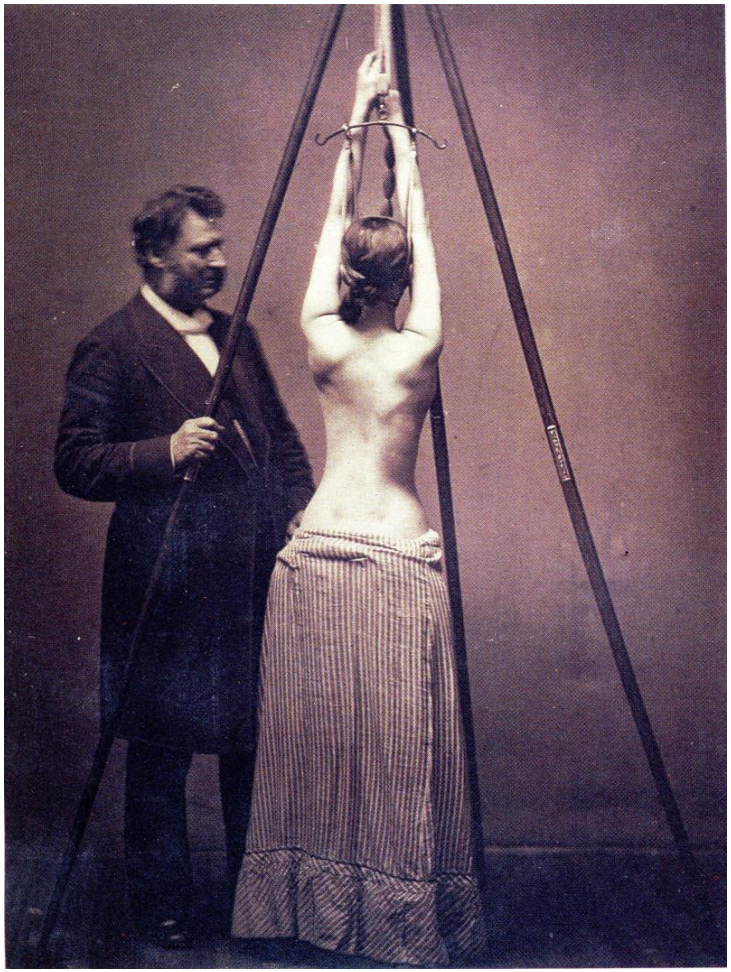


Scoliosis: When to screen, refer and treat

David W. Roberts, MD

Pediatric Orthopaedic Surgery
NorthShore University HealthSystem

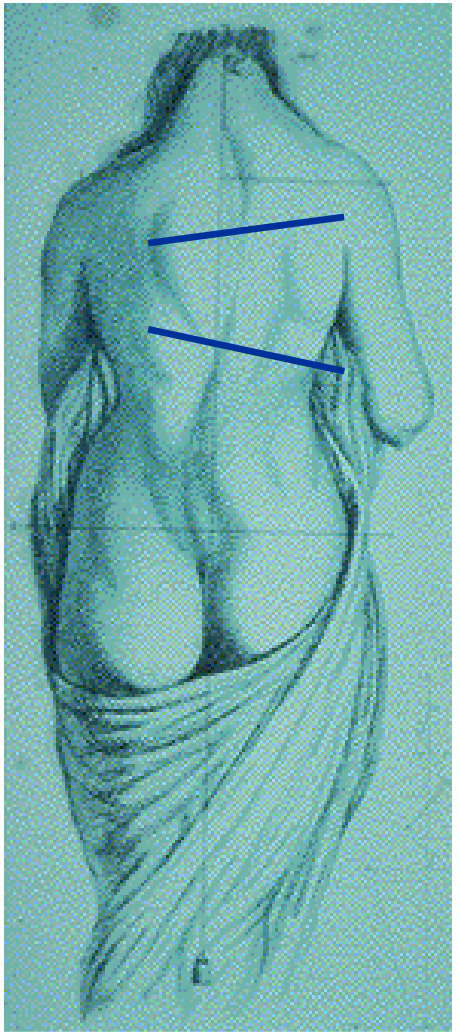
Disclosure Information

David W. Roberts, MD - Pediatric Symposium - 2016

- I have no financial relationships to disclose.
- I will not discuss off-label or investigational uses in my presentation.

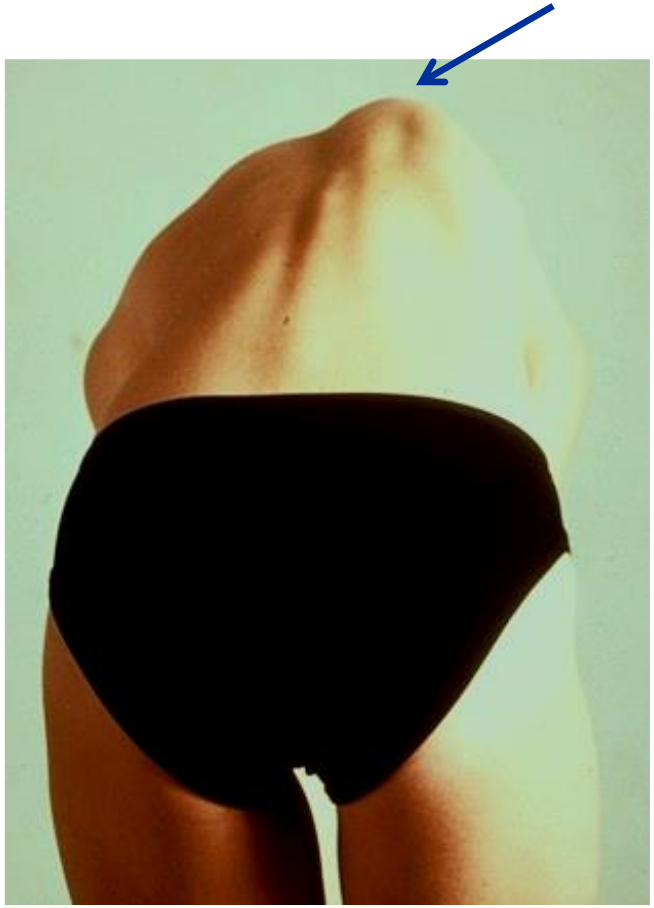
Scoliosis

- Definition:
  - Lateral curvature of the spine >10°
- Idiopathic = unknown cause
  - Most common type
  - Develops in pubertal growth spurt
  - Neurologically normal

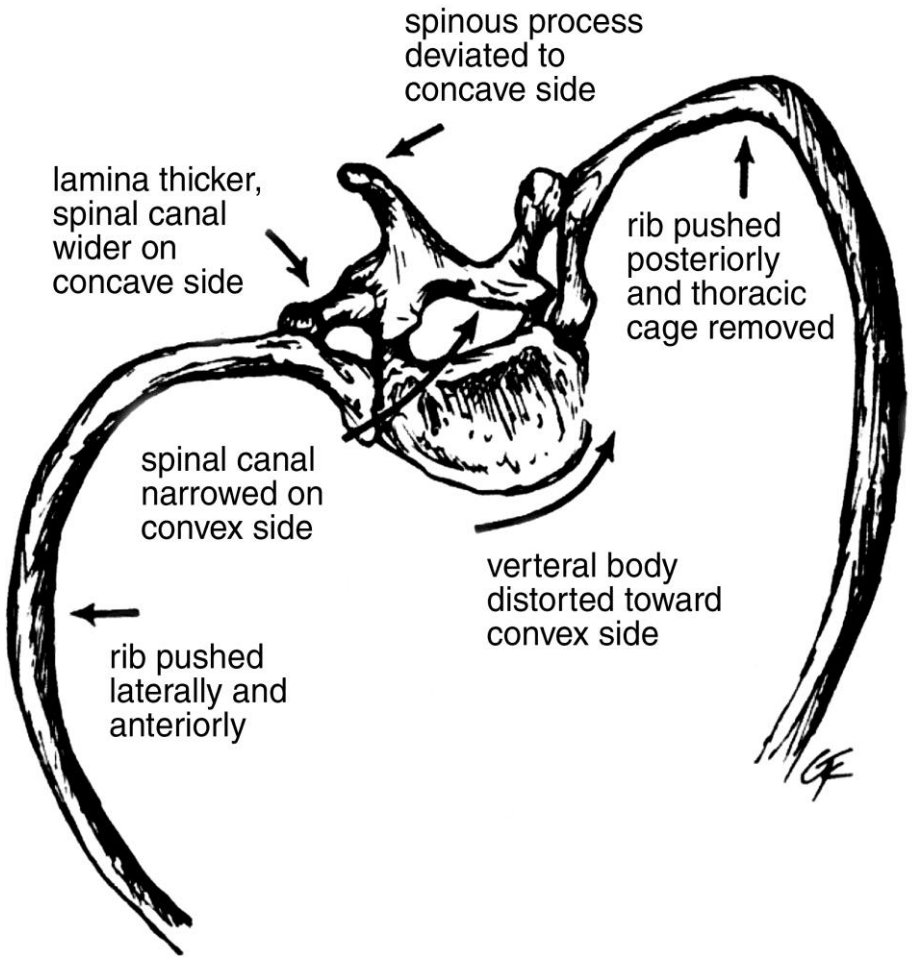


Clinical Features

- Right thoracic
  - most common



Clinical Features



- 3D deformity
  - Coronal
  - Axial
  - Sagittal

Classification — By Age

- Infantile scoliosis age <3
- Juvenile scoliosis age 3–10
- **Adolescent scoliosis** **age 10–16**

Most common

Prevalence — Idiopathic Scoliosis

Cobb Angle	Female: Male	Prevalence (%)
>10°	1.4-2: 1	2-3
>20°	5.4: 1	0.3-0.5
>30°	**10: 1**	0.1-0.3
>40°	___	<0.1

Weinstein, The Pediatric Spine: Principles and Practice, Lippincott-Raven, 1994

Etiology of Idiopathic Scoliosis?

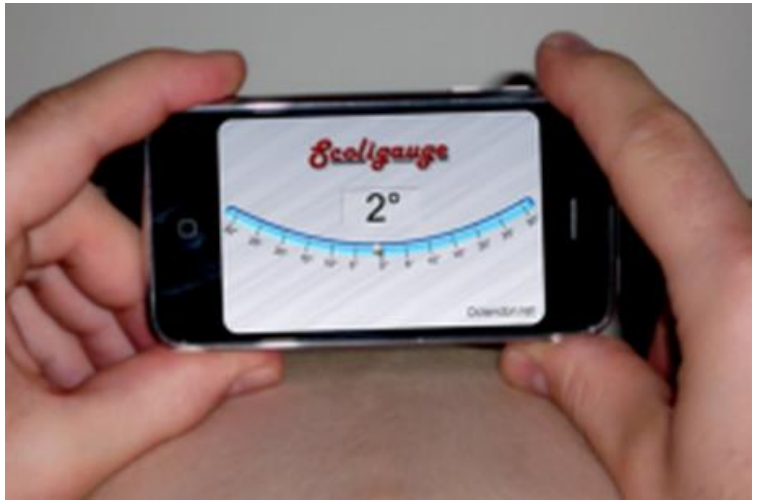
- Unknown
  - Genetic?
    - » 30% cases familial
    - » Autosomal dominant
    - » Incomplete penetrance

Clinical Evaluation

- Physical Exam
  - Shoulder balance
  - Rib prominence
  - Neurologic exam
  - Skin
    - » Café au lait – e.g. NF

Scoliosis Screening

- Scoliometer
  - Adam's forward bend test
  - **>7° → Refer for spine evaluation**
  - Correlates to ~20° Cobb angle
- Controversies
  - Should it be done?
  - Who should do it?
  - Cost?



Screening - Epidemiology

- Results of scoliosis screening
  - 2000 children screened
  - 4.1% positive -- referred
  - Of these – 45% had scoliosis >10 deg (1.8% incidence)
  - Of these – 22% required treatment (0.4% incidence)

    (Yawn JAMA 1999)

- Many false positives!
  - Limb length difference – 1/3 of general population
  - Asymmetry muscle development
  - Chest wall conditions (e.g. pectus)
  - Other orthopedic conditions (e.g. Sprengel's)

    (Hresko JAMA 2013)

Screening — History

- AAOS, SRS
  - 1984: Formally endorsed school screening
- U.S. Preventative Services Task Force
  - 1996: "Insufficient evidence… for or against"
  - 2004: "Recommend against"
    - » No new data to justify this
- AAOS, SRS, POSNA + AAP
  - 2008: Consensus statement
    - » Reaffirmed recommendation for screening
    - » Physician, nurse or schools

Screening — Controversies

- Mandated by some states
  - Not by many (e.g. Illinois)
- Why screen?
  - Asymptomatic at early stage
  - Early treatment with bracing → may prevent surgery
  - Waiting until parent/child notices is too late
- Why not screen?
  - High rate false positives
  - Many mild cases will not need treatment
  - Risk of radiation exposure from x-rays
  - Costs of x-rays and specialist referral

Screening — Recent Evidence

Eur Spine J. 2014 Dec;23(12):2572-85. doi: 10.1007/s00586-014-3307-x. Epub 2014 Apr 29.

Are current scoliosis school screening recommendations evidence-based and up to date? A best evidence synthesis umbrella review.

Płaszewski M[1], Bettany-Saltikov J.

- Systematic review – all studies for/against school screening
- Older reviews (e.g. USPTF)
  - Low-quality studies
  - USPTA based on outdated (2004) data
- More recent reviews
  - Moderate quality studies
  - **In general, support continued school screening programs**

Screening — Recent Evidence

- Early treatment has substantial benefits
  - Bracing is effective – Level I RCT (NEJM 2013)

- Further support for screening!

The New York Times

September 19, 2013

Study Affirms Benefit of Back Braces as Scoliosis Treatment

By CATHERINE SAINT LOUIS

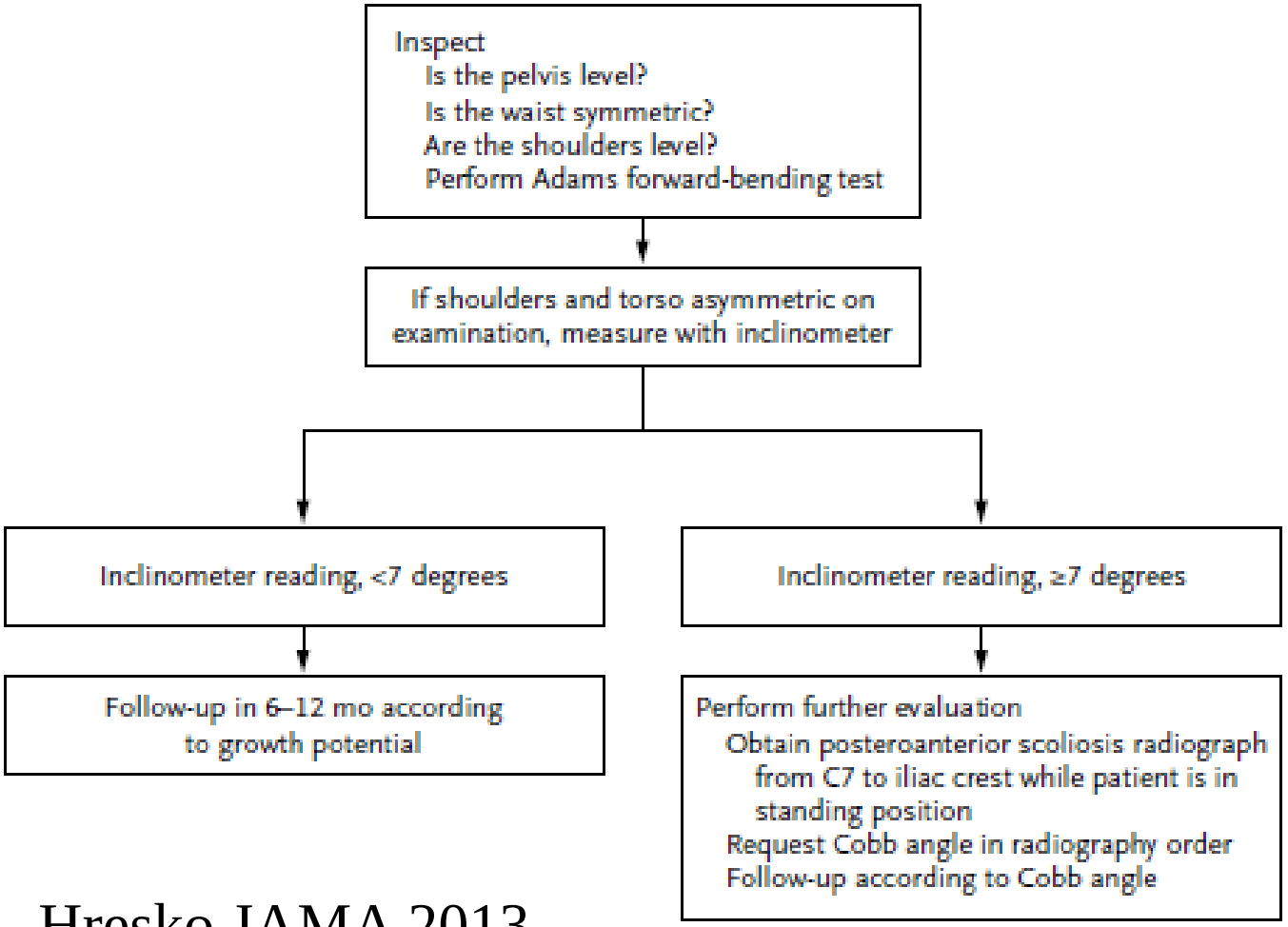
A new study provides the best evidence yet that wearing a back brace will slow the progression of the most common form of scoliosis in adoles

Screening — Bottom Line

- **<u>Screening is recommended</u>**
  - AAP / AAOS / POSNA / SRA consensus guidelines
  - Girls – screen twice: age 10 & 12 (5th and 7th grade)
  - Boys – screen once: age 13-14 (7th-8th grade)

- If scoliometer >7 degrees → **<u>refer</u>**

Screening Algorithm



Hresko JAMA 2013

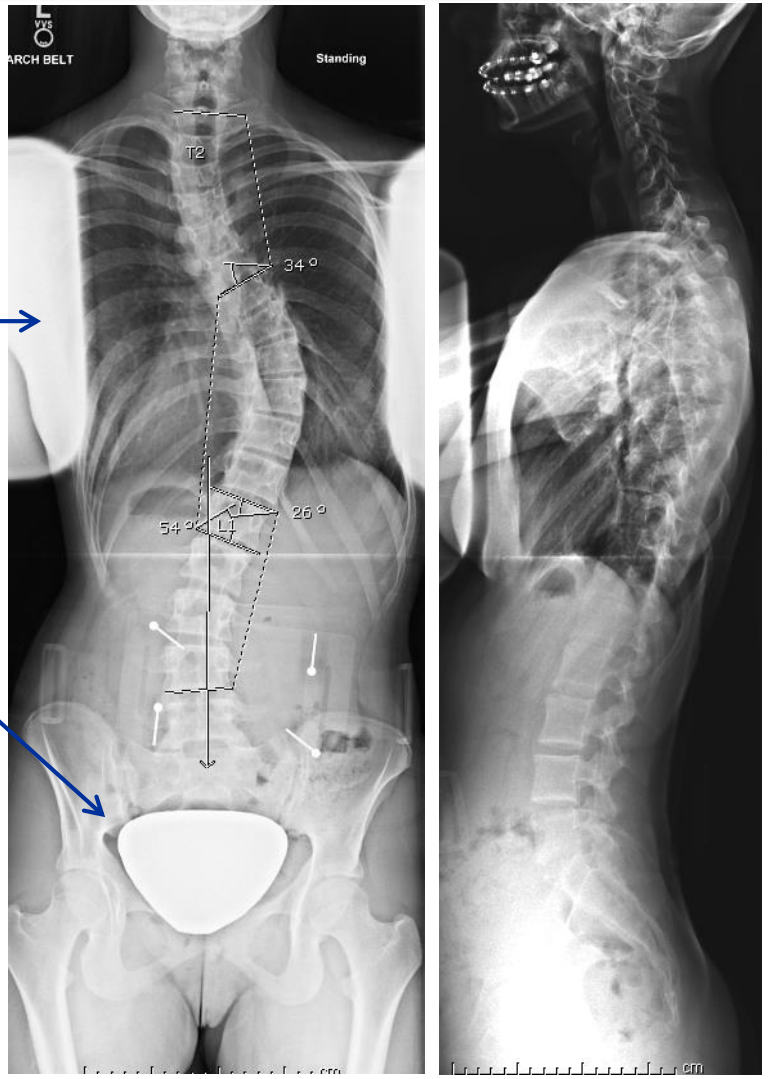
Follow-up Algorithm

Growth Potential	Cobb Angle				
	10–14 degrees	15–19 degrees	20–24 degrees	25–29 degrees	≥30 degrees
Prepubertal girl or boy age ≥10 yr	Follow-up in 1 yr Repeat history and algorithm	Follow-up in 3–6 mo Repeat history and algorithm Refer if there is an increase in Cobb angle of ≥5 degrees	Refer or follow-up in 3 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo	Refer Visit in 1 mo
Pubertal premenarchal girl or boy age 12 to <14 yr	Follow-up in 1 yr Repeat history and algorithm	Follow-up in 3 mo Repeat history and algorithm Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 3 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo	Refer Visit in 1 mo
Postmenarchal girl or boy age 14 to <16 yr	Follow-up in 1 yr Repeat history and algorithm	Follow-up in 6 mo Repeat history and algorithm Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 6 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 6 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo if Cobb angle is ≥45 degrees
Girl 2 yr after menarche or boy age 16 to <18 yr	No treatment necessary Reassure patient	No treatment necessary Reassure patient	Follow-up in 5 yr Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 5 yr Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo if Cobb angle is ≥45 degrees

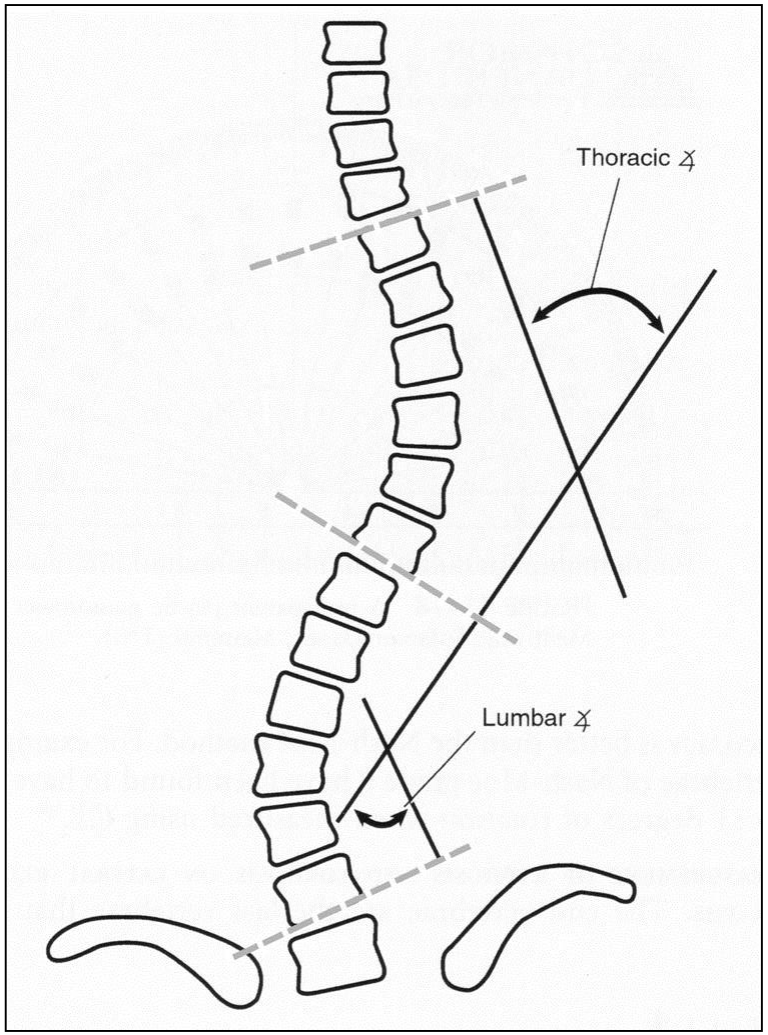
Hresko JAMA 2013

Imaging

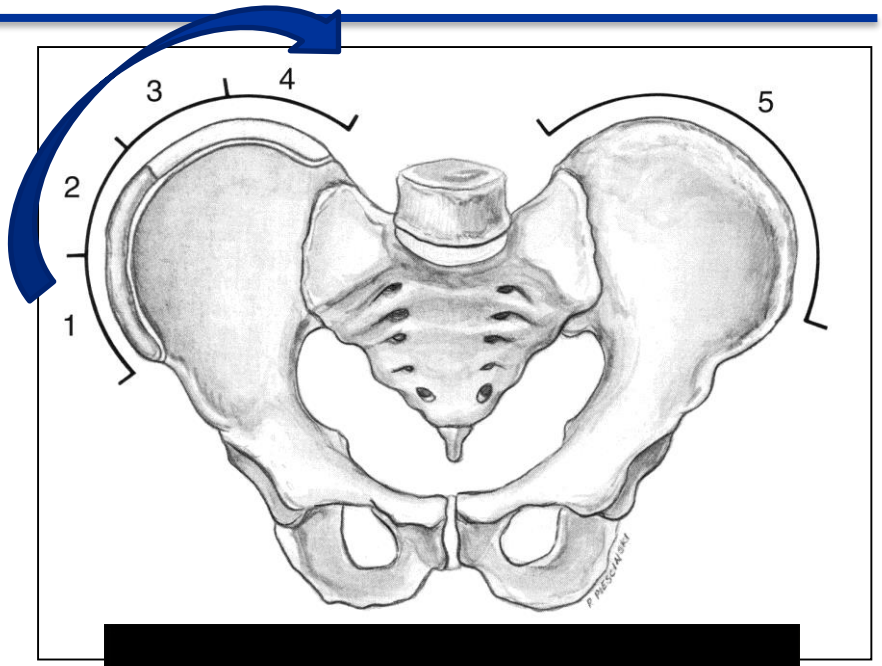
- X-rays:
  - Standing PA and LAT
    - » Occiput → Sacrum
    - » Shields

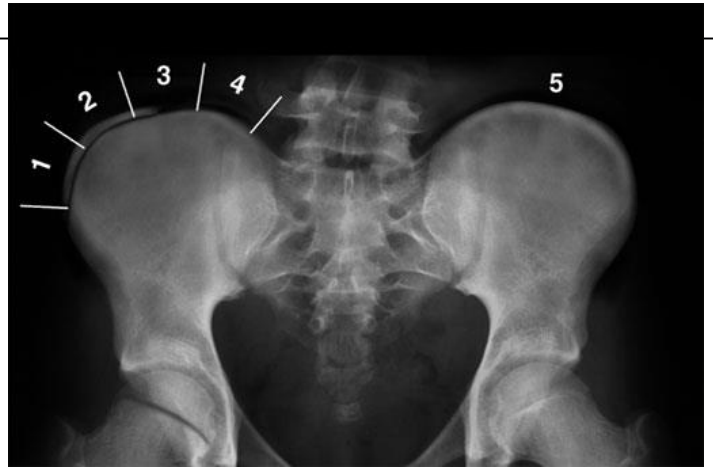


Cobb Angle



Risser Sign



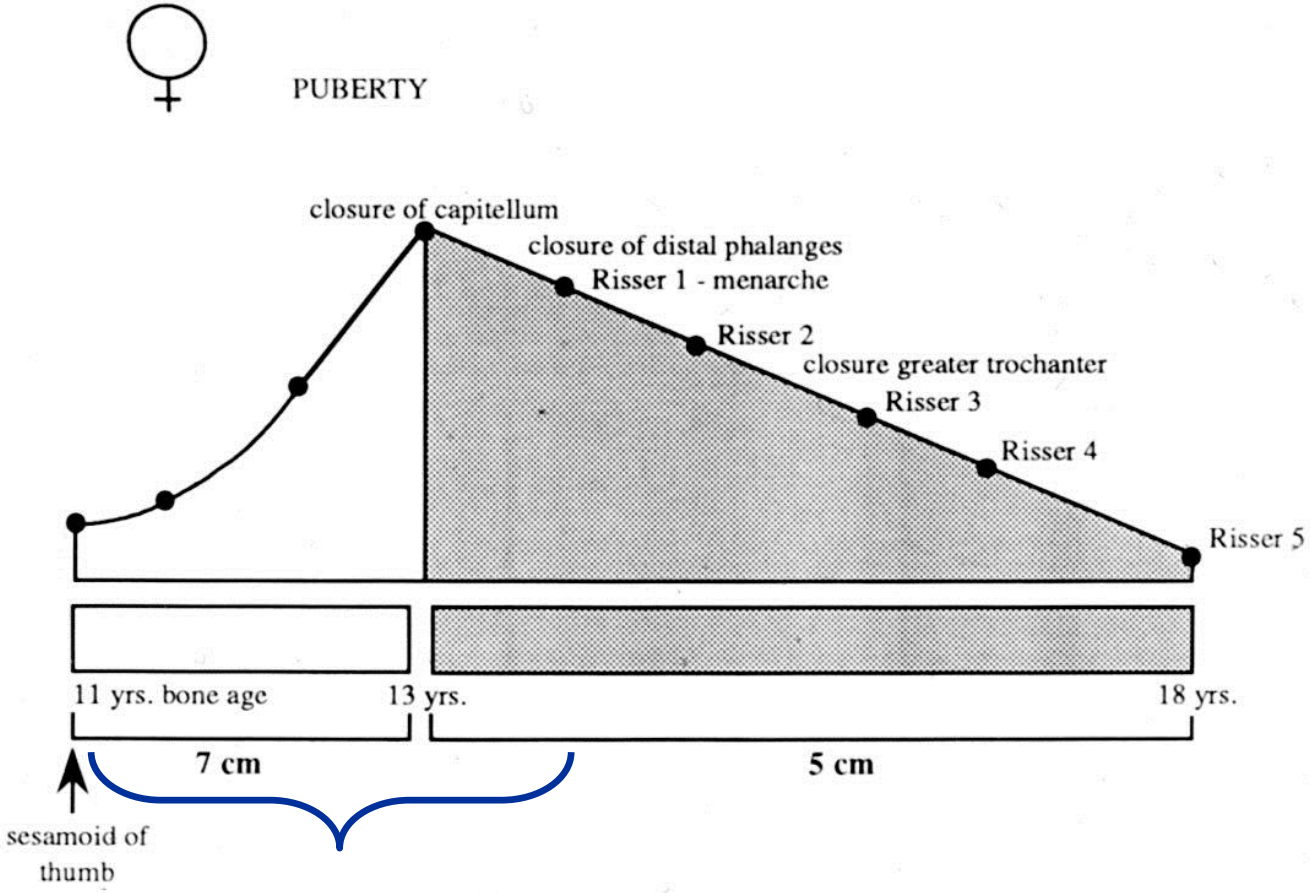


Natural History: Risk of Progression — Initial Curve

Curve Magnitude at Detection	Age at Detection		
	10-12 yr	13-15 yr	16 yr
<19°	25%	10%	0%
20-29°	60%	40%	10%
30-59°	90%	70%	30%
>60°	100%	90%	70%

Nachemson, Lonstein, Weinstein. Report of the SRS Prevalence and Natural History Committee, 1982

Growth Velocity



- 2/3 of growth occurs prior to Risser 1

Natural History:
Risk of Progression — Risser Grade

Risser Grade	% Progression	
	5-19°	20-29°
0 or 1	22%	68%
2, 3 or 4	1.6%	23%

Lonstein JE, Carlson JM. JBJS 1984

Natural History:
Risk of Progression — Curve at Maturity

Thoracic	Lumbar	Thoracolumbar	Combined
Cobb >50°	Cobb >30°	Cobb >30°	Cobb >50°
Apical vertical rotation 30%	Apical vertical rotation >30%	Apical vertical rotation >30%	
Mehta angle >30°	Curve direction Relation L5 to intercrest line Translatory Shifts	Translatory shifts	

Weinstein, SL, Ponseti, IV. Curve progression in idiopathic scoliosis: Long-term follow-up. JBJS 65(A), 1983

Natural History:
AIS at 50-Year Follow-Up

Health and Function of Patients With Untreated Idiopathic Scoliosis
A 50-Year Natural History Study

Stuart L. Weinstein, MD
Lori A. Dolan, MA
Kevin F. Spratt, PhD
Kirk K. Peterson, MD
Mark J. Spoonamore, MD
Ignacio V. Ponseti, MD

Table 2. Cobb Angles by Curve Type and Period

Curve Type	No. (%)	Current Cobb Angles, Degrees Mean (SD) [Range]	Cobb Angles at Skeletal Maturity, Degrees Mean (SD) [Range]
Thoracic	34 (43)	84.50 (30.17) [23-156]	60.48 (26.79) [26-108]
Thoracolumbar	11 (14)	89.54 (32.69) [50-155]	43.63 (8.70) [36-64]
Lumbar	22 (28)	49.41 (26.38) [15-90]	35.05 (13.18) [15-63]
Double major			
Thoracic component	12 (15)	79.08 (21.92) [30-104]	66.00 (21.53) [28-97]
Lumbar component	12 (15)	76.42 (21.88) [32-110]	60.75 (18.06) [26-83]

Weinstein et al JAMA 2003

Natural History:
AIS at 50-Year Follow-Up

Health and Function of Patients With Untreated Idiopathic Scoliosis
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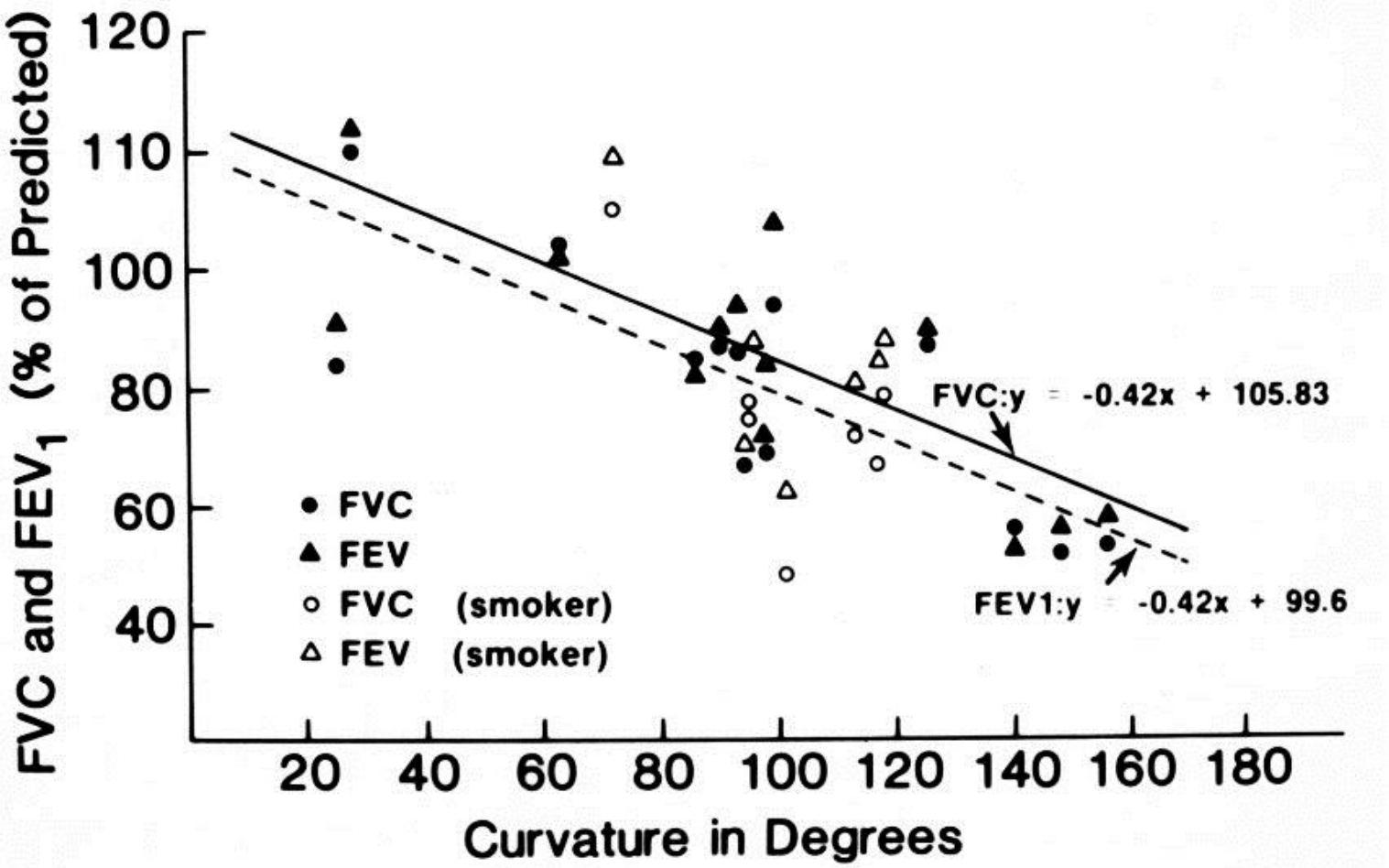
Untreated scoliosis – more likely to have:

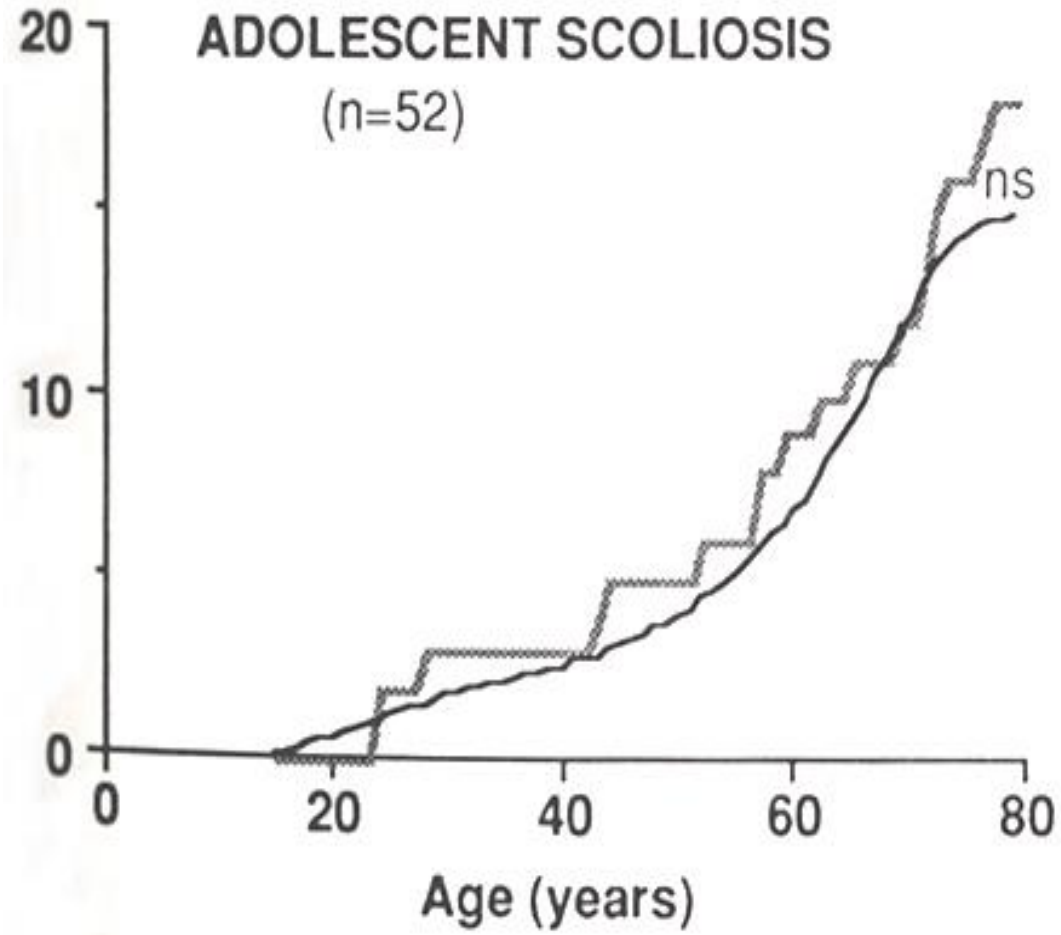
- **Chronic back pain (66%)**
- **Concerns about curve and body image**
- **Shortness of breath if curve big curve >80°**
  - **However, similar mortality to controls**

Weinstein JAMA 2003

Pulmonary Function vs. Curve Magnitude

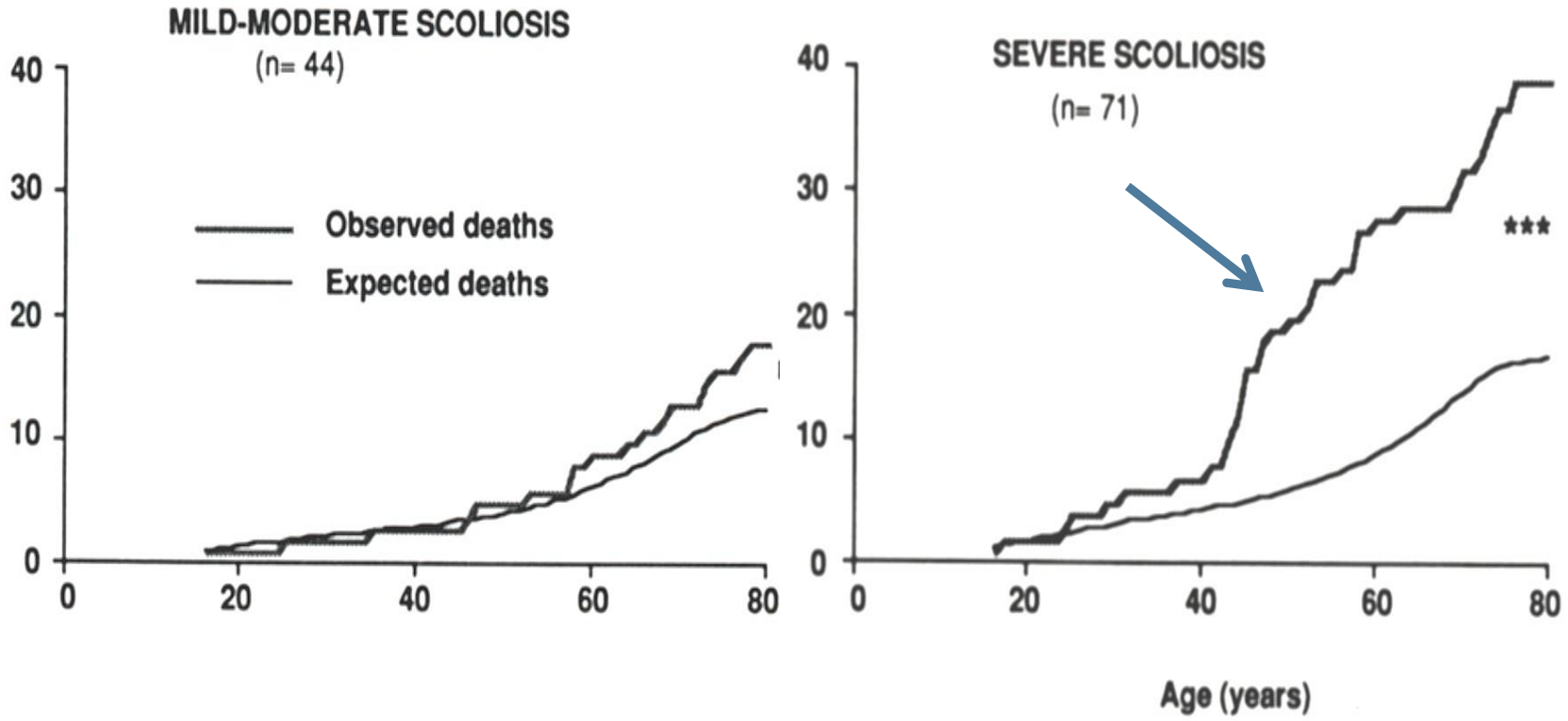


Mortality — Untreated Scoliosis



Pehrsson et al, Spine 1992

Mortality — Untreated Scoliosis



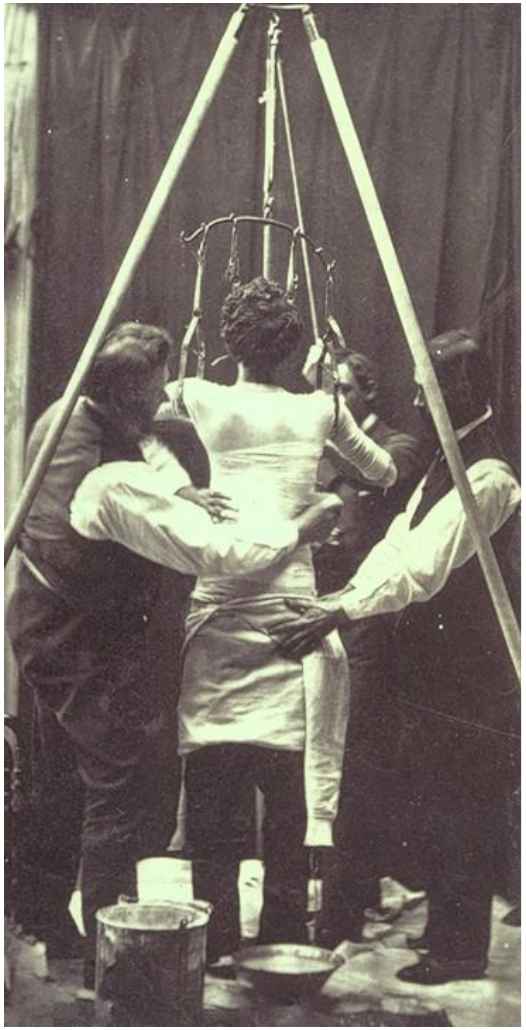
Pehrsson et al, Spine 1992

Treatment Options for Scoliosis

- Observation
- Brace
- Surgery

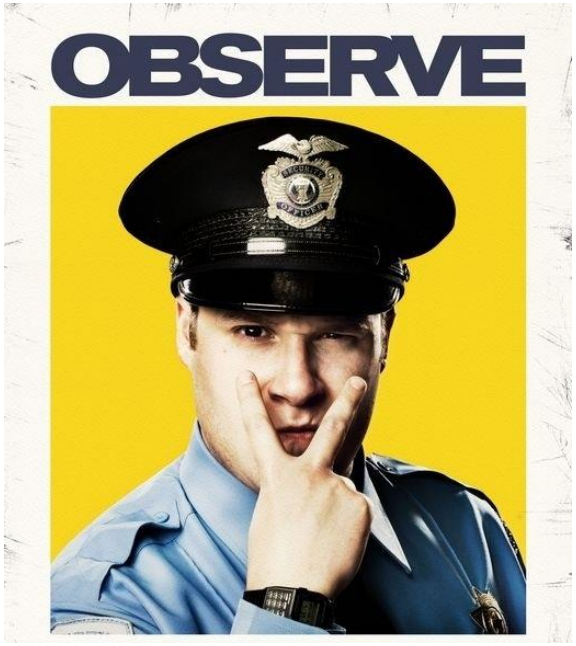
Treatment Guidelines

- Observation 85%
  - Curve <25°
- Brace 15%
  - Curve 25-40°
  - >2 years growth remaining
    - » Risser 0-1
    - » Menses <6 months
- Surgery ~1%
  - Curve >45-50°

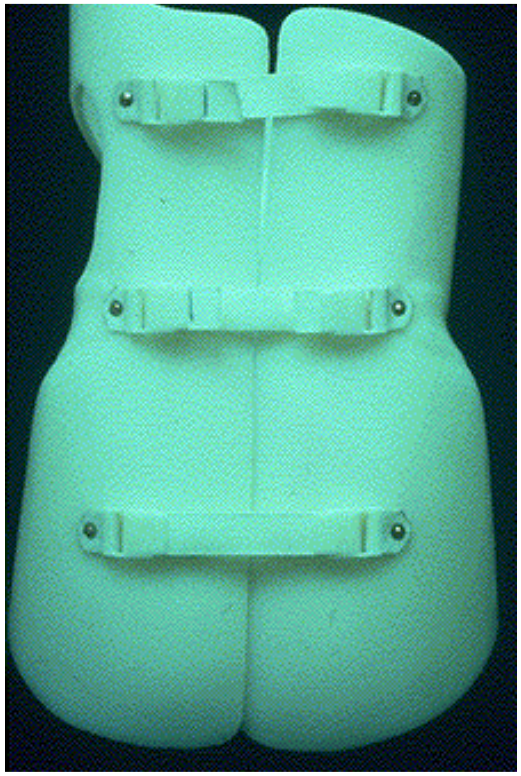


Observation

- Small curves (<25 deg)
- Checks every 4–6 months
- X-rays only as needed
  - Scoliometer checks
  - X-rays only if changed



Bracing: Custom TLSO



- Full time: 18-23 hours/day
- Indications
  - Curves 25-40 deg
  - All types: T, T-L, L

Out vs. In Brace

TLSO With Clothes

Bracing: Bending Brace

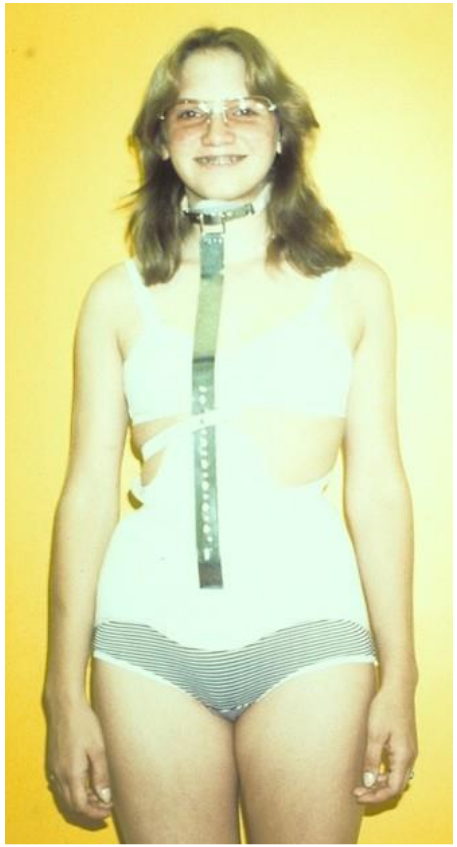
Providence Bending Brace

Charleston Bending Brace

- Indications
  - 25-40 deg
  - Only Lumbar or T-L curves

****** Night-time only (12-14 hrs/day)– better tolerated***

Milwaukee Brace?



- Milwaukee brace
  - No longer used

Joan Cusack
Sixteen Candles (1984)

Lisa Kudrow
Romy & Michelle's HS Reunion (1997)

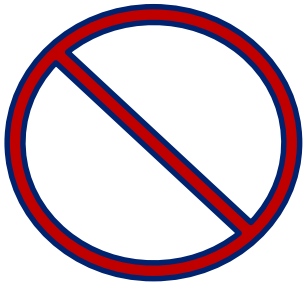
SpineCor Brace?

Eur Spine J. 2013 Dec 31. [Epub ahead of print]

A prospective randomized controlled study on the treatment outcome of SpineCor brace versus rigid brace for adolescent idiopathic scoliosis with follow-up according to the SRS standardized criteria.

Guo J, Lam TP, Wong MS, Ng BK, Lee KM, Liu KL, Hung LH, Lau AH, Sin SW, Kwok WK, Yu FW, Qiu Y, Cheng JC.

- Compared SpineCor vs. standard brace
- 35% progressed vs. 5.6% control (P=0.026)
- **SpineCor = Worse than not treating!!**

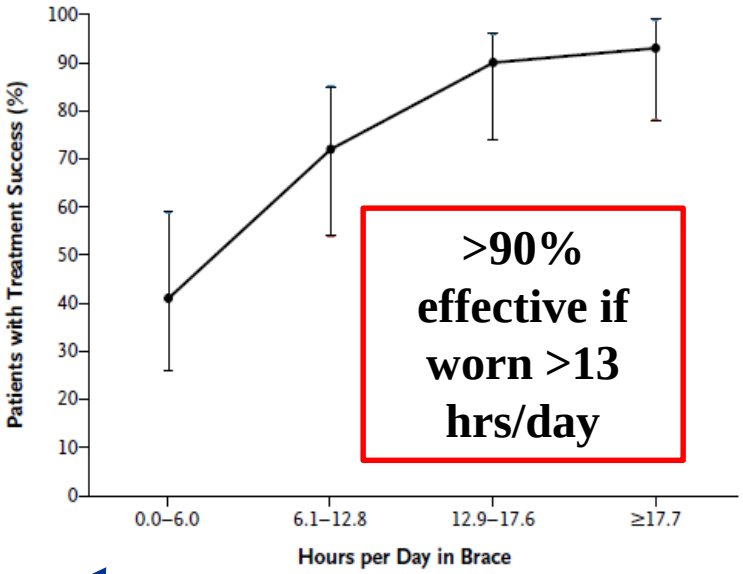


The NEW ENGLAND JOURNAL of MEDICINE

Effects of Bracing in Adolescents with Idiopathic Scoliosis

Stuart L. Weinstein, M.D., Lori A. Dolan, Ph.D., James G. Wright, M.D., M.P.H., and Matthew B. Dobbs, M.D.

- 242 pts – 116 randomized + 126 preference cohort
  - Rx >18 hrs/day
  - Measured actual wear (Temp sensor)
- Success = Skeletal maturity and <50 deg
- Results
  - **IRB stopped early due to clear benefit of brace**
  - **Bracing – Success 75% (vs. 42%)**
    (OR 4.1 [1.9-9.2])
  - **Dose-response – hrs/day brace wear and success (P<0.0001)**



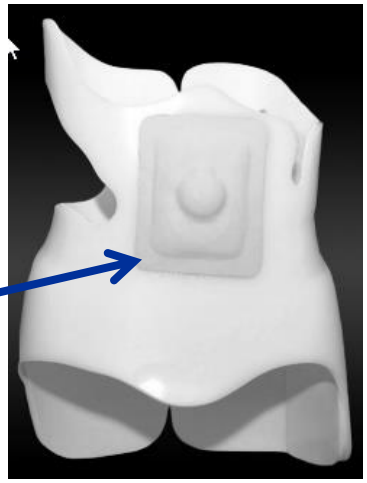
N Engl J Med 2013;369:1512-21.
DOI: 10.1056/NEJMoa1307337

THE JOURNAL OF BONE & JOINT SURGERY
JB&JS

Brace Wear Control of Curve Progression in Adolescent Idiopathic Scoliosis

Donald E. Katz, J. Anthony Herring, Richard H. Browne, Derek M. Kelly and John G. Birch
J Bone Joint Surg Am. 2010;92:1343-1352. doi:10.2106/JBJS.I.01142

Hidden temperature sensor to measure actual brace wear

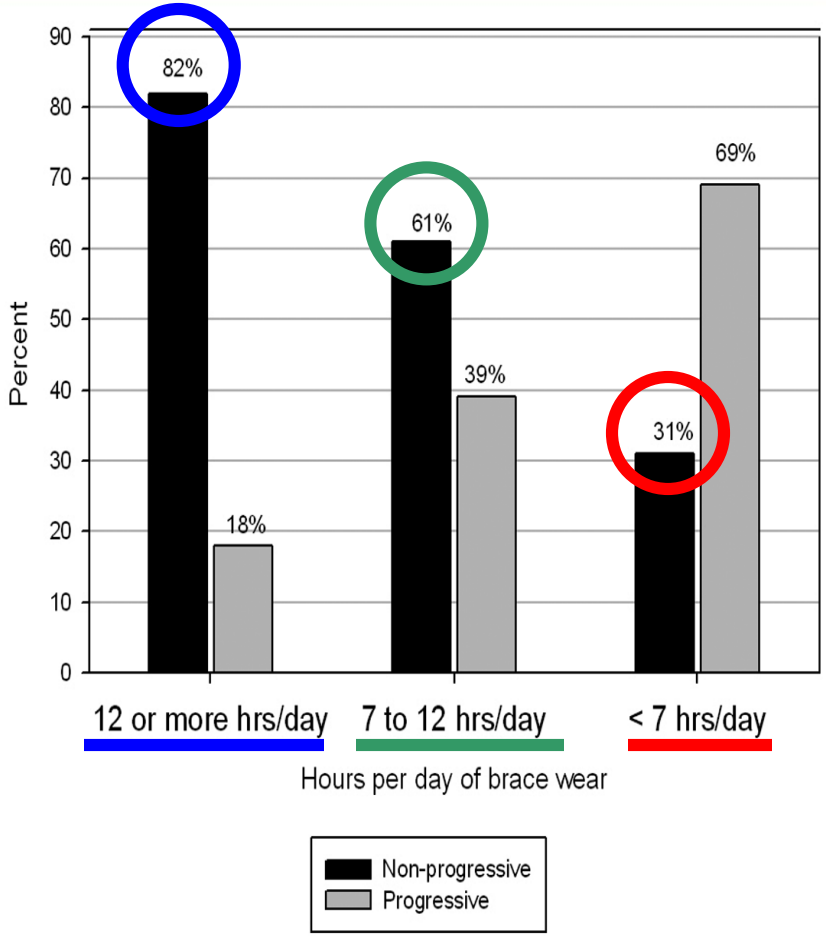


<u>Actual</u> Brace Wear:

>12 h/day = 82% no progression

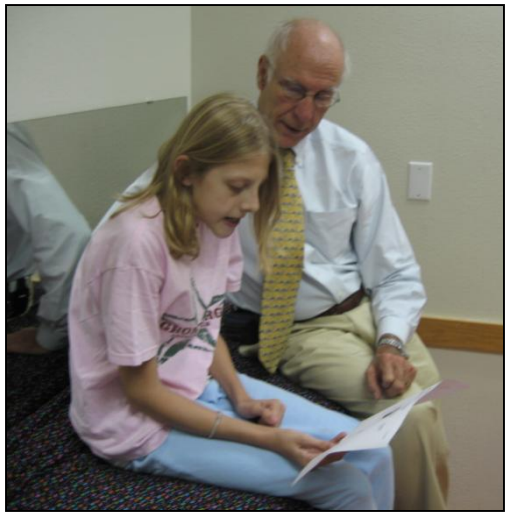
7 h/day = 69% progressed

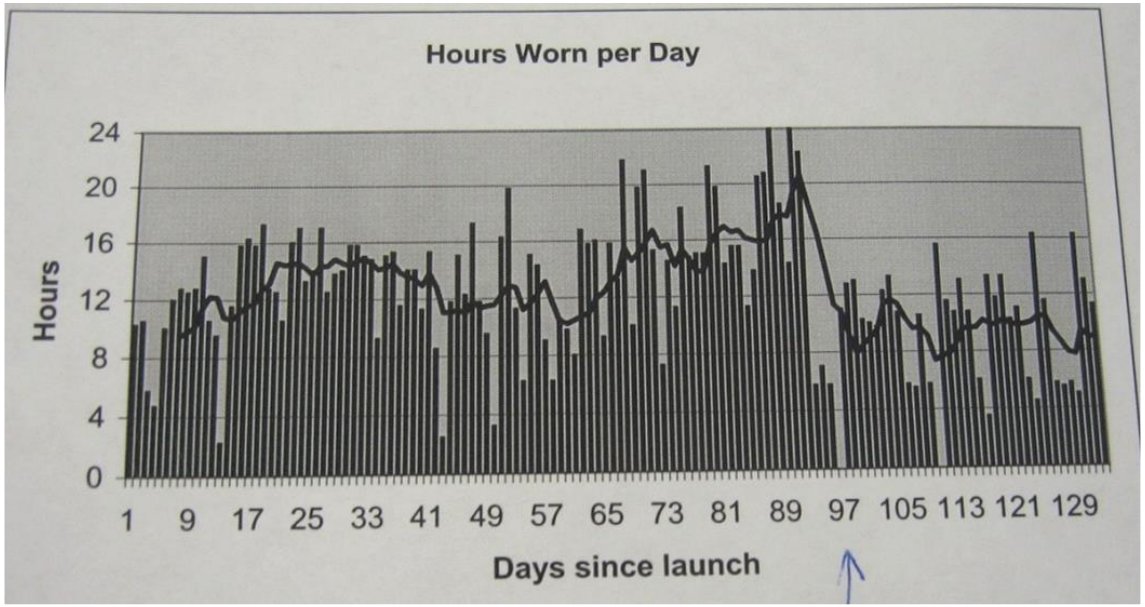
<u>Recommend >16 h/day</u> to get 12h/day actual wear!



Compliance Counseling

- Hawthorne effect → Better wear if monitored





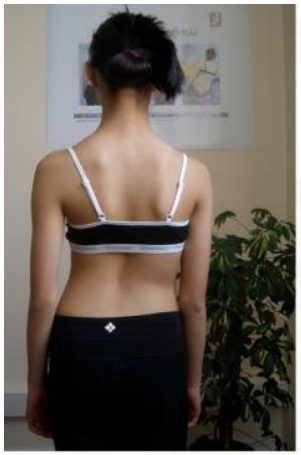
Other Treatments?

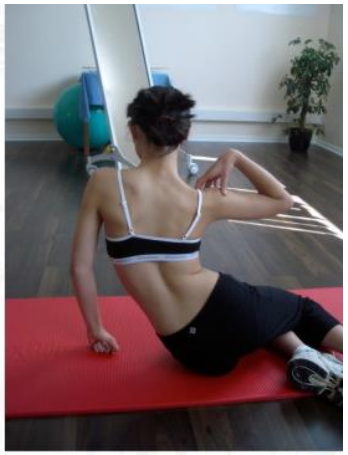
Complementary practices:

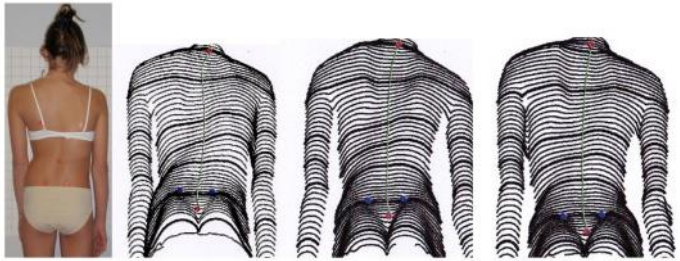
- Can help patients feel better
- Can help strength and flexibility
- Beware of “cures”
  - If sounds too good to be true…
- **Should <u>not</u> replace traditional medical care**

Schroth Method

- Developed 1921
  - Katrina Schroth - Germany
- Involves both bracing + corrective exercises







Weiss, *Scoliosis* 2011

Evidence?

Eur Spine J (2012) 21:382–389
DOI 10.1007/s00586-011-2063-4

REVIEW ARTICLE

Efficacy of exercise therapy for the treatment of adolescent idiopathic scoliosis: a review of the literature

Simon C. Mordecai · Harshad V. Dabke

- Only 12 papers: 9 prospective, 2 retrospective, 1 case series
- Shortcomings
  - Unclear patient recruitment and inclusion criteria
  - Inconsistent assessment curve size with objective/x-ray measures
  - Lack of standardized outcome scores
  - “Significant” statistical changes but not clinically meaningful
  - Unclear if short-term improvement maintained long-term

- **Overall: Poor quality evidence. Well-designed RCTs needed.**

Evidence – Schroth Method

The effect of compliance to a Rigo System Cheneau brace and a specific exercise programme on idiopathic scoliosis curvature: a comparative study: SOSORT 2014 award winner

LouAnn Rivett*, Aimee Stewart and Joanne Potterton

Scoliosis

Rivett *et al. Scoliosis* 2014, **9**:5
http://www.scoliosisjournal.com/content/9/1/5

- 51 girls age 12-16, Cobb 20-50
- Evaluated compliance
  - Brace >20 hrs/day vs. 12 hrs/day
  - Exercises 4x/week vs. 1.7x/week
- Compliant group:
  - Cobb improved 10.2° vs. deteriorated 5.5°
  - Better QoL scores, emotional maturity scores

Evidence – Schroth Method

The effect of Schroth exercises added to the standard of care on the quality of life and muscle endurance in adolescents with idiopathic scoliosis—an assessor and statistician blinded randomized controlled trial: "SOSORT 2015 Award Winner"

Sanja Schreiber[1], Eric C. Parent[1*], Elham Khodayari Moez[1], Douglas M. Hedden[2], Doug Hill[2], Marc J. Moreau[2], Edmond Lou[2], Elise M. Watkins[2] and Sarah C. Southon[2]

Scoliosis

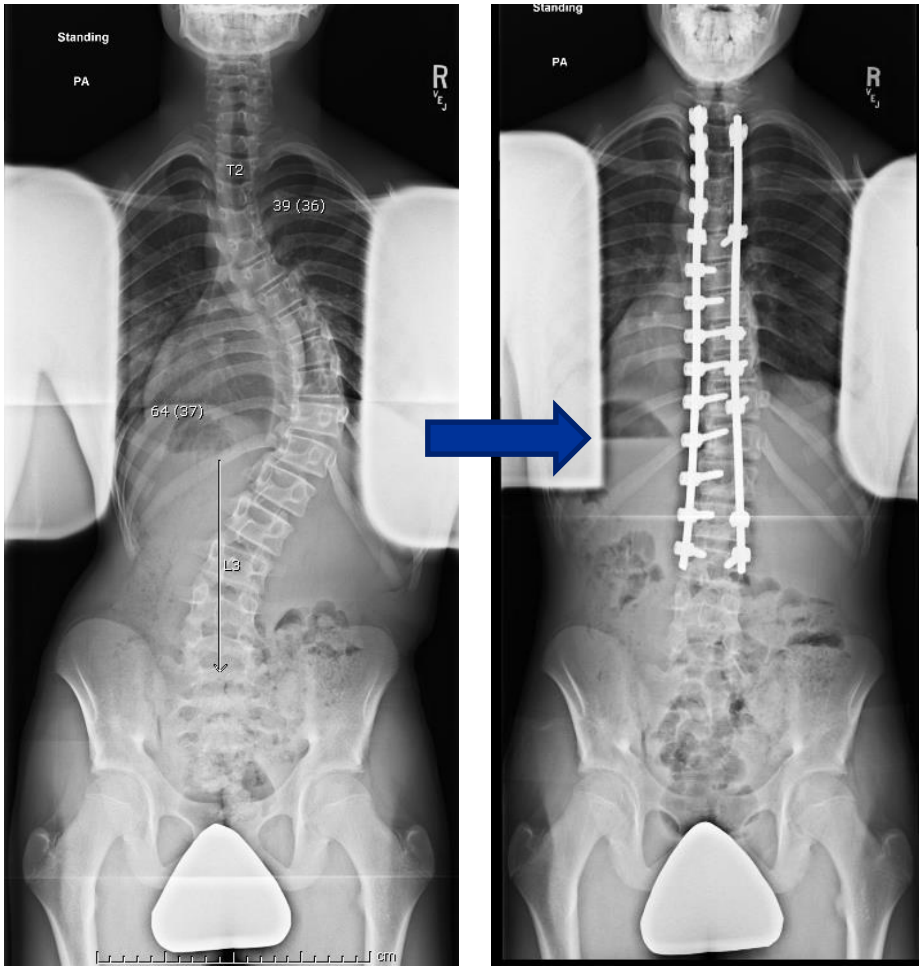
Schreiber *et al. Scoliosis* (2015) 10:24
DOI 10.1186/s13013-015-0048-5

- 50 patients, age 10-18, curves 10-45 deg
- RCT – standard care vs. standard + Schroth – for 6 months
- Results
  - **Schroth PT → improved self-image, less pain on SRS-22/BME scores vs. standard care**
  - **No measurement of radiographic parameters**

Surgical Treatment

- Indications:
  - >45° in growing child
  - >50° in skeletally mature

- Spinal fusion with instrumentation
  - Rods + screws/hooks/wires
  - Bone graft
  - Posterior approach
    - » Most common



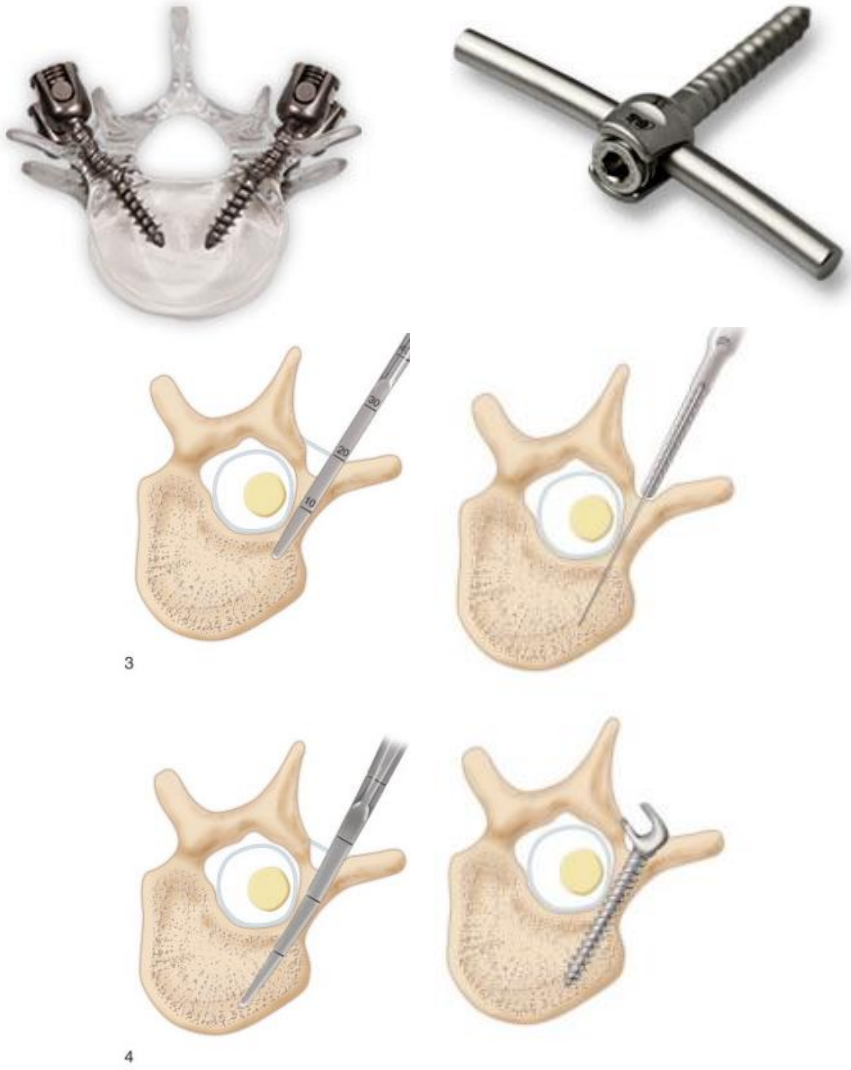
Surgical Treatment: Risks

Potential risks

- Nerve/spinal cord injury
  - » Very rare (0.02%) with modern spinal cord monitoring
- Healing problems (<1%)
- Infection (<1%)
- Hardware problems (1%)

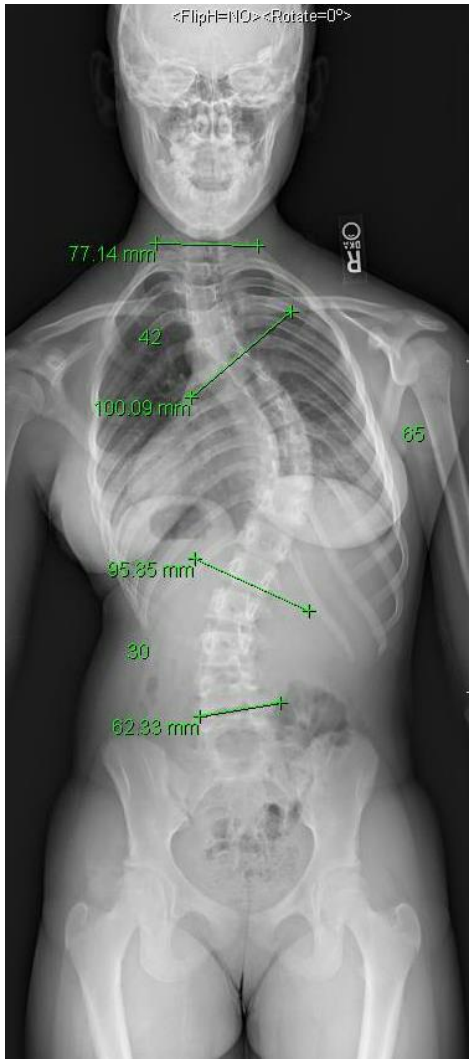
Pedicle Screws

- Started in mid-late 1990s
  - Thoracic pedicle screws
- Gold Standard for scoliosis correction
- Advantages
  - Better “grip” on spine – all 3 columns
  - Better correction (75-80%)
  - No postop brace



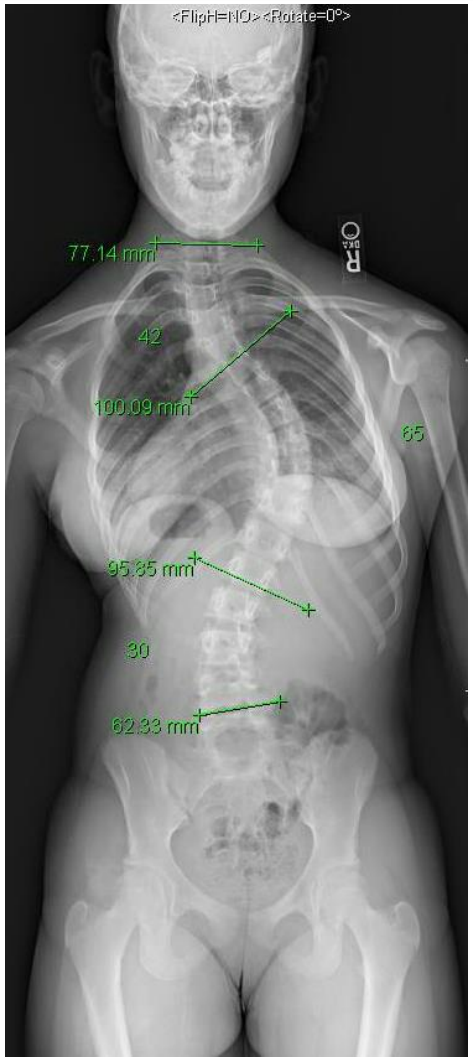
Case 1

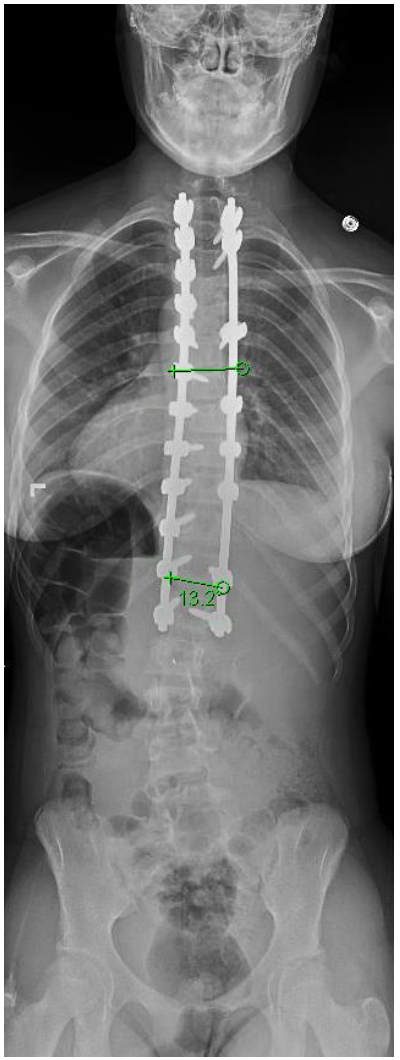
- 12 yo F
- Parent noticed
  - No screening (IL)
- Rx brace for 45 deg
  - Too late… less effective >40 deg
- Progressed to 65 deg



Case 1

- 12 yo F
- PSF T2-L1





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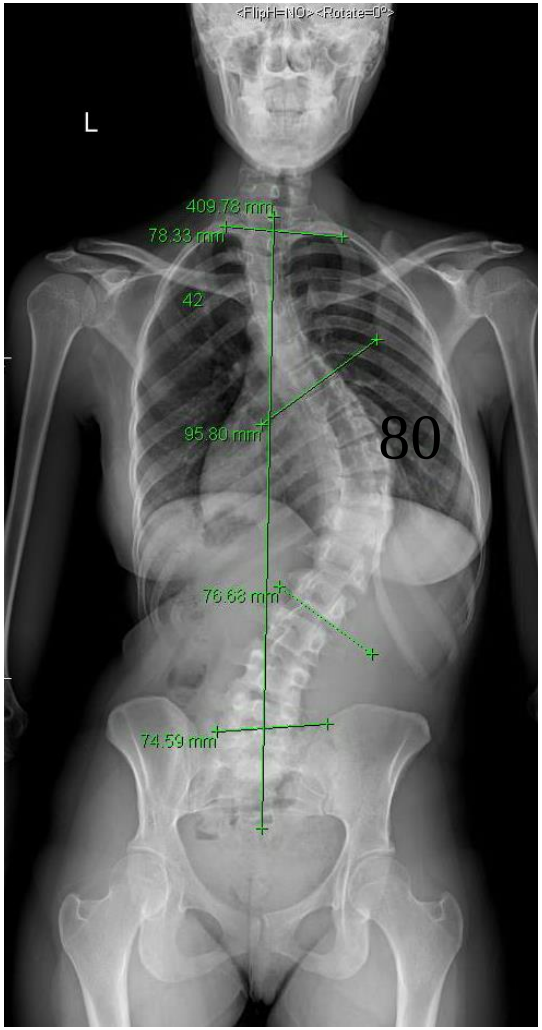
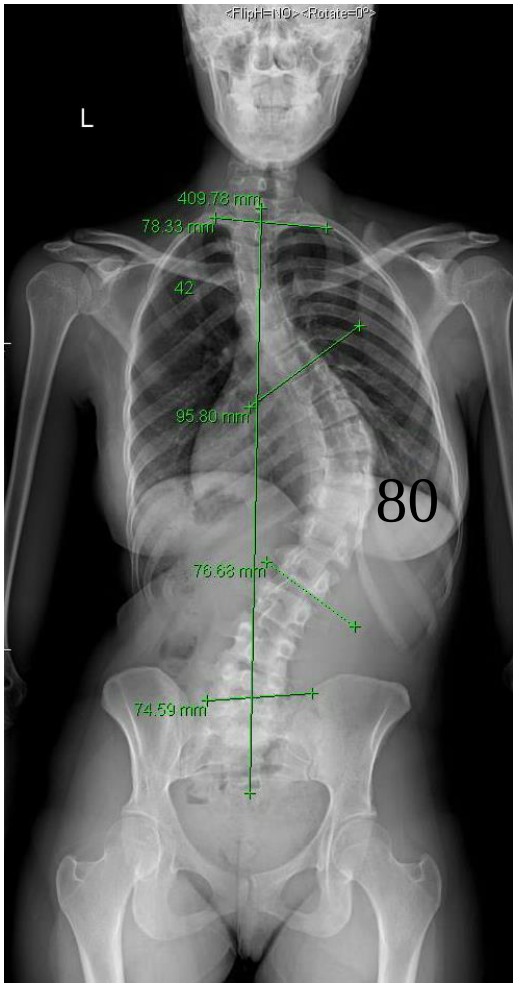
Case 2

- 24 yo F high school teacher
- +Family hx scoliosis
  - Brother, surgery age 15
  - Aunt, mild
- No screening (IL)
- Presented with back pain, SOB, worsening asymmetry



Case 2

- 12 yo F
- PSF T2-L3



PSF for AIS — Results

Male-Female Differences in Scoliosis Research Society-30 Scores in Adolescent Idiopathic Scoliosis

SPINE Volume 36, Number 1, pp 1–7

David W. Roberts,* Jason Savage,* Daniel G. Schwartz,* Leah Y. Carreon,† Daniel J. Sucato,‡ James O. Sanders,§ B. Stephens Richards,¶ Lawrence G. Lenke,|| John B. Emans,‡ Stefan Parent,** Spinal Deformity Study Group,†† John F. Sarwark*

- Review - 644 patients (621 females, 123 males)
  - PSF for AIS: compared SRS-30 scores preop/postop – M vs. F
  - 2-year follow-up

- Results
  - Both males and females: similar and significant improvements in all domains
  - Greatest difference = improved self-image/appearance
  - Gender differences?
    - » Males: better pre-op self-image, less pain and better mental health scores

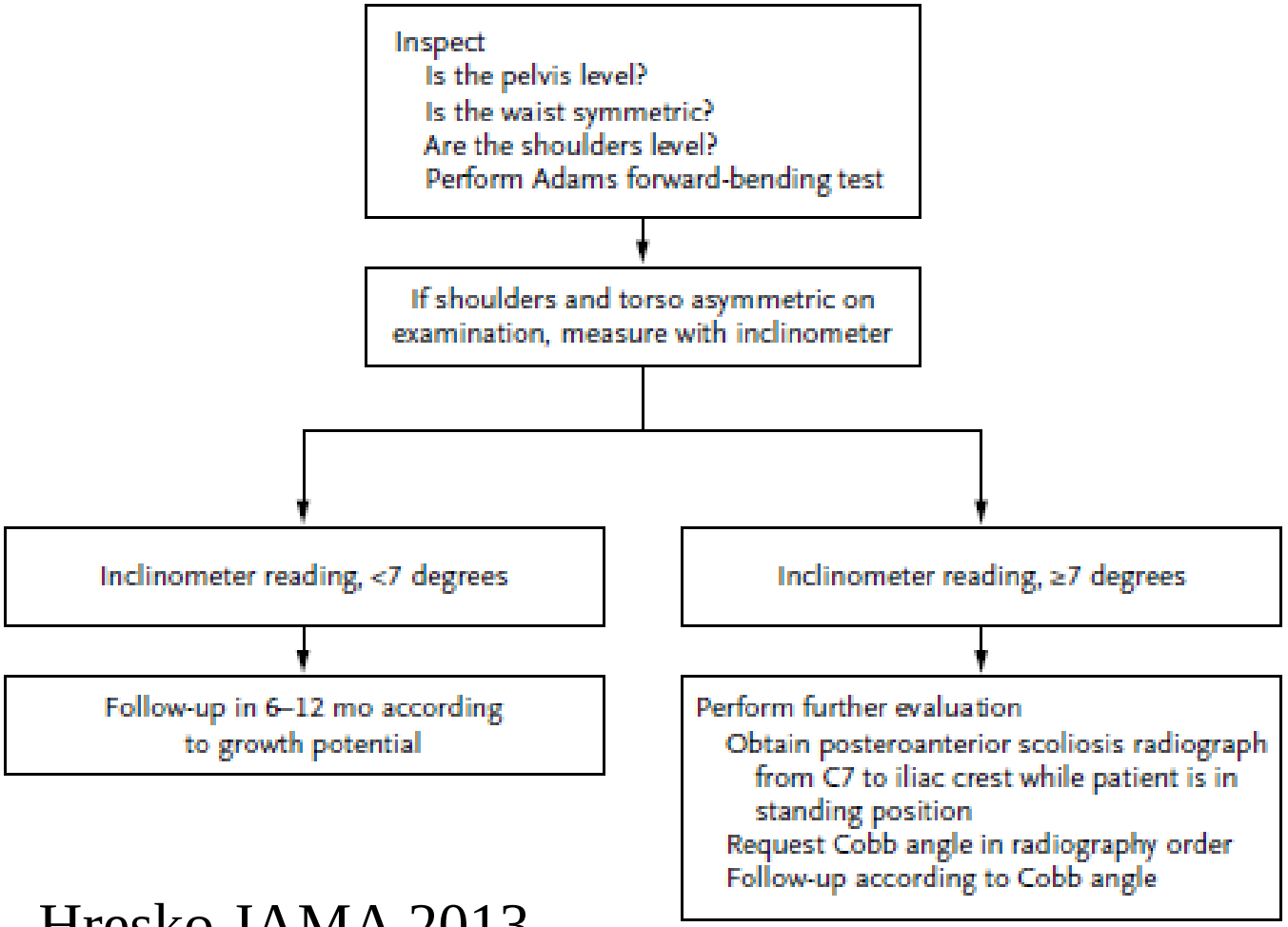
Summary

- Scoliosis = Curve >10°
  - Idiopathic: unknown cause
  - Adolescent girls, runs in families

- Screening = Recommended
  - Girls: age 10 and 12
  - Boys: age 13 or 14
  - >7° Scoliometer (~20° Cobb) → Refer

- Early bracing can prevent need for surgery
  - BRAIST study: level 1 evidence

Screening Algorithm



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Follow-up Algorithm

Growth Potential	Cobb Angle				
	10–14 degrees	15–19 degrees	20–24 degrees	25–29 degrees	≥30 degrees
Prepubertal girl or boy age ≥10 yr	Follow-up in 1 yr Repeat history and algorithm	Follow-up in 3–6 mo Repeat history and algorithm Refer if there is an increase in Cobb angle of ≥5 degrees	Refer or follow-up in 3 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo	Refer Visit in 1 mo
Pubertal premenarchal girl or boy age 12 to <14 yr	Follow-up in 1 yr Repeat history and algorithm	Follow-up in 3 mo Repeat history and algorithm Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 3 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo	Refer Visit in 1 mo
Postmenarchal girl or boy age 14 to <16 yr	Follow-up in 1 yr Repeat history and algorithm	Follow-up in 6 mo Repeat history and algorithm Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 6 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 6 mo Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo if Cobb angle is ≥45 degrees
Girl 2 yr after menarche or boy age 16 to <18 yr	No treatment necessary Reassure patient	No treatment necessary Reassure patient	Follow-up in 5 yr Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Follow-up in 5 yr Repeat radiographic assessment of Cobb angle Refer if there is an increase in Cobb angle of ≥5 degrees	Refer Visit in 1 mo if Cobb angle is ≥45 degrees

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Summary

Treatment:

- Observation — small curves (<25°)
- Bracing — moderate curves (25-40°)
  - Effective if started early
  - Strategies to monitor/improve compliance
- Surgery — severe curves (>45-50°)
  - Posterior spinal fusion w/ pedicle screws
  - Safe, predictable curve stabilization and correction

Thank You!