Radiographic Approaches to Idiopathic Scoliosis in Young People

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Our Patient: Chief Complaint

- L.K. is a 21-year old woman with a history of scoliosis presenting with a chief complaint of progressive spinal deformity and upper back pain.
- She feels that she is leaning more and more to her left and is concerned about how her posture affects her balance and appearance while walking.
- She also has been having increasingly frequent and severe episodes of pain in her upper back that are worse after lifting heavy items at work.
- She denied any weakness, numbness, or other neurological symptoms.
We will return to our patient after reviewing the classification, workup, and treatment of idiopathic scoliosis.
**Definition of Scoliosis**

- *Scoliosis* is a term coined by the ancient physician Galen from the Greek word meaning “bent”, “crooked”, or “curved.” It refers to curvature of the spine in the coronal plane.

- Distinguished from *lordosis* and *kyphosis*, which refer to curvatures in the sagittal plane, although scoliosis syndromes may involve rotational and sagittal components.

- **Clinical definition**: Lateral curvature of the spine greater than 10 degrees as measured by Cobb method on standing radiograph.
Photograph of Scoliosis

Normal Adolescent

Adolescent with Idiopathic Scoliosis

Diagram: Cobb Method

(1) Determine end-vertebrae of curve, i.e. those at upper and lower borders that slope most to the concavity of the curve

(2) Mark the planes of their endplates: the angle between them is the Cobb angle

(3) To calculate the Cobb angle more easily, mark the perpendiculars to these planes and extend them until they meet; this is equivalent to the Cobb angle

Scoliosis is Classified by its Etiology

- **Congenital**: embryologic or intrauterine maldevelopment of vertebral elements, such as vertebral bodies and disks
  - Although abnormalities will be present at birth, spinal deformity may not become apparent until later in childhood

- **Neuromuscular**:
  - due to neuropathies, myopathies, or mesenchymal disorders
    - E.g. cerebral palsy, muscular dystrophy, Marfan’s syndrome
  - secondary to tissue injury from neoplasm, irradiation, infection, trauma
    - E.g. osteoid osteoma, osteochondroma, neurofibroma
  - Note that some physicians classify mesenchymal and secondary causes under a different category

- **Idiopathic**: diagnosis of exclusion
Idiopathic Scoliosis is Further Classified according to Age

- Age at diagnosis is a predictor of prognosis. It has significant predictive value for:
  - Natural history of curve: progression vs. stability vs. resolution
  - Associated neuraxis abnormalities: e.g. syrinx, Chiari I malformation, tonsillar ectopia

- Idiopathic scoliosis is thus classified according to age:
  - Infantile: 0-3 years
  - Juvenile: 4-9 years
  - Adolescent: 10-17 years
  - Adult: ≥ 18 years

1. Khanna 2009
The Role of Radiography

• Initial diagnosis and workup
  – Degree, type, and location of curve
  – Associated abnormalities and/or secondary causes

• Monitoring
  – Curve progression, resolution, or response to treatment

• Treatment planning and execution
  – Brace fit, screw placement

• May include plain films, CT, MRI, and nuclear imaging
Now we will review how to diagnose scoliosis in young people by physical exam and plain film.
Photograph: Physical Exam
Findings of Scoliosis

• Primary care pediatricians trained to screen for scoliosis
  – Look for asymmetry of shoulders, arms, and hips, or obvious curve to spine

• School screening programs remain controversial¹
  – Rareness of disorder causes low specificity and excess radiation exposure to healthy adolescents
  – Unclear benefit of early detection

Photograph: Use of Scoliometer on Physical Exam

- Adams **forward bend test** allows visualization of **rib hump** due to associated rotation, and often makes coronal curvature more apparent
- May be quantified by a **scoliometer**, which acts like a leveler to assess incline

Use of Plain Films to Diagnose Scoliosis

• Plain films are the modality of choice for screening as well as monitoring progression and response to treatment

• Screening film: Upright PA of entire spine, from cervicothoracic junction (C7) to pelvis, plus lateral spine film to assess sagittal curves
  – Include iliac crests to estimate skeletal maturity
    • some providers prefer to obtain radiographs of hand and wrist for this purpose
  – Use long film cassette to image entire spine on one film
Now we will review the general workup and treatment of idiopathic scoliosis in young people.
Prognostic Factors for Idiopathic Scoliosis

- Prognosis depends on:
  - Patient maturity (chronological age, skeletal maturity, pubertal staging)
    - Curves tend to progress during periods of growth
  - Curve severity, type, and location
  - Associated abnormalities

- Substantial curves may progress even after skeletal maturity and cessation of growth
  - Can eventually lead to cardiopulmonary compromise from restrictive lung pathophysiology
Treatment Options for Idiopathic Scoliosis

• Observation: spine films every 3-8 months
  – 6-8 months generally, but 3 months if curve is substantial and/or patient is undergoing rapid growth

• Physical therapy, chiropractic treatment, electrical stimulation, biofeedback
  – May help with associated symptoms but have not been proven to halt curve progression

• Bracing

• Surgical fusion
A Note on Radiation Exposure

• Retrospective cohort studies have shown that women who undergo radiographic monitoring of scoliosis are at increased risk of breast cancer (1.7-fold risk)\textsuperscript{1} and infertility

• To minimize exposure
  – Minimize lateral views after initial imaging
  – PA views reduce radiation to breast, thyroid, and other vital organs\textsuperscript{2}
    without significantly affecting Cobb angle measurement\textsuperscript{3}
  – Breast and gonad lead shields
  – Consider adjusting physical parameters (e.g. use of high-speed film, filtration to maximize contrast) or using digital radiography\textsuperscript{4}

Photographs: Bracing

• Indicated to halt curve progression in skeletally immature patients and prevent need for surgery

• Typically worn 23 hours per day until skeletal maturity is reached
  - Minor curves may require only nighttime bracing
  - Compliance remains a major issue

• Role of radiography: plain films to assess brace fit and monitor curve progression
• Remains somewhat controversial

Image: 3 views of Boston brace. Source: Author.
Surgery: Aims and Technique

- **Primary aim:** prevent curve progression
- **Secondary aims:**
  - partial curve correction
  - improved associated symptoms, such as pain

- **Technique:** most commonly posterior spinal fusion with segmental instrumentation that allows increased flexibility compared to previous method of rod insertion
Role of Radiography in Surgery

• Bending plain films to assess structural nature of curve and plan instrumentation levels
  – Structural curves persist when patient bends towards convexity of curve
  – Non-structural curves correct when patient bends towards convexity of curve. They are often compensatory and should correct with surgical treatment of non-structural curves

• CT to evaluate vertebral structure and plan screw placement
• Intraoperative plain films to assess screw placement
• Postoperative plain films to monitor outcome
Now we will review each of the age classifications of idiopathic scoliosis and meet some companion patients in each group.
Companion Patient #1: Photograph

Infantile Idiopathic Scoliosis: Age 0-3

- Extremely rare. Most commonly seen in males below 1 year of age

- Most progress minimally and resolve spontaneously.

- Some may progress to significant deformity, which might later compromise pulmonary function. For this reason, it is important to monitor these patients closely.

Companion Patient #2: MRI
Juvenile Idiopathic Scoliosis: Age 4-9

• More common in girls, usually as mild (<15°) precursor to adolescent idiopathic scoliosis

• More moderate/progressive variants are highly associated with neuraxis abnormalities
  – Screening MRI is often recommended: image entire spine from brainstem to sacrum, with and without gadolinium

Companion Patient #3: Plain Film

- 8 year old boy whose pediatrician referred him for x-rays to evaluate suspected scoliosis on physical exam

- Plain film revealed substantial left thoraco-lumbar curve

Image Source: PACS, Children’s Hospital Boston

PA plain film of spine demonstrating scoliosis
Companion Patient #3: MRI

- Given his age, the patient was evaluated for neuraxis abnormalities by MRI, which was unremarkable.
- However, his curve continued to progress, and he was ruled to be a good surgical candidate.

T2-weighted MRI of spine, coronal view

Image Source: PACS, Children’s Hospital Boston
Companion Patient #3: Pre-Surgical Bending Films

- Preoperatively, the surgeon opted to obtain bending films

PA plain film of spine

Right bend view of spine demonstrating some persistence of upper curve

Left bend view of spine demonstrating some persistence of upper curve

Image Source: PACS, Children’s Hospital Boston
Companion Patient #3: Pre- and Post-Op Films

- Surgery was successful and he is recovering well

Pre-op PA plain film of spine
Post-op PA plain film of spine

Image Source: PACS, Children’s Hospital Boston
Adolescent Idiopathic Scoliosis: 
Age 10-17

• Highest incidence of scoliosis is in this age group, and it is the form about which the general public is most aware.
• Chiefly affects girls, and demonstrates a wide range of curve severity and prognosis

Cover art of Judy Blume’s young adult novel *Deenie*, the story of an aspiring model who must wear a back brace for scoliosis

Image Source: www.amazon.com
Now that we are discussing adolescent idiopathic scoliosis, we will return to our original patient.
Our Patient: Past Medical History

- Our patient was diagnosed with scoliosis at age 14, during a trauma work-up after being hit by a motor vehicle.
- School screening the previous year had not detected any abnormalities.
- Due to symptoms of upper back pain, multiple plain films and MRIs were ordered to assess for neuraxis abnormalities. All were unremarkable beyond scoliosis.
- After failure of physical and chiropractic therapy, she was fitted for a Boston brace.
Our Patient: Plain Film

- She presented to a new physician at age 21 with chief complaint of progressive spinal deformity and upper back pain
- Admitted to being non-compliant with bracing, only wearing it at night because she was teased at school
- Radiographs demonstrated Cobb angle of 40°, compared to 25° at age 16

Image Source: PACS, BIDMC

PA plain film of spine demonstrating scoliosis
Our Patient: CT

- After failure of physical and chiropractic therapy, she was ruled to be a good surgical candidate.

- Pre-op workup including CT to plan screw placement, assessing relative sizes of pedicles and endplates.

Image Source: PACS, BIDMC

Non-contrast CT of spine, sagittal view
Surgery was successful at halting curve progression and correcting deformity.
Our Patient: Follow-up

• Unfortunately the patient was struck by another motor vehicle during her recovery period. She still suffers chronic back pain.

“Scoli~band, a Livestrong-styled bracelet designed to show unity among scoliosis patients, healthcare providers, and supporters worldwide.”
We will continue with a discussion of “Red Flags,” i.e. concerning symptoms and signs that warrant further evaluation.
Red Flags

• If a young person with scoliosis presents with any of the following, further radiologic workup is warranted to rule out neuraxis abnormalities
  – Pain
    • May also be due to infection or bony tumors, most commonly osteoid osteoma and osteoblastoma¹
  – Focal neurological findings
  – Rapid curve progression
  – Abnormal curve type (e.g. left thoracic curve)
  – Café au lait spots and axillary freckling (neurofibromatosis)
  – Midline connective tissue changes (spinal dysraphism)
  – Interpediculate widening or pedicle erosion on plain film

¹. Davies and Saifuddin 2009
Companion Patient #4: Plain Film

- 10-year-old girl presented with diffuse back pain
- Plain film showed evidence of minor scoliosis

Image Source: PACS, Children’s Hospital Boston
Companion Patient #4: Bone Scan

- Bone scintigraphy did not show evidence of increased uptake, and she was sent home.
- No MRI was done.

Image Source: PACS, Children’s Hospital Boston

One view from radionuclide bone scan series.
Companion Patient #4: Follow-up

• 5 months later, she presented again with worsening back pain and postural instability

• Repeat plain film demonstrated interpedicular widening

• MRI revealed…
Companion Patient #4: MRI

T2-weighted MRI of spine, sagittal view

meningioma

Image Source: PACS, Children’s Hospital Boston
Companion Patient #4: Follow-up

- Tumor was resected, and she is doing well.

- This patient represents an important cautionary tale: back pain accompanying scoliosis in a child should be taken very seriously.
We will conclude with a summary of the different radiographic imaging modalities used in the diagnosis, work-up, and treatment of idiopathic scoliosis in young people.
Summary: Use of Plain Films and CT in Idiopathic Scoliosis

• Plain Films
  – Calculate Cobb angle and skeletal maturity
  – Modality of choice for screening and monitoring
  – Lateral films to assess sagittal curves
  – Bending films pre-operatively
  – Intra-operative to assess screw placement

• CT
  – Assess vertebral abnormalities
  – Pre-operatively to plan screw placement
Summary: Use of MRI and Nuclear Imaging in Idiopathic Scoliosis

• MRI
  – Rule out neuraxis abnormalities
  – Indicated in young patients, particularly if they present with pain or focal neurological findings

• Nuclear Imaging
  – Bone Scintigraphy to evaluate for infection or neoplasm in young person presenting with pain
Thank you for your attention.
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Sources Cited


