Scoliosis: When to screen, refer and treat

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• 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

<table>
<thead>
<tr>
<th>Cobb Angle</th>
<th>Female: Male</th>
<th>Prevalence (%)</th>
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<tbody>
<tr>
<td>&gt;10°</td>
<td>1.4-2: 1</td>
<td>2-3</td>
</tr>
<tr>
<td>&gt;20°</td>
<td>5.4: 1</td>
<td>0.3-0.5</td>
</tr>
<tr>
<td>&gt;30°</td>
<td><strong>10: 1</strong></td>
<td>0.1-0.3</td>
</tr>
<tr>
<td>&gt;40°</td>
<td>___</td>
<td>&lt;0.1</td>
</tr>
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*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
  – $>7^\circ \rightarrow \text{Refer for spine evaluation}$
  – Correlates to $\sim 20^\circ$ 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


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

Plaszewski M¹, 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!

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**Study Affirms Benefit of Back Braces as Scoliosis Treatment**

*The New York Times*

September 19, 2013

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

• **Screening is recommended**
  – 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 → refer
Screening Algorithm

Inspect
  Is the pelvis level?
  Is the waist symmetric?
  Are the shoulders level?
  Perform Adams forward-bending test

If shoulders and torso asymmetric on examination, measure with inclinometer

Inclinometer reading, <7 degrees
  Follow-up in 6–12 mo according to growth potential

Inclinometer reading, ≥7 degrees
  Perform further evaluation
    Obtain posteroanterior scoliosis radiograph from C7 to iliac crest while patient is in standing position
    Request Cobb angle in radiography order
    Follow-up according to Cobb angle

Hresko JAMA 2013
## Follow-up Algorithm

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Hresko JAMA 2013
Imaging

• X-rays:
  – Standing PA and LAT
    » Occiput → Sacrum
    » Shields
Cobb Angle

Risser Sign
<table>
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<tr>
<th>Curve Magnitude at Detection</th>
<th>Age at Detection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10-12 yr</td>
</tr>
<tr>
<td>&lt;19°</td>
<td>25%</td>
</tr>
<tr>
<td>20-29°</td>
<td>60%</td>
</tr>
<tr>
<td>30-59°</td>
<td>90%</td>
</tr>
<tr>
<td>&gt;60°</td>
<td>100%</td>
</tr>
</tbody>
</table>

Growth Velocity

- 2/3 of growth occurs prior to Risser 1
# Natural History: Risk of Progression — Risser Grade

<table>
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<tr>
<th>Risser Grade</th>
<th>% Progression 5-19°</th>
<th>% Progression 20-29°</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 or 1</td>
<td>22%</td>
<td>68%</td>
</tr>
<tr>
<td>2, 3 or 4</td>
<td>1.6%</td>
<td>23%</td>
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Lonstein JE, Carlson JM. JBJS 1984
### Natural History:
**Risk of Progression — Curve at Maturity**

<table>
<thead>
<tr>
<th>Thoracic</th>
<th>Lumbar</th>
<th>Thoracolumbar</th>
<th>Combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobb &gt;50°</td>
<td>Cobb &gt;30°</td>
<td>Cobb &gt;30°</td>
<td>Cobb &gt;50°</td>
</tr>
<tr>
<td>Apical vertical rotation 30%</td>
<td>Apical vertical rotation &gt;30%</td>
<td>Apical vertical rotation &gt;30%</td>
<td>Translatory shifts</td>
</tr>
<tr>
<td>Mehta angle &gt;30°</td>
<td>Curve direction</td>
<td>Relation L5 to intercrest line</td>
<td>Translatory Shifts</td>
</tr>
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</table>

*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

### Table 2. Cobb Angles by Curve Type and Period

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

Weinstein et al JAMA 2003
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

- FVC: $y = -0.42x + 105.83$
- FEV1: $y = -0.42x + 99.6$

Variables:
- FVC (closed circles)
- FEV (triangles)
- FVC (smoker, open circles)
- FEV (smoker, open triangles)

Graph shows the relationship between FVC and FEV1 (% of predicted) with curvature in degrees.
Mortality — Untreated Scoliosis

Pehrsson et al, Spine 1992
Mortality — Untreated Scoliosis

Mild-Moderate Scoliosis (n=44)
- Observed deaths
- Expected deaths

Severe Scoliosis (n=71)

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

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?

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.


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

DOI: 10.1056/NEJMoa1307337

>90% effective if worn >13 hrs/day
Hidden temperature sensor to measure actual brace wear

Actual Brace Wear:
>12 h/day = 82% no progression
7 h/day = 69% progressed

Recommend >16 h/day to get 12h/day actual wear!
Compliance Counseling

- Hawthorne effect $\rightarrow$ 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 **not** replace traditional medical care
Schroth Method

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

Weiss, Scoliosis 2011
Evidence?

- 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

- 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 Schreiber¹, Eric C. Parent¹, Elham Khodayari Moez¹, Douglas M. Hedden², Doug Hill², Marc J. Moreau², Edmond Lou², Elise M. Watkins² and Sarah C. Southon²

- 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:**
  - $>45^\circ$ in growing child
  - $>50^\circ$ in skeletally mature

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

• 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

Inspect
Is the pelvis level?
Is the waist symmetric?
Are the shoulders level?
Perform Adams forward-bending test

If shoulders and torso asymmetric on examination, measure with inclinometer

Inclinometer reading, <7 degrees
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Hresko JAMA 2013
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Hresko JAMA 2013
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!