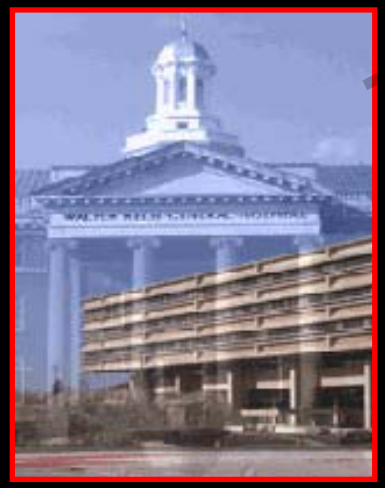
Perioperative Considerations in AIS: Classification and Imaging



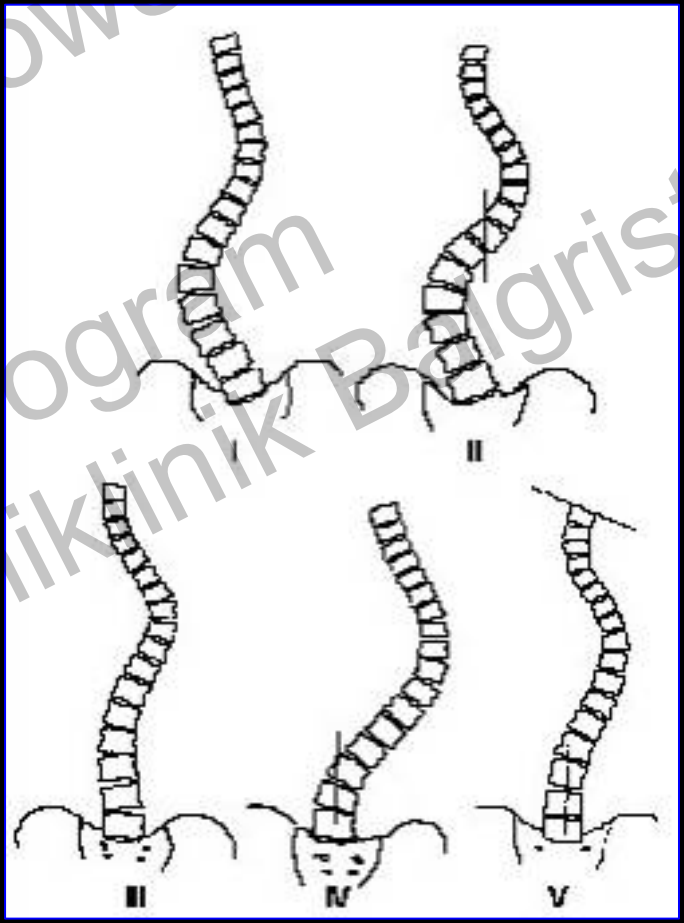
Ronald A. Lehman, Jr., M.D.
Chief, Pediatric and Adult Spine Surgery
Associate Professor of Surgery
Assistant Professor of Neurology
Walter Reed Army Medical Center
Washington, D.C., USA

Scoliosis Research Society 2011 Traveling Fellowship

KING, MOE, *et al*. (JBJS 1983)

5 TYPES:

I. L>T (both cross midline)
II. T>L (both cross midline)
III. Thoracic only
IV. Thoracic only (L4 tilted into curve)
V. Double Thoracic (+T1 Tilt)



BENEFITS

- First classification that was treatment-based
- Based on extensive Harrington Instrumentation experience
- Promoted “Selective Fusions” of Type II curves when appropriate
- Recognized Double Thoracic curve pattern when appropriate (V)
- Gold Standard for 20 years!

PROBLEMS

- Fair-to-poor inter & intraobserver reliability by 2 separate studies
  - Lenke, *et al*. and Cummings, *et al*. JBJS 1998
- Uniplanar - coronal plane-only assessment
- Often tough distinction between Type II & III curves (does the lumbar curve cross the midline?)
- Double and Triple Major curves and isolated Thoracolumbar/Lumbar curves excluded
- Based on Harrington Instrumentation principles

AIS

A NEW CLASSIFICATION TO GUIDE EXTENT OF SPINAL ARTHRODESIS

SIX GOALS

1. Comprehensive - all curve types
2. 2-Dimensional - increased emphasis on sagittal plane
3. Treatment-based
4. Reliable - inter and intraobserver
5. Specific objective criteria to separate curve types
6. Practical and easily understood/usable to scoliosis surgeons

Lenke, Betz, Harms, Bridwell, Clements, Lowe, Blanke. *JBJS 83A(8):1169-81, 2001*

DEFINITIONS *(SRS)*

MAJOR CURVE = LARGEST COBB

Always Included in Fusion

↓

MINOR CURVE = ALL OTHERS

↓

??? Include in Fusion

MINOR CURVE
STRUCTURAL CRITERIA

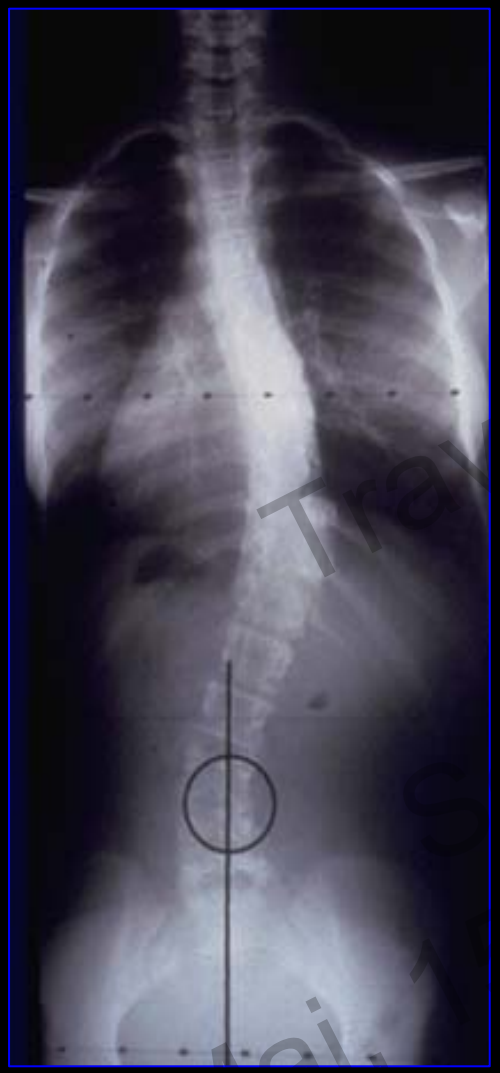
	CORONAL S.B.	SAGITTAL
PT	$\geq 25^{o}$	$\geq {}^{+}20^{o}$ (T2-T5)
MT	$\geq 25^{o}$	$\geq {}^{+}20^{o}$ (T10-L2)
TL/L	$\geq 25^{o}$	$\geq {}^{+}20^{o}$ (T10-L2)

CURVE TYPES (1-6)

CURVE TYPE	PT	MT	TL/L	DESCRIPTION
1	NS	S*	NS	Main Thoracic (MT)
2	S	S*	NS	Double Thoracic (DT)
3	NS	S*	S	Double Major (DM)
4	S	S*	S*	Triple Major (TM)
5	NS	NS	S*	Thoracolumbar/Lumbar (TL/L)
6	NS	S	S*	Thoracolumbar/Lumbar-Main Thoracic (TL/L-MT)

S = Structural
NS = Non-Structural
***Major (largest curve)**

LUMBAR SPINE MODIFIER



A

B

C

SAGITTAL THORACIC MODIFIER
(-, N, or +)

T5-T12 SAGITTAL COBB	
COBB	**MODIFIER**
$<^{+}10^{o}$	-
$^{+}10$ - $^{+}40^{o}$	N
$>^{+}40^{o}$	+

-

N

+

NEW CLASSIFICATION SYSTEM OF AIS

3 COMPONENTS

Curve Type (1-6)

+

Lumbar Spine Modifier (A, B, or C)

+

Sagittal Thoracic Modifier (**-, N, or +**)

=

Curve Classification (e.g. 1B+)

RELIABILITY TESTING

	INTEROBSERVER	INTRAOBSERVER
King	0.49	0.62
New (Developers)	0.92	0.83
New (Independent)	0.74	0.89

- **0.75 = GOOD/EXCELLENT**
- **Same 27 Cases of AIS Utilized for Trials**

AIS ALGORITHM

X-RAYS

↓

CLASSIFICATION

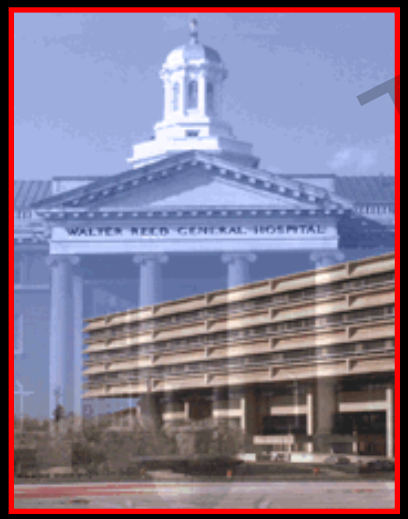
↓

TREATMENT

↓

OUTCOME

The Reliability of Preoperative Supine Radiographs to Predict the Amount of Curve Flexibility in Adolescent Idiopathic Scoliosis

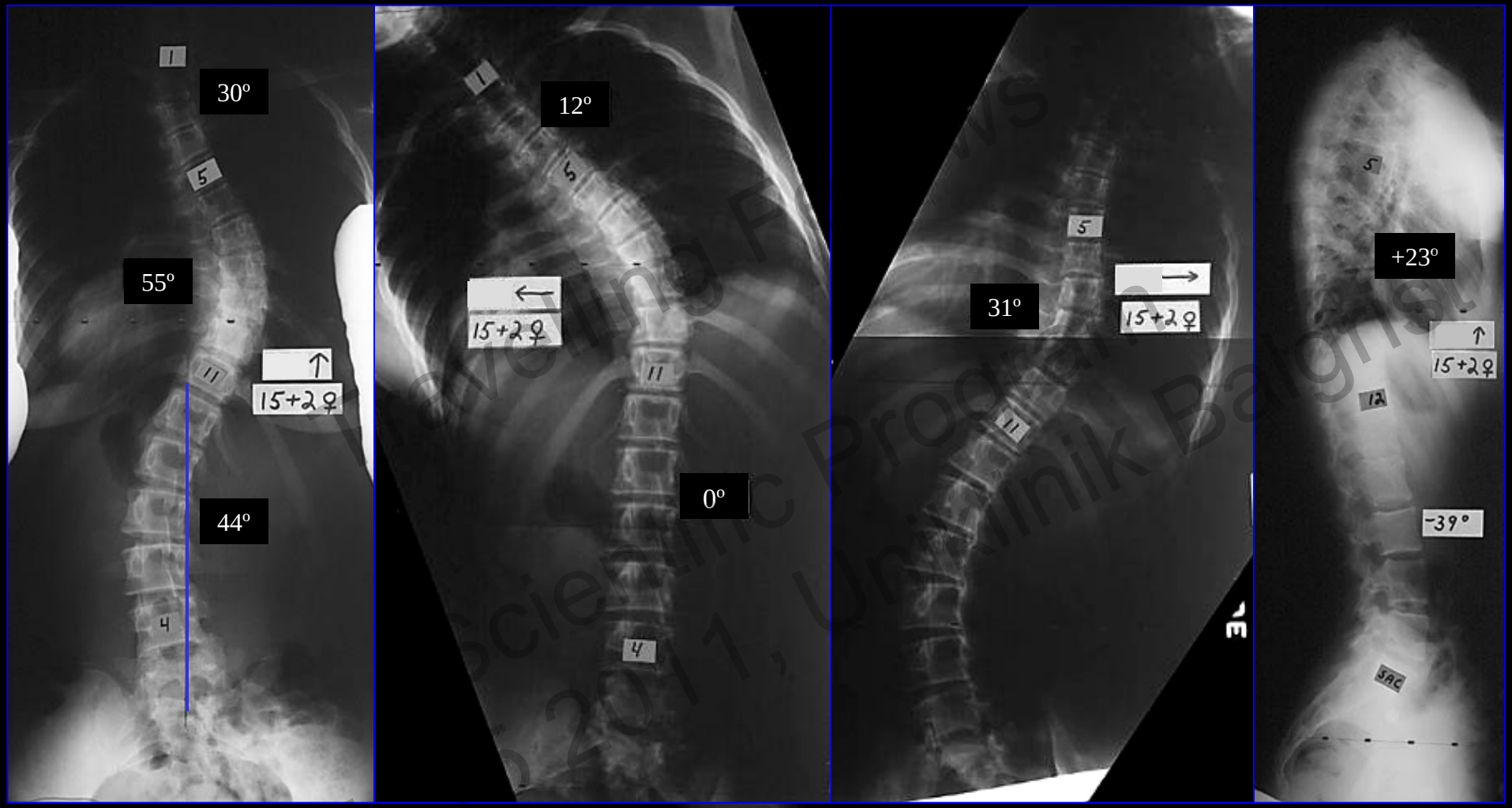


Gene Cheh MD
Lawrence G. Lenke, MD
Ronald A. Lehman, Jr., MD
Yongjung J. Kim, MD
Keith H. Bridwell, MD
Ryan Nunley, MD
Kate Keeler, MD

Washington University School of Medicine, St. Louis, MO

Scoliosis Research Society Traveling Fellowship 2011

CURVE CLASSIFICATION 1BN

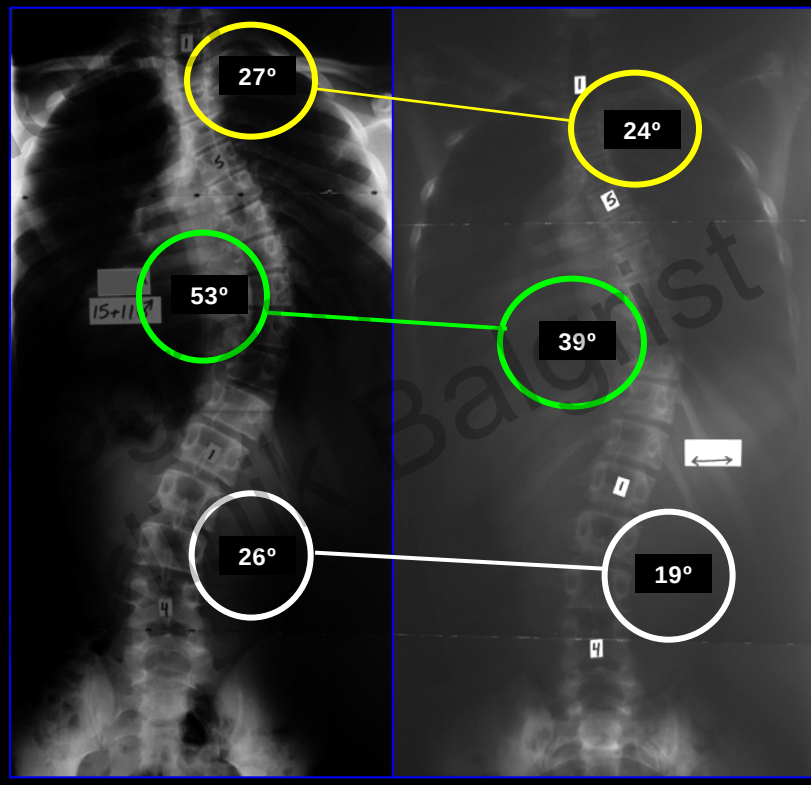


LEFT SIDE BENDING

RIGHT SIDE BENDING

INTRODUCTION

- Side bending Radiograph is highly subjective with much variability possible within centers & from 1 center to the next
- Preop supine coronal long-cassette x-ray is not effort nor technician-dependent
  - More reliable and reproducible
  - Should be the same each time at all centers!
  - Cobb measurement changes in each spinal region should reflect the inherent "stiffness" of those regions



UPRIGHT SUPINE

PURPOSE

Determine the reliability of using Supine long-cassette radiographs as a substitute for side bending films to predict curve flexibility and fusion regions in operative AIS

METHODS

- 689 AIS patients had preop standing AP/Lat, right & left side bending, & supine films
- All curves classified using Lenke Classification
- Patients grouped by location of Major curve
  - Group I - MT (Types 1-4)
  - Group II - TL/L (Types 5 & 6)
- Excluded patients with TL kyphosis >20º

COBB MEASUREMENTS (n=689)

Radiographs	Proximal Thoracic (n=282)	Main Thoracic (n=524)	Thoracolumbar /Lumbar (n=496)	P-Value
Standing PA	35±9.7º	58±16.3º	47±14.4º	
Supine AP	31±9.9º	46±15.7º	34±13.1	
Side Bending AP	24±10.6º	33±17.3º	19±14.4º	
Supine Flexibility	13±13.5%	21±11.1%	28±15.7%	<0.001
Side Bending Flexibility	34±18.9%	46±18.9%	64±22.9%	<0.001

Group I. Lenke Curve Types 1-4

Supine Predictor	Side Bend	Standing	Equation
PT	r=0.834, p<0.0001	r=0.862, p<0.0001	PT SB = (-5.46) + 0.93 (PT SUP) (r=0.73, p<0.0001)
MT	r=0.894, p<0.0001	r=0.896, p<0.0001	
TL/L	r=0.800, p<0.0001	r=0.877, p<0.0001	TL/L SB = (-11.11) + 0.84 (TL/L SUP) (r=0.67, p<0.0001)

Group II. Lenke Curve Types 5-6

Supine Predictor	Side Bend	Standing	Equation
PT	r=0.785, p<0.0001	r=0.862, p<0.0001	PT SB = (-3.578) + 0.79 (PT SUP) (r=0.62, p<0.0001)
MT	r=0.876, p<0.0001	r=0.859, p<0.0001	MT SB = (14.10) + 0.93 (MT SUP) + 0.25 (PT SUP), (r=0.79, p<0.0001)
TL/L	r=0.681, p<0.0001	r=0.841, p<0.0001	

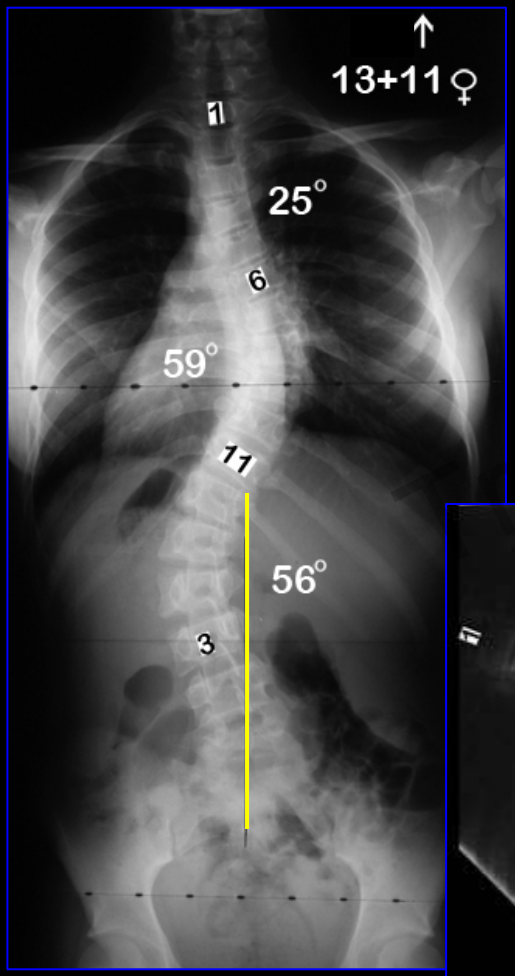
PREDICT STRUCTURALITY?

- Used ≥40º for TL/L Curves & ≥30º for PT & MT Curves as threshold of structurality in preop supine radiograph
- Compared to side bending current standard of ≥25º
- Was minor curve(s) considered structural in actual surgery and included in the fusion of major curve?

CURVE "STRUCTURALITY" PREDICTION

Curve Location	Structural Criteria	Positive Predictive Value	Negative Predictive Value
Proximal Thoracic	Supine 30º	0.458	0.922
	SB 25º	0.504	0.923
Main Thoracic	Supine 30º	0.548	0.911
	SB 25º	0.558	0.894
Thoracolumbar/ Lumbar	Supine 40º	0.685	0.946
	SB 25º	0.758	0.739

CURVE CLASSIFICATION 1CN

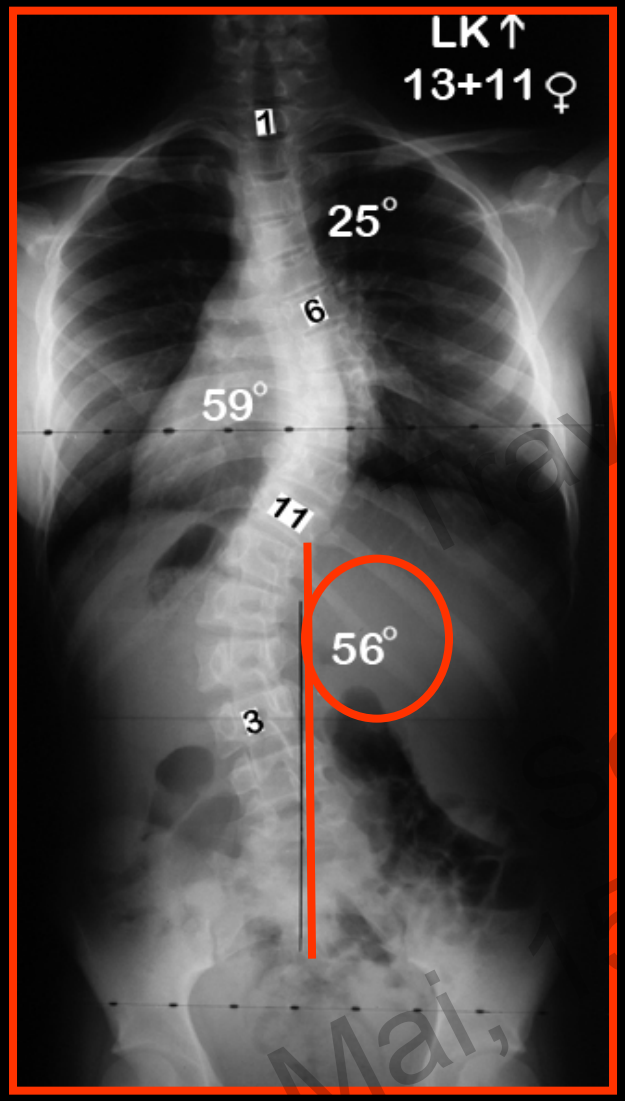


PREOP

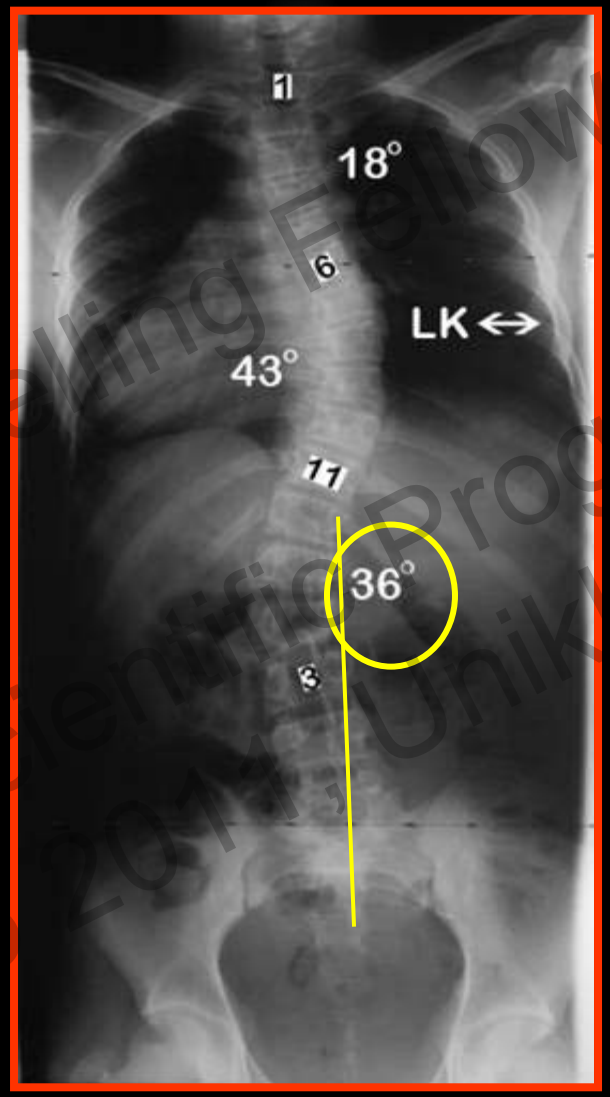
T – 14º

L – 14º

SUPINE FLEXIBILITY



UPRIGHT- C

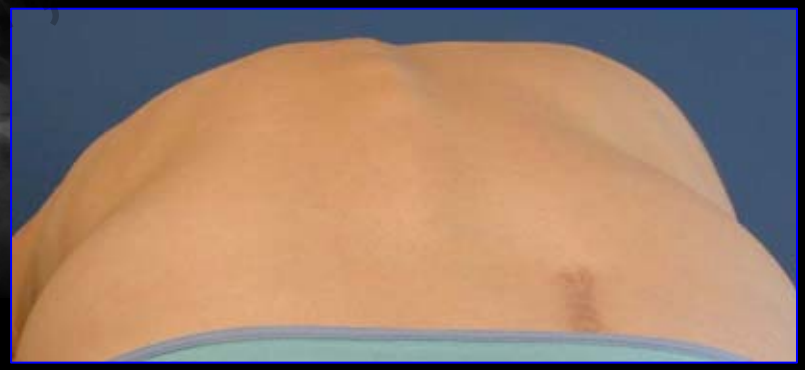


SUPINE- B

PUSH PRONE

PSF T4-T11

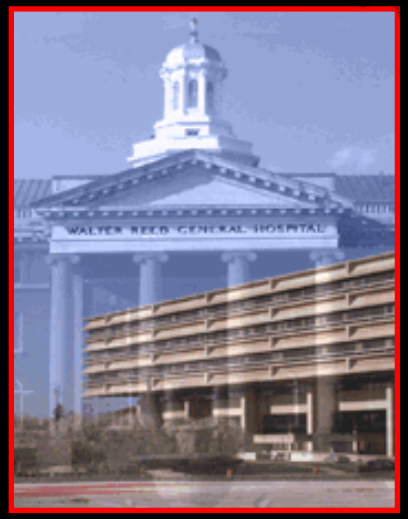
PREOP POSTOP



CONCLUSIONS

- A single preoperative SUPINE x-ray is:
  - Non-effort/Technician dependent
  - Reliable in and between centers
  - Highly predictive of side bending x-rays in the PT, MT, & TL/L regions
  - Adjunct to predicting
    - Curve flexibility
    - Curve type
    - Structural *vs*. Non-structural - minor curves
    - Replacement for Side Benders?????

Accuracy/Benefit of Intraoperative Scoliosis Radiograph to Determine Ultimate Correction and Balance on the Postoperative Standing Film. Should it be Mandatory?



Ronald A. Lehman, Jr., MD*
Lawrence G. Lenke, MD#
Melvin D. Helgeson, MD*
Tobin T. Eckel, MD*
Kathryn A. Keeler, MD#

*Walter Reed Army Medical Center, Washington, D.C.

#Washington University School of Medicine, St. Louis, MO

Introduction

- Thoracic Pedicle Screws
  - More expensive
  - Sig. better major and minor curve correction
  - No neurologic problems and improved PFTs
  - Enables shorter fusion length than hooks

    Kim YJ and Lenke LG, et al. *Spine* 2004.
- Imaging- essential to eval correction & implant placement
- CTs - accurate to identifying malpositioned implants
  - Limitations: 1) cost 2) radiation exposure 3) lack of IO avail.
  - Supine position masks true deformity
  - Cobb angle spontaneously corrects ~30% when supine

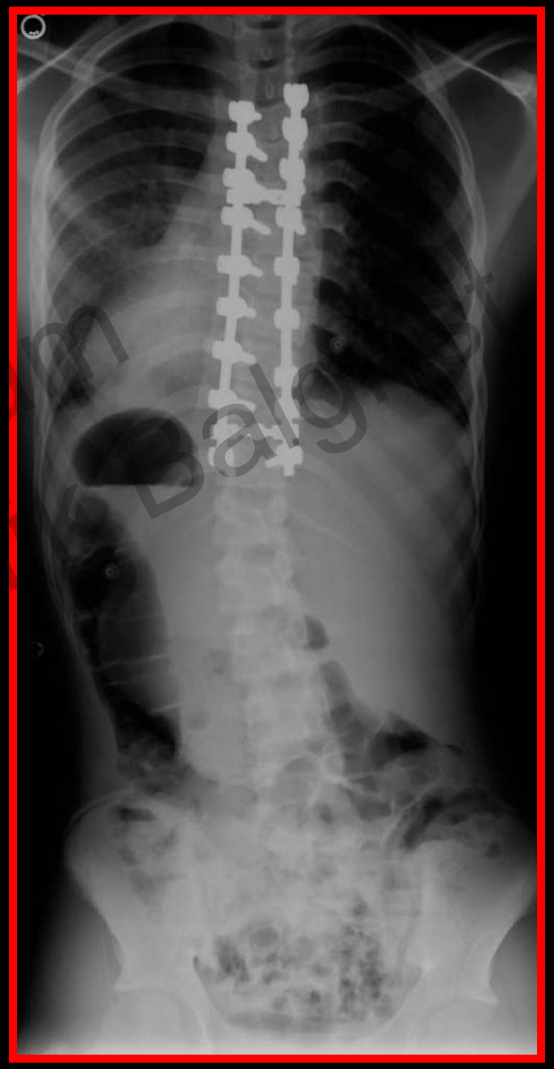
    Yazici et al., *J Pediatr Orthop* 2001

Purpose

To determine if there was radiographic correlation between long-cassette, intraoperative scoliosis films and the postoperative standing radiographs during the treatment of AIS with pedicle screw instrumentation

Methods and Materials

- Forty-four (44) consecutive AIS pts. PSF w/ TPS
- Radiographic measurements (curve magnitudes, coronal and sagittal balance, disc angles, etc.)
  - preoperative (PreO)
  - intraoperative (IO)
  - postoperative (PO)
- Intraoperative (IO), prone scoliosis film was obtained after instrumentation and correction
- Compared to the PO, standing film.



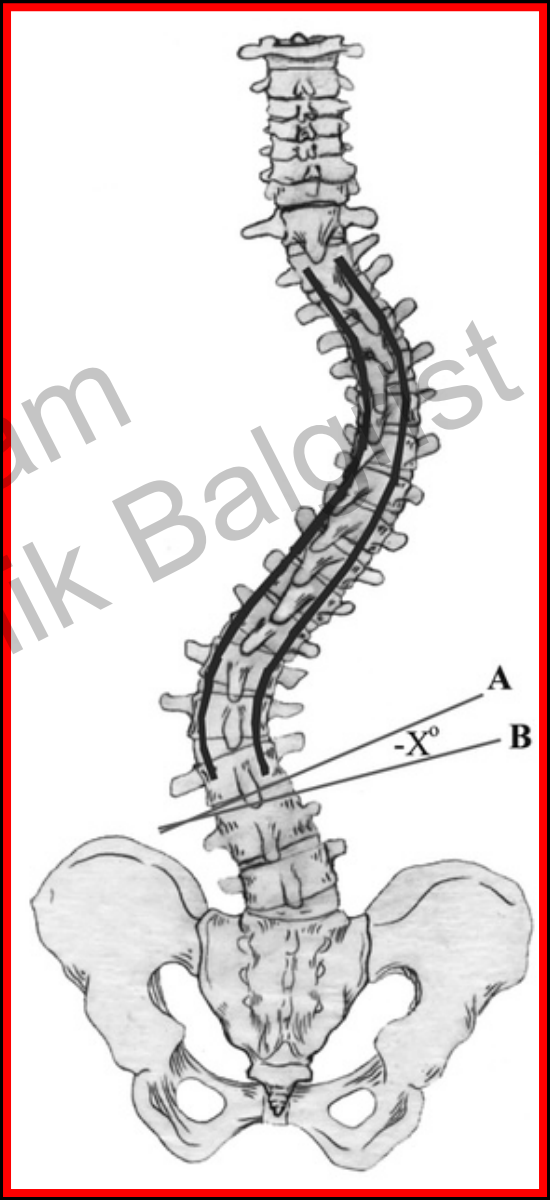
Results

Results

- Curve magnitude (MTC)
  - PreO: 57.5° ± 11.9SD
  - IO: 19.34° ± 8.62SD
  - PO: 17.45° ± 9.02SD
- Average age -15.1±2.21SD years
- Significant correlation ($p<0.005$) in curve magnitude on IO and PO films for:
  - proximal (PTC) – $r = 0.748$
  - main (MTC) – $r = 0.847$
  - TL/L curves – $r = 0.775$
- 77.3% showed diff. of ≤ 5° from IO to PO

Results

- LIV-H and LIV-α correlation from IO to PO
  - (r=0.497, p=0.001 and r=0.43, p=0.004, respectively).
- 84.1% of cases had correlation less than 5°
- LIV to CSVL & apex of the lumbar curve to the CSVL significantly correlated
  - (r=0.57, p<0.0005 and r=0.50, p=0.001, p=0.001).



Case Example

Preop PA | Intraop PA | Revision IO PA | Immediate PO

Conclusions

- The intraoperative, long-cassette scoliosis film significantly correlated with the immediate postoperative, standing films for virtually all curve correction and balance parameters.
- Use of intraoperative films provide a valuable tool to guide intraoperative decision-making.
- Intraoperative scoliosis films foreshadow the ultimate correction and balance obtained on the immediate postoperative film.

Thank You!