1. What are the most common spinal deformities that require recognition by the clinician?

Traditionally spinal deformities have been classified into those that affect predominantly the coronal plane (e.g., idiopathic scoliosis) and those affecting the sagittal plane (e.g., Scheuermann’s kyphosis). In reality, spinal deformities are complex and simultaneously affect the sagittal, coronal, and axial plane alignment of the spinal column and its relationship to pelvis and thoracic cage. A spinal deformity may result from a pathologic process at a single vertebra level (e.g., spondylolisthesis), or multiple spinal levels (e.g., Scheuermann’s kyphosis), or it may involve the entire spinal column and pelvis due to compromised postural support mechanisms (e.g., neuromuscular scoliosis).

2. Why does the assessment of spinal deformities require a comprehensive assessment of the patient’s health status?

Every facet of human disease is associated with spinal deformities. The etiology of spinal deformities is wide ranging and includes congenital disorders, developmental disorders, degenerative disorders, trauma, infection, tumor, metabolic disorders, neuromuscular disorders, and conditions whose precise etiology remains elusive (e.g., idiopathic scoliosis). Clinical examination is critical for detection of spinal deformities and makes subsequent detailed assessment possible. Radiographs and higher-level imaging studies are required to document the severity and extent of a specific spinal deformity. A spinal deformity may be only one manifestation of an underlying systemic disorder that may affect multiple organ systems.

3. What are the potential consequences of untreated spinal deformities?

The consequences depend on many factors, including age, underlying health status, deformity etiology, deformity magnitude, and the potential for future progression of the deformity during the patient’s lifespan. Potential consequences of untreated spinal deformity may include cosmetic problems, pain, neurologic deficit, postural difficulty, and impairment in activities of daily living. Severe thoracic deformity may impair respiratory mechanics with resultant hypoxemia, pulmonary hypertension, cor pulmonale, or even death.

4. Describe the basic components of the clinical assessment of a patient with spinal deformity.

1. Detailed history:
   - What is the presenting complaint? (deformity? pain? neurologic symptoms? impaired function in activities of daily living? cardiorespiratory symptoms?)
   - When was the deformity first noticed?
   - Is there a family history of spinal deformity?
   - Were there any abnormalities during development?
   - What is the patient’s maturity and growth potential?
   - Has prior treatment been performed?
   - Are there any associated general medical problems?

2. Comprehensive physical exam
   - Inspection. The patient must be undressed to fully assess the trunk and extremities. Assess for asymmetry of the neckline, shoulder height, rib cage, waistline, flank, pelvis, and lower extremities. The patient should be assessed in the standing position and bent forward to 90°. The patient should be inspected from both anterior and posterior aspects as well as from the side. Note any skin lesions (e.g., midline hair patch, sinus tract, hemangiomas, café-au-lait pigmentation). Observe the patient’s gait. Observe body proportions and height.
   - Palpation. Palpate the spinous processes and paraspinous region for tenderness, deviation in spinous process alignment, or a palpable step-off.
   - Spinal range of motion. Test flexion-extension, side-bending, and rotation. Any restriction or asymmetry with range of motion is noted.
   - Neurologic exam. Assess sensory, motor, and reflex function of the upper and lower extremities, including abdominal reflexes.
   - Spinal alignment and balance in the coronal plane. Normally the head should be centered over the sacrum and pelvis. A plumb line dropped from C7 should fall through the gluteal crease.
Spinal alignment and balance in the sagittal plane. When the patient is observed from the side, assess the four physiologic sagittal curves (cervical and lumbar lordosis, thoracic and sacral kyphosis). When the patient standing with the hips and knees fully extended, the head should be aligned over the sacrum. The ear, shoulder, and greater trochanter of the hip should lie on the same vertical line.

Extremities. Measurement of leg lengths and assessment of joint flexibility is performed. Note any contractures or deformities involving the extremities (e.g. cavus feet).

Examination of related body systems. A detailed medical assessment should be performed. Some spinal deformities are associated with abnormalities in other organ systems, especially the nervous system and renal system. Screening for cardiac disorders, vision problems, hearing problems, and learning disorders may be required.

5. What are the most common types of scoliosis?
Scoliosis refers to a spinal deformity in the coronal (frontal) plane. The commonly described causes of scoliosis include:
- Idiopathic
- Neuromuscular (e.g. cerebral palsy, muscular dystrophy, myelomeningocele, Friedreich’s ataxia)
- Congenital: failure of formation (e.g. hemivertebra), failure of segmentation (e.g. congenital bar)
- Neurofibromatosis
- Mesenchymal (e.g. Marfan syndrome, Ehlers-Danlos syndrome)
- Trauma
- Secondary to extraspinal contracture (e.g. after empyema)
- Osteochondrodystrophies (e.g. Morquio’s syndrome, diastrophic dwarfism)
- Infection
- Metabolic (e.g. osteoporosis, rickets)
- Tumor (spinal cord or vertebral column)
- Related to anomalies of the lumbosacral joint (e.g. spondylolisthesis)

6. Describe the assessment of an adolescent referred for evaluation for possible scoliosis.
The patient should be examined with the back exposed (Fig. 7-1). First the patient is examined in the standing position. Then the patient is examined as he or she bends forward at the waist with the arms hanging freely, the knees straight, and the feet together. Findings that suggest the presence of scoliosis include:
- Shoulder height asymmetry
- Scapula or rib prominence
- Chest cage asymmetry
- Unequal space between the arm and the lateral trunk on side to side comparison
- Waist line asymmetry
- Asymmetry of the paraspinous musculature

7. What is a scoliometer? How is it used?
In North America, it is common for children in the 10- to 14-year age group to undergo a screening assessment at school for detection of scoliosis. The Adams test (assessment for spinal asymmetry with the patient in the forward-bending position) is typically used to assess for possible scoliosis. The use of an inclinometer (scoliometer) has been popularized to quantitate trunk asymmetry and help decide whether radiographs should be obtained to further evaluate a specific patient. The scoliometer is used to determine the angle of trunk rotation (ATR). The ATR is the angle formed between the horizontal plane and the plane across the posterior aspect of the trunk at the point of maximal deformity when a region of the spine is evaluated with the patient in the forward-bending position. According to its developer, an ATR of 5° is correlated with an 11° curve and an ATR of 7° is correlated with a 20° curve.

8. How is scoliosis due to leg-length discrepancy distinguished from other types of scoliosis?
Performing the forward-bend test with the patient in the sitting position eliminates the effect of leg-length discrepancy on the spine. Alternatively, evaluation of the patient after placing wood blocks beneath the shortened extremity eliminates the contribution of leg-length discrepancy to pelvic obliquity and scoliosis. Finally, leg-length inequality should be directly quantitated with a tape measure by determining the distance from anterior-superior iliac spine to medial malleolus.

9. What is the significance of painful scoliosis in pediatric patients?
The presentation of painful scoliosis is atypical in the pediatric patient. If pain is present in the pediatric patient with idiopathic scoliosis, it is typically mild, nonspecific, intermittent, and nonradiating. It is typically mechanical (improves with rest), does not awaken the patient from sleep, and does not limit activity. Persistent severe back pain should prompt the physician to further investigate the cause of the patient’s symptoms. Workup (e.g. lateral spinal radiograph, magnetic resonance imaging [MRI], bone scan) is needed to rule out etiologies such as spinal tumor, spinal infection, spondylolisthesis, or Scheuermann’s disease.
Clinical Evaluation of Scoliosis

Anterior superior iliac spine
Umbilicus
Medial malleolus

Measurement of leg length for determination of pelvic obliquity
\[ AB = \text{actual leg length} \]
\[ A'B = \text{apparent leg length} \]

Gauging trunk alignment with plumb line

Measurement of rib hump with scoliometer

Estimation of rib hump and evaluation of curve unwinding as patient turns trunk from side to side

Older sister, severe curve
Younger sister, mild curve
Examination of all siblings to detect early scoliosis

Figure 7-1. A, Clinical evaluation of scoliosis. B, Thoracic scoliosis. C, Thoracic and lumbar scoliosis. (A. Reprinted from The Netter Collection of Medical Illustrations – Musculoskeletal System, Part II, Developmental Disorders, Tumors, Rheumatic Diseases and Joint Replacements, p. 34. ©Elsevier Inc. All Rights Reserved.)
10. **What conditions should be considered in the differential diagnosis of neckline asymmetry or shoulder height asymmetry?**
   In addition to an upper thoracic curvature secondary to idiopathic scoliosis, other conditions that may be responsible for this clinical finding include torticollis, Klippel-Feil syndrome, and congenital vertebral anomalies.

11. **What is Klippel-Feil syndrome?**
   *Klippel-Feil syndrome* refers to a congenital fusion of the cervical spine associated with the clinical triad of a short neck, low posterior hairline, and limited neck motion.

12. **What condition should be considered in a child with limited lumbar flexion and a fixed lumbar lordosis?**
   Lumbar lordosis that is rigid and does not correct when the patient is asked to perform a forward-bend test suggests the possibility of an intrathecal mass (tumor). A workup should be initiated to rule out this possibility, including an MRI of the spine.

13. **What should an examiner assess in the evaluation of an adult patient with scoliosis?**
   In contrast to pediatric patients, it is not uncommon for adult patients with scoliosis to present with back pain. However, the incidence of back pain in the adult population is significant regardless of the presence of a spinal deformity. Thus, it cannot be assumed that symptoms of back pain are necessarily related to the presence of a spinal deformity. Examination of the adult patient should be directed at localizing the painful areas of the spine. Is the pain localized to an area of deformity, or is it localized to the lumbosacral junction? Does the patient have symptoms consistent with spinal stenosis or radiculopathy that warrant further workup with spinal canal imaging studies (MRI and/or computed tomography [CT]-myelography)? Is there evidence of deformity progression or cardiopulmonary dysfunction? There are no short cuts in the evaluation of spinal deformity, and a complete history and physical exam are mandatory.

14. **What is sciatic scoliosis?**
   Pain as a result of lumbar nerve root irritation secondary to a disc herniation or spinal stenosis may lead to a postural abnormality that mimics scoliosis. This condition has been termed *sciatic scoliosis*.

15. **Define gibbus.**
   The term *gibbus* derives from the Latin word for hump. It refers to a spinal deformity in the sagittal plane characterized by a sharply angulated spinal segment with an apex that points posteriorly (Fig. 7-2).

16. **What are the common causes of increased thoracic kyphosis?**
   Thoracic kyphosis is one of the four physiologic sagittal curves in normal people. Many different spinal pathologies can lead to an abnormal increase in thoracic kyphosis. In the pediatric population, increased thoracic kyphosis is commonly associated with Scheuermann's disease or congenital spinal anomalies. In the adult population, a wide range of pathology can manifest as increased thoracic kyphosis. A common cause is osteoporotic compression fractures, which lead to an increased thoracic kyphotic deformity termed *dowager's hump* (Table 7-1).

17. **How are postural kyphosis and kyphosis due to Scheuermann's disease distinguished clinically?**
   Postural kyphosis (postural roundback) and Scheuermann's kyphosis are common causes of abnormal sagittal plane alignment in teenagers (Fig. 7-3). They can be distinguished on clinical assessment by performing a forward-bend test and observing the patient from the side. With postural kyphosis, the sagittal contour normalizes because the deformity is flexible. In kyphosis due to Scheuermann's disease, the deformity is rigid (structural) and does not normalize on forward bending.
18. What is sagittal imbalance syndrome? What are the most common causes?

*Sagittal imbalance syndrome* is a disabling postural disorder characterized by low back pain, forward inclination of the trunk, and difficulty in maintaining an erect posture. The patient attempts to compensate for this abnormal posture by either hyperextending the hips or standing with the hips and knees flexed. This syndrome results from decreased lumbar lordosis with subsequent global imbalance in the sagittal plane. The disorder was initially termed *flatback syndrome* and described in association with the surgical treatment of scoliosis, in which a fusion was performed into the lower lumbar spine in association with distraction instrumentation resulting in loss of normal lumbar lordosis. When a patient with a sagittal imbalance syndrome attempts to stand with the hips and knees fully extended, the head is no longer aligned over the sacrum. The reference line connecting the ear, shoulder, and greater trochanter of the hip lies anterior to an imaginary line drawn upward from the patient’s feet. (Fig. 7-4) Additional causes of sagittal imbalance syndrome include hypolordotic lumbar fusions, deterioration of motion segments proximal or distal to a previous fusion mass, and pseudarthrosis.

19. What additional evaluation is indicated for a patient who presents with a congenital spinal deformity?

Congenital spinal deformities are associated with abnormalities in other organ systems in a significant number of patients. Assessment for associated anomalies is part of the workup of a patient with congenital scoliosis. Associated anomalies of the neural axis (spinal dysraphism) are evaluated with an MRI of the spine. Nonspinal anomalies most frequently involve the renal system may be evaluated with renal ultrasound or intravenous pyelography.

20. Describe the key points to assess during examination of a patient with spinal deformity secondary to neuromuscular disease (Fig. 7-5).

- Assessment of level of function. Can the patient sit independently? Is the patient ambulatory?
- Assessment of general health status. Is there a history of seizures, frequent pneumonia, or poor nutrition?
Figure 7-4. A, Flatback syndrome. B, Normal sagittal plane alignment.

Figure 7-5. Neuromuscular scoliosis. A, Long sweeping curve with associated pelvic obliquity and loss of sitting balance. B, Assessment of curve flexibility.
Evaluation of head control, trunk control, and motor strength. Does the underlying neuromuscular problem result in a spastic, flaccid, or athetoid picture?

Assessment of curve flexibility. Curve flexibility can be assessed by grasping the head in the area of the mastoid process and lifting the patient from the sitting or standing position.

Is pelvic obliquity present? Is it correctable with traction and positioning?

Evaluation of the hip joints for coexistent pathology, including contractures.

Is the patient’s underlying neuromuscular disorder associated with any other organ system problems? For example, Duchenne muscular dystrophy is associated with cardiomyopathy.

Documentation of pressure sores and areas of skin breakdown.

21. What findings may be noted in a pediatric patient with spondylolisthesis?

Spondylolisthesis in children may present with a variety of symptoms and physical findings, depending on the degree of slippage and the degree of kyphosis at the level of the slip. Low back pain and buttock pain are the most common presenting symptoms. Physical exam typically reveals localized tenderness with palpation at the level of slippage. Hamstring tightness is a commonly associated finding. In the most severe cases, the patient is unable to stand erect because of sagittal plane decompensation associated with compensatory lumbar hyperlordosis and occasionally neurologic deficit (Fig. 7-6).

Key Points

1. The key components of the evaluation of a spinal deformity patient are a detailed patient history, comprehensive physical examination, appropriate diagnostic imaging studies, and assessment for potential abnormalities in other organ systems (e.g. renal, cardiac, gastrointestinal, pulmonary).

2. Consequences of untreated spinal deformity include cosmetic problems, pain, neurologic deficit, postural difficulty, pulmonary compromise, and impairment in daily living activities.

Websites


Bibliography