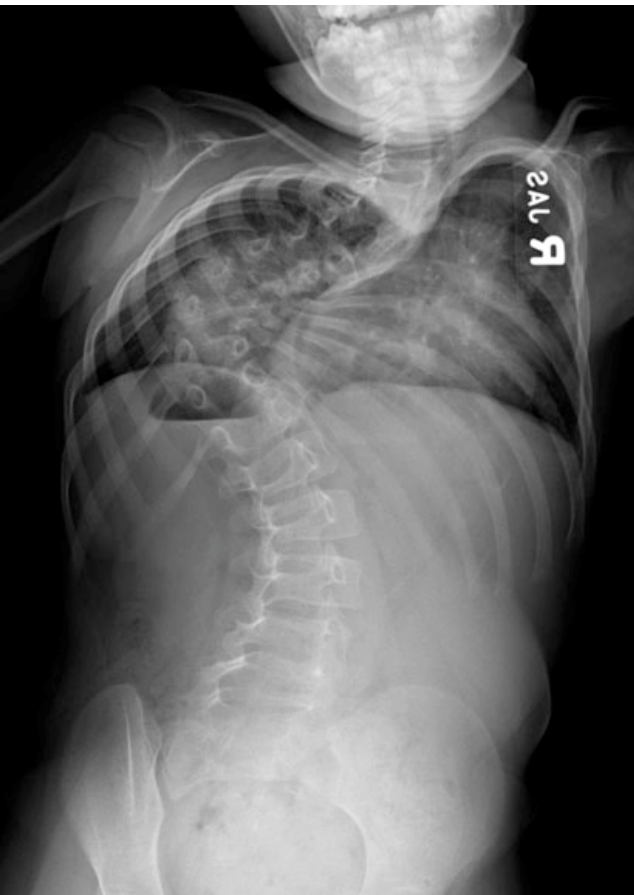
- ▶ 3/32 JK with Luque Trolley

PJK

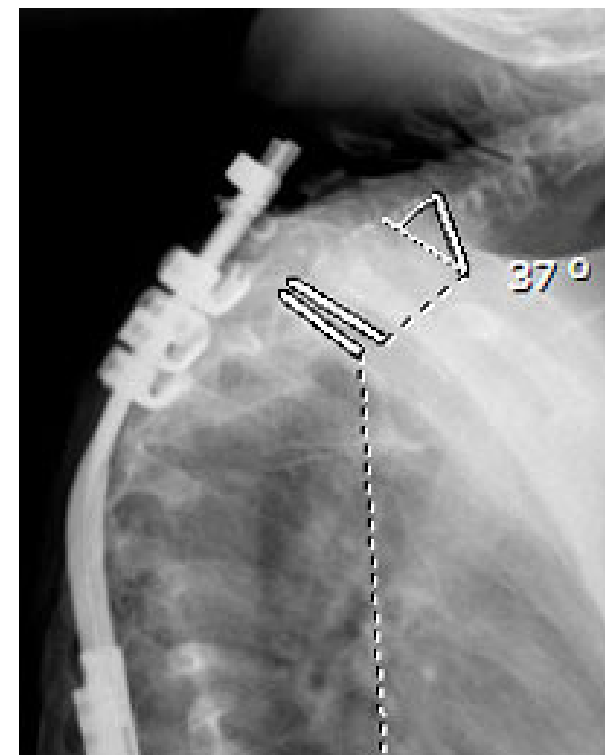
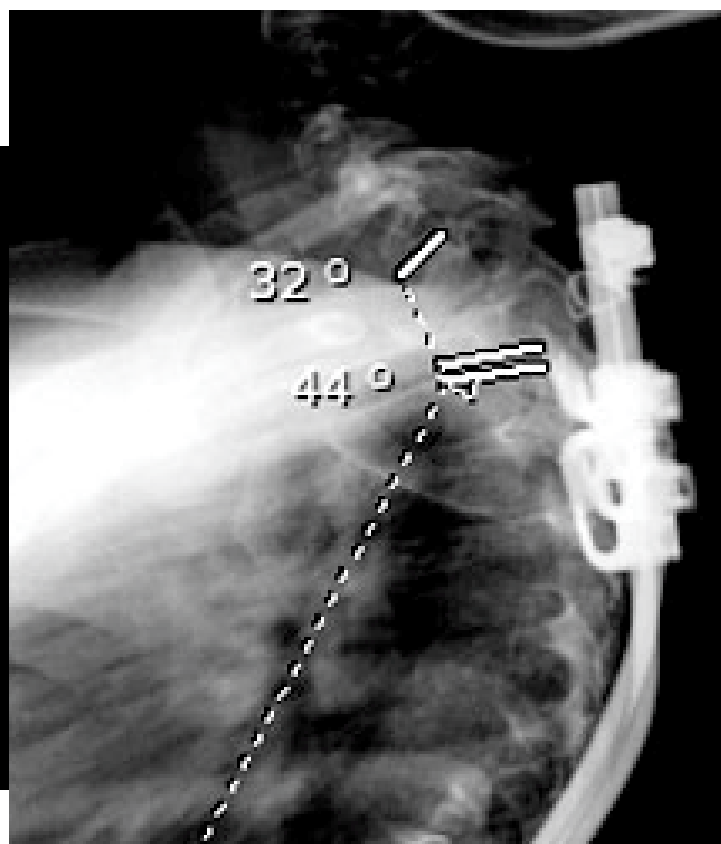
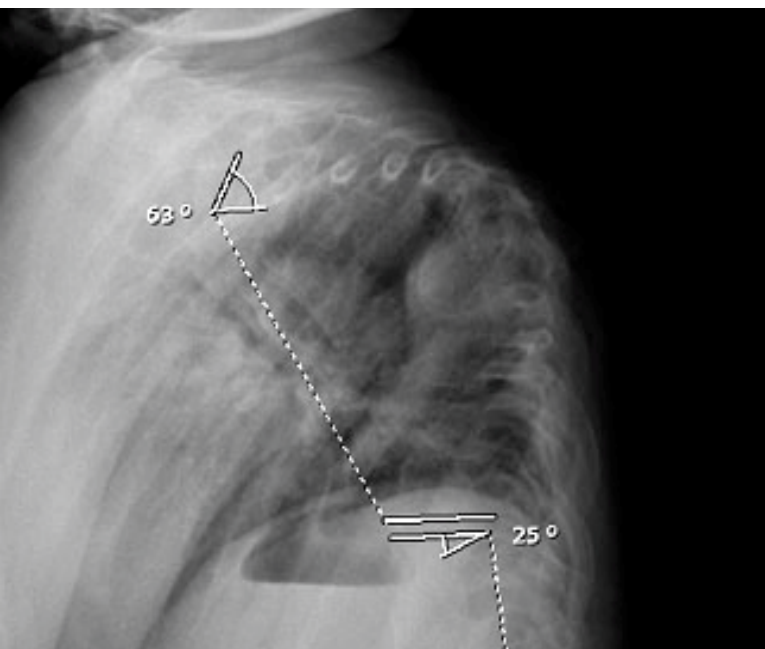
- ▶ +/- predicted by initial HK
- ▶ ? Prevent by appropriately chosen and placed instrumentation-maybe
- ▶ Treat aggressively when large
- ▶ VEPTR ??????????



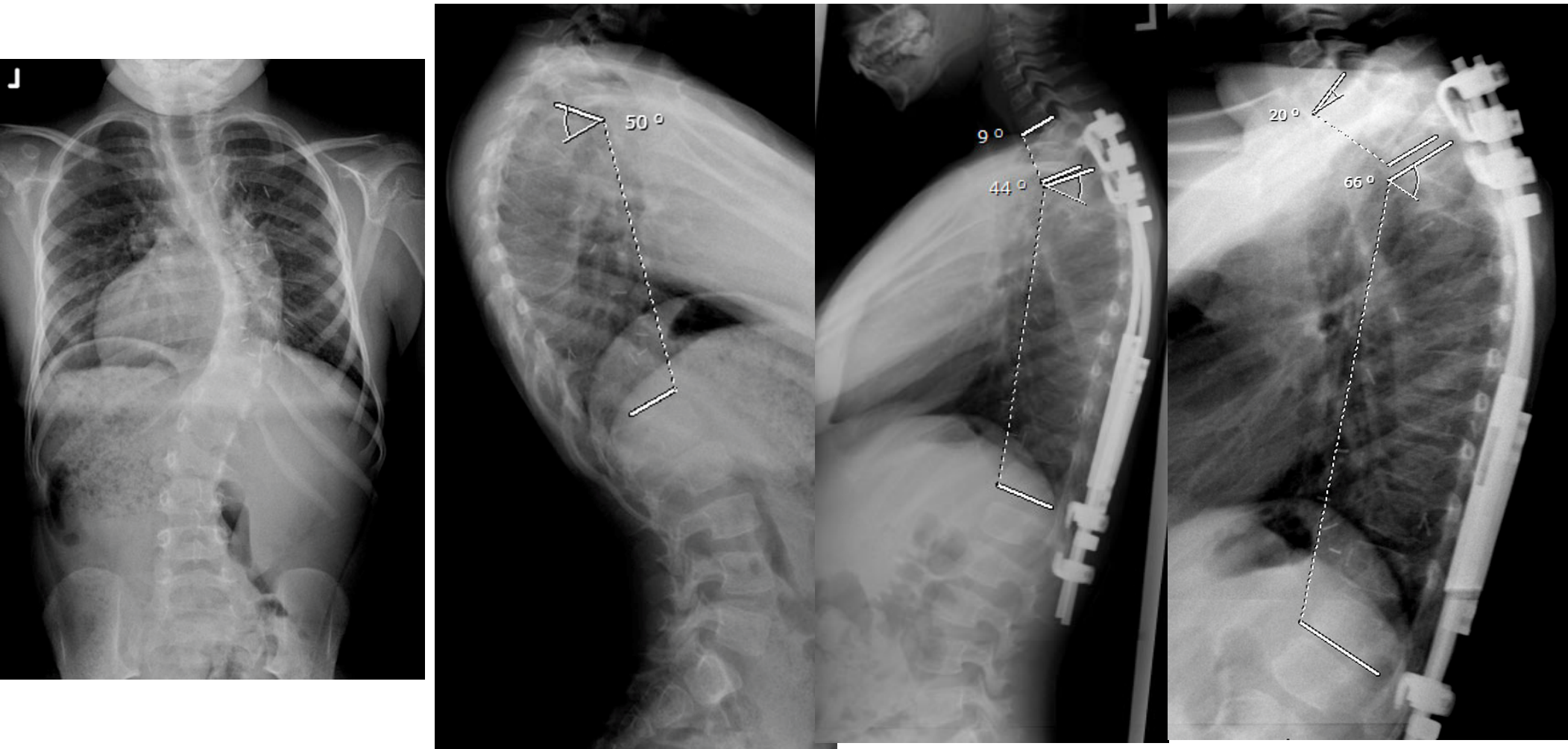
Prox. Junctional Kyphosis-GR (Prader-Willi)



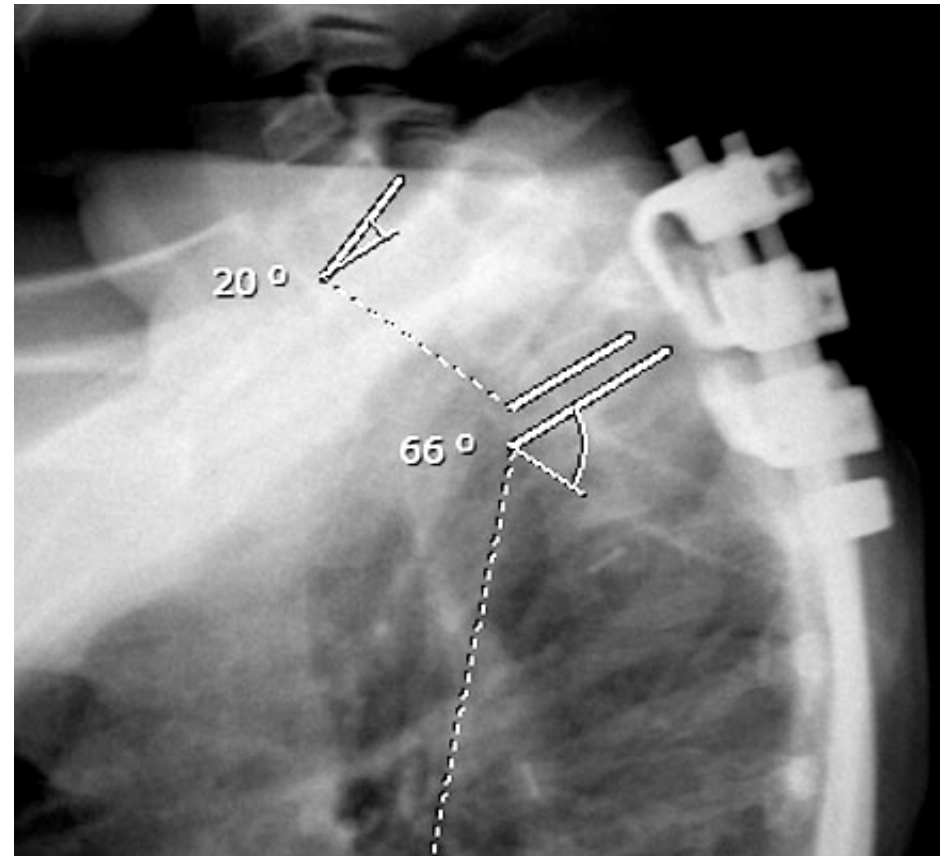
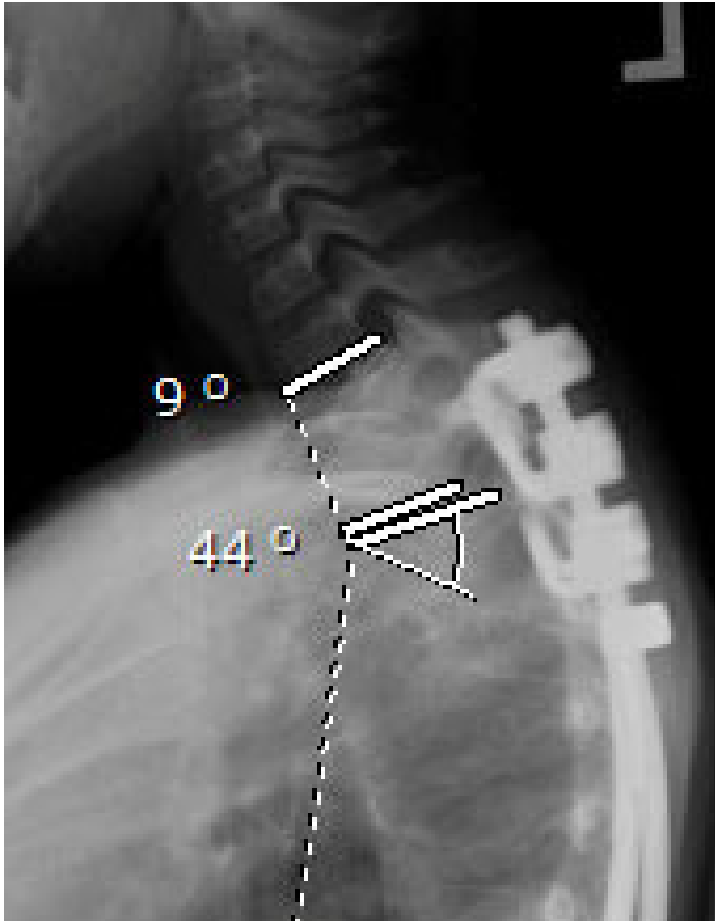
PJK -



PJK – GR (Neuroblastoma)



PJK - GR

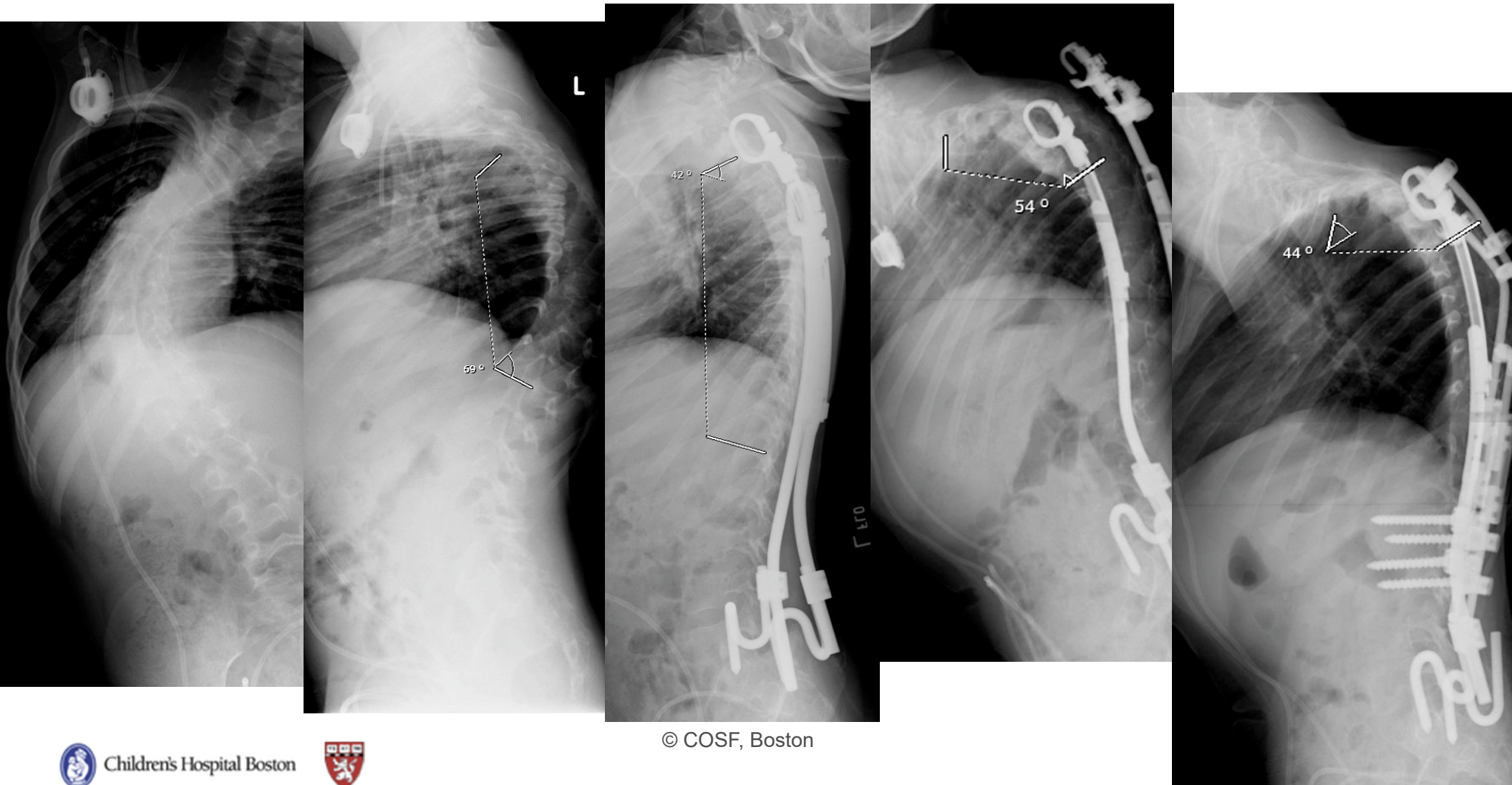


VEPTR

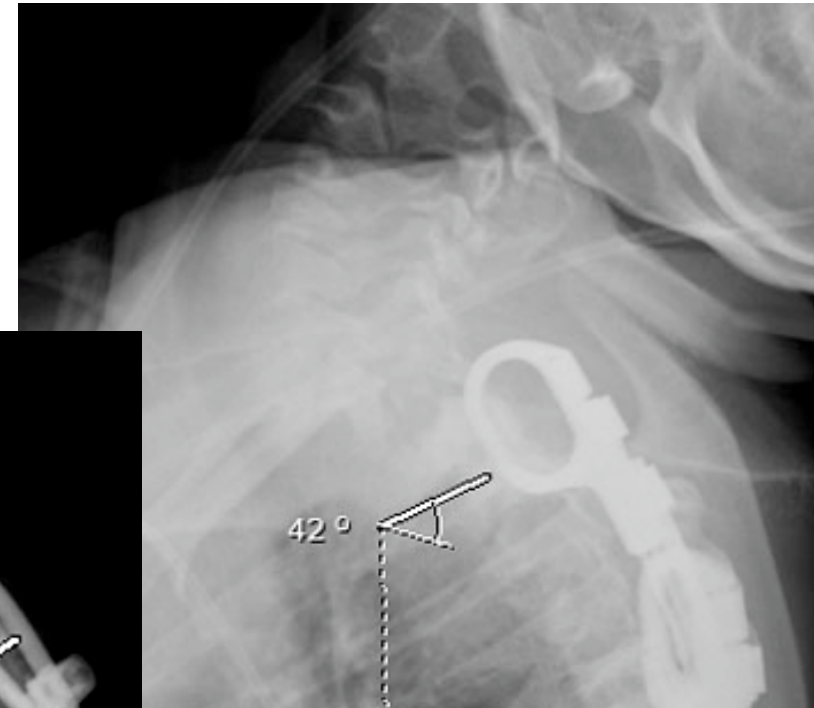
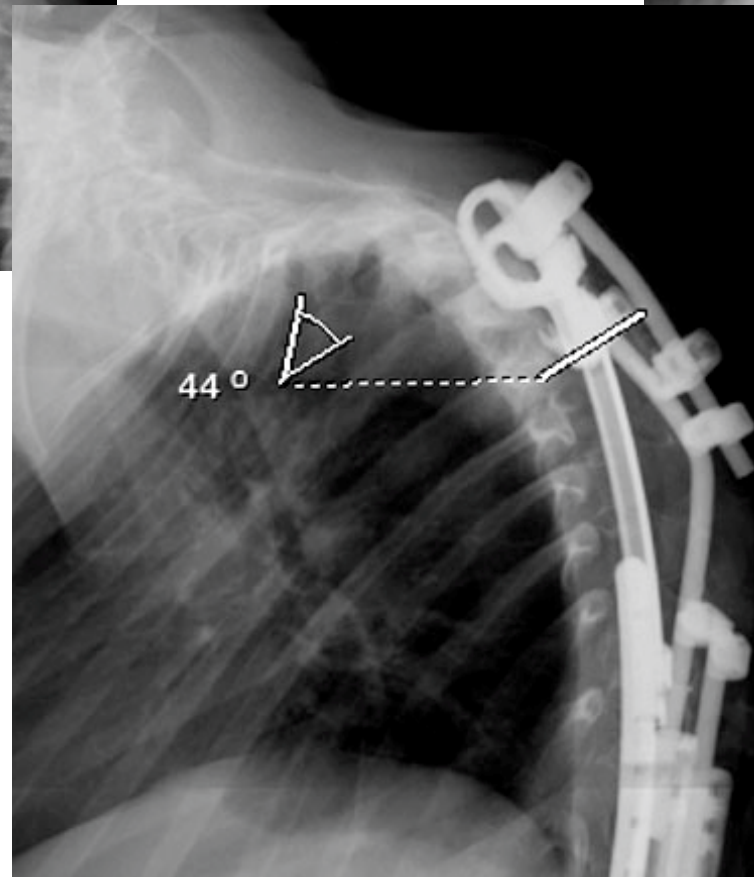
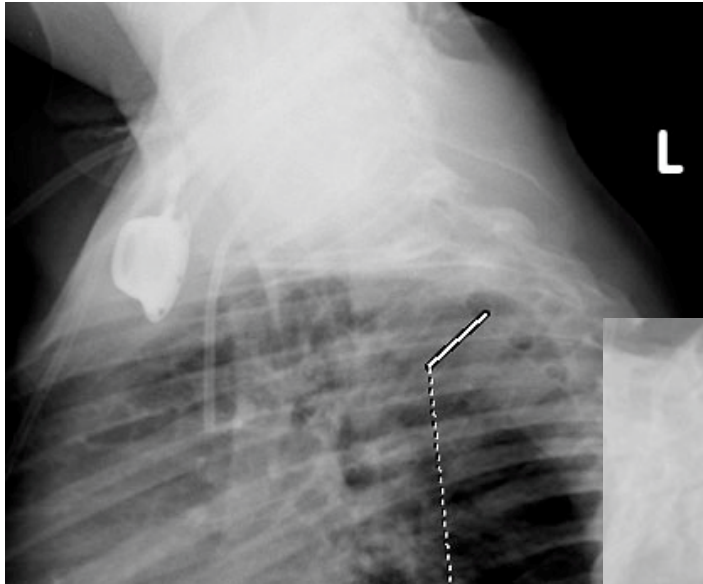
- ▶ The solution:
 - ▶ No transitional rigidity
 - ▶ No soft tissue dissection



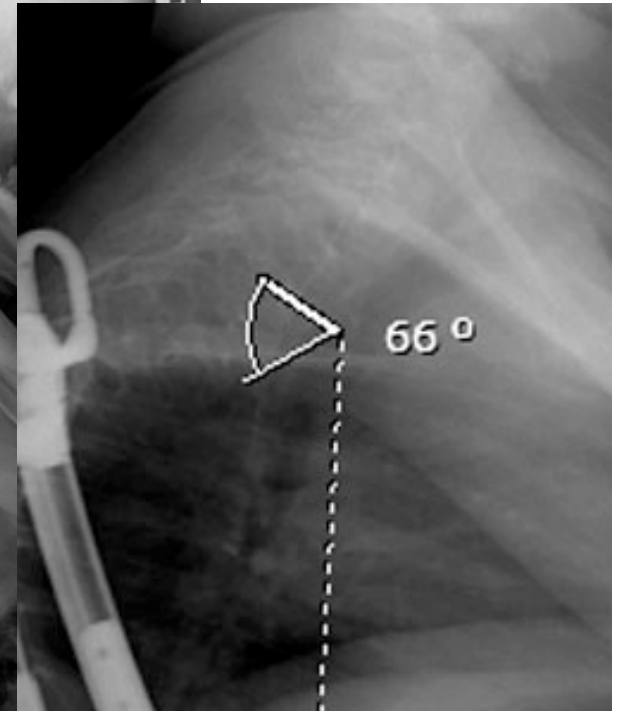
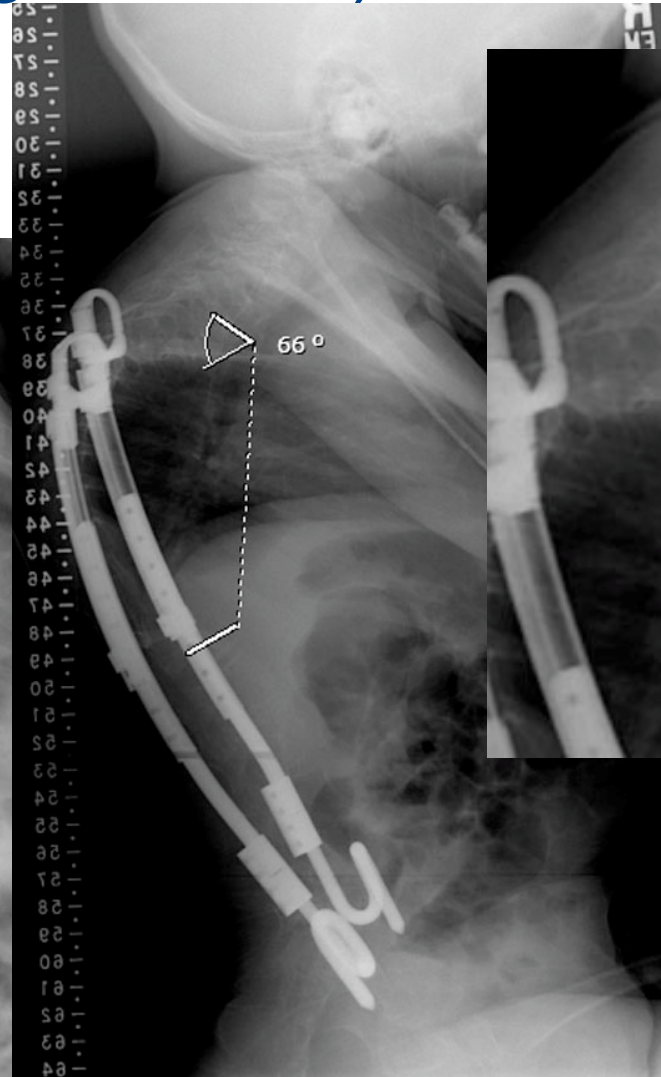
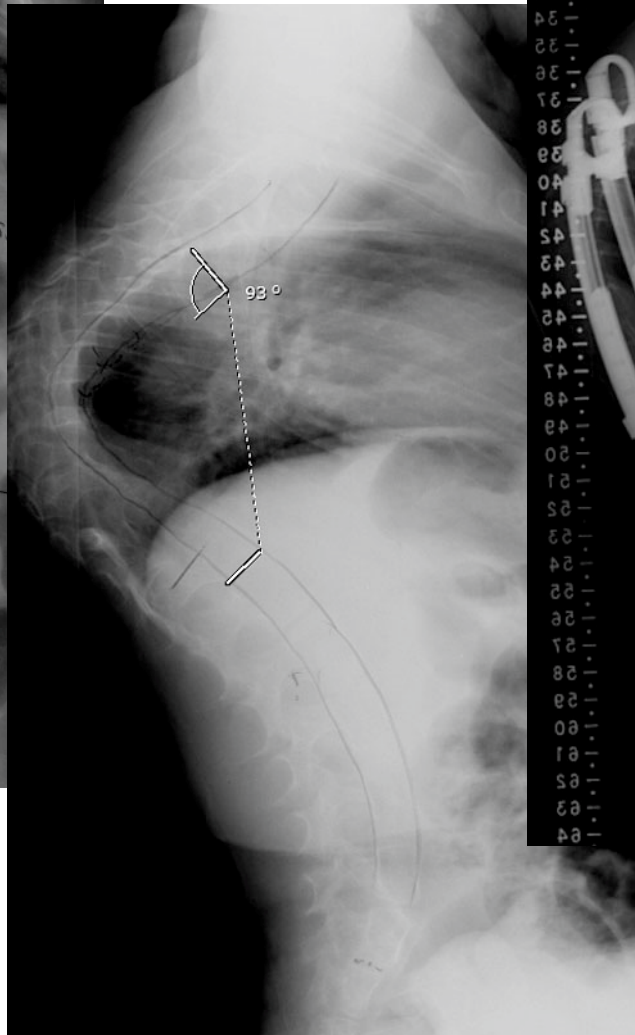
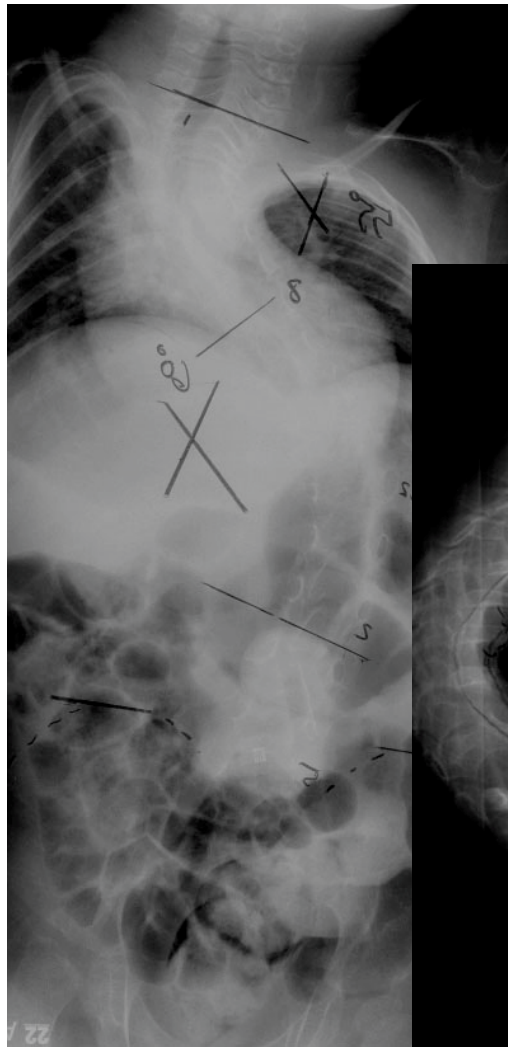
PJK – VEPTR (Intraspinal tumor, TIS)



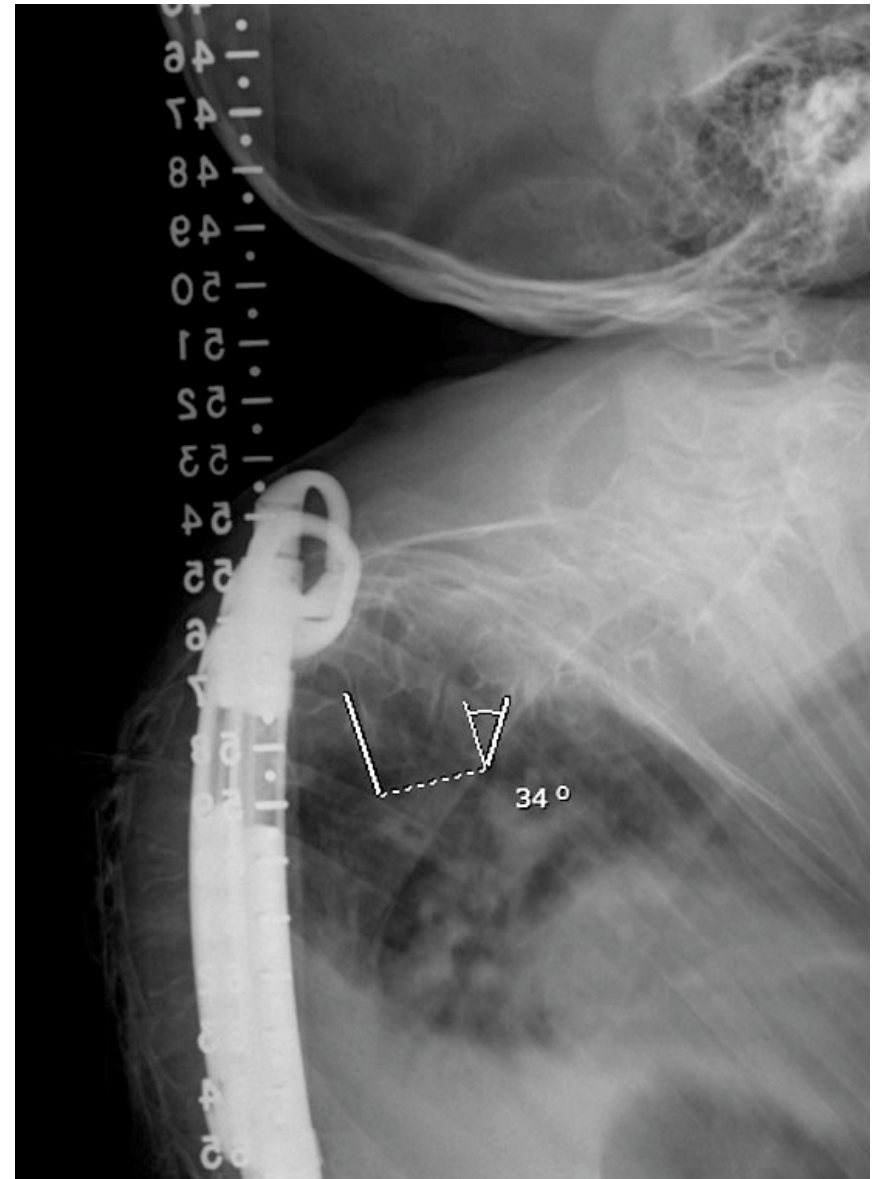
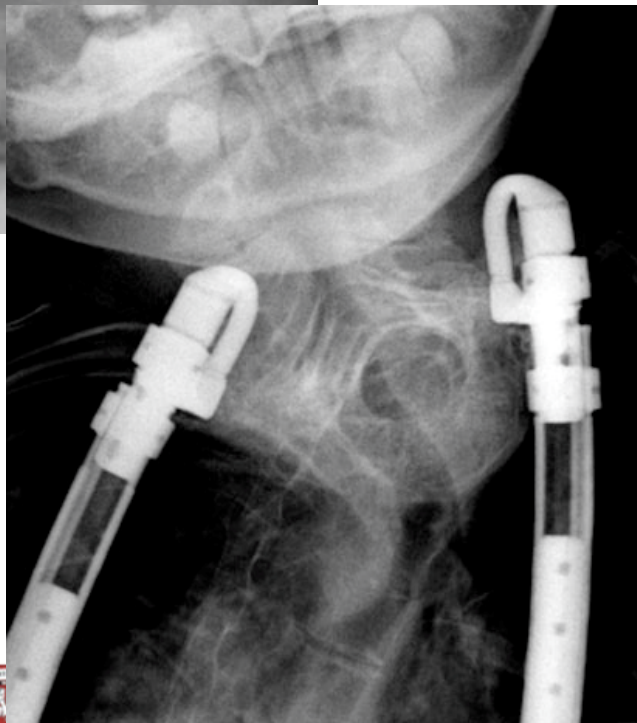
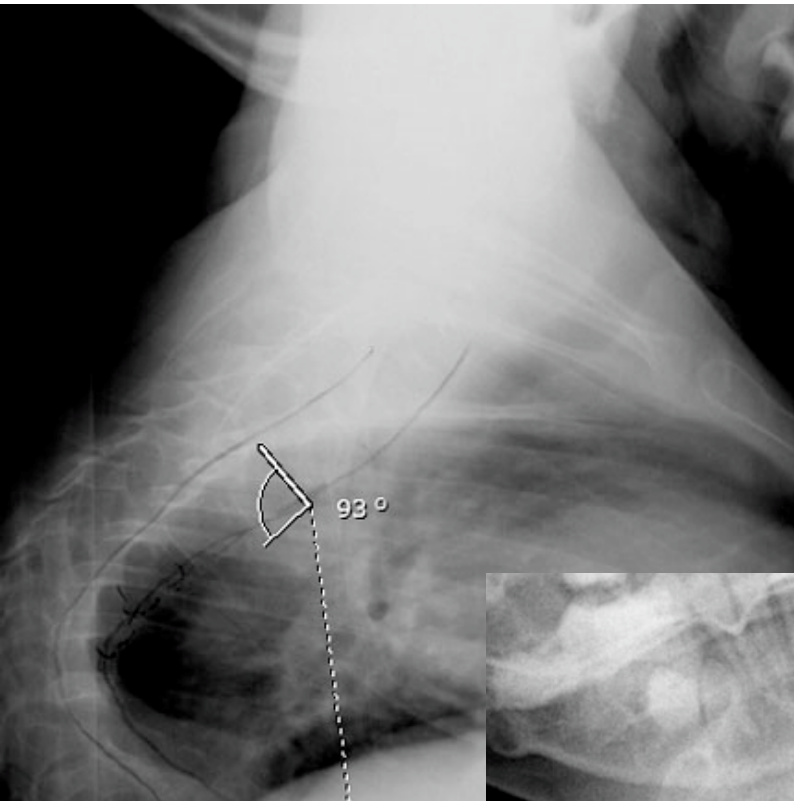
PJK - VEPTR



PJK – VEPTR (Cong. Myopathy, Restrictive Lung Disease)



PJK - VEPTR



VEPTR

- ▶ ?soft tissue destruction as cause for PJK
- ▶ Does not grip the spine, so cannot control the spine



- ▶ It is not possible to make accurate generalizations about the population of individuals undergoing growing rod and VEPTR treatment. They have an extremely variable physiologic makeup. The complications in sagittal alignment are due in part to mechanics, but also relate to the biology, eg connective tissue disorders, altered neuromuscular factors, etc..... But,



Hyperkyphosis

- ▶ Treat when present at onset by controlling the spine
- ▶ Choose appropriate, stable anchors, and construct(DR)
- ▶ Include kyphotic segments
- ▶ Protect the anchors by minimizing stress – pre-op traction, positioning, anchor fusion, delayed manipulations (individualize to deformity, pathology)
- ▶ ?Avoid apical fusions in HK ?anterior fusion



Hyperkyphosis

- ▶ Occurrence during treatment predicted by initial HK
- ▶ VEPTR (is nice) but not for kyphosis control
- ▶ Treat in timely manner rod contouring, cantilever correction



PJK

- ▶ Does exist – can be significant
- ▶ ?More to come – occur over time in SK
- ▶ ?Predict by initial HK
- ▶ VEPTR will not control upper Thoracic spine - ??No,No
- ▶ Treat in timely fashion – extend anchor with stable fixation





Galen ministering to gladiators wounded in the arena at Pergamon



Sagittal Alignment Results Dual GR

Lordosis

Lordosis	Pre-Op	Last
Lordosis	46.5°	47.9°
Lordosis > 60°	6 (69°) (65° - 78°)	A? Normal
Lordosis > 60°	-	3 (75°) (67° - 90°)
Lordosis < 40°	5 (18.6°) (+3 to 37°)	3/5 normalized
Lordosis < 40°		5 (29.2°) (17° - 39°) 3 developed



- ▶ Controlling deformity requires secure anchors – difficult to obtain in the GR population with limited fixation points and small, often weak bones. Goal is to maximize fixation stability and minimize the stress on the anchor; pre-op traction, positioning, anchor fusion prior to manipulations, and delayed corrective forces.

Secure anchors are difficult to obtain in the GR population. There are minimal fixation points and these are in small, often weak bones. The goal is to maximize the fixation strength via stable anchor (3 level staggered hook claw, pedicle screws?)

