Adolescent Idiopathic Scoliosis

APP Spring Conference – 2025

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Department of Orthopedic Surgery

Akron Children's Hospital

- Special Thanks – Dr. Lorena Floccari
  - Director of the Spine Center of Excellence
  - Please refer to her Pediatric and Adolescent Spinal Deformity lecture under ACH Grand Rounds Enduring Materials
    - Scoliosis Grand Rounds.pptx

- Disclosures - None

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Spine Center of Excellence

- **Providers**
  - Dr. Todd Ritzman, Dr. Lorena Floccari, Dr. Kenneth Bono, Amanda Edmonds, Jessica Westfall, Jennifer Warmus, Donte Leonard, and Aaron Wickham
- **Locations**
  - Akron, Mansfield, North Canton, Boston Heights, Medina, Mahoning Valley, Warren, and Beachwood.

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Objectives

1. Summarize the epidemiology, etiology, presentation, and natural history of Adolescent Idiopathic Scoliosis.
2. Discuss effective screening, referral, and imaging studies for scoliosis patients.
3. Discuss indications for treatment and treatment options.
4. Review clinical pathways at ACH for AIS patients.
5. Discuss health equity as it relates to scoliosis and current projects focused on addressing disparity at ACH.

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Scoliosis

- Scoliosis is a spinal deformity (curve) of the spine >10°
- < 10 degrees of curvature is ‘spinal asymmetry’
- Truly also a 3-dimensional deformity in all planes
  - Coronal – lateral curve
  - Sagittal – lordosis
  - Axial – rotation

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Main Class and Subtype	Demographic and Clinical Characteristics
Idiopathic	
Infantile	Occurs in the first 3 years of life; male preponderance; levoscoliosis is more common than dextroscoliosis
Juvenile	Occurs at age 4–10 years; female preponderance; dextroscoliosis is more common than levoscoliosis
Adolescent	Occurs at age 10–18 years; female preponderance; dextroscoliosis is more common than levoscoliosis
Congenital	
Osteogenic	Wedge-shaped vertebrae, hemivertebrae, fused vertebrae, unilateral bar
Neuropathic	Tethered cord, syringomyelia, Chiari malformation, (myelo)meningocele, diastematomyelia
Developmental	
Skeletal dysplasia	Achondroplasia
Skeletal dysostosis	Neurofibromatosis, osteogenesis imperfecta
Neuromuscular	
Neuropathic (acquired)	Cerebral palsy, spinocerebellar degeneration, poliomyelitis
Myopathic	Muscular dystrophy of various types (eg, Duchenne dystrophy)
Tumor-associated	
Osseous	Osteoid osteoma, osteoblastoma
Extraosseous	Extramedullary (eg, neurofibroma) or intramedullary (eg, astrocytoma) tumor

Idiopathic Scoliosis

- 80% of scoliosis cases are idiopathic
- 90% never require active treatment
- 10% have a progressive curve that requires treatment

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Adolescent Idiopathic Scoliosis (AIS)

- Adolescent
  - Presentation AFTER age 10
- Idiopathic
  - No underlying cause
  - Diagnosis of exclusion

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AIS Etiology

- Unknown but likely multiple factors
  - Genetics
    - Chromosomal abnormality
  - Family history (~30%)
  - Hormonal
  - Vitamin D deficiency/bone density issues
- Abnormal vertebral growth
  - Theory that there is more anterior growth of the spine resulting in curvature and then rotation

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AIS Epidemiology

- The incidence is ~1-3%
- 1:1 male to female ratio in curves < 30 degrees
- 1:10 male to female ratio in curves > 30 degrees
- Females are 5x more likely to progress and require treatment

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AIS Natural History

- General concept: curves can progress throughout *growth* and large curve (>45-50 degrees) can continue to progress throughout *life*
  - Leading to issues with self-image, pain, cardiopulmonary dysfunction, and mortality (curves >70 degrees)

- Curves accelerate rapidly during peak height velocity thus early recognition and treatment is imperative

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Weinstein Study

- University of Iowa published in 1981 with 50-years of follow-up
  - Established that curve progression occurs most rapidly during growth
    - <40° stop progressing after skeletal maturity
    - ≥50° often keep progressing after skeletal maturity
      - Mean 1° progression per year
  - Back pain in 61% of patients (vs. 31% of controls) with untreated scoliosis >50°
    - mild-moderate
    - chronic pain
    - Lumbar > thoracic

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Weinstein Study

- Diminished pulmonary function with scoliosis >60°
  - Curves >60°: Decreased TLC, FVC
  - Curves >80°: Dyspnea upon exertion & sleep apnea

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Natural History in Summary

- Curves <40° *unlikely to progress* after skeletal maturity
- Curves >50° *likely to progress* after skeletal maturity

- Curves >60° decrease lung function
- Curves >70° increase mortality
- Untreated curves have long term back pain

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AIS Presentation

- Often noted by parents or at well child checks
- Patients may note asymmetry themselves or cosmetic concerns
- Back pain
  - May be present in 25-50% of patients with AIS
- Abnormal or severe back pain as well as neurologic symptoms are rare, concerning, and warrant further workup

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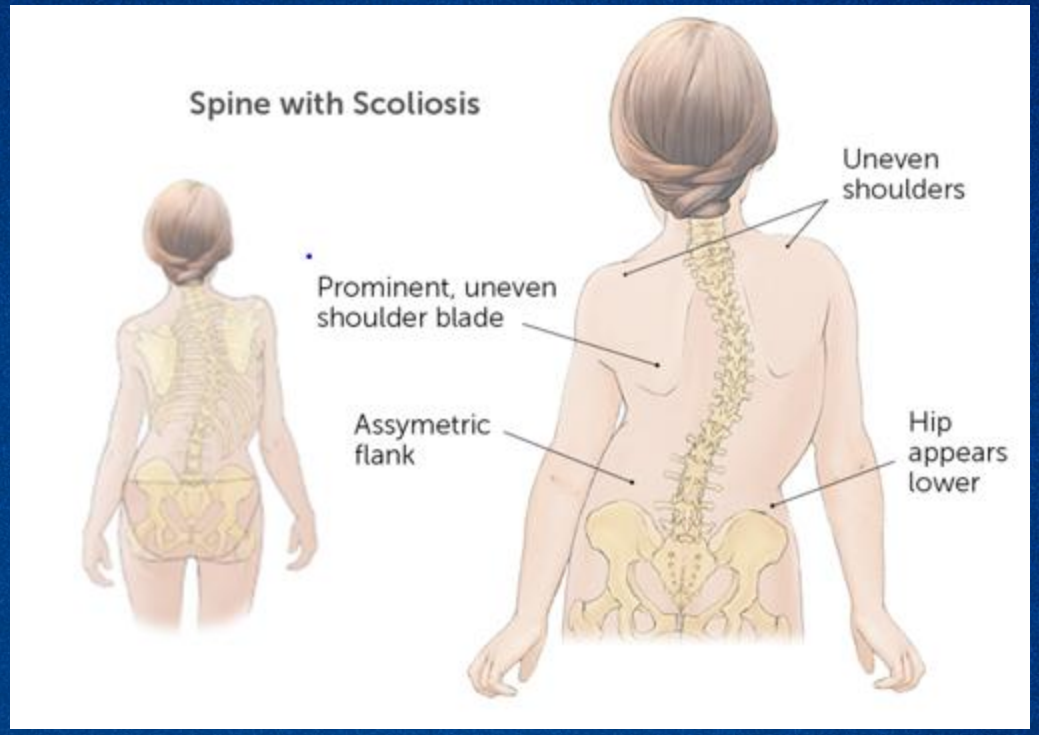
AIS Physical Examination

- Asymmetry
  - Shoulder
  - Scapula
  - Waistline
  - Iliac crest
- Trunk shift



Obese patients may be more difficult to assess/hide smaller curves

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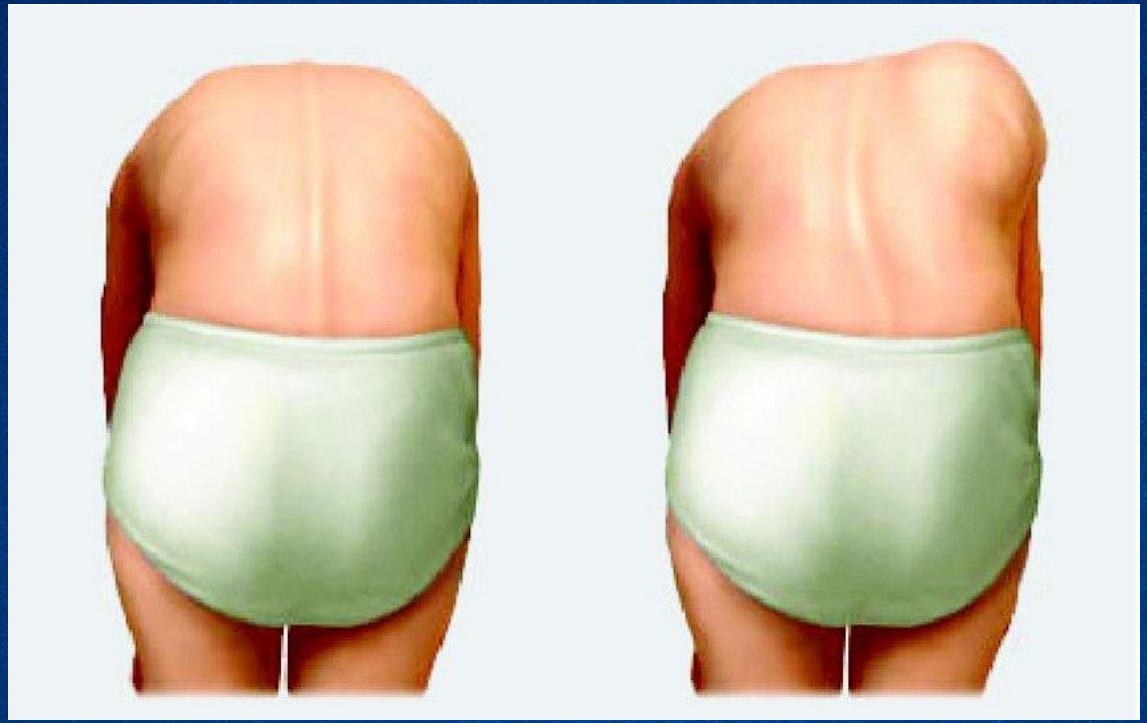
Atypical Physical Exam Findings

- A left thoracic curve
- Thoracic kyphosis rather than hypokyphosis or lordosis
- Spinal dysraphism or neurocutanous lesions

Adam’s Forward Bend Test

- Legs and feet together, knees straight, arms together (like diving)
- Bend forward and stop when chest level to the ground
- The patient’s head should be relaxed forward

Expected Clinical Exam



Right thoracic curve

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Adam's Forward Bend Test

- 7° scoliometer reading = 20° scoliosis
- Difficult exam?…Consider a seated scoliometer reading
- Still uncertain? Obtain radiographs and/or consider Ortho referral or e-consult

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Imaging - Radiographs

- **Standing PA ONLY**
  - **DO NOT** obtain *unstitched, separate lumbar/thoracic films*
  - PA imaging offers significantly less radiation to thyroid (4x) and breasts (8x)
- Lateral films should be obtained at least once during scoliosis evaluation and for patients with reported back pain
- Triradiate cartilage and iliac crests need to be visualized to assess skeletal maturity/guide treatment

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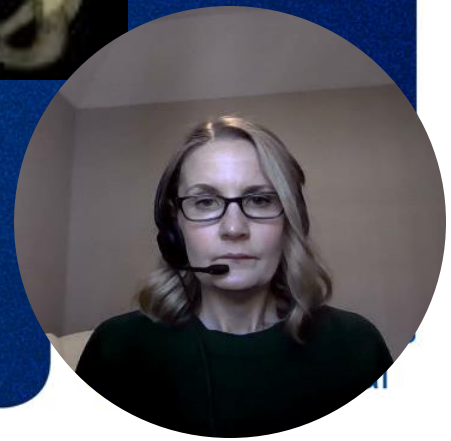
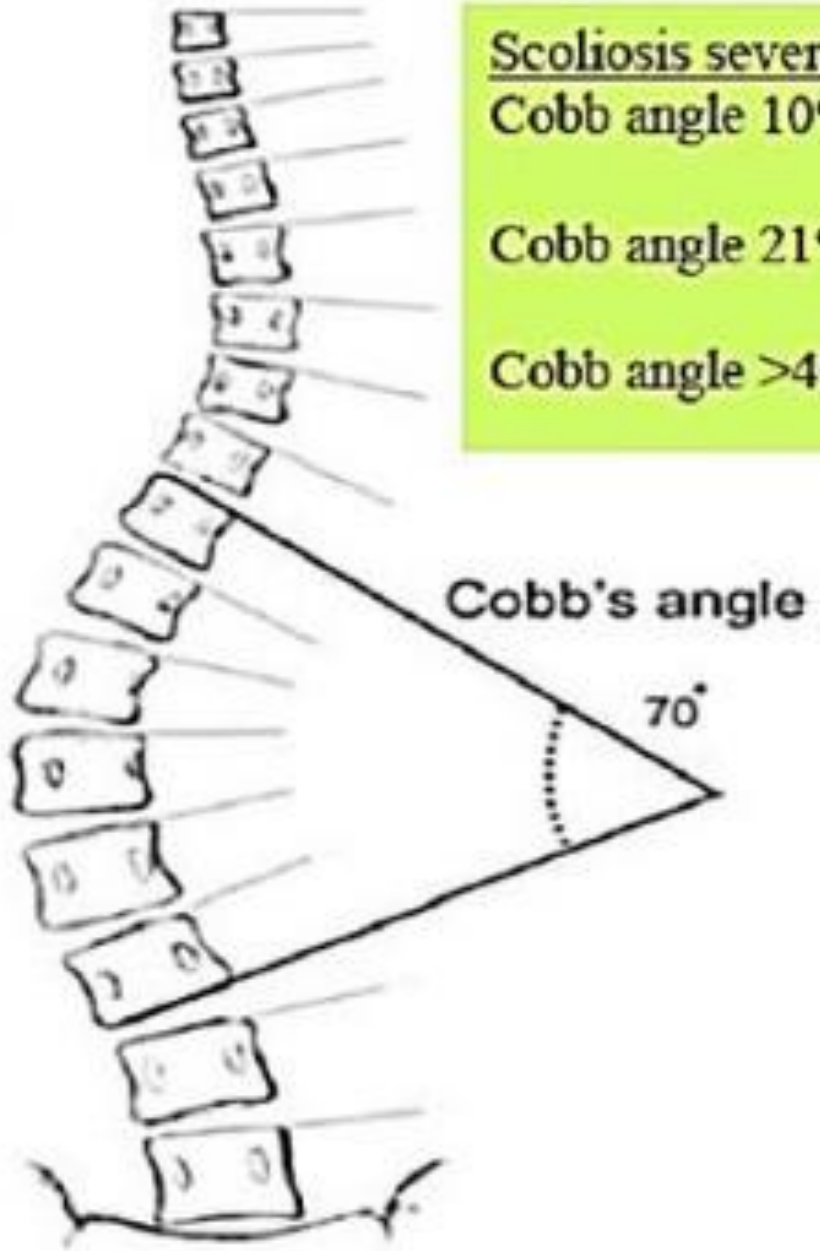
Radiographs - EOS

- Available in Akron and MV for patients referred to Orthopedics
  - ¼ the radiation of traditional radiographs
- Provides 3D images for pre-operative planning





Scoliosis severity:

Cobb angle 10° to 20° =mild

Cobb angle 21° to 40° = moderate

Cobb angle >40° =severe

AIS – Advanced Imaging

- MRI
  - Atypical curves
  - Abnormal physical exam
  - Significant pain
  - Rapid progression
  - Progression despite brace compliance
  - Early onset curve (< 10 years of age)
- CT
  - Rarely indicated in AIS
  - More commonly necessary for congenital scoliosis

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AIS Treatment

- Dependent upon curve magnitude and assessment of maturity (growth remaining or lack thereof)
- Essentially, AIS patients need non-operative treatment for curves 25-45 degrees
  if skeletally immature and surgery
  if curves > 45-50

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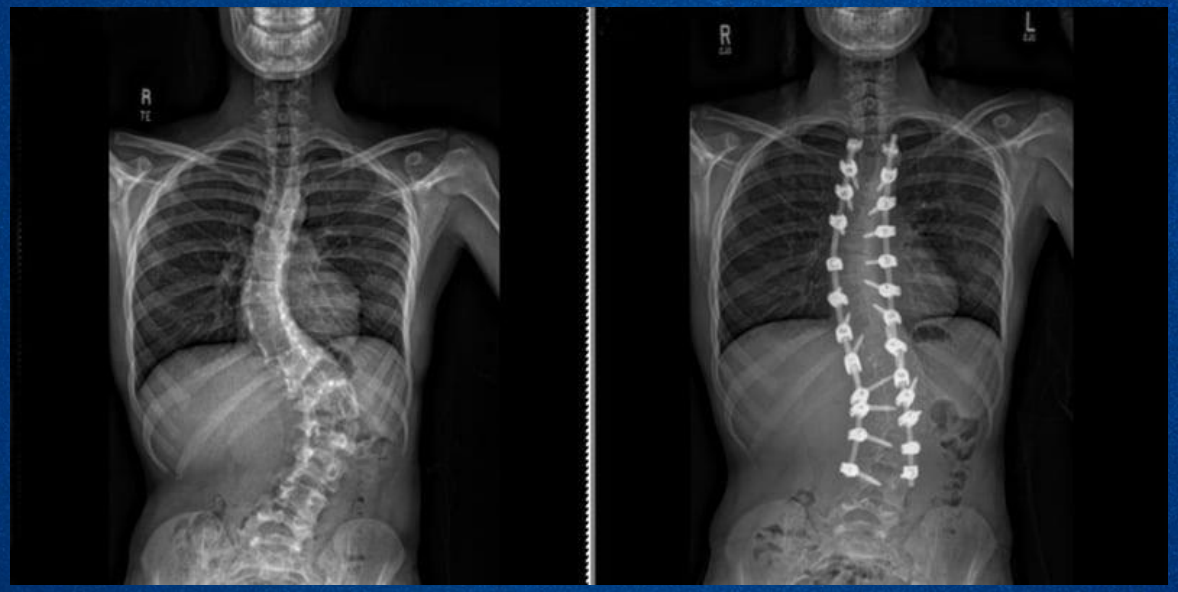
AIS Treatment Goals

- Prevent continued scoliosis progression throughout life and the associated complications
- Avoid Surgery !



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Assessments of Maturity

- Menarchal Status
  - Girls typically grow about 18-24 months after their first period
  - Most girls are done growing around age 14
- Height
  - We utilize this in addition to other measures to determine if growth remains
  - Useful in decision-making regarding brace treatment

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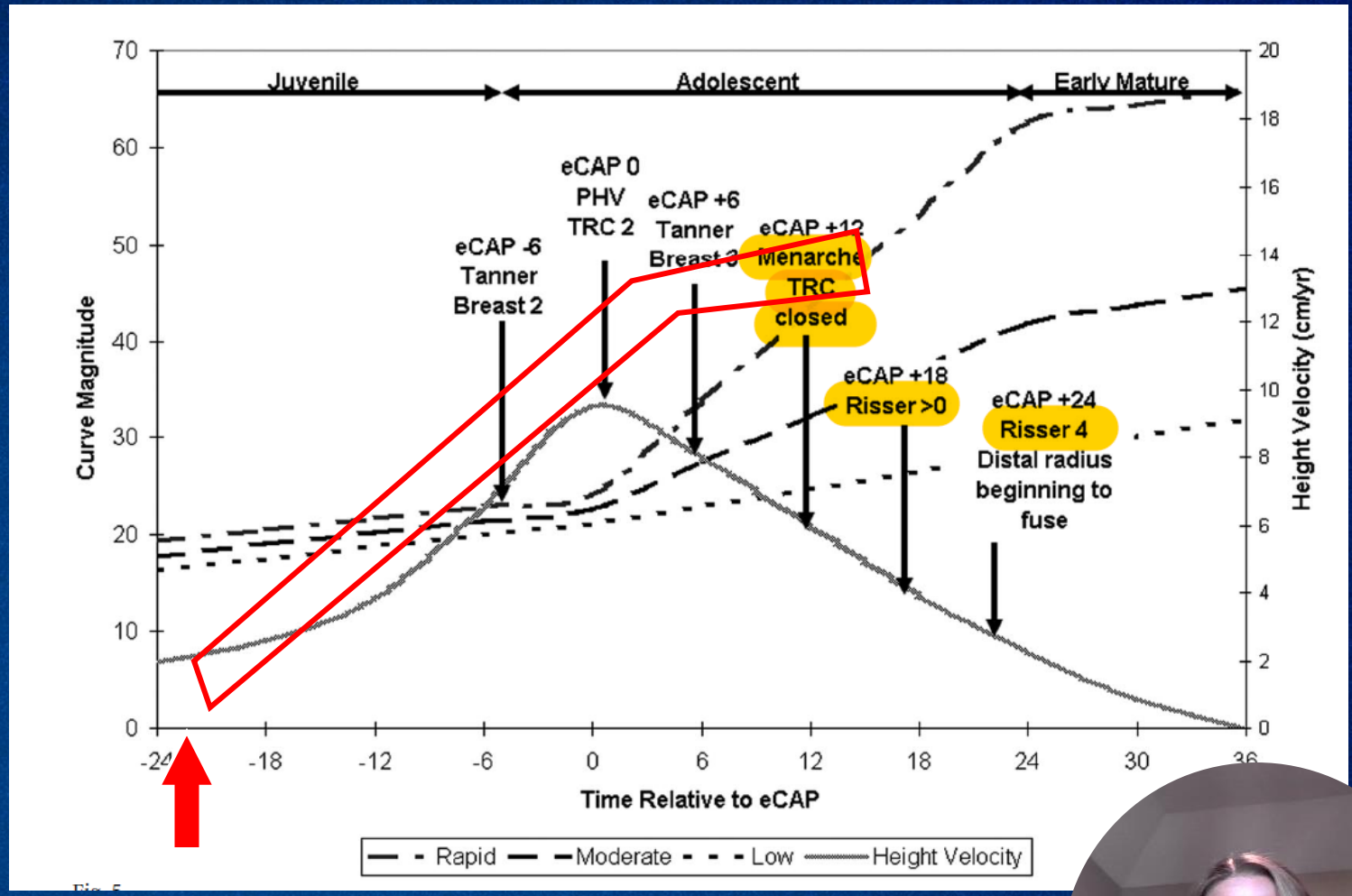
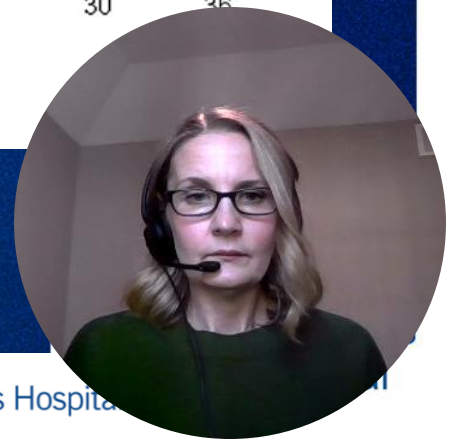
Maturity Assessment and Curve Progression in Girls with Idiopathic Scoliosis

By James O. Sanders, MD, Richard H. Browne, PhD, Sharon J. McConnell, MS, Susan A. Margraf, RN, Timothy E. Cooney, MS, and David N. Finegold, MD

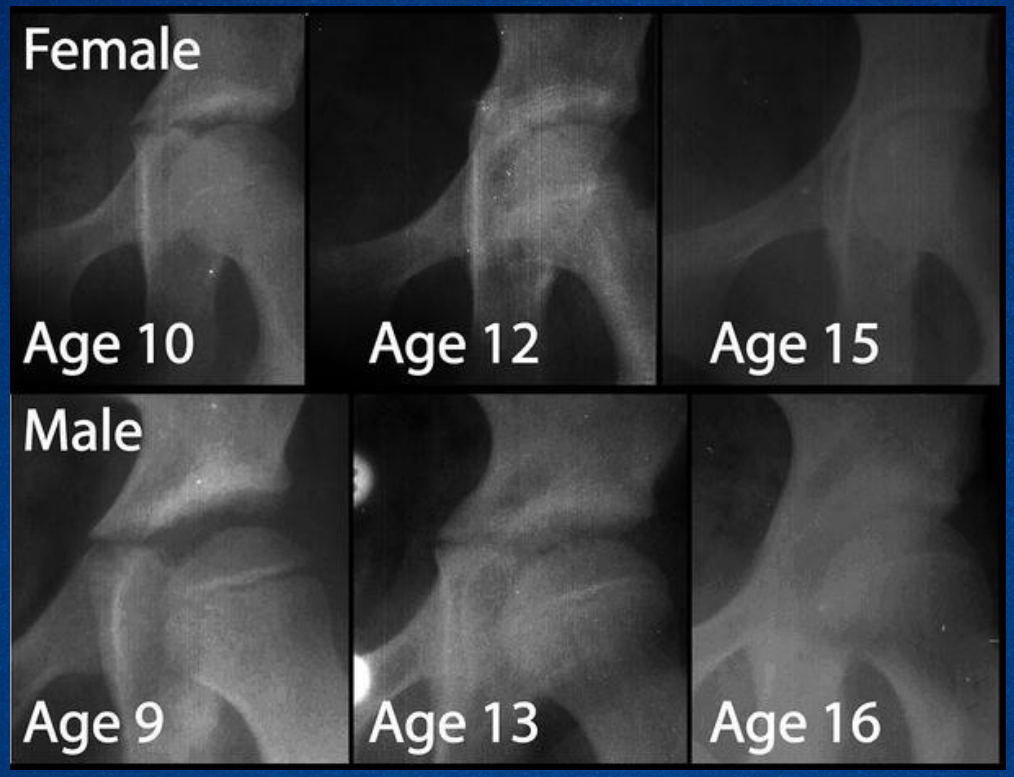
Investigation performed at Shriners Hospitals for Children, Erie, Pennsylvania



Sanders et al, JBJS 2007



Assessment of Maturity (Growth Remaining)



Triradiate Cartilage

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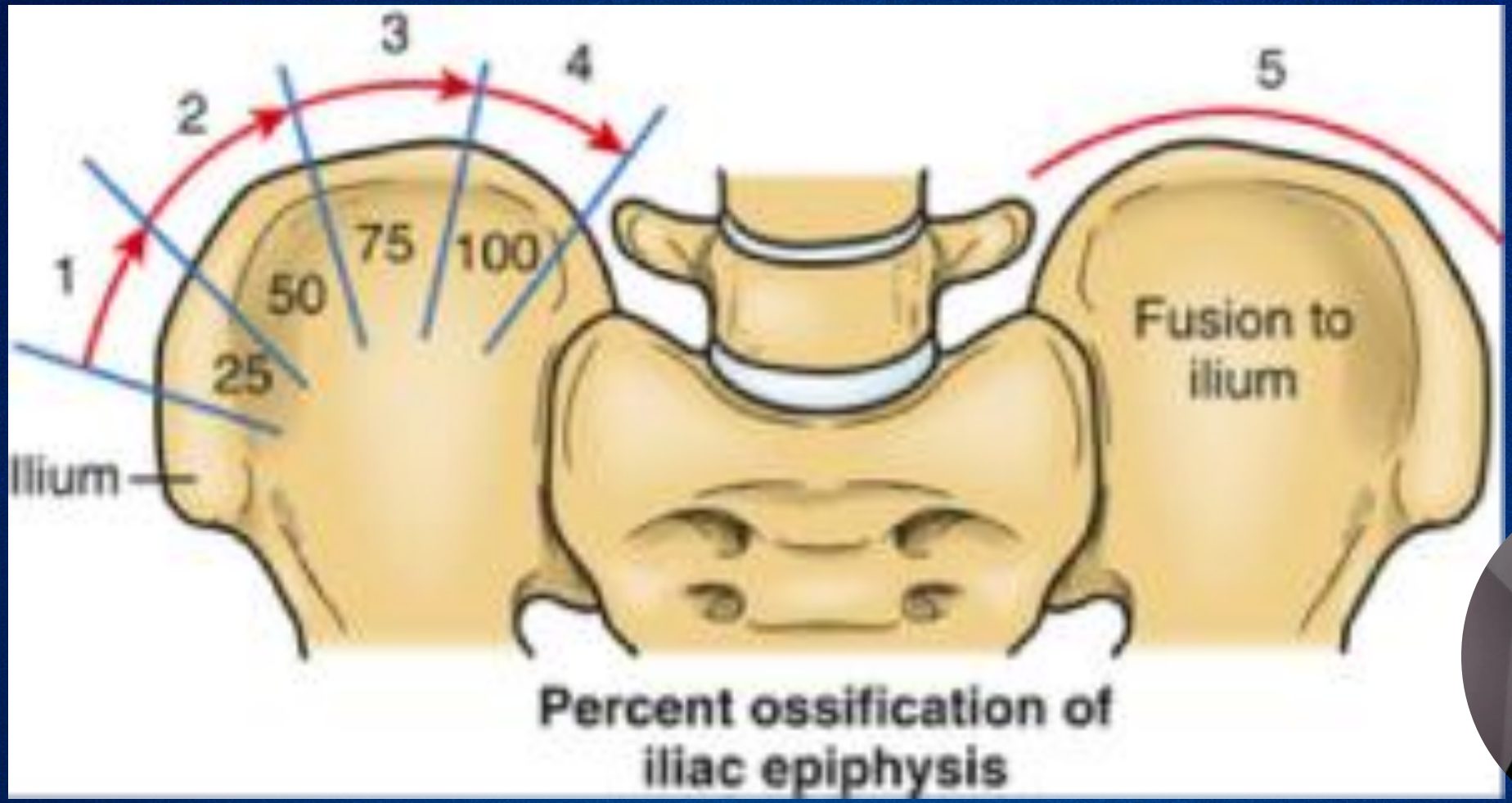

Risser Sign

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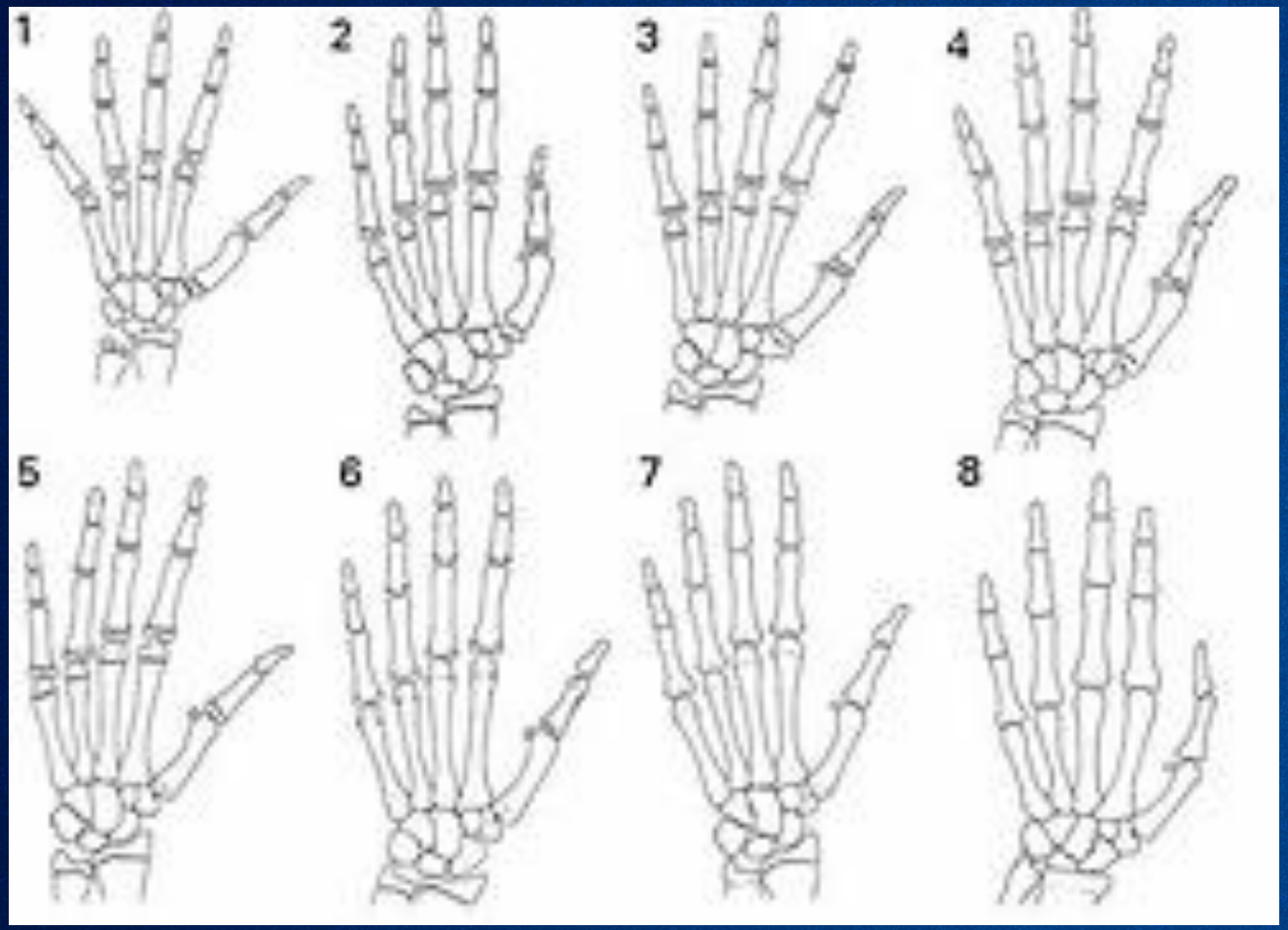
Risk of Progression – Cobb Angle

Table 1. Incidence of Progression as Related to the Magnitude of the Curve and the Risser Sign

	Percentage of curves that progressed	
Risser sign	*5- to 19-degree curves*	*20- to 29-degree curves*
Grade 0 or 1	22	68
2, 3, or 4	1.6	23

The Sanders Maturity Scale



- Based on ossification patterns of the bones in the hand on a standard hand x-ray
- Allows for earlier and more accurate prediction of peak growth velocity

10 years old

30 degrees

11 years old

40 degrees

12 years old

105 degrees

Scoliosis can rapidly progress to surgical magnitudes during peak growth velocity!

AIS Treatment Algorithm

- 0-20° Observation with follow-up dependent upon maturity
- 20°-45° Bracing until skeletally mature
  - The goal is to slow down curve progression during growth

  Consider Schroth PT
- >45-50° Surgery

Vitamin D supplementation recommended for all scoliosis patients

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AIS Bracing

- Indicated for curves of 20-45 degrees in patients with *growth remaining*
- Slows curve progression during growth to prevent the need for surgery
- Effective if worn as prescribed

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AIS Bracing Contraindications

- Curves >45°
- Skeletally mature
- Physiologic intolerance
  - Pulmonary, neuromuscular disorder, or other disorders
- Psychological intolerance

Effects of Bracing in Adolescents with Idiopathic Scoliosis

Authors: Stuart L. Weinstein, M.D., Lori A. Dolan, Ph.D., James G. Wright, M.D., M.P.H., and Matthew B. Dobbs, M.D. Author Info & Affiliations

Published October 17, 2013 | N Engl J Med 2013;369:1512-1521 | DOI: 10.1056/NEJMoa1307337

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- Randomized hallmark clinical trial that demonstrated that bracing was effective as patients avoiding surgery 72% of the time

- Demonstrated the dose-dependent nature of bracing
  - When the brace was worn >13 hours per day, 90% of patient's curves were <50 degrees at skeletal maturity

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TLSO (Boston)

- “All the time” brace
- Absolute minimum wear 16 hours per day

Nighttime (Providence/Charleston)

- Minimum of 8-10 hours per night
- Best for lower magnitude and lumbar curves

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Schroth PT

- Specialized physical therapy provided by PTs with intensive training
- Focuses on core strengthening, postural training, and strengthening weak muscles to obtain better muscle symmetry
- Available in Akron and MV

Treatment – Posterior Spinal Fusion

- Scoliosis curves > 45-50 degrees
- Goals
  - Primary – to fuse the spine to prevent continued scoliosis curve progression
  - Secondary – correct or improve the deformity
- Early recognition of surgical magnitudes is important
  - Surgical complications and complexity increase with larger curve magnitude at timing of fusion (blood loss, fusion levels, anesthesia time, etc...)

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Posterior Spinal Fusion

- Remove the posterior facet
- +/- Ponte osteotomies
  - Removal of the facet joints, lamina, and posterior ligaments
  - Helps with deformity correction for larger/stiffer curves
- Insert screws and rods
- Apply bone graft to enable vertebral fusion

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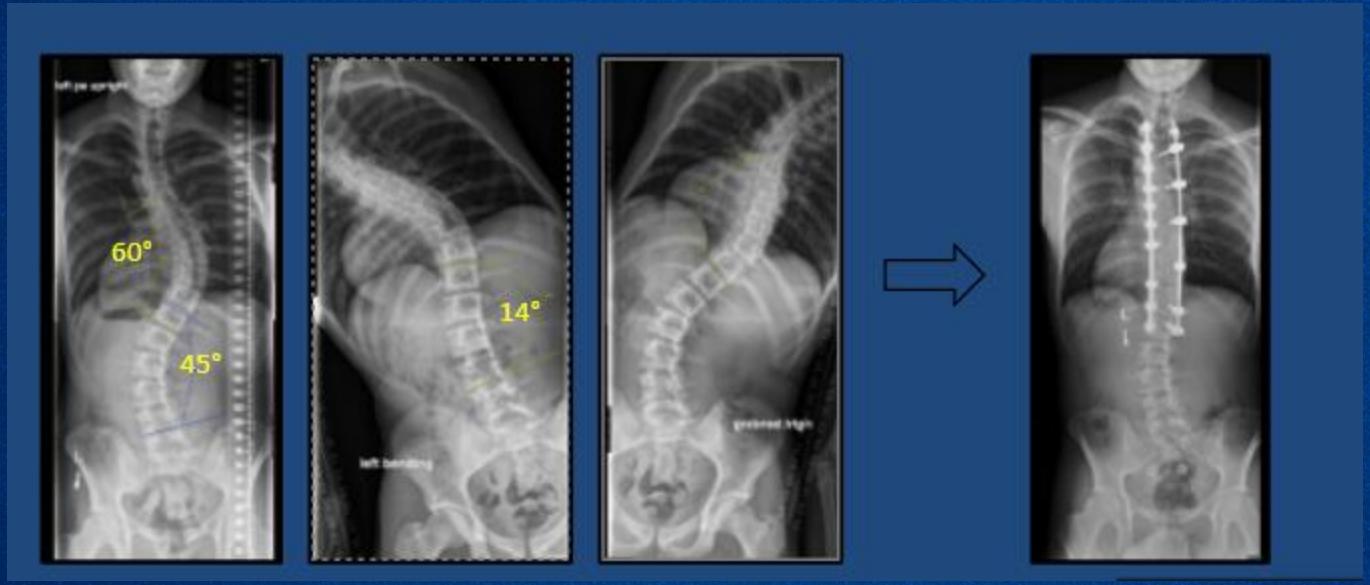
Posterior Spinal Fusion

- Minimize fusion levels when possible
  - Selective thoracic fusion is ideal
  - Avoid lumbar fusion and preserve mobility if possible



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Vertebral Body Tethering

- Newer surgical procedure that utilizes remaining growth of the spine
- Goal is to preserve spine mobility and avoid fusion
- Very specific inclusion criteria (Risser 3 or 4, flexible curves between 45-60 degrees)

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Why operate during adolescence?

- Adolescents have excellent surgical outcomes
  - Fewer instrumented levels, better correction, and easier recovery
- Adolescents have caretakers to assist with recover and do not have other obligations (work, families, college)

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AIS Clinical Pathway

- Multi-disciplinary perioperative pathway
  - Standardized pre-operative appts, radiographs, labs, consults, nutrition, surgical anti-sepsis, intra-operative management (neuromonitoring, antibiotics/analgesia, and post-operative recovery (pain medication, nutrition, activity)
  - Resulted in decreased hospital length of stay, PICU admissions, infection, ED visits, and readmissions.

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AIS Post-Operative Care

- Typically return to full activity by 6 months
  - 3 months cleared for independent aerobic activity

But how do we avoid a Posterior Spinal Fusion in the first place?

Early detection of scoliosis through screening and implementation of non-operative treatment (bracing) when indicated.

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Universal School Screenings

- The United States Preventative Services Task Force (USPSTF) issued a statement initially recommending *against* screening programs (changed to inconclusive in 2018)
- Thus, AAOS/SRS/POSNA/AAP released a consensus statement recommending routine screening
  - Twice for girls at age 10 and 12 and once for boys at age 13 or 14
- Screenings are necessary to identify scoliosis and initiate treatment if indicated (idiopathic scoliosis is asymptomatic)

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Primary Care Scoliosis Referral Pathway

- Developed to standardize screening/clinical care/referrals to Orthopedics

- Goals:
  - Reduce unnecessary subspecialty visits (time/cost)
  - Appropriate ortho referral timeline
  - Reduce radiation exposure/cost
  - Implement treatment if indicated
    - Ultimately early recognition of scoliosis and avoidance of patients presenting with a PSF as their only treatment option

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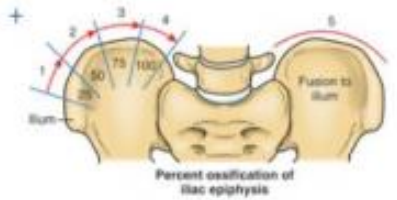
Primary Care Scoliosis Referral Pathway

*Order imaging with diagnosis "Curvature of Spine"
** Refer to Orthopedics with diagnosis "Scoliosis, unspecified"

Scoliosis Concern or Screening

- Scoliometer ≤ 3° → Follow up at annual well child check (WCC) → Cobb angle ≤ 10° Follow-up at annual WCC
- Scoliometer 4°-7° → * Obtain radiographs Scoliosis 1 view, standing PA **OR** scoliosis 2 views, standing PA and lateral if back pain → Cobb angle 11-20° → Refer to Ortho if immature (Risser 0-3 +); No referral indicated if mature (Risser 4-5 +) Follow up at annual WCC
- Scoliometer ≥ 8° → **Refer to Orthopedics



Percent ossification of iliac epiphysis

Victoria Sports and Rehabilitation Clinic (2016)

Minimum Scoliosis Screening Recommendations: Girls at age 10 and 12, and boys at age 13 and 14

Normal Variants on Radiograph Interpretation

- Spina bifida occulta, Schmorl's nodes, apophyses, transitional vertebrae, pelvic tilt (<2cm)
- Consider e-consult to Ortho for any other radiographic findings

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Questions or Uncertain?

- Consider an e-consult to Ortho or refer!

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Health Disparity

- Exists when there is difference in care quality, access, and experience between population groups.
- Known disparity exists within the subspecialties, including pediatric orthopedics
- More specifically, known inequity exists amongst patients with scoliosis

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Health Disparity – AIS

- Health care disparity regarding patients with scoliosis related to socioeconomic status, insurance type, and race
- Delayed care may reduce the option for non-operative management (bracing) and/or increase the risk of surgical complications due to larger magnitude curves at presentation.
- Black patients with public insurance are the most at-risk to present with severe scoliosis and scoliosis exceeding bracing magnitude (Heffernan et al, 2022).

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SCOLIOSIS

Impact of Social Determinants of Health on Adolescent Idiopathic Scoliosis Curve Severity

Orellana, Kevin J. BS*; Lee, Julianna BA*; Yang, Daniel MS*; Hauth, Lucas BS*; Flynn, John M. MD*,†

Author Information

Journal of Pediatric Orthopaedics 44(2):p e168-e173, February 2024. | **DOI:** 10.1097/BPO.0000000000002529

- COI (childhood opportunity index) utilized to reflect socioeconomic status
  - 31% of high COI patients presented with curves within bracing magnitude compared to only 13% of patients with low COI
  - COBB angle was on average 6 degrees higher for low COI patients as compared to those in the high COI

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- The Joint Commission initiated requirements for health care facilities to implement measures to address health care disparities - effective January 2023

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Health Disparity at ACH

- Scoliosis/spinal asymmetry referrals from ACHP/Locust Peds to Ortho
- Significant disparity amongst Black population

Patient Race Nm	Referral Count	% of Total Referrals	Brace Order Count	% Brace Ordered	Case Request Count	% Case Request
African American/Black	55	11.93%	6	10.91%	3	5.45%
American Indian and Alaska Native	2	0.43%			0	0.00%
Asian	7	1.52%			0	0.00%
Native Hawaiian and Other Pacific Islander	1	0.22%			0	0.00%
Other	1	0.22%			0	0.00%
Patient Refused	1	0.22%			0	0.00%
Unknown	15	3.25%	1	6.67%	1	6.67%
White or Caucasian	379	82.21%	27	7.12%	8	2.11%
Total	**461**		**34**		**12**	

Black children are 2-3x as likely to present with surgical magnitude curves as compared to White children

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Orthopedics/School-Based Health Project

Collaborative project between Ortho/SBH (present at APS)

Implementing FREE, targeted scoliosis screenings at Akron Public Schools to a high-risk age group (6th graders) performed by ACH APS Providers/Orthopedic APPs

Using scoliometer measurements and our Primary Care Scoliosis Referral Pathway for guidance

Why Akron Public Schools?

- Less that 50% of APS students receive well child checks
- Akron Public Schools include a significant minority population (46% are Black)
- Existing collaborating between ACH and APS

Akron Public Schools

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Summary

Benefits of Implementation of scoliosis screenings to a targeted high-risk population:

- Address health care disparities
- Identify patients in which bracing can be implemented earlier
- Potentially avoid costly, high-risk spinal fusion.

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Question #1

1. Scoliosis is defined as a spinal deformity or curve of the spine greater than ____ degrees.
    a. 10
    b. 20
    c. 30

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Question #1

1. Scoliosis is defined as a spinal deformity or curve of the spine greater than ____ degrees.
    a. 10
    b. 20
    c. 30

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Question #2

2. Scoliosis screening is recommended for boys at age ____.
    a. 10
    b. 12
    c. 13/14

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Question #2

2. Scoliosis screening is recommended for boys at age ____.
    a. 10
    b. 12
    c. 13/14

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Question #3

3. A patient with a scoliometer reading of ____ and above should be referred to Orthopedics.

    a. 3

    b. 8

    c. 7

Question #3

3. A patient with a scoliometer reading of ____ and above should be referred to Orthopedics.

    a. 3

    b. 8

    c. 7

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Question #4

4. A 10-year-old female is screened for scoliosis during her well child check and her scoliometer reading is 6. What should the primary care provider do next?

a. refer directly to Ortho

b. obtain a standing PA view of the spine (and lateral if she complains of back pain)

c. repeat a scoliosis screening in 1 year

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Question # 4

4. A 10-year-old female is screened for scoliosis during her well child check and her scoliometer reading is 6. What should the primary care provider do next?

a. refer directly to Ortho

b. obtain a standing PA view of the spine (and lateral if she complains of back pain)

c. repeat a scoliosis screening in 1 year.

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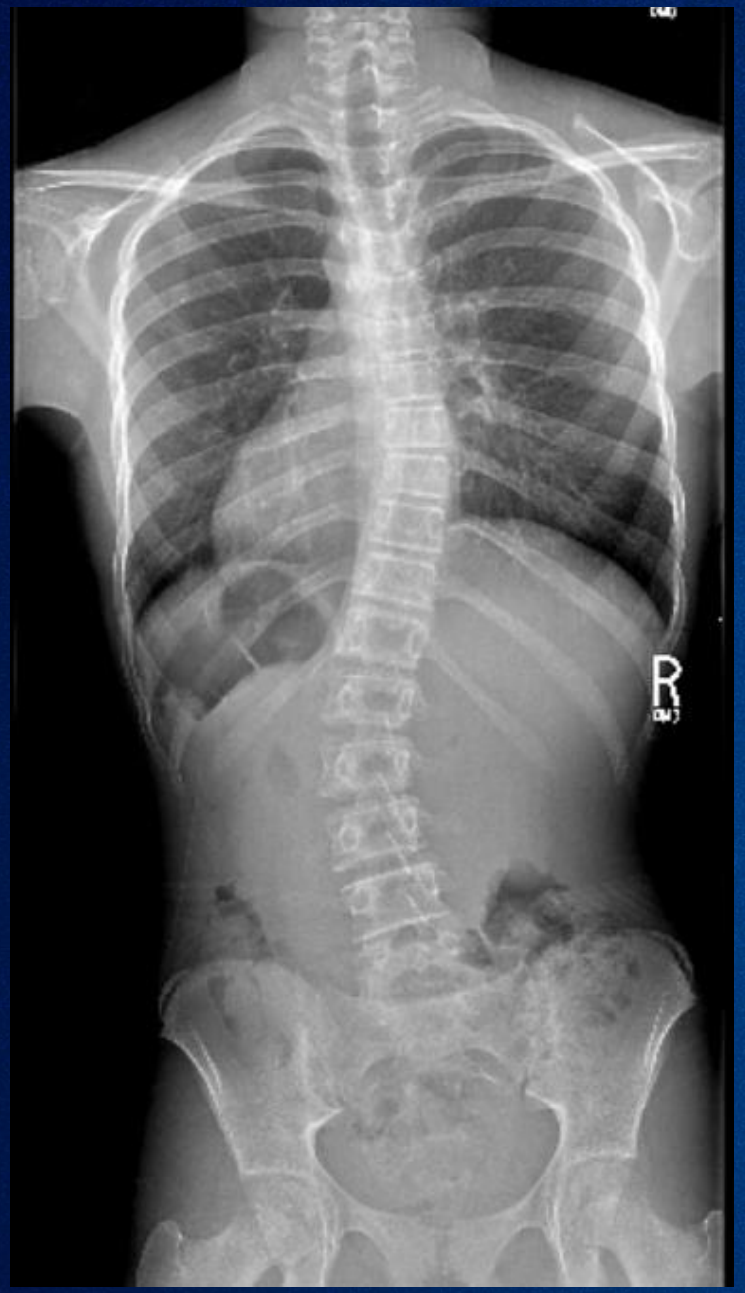

Case #1

- 13-year-old female
- Pre-menarchal
- TRC closed, Risser 1
- Right thoracic curve 25 degrees, and left thoracolumbar curve 30 degrees
- Reassuring clinical exam and history

- Typical AIS curve (right thoracic), growth remaining, curve between 25-45 degrees → BRACE

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Case #1

- Boston brace for ~18 months
- Radiograph 1 year after skeletal maturity
- No progression
- AVOIDANCE of posterior spinal fusion

Case #2

- 15-year-old male
- TRC closed, Risser 4
- Right thoracic curve 53 degrees
- Reassuring clinical exam and history

- Typical AIS curve (right thoracic), no growth remaining, curve > 50 degree → POSTERIOR SPINAL FUSION

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Case #2

- Mature with a large magnitude curve at presentation thus bracing was not an option
- Concern for continued progression of curve throughout life
- Patient doing well s/p PSF

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Case #3

- 7-year-old female
- Pre-menarchal
- TRC open, Risser 0
- Right thoracic curve 26 degrees, and left thoracolumbar curve 30 degrees
- Reassuring clinical exam

- Early-onset (<age 10-NOT AIS) despite the right thoracic curve

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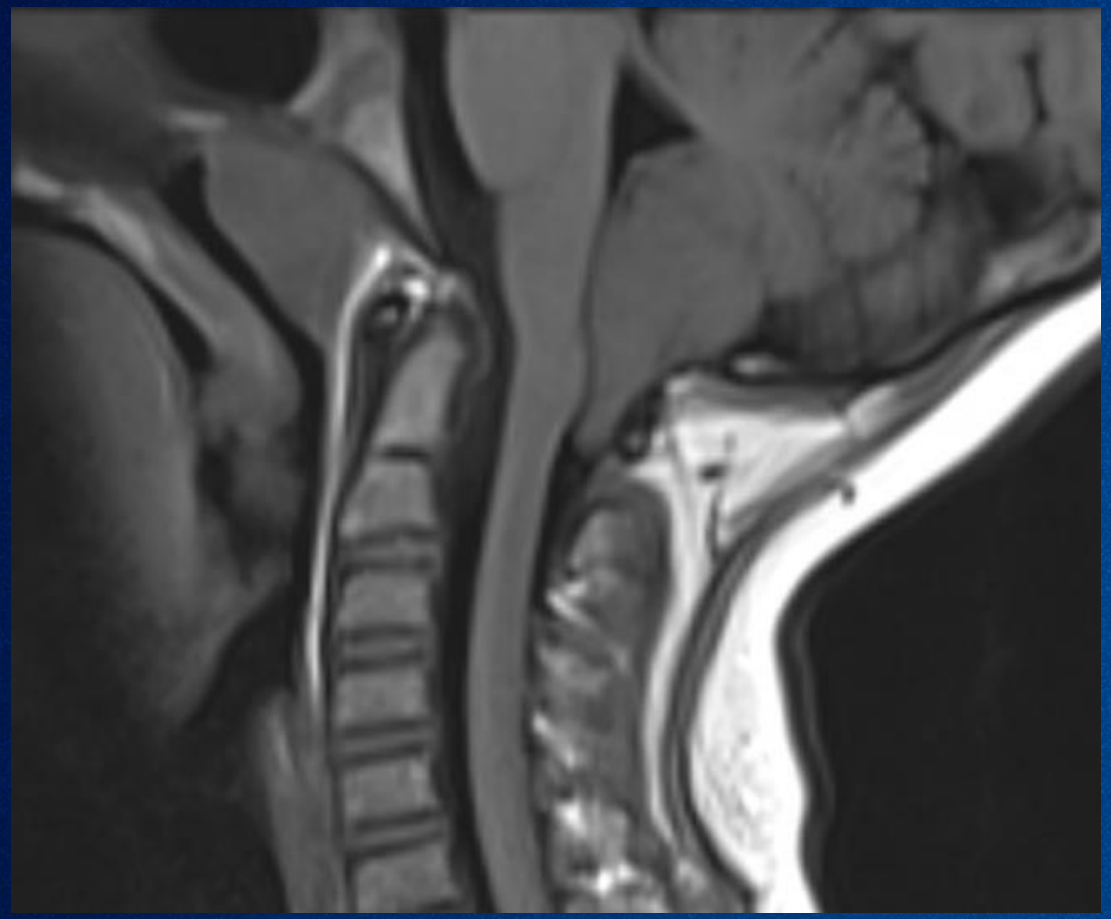
Case #3



- Early onset scoliosis
- ~20-25% chance of intraneural pathology
- Chiari – refer neurosurgery

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Case #4

- 13-year-old female
- 2 years post-menarchal
- TRC closed, Risser 4
- 39 degree right thoracic curve
- Reassuring clinical exam and history

- Typical AIS curve (right thoracic), no growth remaining, curve < 50 degrees
  Observation

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Thank you!

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References

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