CHAPTER 7

Back Pain

Back pain in children and adolescents is not as common as in adults, but neither is it as uncommon as was previously thought. According to recent studies, more than 50 percent of children experience some back pain by 15 years of age,[17] and up to 36 percent of school-age children experience episodes of low back pain.[4,69] Medical attention is rarely sought for the problem,[4,17,73] though, which contributes to the assumption that back pain is rare in the pediatric population.

The presence of back pain in children and adolescents has also traditionally been associated with an underlying pathologic condition. A 1985 study reported finding a specific diagnosis in 84 percent of children who presented with back pain.[46] However, in a 1995 retrospective study of 226 children evaluated by bone scan for a primary complaint of chronic back pain, a specific cause was established in only 22 percent of cases.[31] Factors associated with establishing specific causes included constant (versus intermittent) pain, male sex, and a brief duration of symptoms.

Generally, young children and toddlers are unlikely to exaggerate symptoms, and a pathologic abnormality can usually be found as the cause of their back pain. But back pain in older children and adolescents, is often more like that in adults than that in very young children. This pattern of back pain in children shows that not all cases must be evaluated with a full array of sophisticated diagnostic studies such as bone scintigraphy, computed tomography (CT), single-photon emission computed tomography (SPECT), magnetic resonance imaging (MRI), and laboratory tests.

However, it is important that all patients with back pain have a careful examination to avoid missing or delaying the diagnosis of serious problems, as many cases are organic.[46,52,54,92] An understanding of the potential causes of back pain will enable the orthopaedist to properly evaluate the patient and treat the problem. The onus is on the orthopaedist to determine which patients are most likely to have a true pathologic cause for their pain and whether they need a complete workup and treatment. The first steps in differentiating these patients from those who need only symptomatic treatment and observation are a comprehensive history and physical examination.

History

A thorough, detailed history provides the clinician with the most important information when evaluating children with back pain.

NATURE OF THE PAIN

First, the nature of the pain—its onset, character, and location—must be determined. Acute pain of sudden onset in the setting of preceding trauma is seen with fractures, ligamentous sprain, disk herniations, and slipped vertebral apophysis or apophyseal ring fractures. Symptoms usually appear within 24 hours. Slow-onset, insidious pain is more characteristic of Scheuermann's kyphosis, benign tumors, and malignancies. Mild pain of short duration following a sports activity is usually due to muscle strain. Recurrent pain associated with specific activities is more likely due to conditions such as spondylolysis, spondylolisthesis, Scheuermann's kyphosis, or a herniated disk, while persistent, unremitting pain and night pain are more often associated with tumors and infections. In general, the longer the pain persists, the more likely it is due to a potentially serious problem. Malignant tumors of the spine and spinal cord may cause persistent back pain that intensifies over time.

The site of the pain and any associated radiation are also important clues to a possible underlying cause. Localized back pain may be due to spondylolysis or neoplasms. Pain in the lumbar region is associated with spondylolysis, whereas thoracic pain may be due to Scheuermann's kyphosis. Inflammatory processes and overuse syndromes usually result in a more diffuse or generalized pain that is felt over a fairly wide anatomic area. Pain that radiates to the buttocks or lower limb may indicate a herniated lumbar disk, vertebral apophysis fracture, epidural abscess, or intraspinal tumor.[19,51]

CONSTITUTIONAL SYMPTOMS

If a patient has coexisting constitutional symptoms such as fever, chills, malaise, anorexia, or weight loss, the back pain may be due to a systemic malignancy (e.g., leukemia) or an infection. Antecedent bacterial or viral infections may indicate pain due to diskitis. The presence of neurologic symptoms such as numbness, weakness, changes in balance or coordination, gait abnormalities, or bowel or bladder dysfunction should be noted, since these symptoms are rarely seen with benign conditions in children.[37]

AGGRAVATING AND ALLEVIATING FACTORS

The physician should ask about factors that exacerbate or relieve the pain. The relationship of pain to an activity is important to recognize. Sports activities that involve repeti-

tive hyperextension of the lumbar spine (e.g., gymnastics, football, dancing, rowing) place shear forces across the lumbar spine and increase the risk of spondylolysis and spondylolisthesis.* Frequent participation at a high level of intensity in sports activity and training can lead to stress fractures or overuse syndromes.[97] Back pain due to spinal neoplasms is constant and progressive and does not vary with activity. Pain that is worse at night, when the patient is supine, or that is not relieved with rest may be due to a malignancy. Night pain has been linked to neoplasms, particularly in young children. Rest usually alleviates pain due to spondylolysis, spondylolisthesis, Scheuermann's kyphosis, muscle strains, or overuse syndromes. Back pain due to osteoid osteoma often is relieved by nonsteroidal anti-inflammatory drugs (NSAIDs).

AGE-RELATED CONDITIONS

Although no disorder is entirely unique to a particular age group, the age of the patient can assist the clinician in the differential diagnosis. Back pain in children less than 4 years old is most likely due to an infection or a neoplasm, which should be promptly diagnosed and treated. Diskitis and vertebral osteomyelitis are more common in children under 10 years of age, and the neoplasms seen in this age group include eosinophilic granuloma, leukemia, neuroblastoma, and astrocytoma.[37] Patients over 10 years of age are more likely to have back pain secondary to trauma or overuse syndromes, which can result in spondylolysis, spondylolisthesis, Scheuermann's kyphosis, disk herniation, or slipped or fractured vertebral apophysis. Spondylolysis and spondylolisthesis are the most common causes of identifiable lumbar back pain in active adolescents.[62] Spondylolysis usually is asymptomatic prior to the adolescent growth spurt. Scheuermann's kyphosis is the most common cause of thoracic back pain in teenagers (with boys affected more often than girls). Lumbar Scheuermann's disease is seen in older adolescents (onset commonly occurs during the adolescent growth spurt), and also is more frequent in boys. Neoplasms associated with older children include osteoblastoma, osteosarcoma, and lymphoma. Tumors such as osteoid osteoma and aneurysmal bone cysts are not specific to any age group.

PSYCHOSOMATIC PAIN

Psychosomatic back pain may be seen in pre-adolescents or adolescents.[4,37,46,84] The clinician should ask whether other family members, friends, or role models of the patient have similar symptoms. The diagnosis of conversion reaction is one of exclusion. Even when conversion reaction is suspected, a complete workup is still called for before a definitive diagnosis of psychosomatic pain is made.

ASSESSMENT OF GENERAL SYMPTOMS

The history should conclude with a general systems assessment in which other medical problems and family history are reviewed. Myriad medical conditions, ranging from the benign to the serious, can manifest with back pain.

*See references 7, 16, 32, 41, 49, 50, 66, 91, 92, 95.

Physical Examination

Proper physical examination requires that the patient disrobe. Socks need to be removed so that the feet can be examined, because neurologic abnormalities may lead to foot deformities such as cavus.

GENERAL INSPECTION

The clinician should start the physical examination by observing the child's general habitus and affect. Patient posture, movement, and gait should be observed, as abnormalities may suggest a neurologic disorder. The skin should be inspected for cutaneous lesions associated with intraspinal disorders, such as midline skin defects (e.g., hemangiomas, sinuses, lipomas, hair patches), café-au-lait spots, and cysts. Midline skin defects and cysts often communicate with deeper nerve structures, and their presence may indicate underlying problems such as a spinal cord abnormality or dysraphism.

ASSESSMENT OF THE SPINE

Next, the clinician should examine the spine by inspection and palpation for posture and alignment. Scoliosis can be detected by having the patient bend forward while standing. The presence of trunk lean or decompensation may indicate underlying pathology such as herniated disks or neoplasms. Spinal flexibility should be assessed. When the child bends forward, reversal of the normal lumbar lordosis should occur. Stiffness, listing, or dysrhythmia during this maneuver is highly indicative of a pathologic cause for back pain (Figs. 7–1 and 7–2). A child with diskitis will bend the knees,

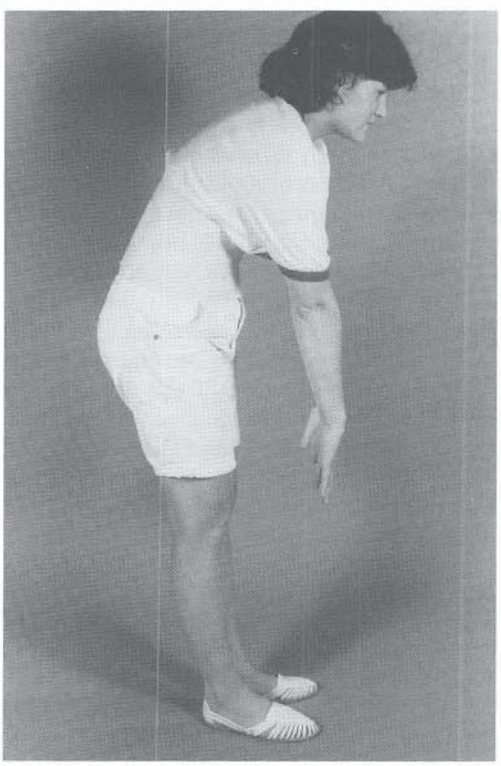


FIGURE 7–1 Adolescent with disk herniation and limited maximal forward bend due to tight hamstrings and sciatica.

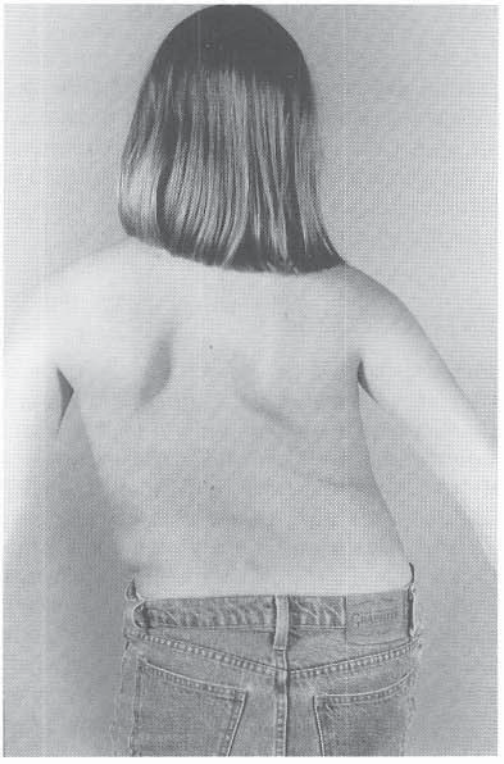


FIGURE 7–2 Adolescent with grade IV L5–S1 spondylolisthesis. Note the olisthetic scoliosis present secondary to pain.

rather than bend over at the spine, to retrieve an object from the floor. Hyperextending the spine while the child is standing on one leg can exacerbate lumbar pain due to pars interarticularis lesions (i.e., spondylolysis and spondylolisthesis). The straight-leg-raising test is used to rule out herniated disks or apophyseal fractures. Children with back pain will often have hamstring tightness, which may be expressed in diminished straight-leg raising or inability to touch the floor with the fingers without bending the knees. The back should be palpated for tenderness, muscle spasms, and anatomic abnormalities. Patients with spondylolisthesis may have an L5–S1 step-off or "heart-shaped" buttocks.

NEUROLOGIC ASSESSMENT

A careful neurologic examination is crucial for diagnosing spinal cord pathology in patients with back pain. Motor and sensory function and deep tendon and abdominal reflexes should be tested. Asymmetric findings should be noted. The presence of long-tract signs should be determined. Clonus or an abnormal Babinski reflex may indicate a central nervous system (CNS) abnormality, such as spinal cord anomaly or compression. The abdominal reflex is tested by stroking the skin in each of the four quadrants of the umbilicus and noting movement of the umbilicus toward the quadrant stroked. An abnormal abdominal reflex may indicate spinal cord pathology. Asymmetry or absence of abdominal reflexes can be associated with syringomyelia.

GENERAL PHYSICAL ASSESSMENT

Finally, a general physical examination is performed to make sure the patient's back pain is not caused by nonorthopaedic conditions such as urinary tract infection, hydronephrosis, ovarian cysts, or inflammatory bowel disease leading to lumbar pain, or pneumonia with chest wall pain.

Diagnostic Studies

The history and physical examination findings will help determine which diagnostic studies are appropriate (Table 7–1). Standard radiographs should be ordered for all children age 4 years or younger with back pain and in older children when the pain has lasted 2 months or longer, when the pain is severe enough to wake the child from sleep, or when the child has coexisting constitutional symptoms. Plain radiographic appearances will guide the clinician in deciding on additional diagnostic studies. At the other end of the spectrum are older children with activity-related pain of short duration and whose neurologic examinations are normal. These patients do not need additional diagnostic workup, and need only be observed for at least 1 month. The extent of additional workup for children who fall between these two groups needs to be decided on an individual basis.

RADIOGRAPHY

Plain radiographs are the best diagnostic screening test for children with back pain.[31,78] The films should be carefully examined for vertebral alignment, disk space narrowing, vertebral end-plate irregularities, vertebral scalloping, and lytic or blastic lesions. Anteroposterior (AP) and lateral views of the spine obtained without shielding are usually sufficient for this purpose. It is important that the pelvis be adequately visualized on plain radiographs, since sacral and pelvic lesions can manifest with back pain. Lesions or stress reactions around the sacroiliac joint may mimic spondylolysis or spondylolisthesis, while lesions around the ischium and greater sciatic notch may cause radicular symptoms.

A lateral view of the spine usually shows the pars interarticularis defect in patients in whom spondylolysis or spondylolisthesis is the cause of back pain. If the film is equivocal, oblique views and a spot lateral film of the lumbosacral junction may better delineate the condition. A coned-down

TABLE 7–1 **Appropriate Use of Diagnostic Studies in the Workup of Back Pain**

- **Plain radiography:** Best diagnostic screening test for children with back pain.
- **Other imaging modalities:** If plain radiographs are equivocal or nondiagnostic but the history and physical examination findings suggest a pathologic cause, more sophisticated imaging modalities should be used:
  - **Triphasic technetium bone scans:** Used in patient with normal findings on neurologic examination.
  - **CT:** Provides the best images of bony anatomy of areas of involvement.
  - **SPECT:** Used when bone scans are equivocal or nondiagnostic.
  - **MRI:** Used in patients with abnormal findings on neurologic examination.
- **Laboratory tests:** CBC count and ESR and/or CRP should be ordered for all young children with back pain, patients with night pain, and any child with coexisting constitutional symptoms.

spot radiograph, which provides greater bony detail, may be ordered to better demonstrate any questionable lesions seen on screening views or to evaluate a specific painful area of the spine.

Although plain radiographs may demonstrate scoliosis in the patient with back pain, the deformity usually does not cause significant back pain. When questioned, up to 33 percent of adolescents with idiopathic scoliosis report some back pain; however, it is usually located over the rib prominence. The finding of scoliosis requires its own workup, but the cause of the back pain remains to be determined. Careful examination of the apex of the curvature on the convex side may reveal a bony lesion, with the spine deviating away from the irritating process.

When plain radiographs are equivocal or nondiagnostic but the history and physical examination findings are highly suggestive of a pathologic cause for the patient's pain, more sophisticated imaging modalities are recommended.

BONE SCAN

A triphasic technetium bone scan is recommended for those patients whose neurologic examinations are normal.[71] Scintigraphy is very sensitive in localizing pathologic processes that affect the bone, such as infection, benign and malignant neoplasms, and stress fractures, which appear as areas of increased uptake of the radioactive material. Bone scans are also of value in assessing the healing process of established lesions. Pinhole collimation may be helpful in localizing increased uptake more readily and in providing better detail around a stress fracture or tumor nidus. Bone scans should cover the entire spine and, as with plain radiography, the pelvis. Scintigraphy is quite sensitive for infection, benign and malignant tumors, and occult fractures; however, it is not specific in defining the precise nature of a lesion.

COMPUTED TOMOGRAPHY

Computed tomography is not used as a screening tool, but the scans provide the best images of the bony anatomy of areas of involvement. Thus, when lesions such as bone tumors and fractures are observed on plain radiographs or scintigraphy, CT is the best imaging modality for further defining the status of the process. Although the lesions can be visualized on MRI, surrounding edema may obscure the precise site or extent of the abnormality. CT can also be used to assess spondylitic lesions in the lumbar spine and to evaluate the healing process in the pars area.

SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY

SPECT, which combines the physiologic data of a bone scan with the localizing ability of CT, is a more precise imaging modality for localizing spinal lesions and for diagnosing spondylolysis and stress fractures in the lumbar spine.[7,12,18,58] SPECT may be used when bone scans are nondiagnostic or equivocal. SPECT has been reported to be more sensitive than scintigraphy in assessing diseases affecting the lumbar spine.[59]

MAGNETIC RESONANCE IMAGING

If the patient's neurologic examination is abnormal, images of the neural axis should be obtained. In the past, CT-enhanced myelography was the modality of choice for imaging the spinal cord. Today, MRI is used more often to evaluate the spinal cord and neural elements. MRI provides more accurate images of spinal neoplasms, syringomyelia, diskitis, herniated disks, and other conditions.

LABORATORY TESTS

Laboratory tests should be ordered for all young children with back pain, patients with night pain, and any child with coexisting constitutional symptoms. A complete blood cell (CBC) count with differential and peripheral smear and the erythrocyte sedimentation rate (ESR) should be obtained as an initial screening study. Assessment of C-reactive protein (CRP) is used to measure an acute-phase reactant, but its specific value in patients with back pain has not been established. Urinalysis may be used to screen for urologic conditions that might be contributing to the patient's symptoms and signs. If a rheumatologic disease is included in the differential diagnosis, the clinician should determine HLA-B27, rheumatoid factor, antinuclear antibody, and Lyme titers.[5,10,52,76]

Differential Diagnoses

MECHANICAL DISORDERS

Muscle Strain. Muscle strain is a relatively common cause of back pain in the adolescent athlete.[41] The duration of the symptoms and a history of antecedent physical activity help in the diagnosis. On physical examination, the pain does not radiate, and neurologic findings are normal. Treatment includes modification of activity, application of ice first and heat later, and NSAIDs. The patient can resume athletic activities when the pain resolves, but special attention should be paid to the training regimen to ensure that the problem does not recur.[41] Muscle strains usually resolve quickly, within several weeks. If the pain persists, radiographs should be obtained to rule out other potential disorders, such as spondylolysis.

Disk Herniation. Although less common than in adults, disk herniation is occasionally seen in children and adolescents.[13,15,30,35] Trauma, either acute or chronic and repetitive, usually is the cause of herniations in this patient population. The patient most often presents with back pain that radiates into the legs. The onset of pain may be either acute or insidious. The pain is exacerbated by activity and sometimes by coughing or sneezing. Lumbar spasms may result in an abnormal gait.

Physical examination will reveal a compromise in spinal mobility, and the patient may list on forward bending. Almost all patients will have a positive straight-leg-raising test (Lasègue's sign). The presence of neurologic signs (e.g., decreased or absent reflexes, numbness, weakness) is observed less frequently in children and adolescents than in adults.[23] A high incidence of other spinal anomalies, such

as transitional vertebra, spondylolisthesis, congenital spinal stenosis, and lateral recess narrowing, have been noted in children with herniated disks.[15,30]

Plain radiographs are usually unremarkable but may occasionally show reactive scoliosis or asymmetric facet orientation at the level of the herniation.[39] The herniated disk can be clearly seen on MRI (Fig. 7–3), and this imaging modality is now preferred over CT myelography. MRI also is very helpful in differentiating herniation from epidural abscess, spinal cord tumor, abnormalities of the conus or cauda, and apophyseal separation.[37,53] Care is advised, though, when interpreting MRI, because false positive findings such as bulging and degenerative disk changes have been noted in asymptomatic adolescents. MRI results need to be carefully correlated with patient symptoms and physical examination findings. CT can help identify congenital lumbar spinal stenosis.

In most cases, patients are initially treated conservatively with restriction of activity, a short period of rest, NSAIDs, muscle relaxants, and physical therapy. However, if the child or adolescent does not respond to this therapeutic approach, improvement can be achieved with surgical diskectomy. Prolonged conservative treatment of a herniated disk has been associated with persistent pain.[23]

Apophyseal Ring Fracture/Slipped Vertebral Apophysis. Apophyseal ring fractures occur at the junction between the vertebral body and the cartilaginous ring apophysis, before complete fusion has occurred.[37] The posteroinferior apophysis avulses from the vertebral body and is displaced into the spinal canal.[90] This injury is seen specifically in adolescents, particularly male weight lifters. It is caused either by acute trauma secondary to rapid flexion with axial compression or by repetitive microtrauma.[90]

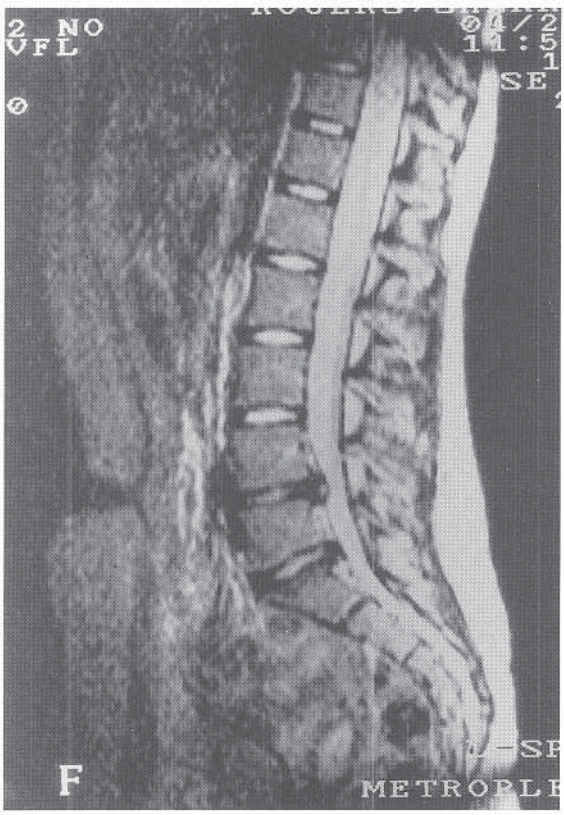


FIGURE 7–3 MRI of herniated disk at L4–5.

The patient usually presents with the sudden onset of back pain that radiates into the legs. The pain is constant and burning in nature and similar to that of a herniated disk, but its onset is more acute. The patient may complain of a stiff back. Neurologic signs usually are not present.

Plain lateral radiographs will reveal a small, triangular piece of bone that represents the avulsed vertebral apophysis next to the vertebral body. The most common site of injury is the posteroinferior apophysis of the fourth lumbar vertebra.[90] It is often difficult to see the bony fragment on plain radiographs; CT can be helpful in identifying it.

Surgical removal of the bony fragment with attached cartilage and disk is the treatment of choice.

Spinal Fracture. Fractures of the spine obviously will cause back pain. If the energy of the injury or the severity of the pain is such that a fracture may have occurred, radiographs should be obtained immediately.

DEVELOPMENTAL DISORDERS

Spondylolysis and Spondylolisthesis. Spondylolysis refers to a defect (stress fracture) in the pars interarticularis, usually located in the lumbar spine. Spondylolysis is most commonly caused by repetitive microtrauma during a child's growth period.[64] The defect is bilateral in approximately 80 percent of cases and unilateral in 20 percent, with defects found at more than one level in 4 percent of patients.[64]

Spondylolisthesis occurs when the pars defects are bilateral at the same level and there is subsequent forward slippage, or subluxation, of the upper vertebral segment on the one below. This most commonly occurs when the fifth lumbar vertebra slips forward on the sacrum.

Spondylolysis and spondylolisthesis are normally caused by repetitive hyperextension of the spine, which causes shear of the posterior elements, and they are most often seen in gymnasts, divers, dancers, and football linemen.* Over time, the continual stresses can result in fracture of the pars interarticularis, with ensuing pain and/or listhesis.

Patients present with low back pain of mild to moderate severity that may radiate into the buttocks or legs. The pain is exacerbated by activity (particularly that involving hyperextension or twisting of the lumbar spine) and is alleviated by rest.

Physical examination may reveal postural changes, particularly flattening of the normal lumbar lordosis if spondylolisthesis has occurred. Hamstring tightness is common, and the patient may walk with a shuffling, stiff-legged gait. Hamstring tightness also will limit the patient's ability to bend forward. Palpation of the paraspinal muscles may elicit pain. In cases of spondylolisthesis where the subluxation is significant, the examiner will be able to feel a step-off at the L5–S1 level. Vertical positioning of the sacrum may result in flattened buttocks, and the patient will often have a protruding abdomen with transverse abdominal creases.

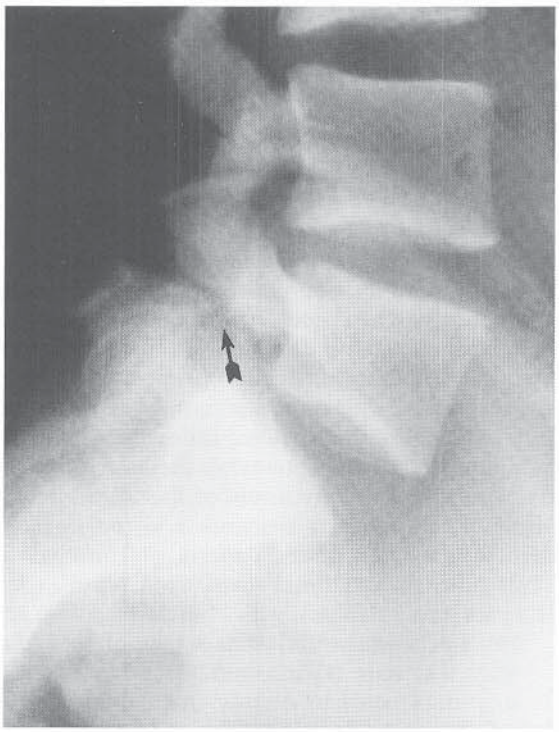
Lateral radiographs may show spondylolysis, but oblique views of the lumbosacral spine can be helpful in less obvious

*See references 7, 16, 32, 41, 49, 50, 66, 91, 92, 95.

cases. The telltale radiographic finding of spondylolysis is a lytic defect in the pars interarticularis. In isthmic defects, this appears as the collar of the "Scotty dog" sign (Fig. 7–4). When plain radiographs are nondiagnostic, scintigraphy is useful in diagnosing the prefracture stage and can help demonstrate an occult pars fracture. Scintigraphy can also help in the evaluation of the healing activity of established lesions. SPECT scans provide superior images of prefractures and occult pars fractures.[12,58] In the prefracture and acute stages, there is increased uptake. As the lysis becomes chronic, this increase in uptake is no longer observed. MRI has been proposed as helpful in the early detection of spondylolysis.[96] Scoliosis may coexist with spondylolysis and spondylolisthesis; however, these curves usually are mild and may appear atypical for idiopathic scoliosis.

Treatment of spondylolysis and type 1 spondylolisthesis (less than 25 percent slip) starts by modifying the patient's activities. The patient is restricted from sports participation until the symptoms resolve. Athletic activities are then gradually resumed, with the individual avoiding activities that result in repetitive hyperextension or twisting of the spine. If the fracture is acute, orthotic management with a low-profile TLSO can alleviate symptoms and aid healing.[64] Additional treatments that may help relieve the pain include rest, NSAIDs, hamstring stretching, and strengthening of the abdominal and paraspinal muscles.

Surgical intervention is indicated if the pain persists despite these conservative therapies. Controversy exists, however, as to whether spondylolysis is best treated with repair of the spondylolytic defect itself or by posterolateral fusion. Surgical treatment of spondylolisthesis depends on the severity of the slip. Surgery is indicated for slips with greater than 50 percent translation, and for milder slips that remain symptomatic despite conservative treatment. The surgical treatment is discussed further in Chapter 13, Other Anatomic Disorders of the Spine.



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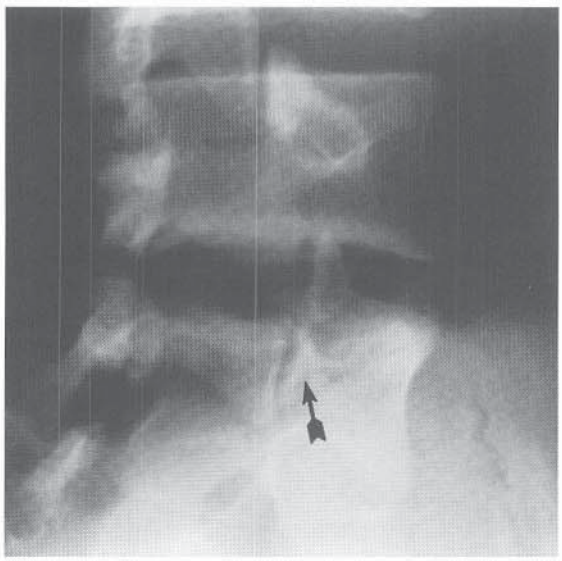

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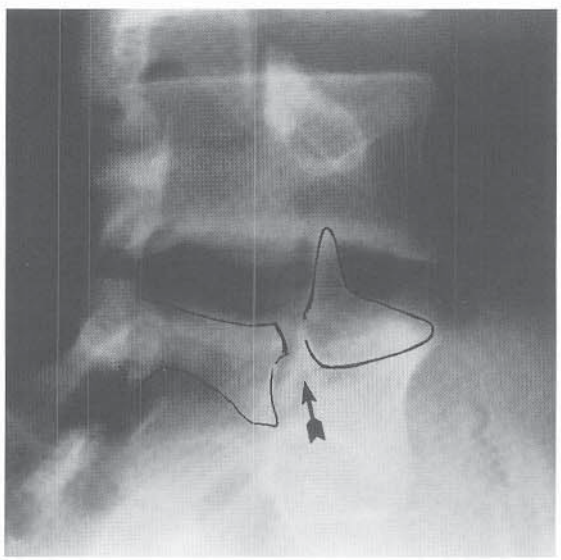

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FIGURE 7–4 **A,** Radiograph features of spondylolysis showing lytic defect (*arrow*) in the pars interarticularis. **B,** In isthmic defects, this appears as the collar of the "Scotty dog" sign. **C,** Collar of "Scotty dog" sign outlined on film.

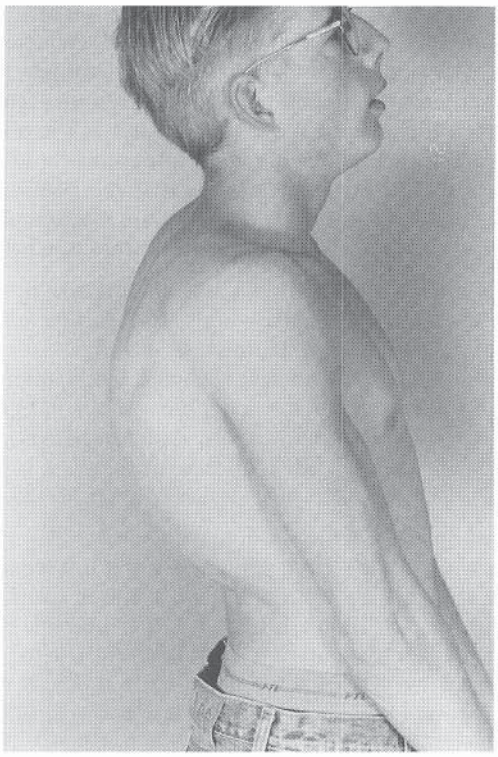


FIGURE 7–5 Increased thoracic kyphosis in a patient with Scheuermann's kyphosis.

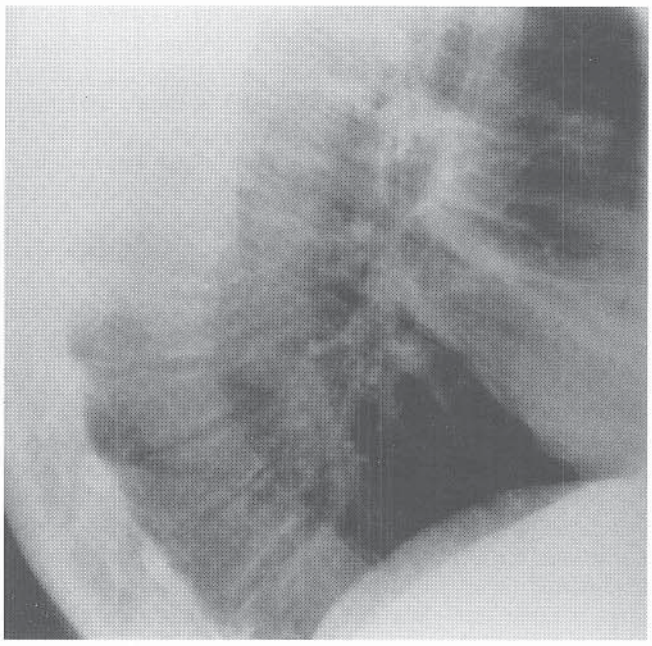
Scheuermann's Kyphosis. Scheuermann's kyphosis is characterized by anterior wedging of three consecutive vertebrae, leading to a kyphotic deformity. Abnormalities in the vertebral end-plates and intravertebral herniation of disk material (Schmorl's nodules) are also seen.

Back pain from Scheuermann's kyphosis is usually localized to the midscapular region at the middle of the kyphosis. The pain, described as aching in nature, usually is exacerbated by prolonged sitting, standing, and physical activity. Often the pain is not severe, and the primary complaint instead is poor posture. There are no associated neurologic or constitutional symptoms.

On physical examination, the clinician will note an increased thoracic kyphosis (Fig. 7–5). The deformity is more obvious on forward bending and does not flatten when the patient performs hyperextension movements or lies supine. Compensatory lumbar hyperlordosis is less obvious but still notable. The patient may have hamstring tightness. The neurologic examination usually is normal.

Radiographic findings (AP, lateral, and supine hyperextension lateral views) include thoracic kyphosis exceeding 50 degrees, and more than 5 degrees of anterior wedging at three adjoining vertebrae (Fig. 7–6).[88] Other findings that may be observed include end-plate irregularities or sclerosis, disk space narrowing, Schmorl's nodules, and anterior defects of the vertebral bodies. Scintigraphy is not necessary in the diagnosis.

Most patients are treated nonsurgically with extension exercises. Patients who still have future spinal growth may benefit from brace treatment during this period. Selective criteria for brace treatment include adequate remaining spinal growth time and flexibility of the kyphosis as demon-



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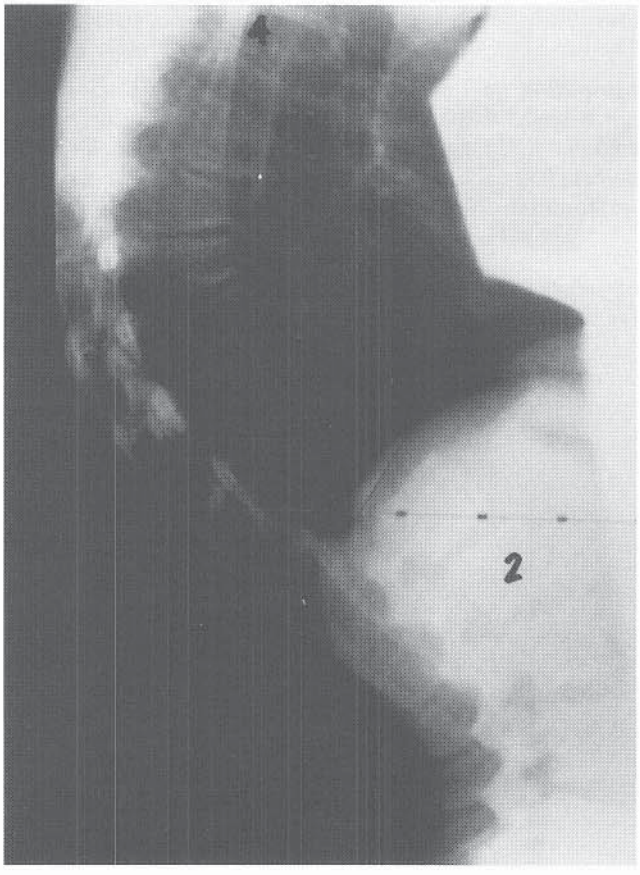

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FIGURE 7–6 **A,** Radiograph of Scheuermann's kyphosis showing thoracic kyphosis and more than 5 degrees of anterior wedging at three adjoining vertebrae. **B,** Radiograph showing thoracic kyphosis and hyperlordosis of the lumbar spine.

strated on stress radiographs. Orthotic management is continued until skeletal maturity. The Milwaukee brace is considered the most effective orthosis for treating Scheuermann's kyphosis.[43,63,83] If the kyphosis is severe and rigid, serial casting prior to brace application may improve the deformity.[24,89] Exercises that stretch the hamstrings and lumbodorsal fascia and strengthen the abdominal muscles may provide symptomatic relief from the pain.

Surgical intervention by spinal fusion is discussed in Chapter 12, Kyphosis. Indications for surgery include kyphosis greater than 70 degrees, progressive deformity, recalcitrant pain, and valid concerns about the patient's appearance.

Lumbar Scheuermann's Disease. Lumbar Scheuermann's disease, a condition similar to Scheuermann's kyphosis, involves the thoracolumbar spine and is thought to be caused by overuse. A strong association has been reported with spondylolysis, believed to be due to compensatory hyperlordosis of the lumbar spine.[68] Microfractures of the vertebral end-plates result in lower back pain. Radiographic findings include end-plate irregularities, disk space changes, Schmorl's nodules, and, occasionally, anterior wedging of vertebrae with loss of lordosis (Fig. 7–7). SPECT scans may show increased uptake at one or two levels.[59] These patients may subsequently experience multilevel disk degeneration.[45] The use of an orthosis often alleviates symptoms.

Idiopathic Scoliosis. Previously, idiopathic scoliosis was not believed to be associated with back pain. However, in a recent study comprising 2,442 patients with scoliosis, 32 percent had back pain.[78] An underlying pathologic condition was found in only 9 percent of the patients with pain. Painful left thoracic curves (which have been linked with intraspinal pathology such as diastematomyelia and syringomyelia) were predictive of pathology. Plain radiographs were most likely to identify bony pathology when present. Careful inspection of the apex of the deformity and the lumbosacral junction (for spondylolisthesis) will occasionally identify a bony lesion. The authors noted that if the patient had a normal neurologic examination and plain radiographs were unremarkable, further imaging studies were not helpful.[78]

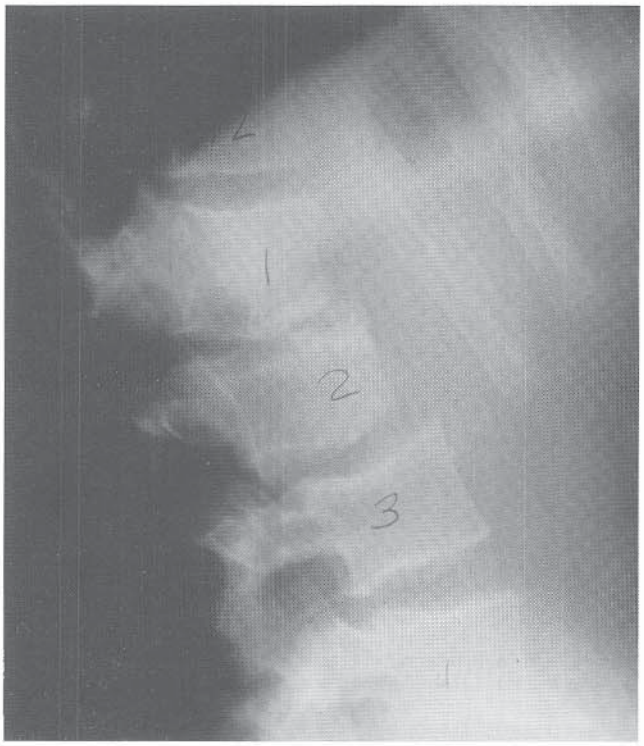


FIGURE 7–7 Radiograph of lumbar Scheuermann's disease showing end-plate irregularities, disk space changes, Schmorl's nodes, and anterior wedging of vertebrae, with loss of lordosis at L1–2.

Syringomyelia. Syringomyelia is characterized by cavitation of the spinal cord involving pathways that carry impulses of pain and temperature sensations. The patient may have atypical, painful thoracic scoliosis. Other findings include headache, neck pain, cavus foot, abnormal gait, and asymmetry of abdominal reflexes. Radiographs may reveal left thoracic scoliosis. MRI of the entire spine is recommended whenever intraspinal lesions are suspected.

Tethered Spinal Cord. Children with a tethered spinal cord may present with low back pain, new-onset or recently progressive scoliosis, spasticity with or without contractures, and a decrease in motor function. Other possible findings include bladder dysfunction and Babinski's sign. Radiographs may reveal diastematomyelia or spina bifida occulta. MRI is required for a definitive diagnosis and typically shows a thickened filum or low-lying conus (L3 or below). Tethered cord release may lead to complete resolution of associated back pain.

Idiopathic Juvenile Osteoporosis. This rare condition normally affects prepubescent children age 10 years or younger.[28,48,60,75,86] The primary presenting symptoms of idiopathic juvenile osteoporosis are back pain, long bone pain due to compression fractures, and difficulty walking.[86] Radiographic findings typically include vertebral compression and multiple growth-arrest lines. This disease must be differentiated from leukemia. The back pain is usually treated symptomatically. For medical management, the patient should be referred to a pediatric rheumatologist.

INFECTIOUS AND INFLAMMATORY CONDITIONS

Diskitis. Diskitis is most often seen in children ages 1 to 5 years, but it can occur at any age. Presenting symptoms and signs vary widely and may include back or abdominal pain, a limp, or refusal to walk. Often the child appears ill, but less than half have a fever. Physical examination reveals decreased range of motion of the spine. When asked to pick up an object from the floor, the child will often refuse to bend to do so and instead will squat down while keeping the lower back straight to prevent spinal motion. Tenderness on palpation may be elicited during the physical examination.

Radiographic changes usually lag behind clinical findings, and radiographs may be unremarkable early in the course of the disease. Subtle narrowing of the involved disk space is the first abnormality seen on plain lateral radiographs of the thoracolumbar spine. End-plate irregularities at the adjacent vertebra may follow (Fig. 7–8). When plain radiographs are nondiagnostic, scintigraphy helps localize the infection by revealing increased uptake across the affected disk. MRI helps localize the lesion and delineates the extent of bone and soft tissue involvement (Fig. 7–9), and can

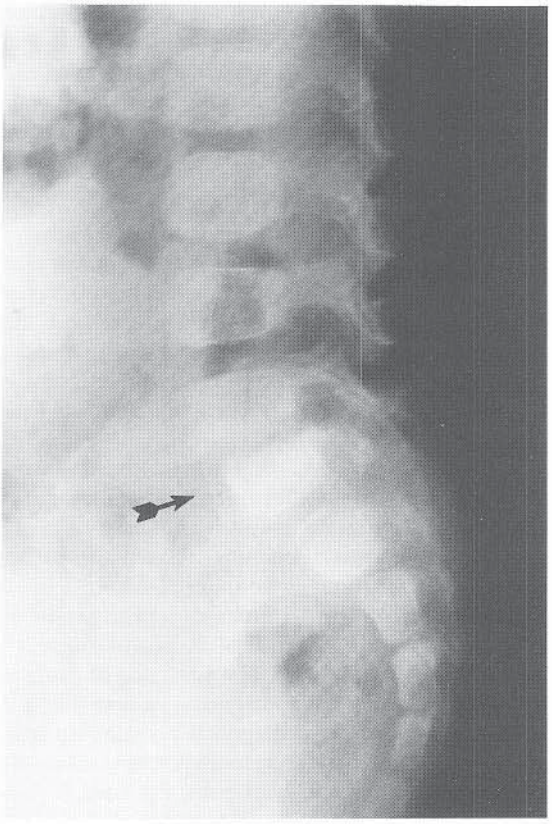


FIGURE 7–8 Diskitis. Subtle narrowing of the involved disk space is the first abnormality seen on plain lateral radiographs of the thoracolumbar spine. End-plate irregularities at the adjacent vertebra may follow.

reveal associated epidural abscesses that need to be surgically drained. Patients with epidural abscesses have, in addition to back pain and fever, conspicuous root symptoms, muscle weakness, and decreased reflexes.[51] In older children it may be difficult to distinguish diskitis from intervertebral disk herniation on MRI.

Laboratory studies are helpful in the diagnosis. An elevated ESR has been reported in over 90 percent of patients with infection of the spine,[37] but the WBC count is less reliable, with one study finding a high-normal count in only 40 percent of patients with established spine infections and an abnormal count in only 10 percent of cases.[79]

The treatment of diskitis has been controversial. Although there is some disagreement as to whether diskitis represents a bacterial infection, most believe it does.[79] When positive cultures of disk space material are obtained, the organism most commonly isolated is *Staphylococcus aureus.* However, because cultures of disk space material are positive in only 60 percent of cases, routine disk cultures are not necessary. Intravenous antibiotic treatment with coverage for *S. aureus* is recommended upon diagnosis.[79,80] Bedrest, casting, or bracing to immobilize the spine have also been advocated in the treatment of diskitis.[20] It is not necessary to perform routine biopsy and debridement. Surgery should be limited to those cases in which the child's condition does not improve after several days of rest and antibiotic therapy, or when an abscess is seen on imaging studies.

Vertebral Osteomyelitis. Distinguishing between vertebral osteomyelitis and diskitis in children can be difficult. Although the two entities were once considered distinct, most clinicians now believe they represent a similar infectious process, with osteomyelitis a continuation of diskitis.[87] When the two disorders converge, the condition is referred to as *infectious spondylitis.*[79] Osteomyelitis results in more significant vertebral bony changes. In otherwise healthy children, *S. aureus* is the most frequently isolated organism, just as in diskitis. Tuberculosis, however, is increasing in prevalence once again, particularly in children from developing countries. Significant radiographic changes, such as bony destruction, kyphosis, and soft tissue abscesses, are usually seen in cases of tuberculous osteomyelitis.

Ankylosing Spondylitis. Ankylosing spondylitis, which affects males more often than females, may manifest with back pain during adolescence. Physical examination will reveal loss of spinal flexibility with inability to reverse lumbar lordosis on forward bending. Other possible findings include abnormal kyphosis and limited chest expansion during deep inspiration. Plain radiographs may show sclerosis, narrowing, blurring, or fusion of the sacroiliac joints. When radiographs are nondiagnostic, MRI is superior to scintigraphy in demonstrating the inflamed sacroiliac joint.[11] Patients with ankylosing spondylitis often have a positive HLA-B27 blood test.

Juvenile Rheumatoid Arthritis. Along with joint pain or stiffness, patients with juvenile rheumatoid arthritis may also have back pain.[33] The cervical spine is affected more often than the thoracic or lumbar spine. However, when a child with rheumatoid arthritis complains of neck or back

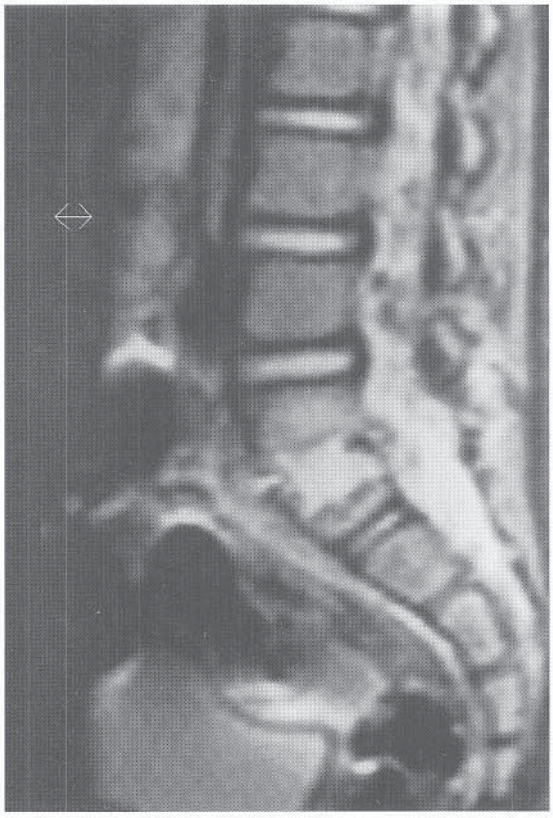


FIGURE 7–9 Diskitis. MRI helps localize the lesion and delineates the extent of bone and soft tissue involvement.

pain, the clinician should perform a thorough examination to rule out other causes of the pain first (e.g., infection, tumor, fracture).

NEOPLASMS

Osteoid Osteoma. Osteoid osteomas, along with osteoblastomas, are the most common benign spinal tumors found in children.[22] When osteoid osteomas involve the spine, they are usually found in the posterior elements—the lamina or pedicle. Patients typically complain of back pain that is worse at night and is alleviated with NSAIDs. Physical examination may reveal a decrease in spinal mobility or mild scoliosis with a list. Neurologic deficits are rare.

It is difficult to identity the lesion on radiographs, and plain films are usually nondiagnostic. The lesion appears radiographically as a small radiolucent area, usually surrounded by sclerosis. Scintigraphy reveals increased uptake in the lesion. CT is the best imaging modality for accurately localizing the nidus within the vertebrae (Fig. 7–10).

Because medication affords some patients relief from associated pain, an initial trial of NSAIDs should be carried out. For most patients, though, osteoid osteomas are treated by complete surgical excision of the lesion, which results in almost immediate relief of the pain. Resection of the lesion by cautious percutaneous CT-guided burring of the nidus has been reported to be successful in resolving symptoms in a few cases.[6] If the associated scoliosis has been present for longer than 15 months, the spinal deformity may persist despite surgical intervention.

Osteoblastoma. Approximately 40 percent of osteoblastomas occur in the spine. Like osteoid osteomas, they usually are found in the posterior elements, but owing to their size they may extend into the vertebral body. Patients may have back pain, but the pain is not as intense as that associated with osteoid osteomas nor is it more severe at night.[14] Because of their size, osteoblastomas (unlike osteoid osteomas) may cause neurologic symptoms such as radiculopathy. Approximately 40 percent of children with osteoblastomas have scoliosis.[14] Plain radiographs often are able to depict the lesion. CT is helpful in localizing the neoplasm and delineating its extent, and in guiding surgical removal. Treatment of osteoblastomas is surgical resection, which is followed by a recurrence rate of approximately 10 percent.

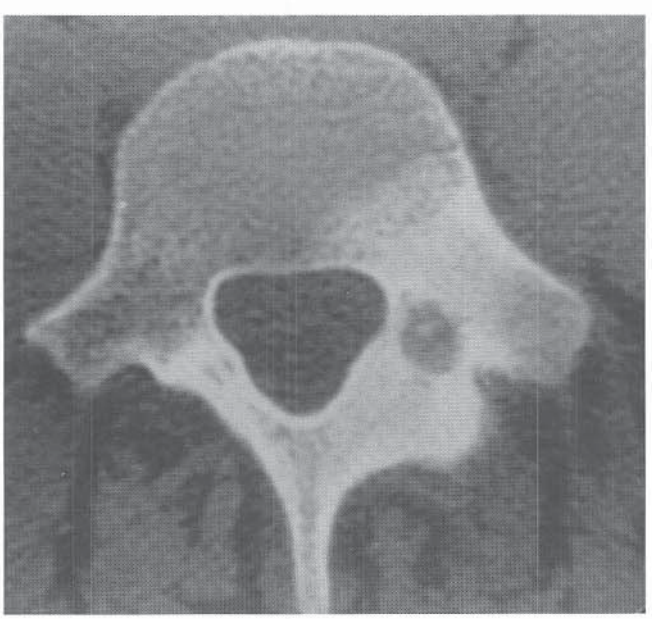


FIGURE 7–10 CT scan of osteoid osteoma in the pedicle of L5.

Eosinophilic Granuloma (Histiocytosis X). Spinal involvement is seen in 10 to 15 percent of children with histiocytosis X. The skeletal lesions may be single or multiple and may be associated with a systemic disorder such as Hand-Schüller-Christian disease or Letterer-Siwe disease (which carries a poorer prognosis). Back pain secondary to eosinophilic granuloma is localized over the affected vertebrae. Usually the patient does not have associated neurologic signs.

Radiographs may reveal lytic lesions within the vertebral body or posterior elements.[34] Larger lesions may cause collapse of the vertebral body, resulting in vertebra plana and the classic coin-on-end appearance. Extensive collapse is generally seen more often in younger children.

The differential diagnosis includes leukemia and infectious processes. Surgical biopsy of atypical lesions is indicated to rule out malignancy. The presence of multiple lesions can help confirm the diagnosis or provide a more accessible biopsy site, if the diagnosis remains unclear.

Because some patients experience spontaneous resolution of their skeletal lesions and back pain, the need for surgery or radiation therapy remains controversial. Pain control usually can be achieved through bedrest or spinal support through immobilization in a brace or cast.[34,81] Some physicians recommend radiation therapy for children who have neurologic deficits.[37] Patients with significant neurologic compromise or multifocal lesions may need surgical debridement of the lesions and spinal stabilization.[34]

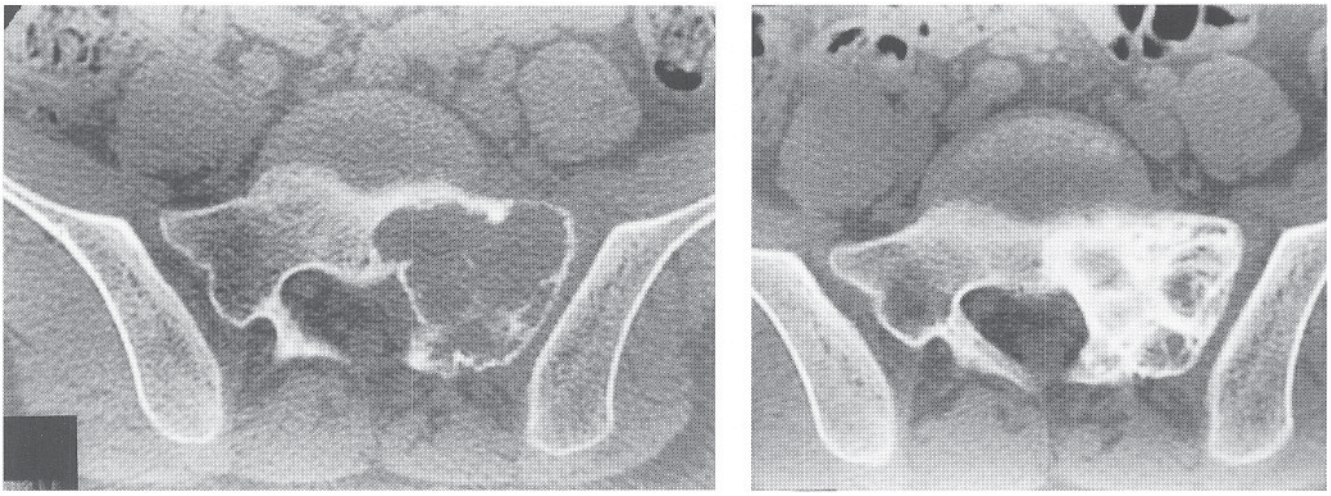
Aneurysmal Bone Cysts. Approximately 15 to 20 percent of aneurysmal bone cysts involve the spine.[1,42,93] Usually the cysts arise in the posterior elements of the spine; however, they can extend into the anterior vertebral column. The associated pain may be due to the tumor itself or to a pathologic fracture.

Radiographs reveal an expansile lucent lesion that may have a "bubbly" or "blown-out" appearance. CT can further delineate the extent of the cyst and demonstrate the thin rim of surrounding bone (Fig. 7–11).

Aneurysmal bone cysts of the spine are treated by surgical curettage and bone grafting.[2,26] Postoperative recurrence is not unusual,[3,93] with a 10 percent rate reported.[70] Because the lesions are extremely vascular, preoperative angiography with Gelfoam embolization can decrease the amount of intraoperative blood loss.[1,8,21,26,29,55,94] Spinal cord monitoring is advised during embolization, as neurologic injury has been reported.[9,27] Cases of definitive treatment with repeated embolization have been reported.[25,38,56,77]

Malignancies

ACUTE LYMPHOCYTIC LEUKEMIA. Leukemia is the most common malignancy producing back pain. In approximately 6 percent of children with acute lymphocytic leukemia, the presenting complaint is back pain.[82] To make the correct diagnosis requires a high level of suspicion. The clinician should look for constitutional symptoms (fatigue, lethargy, pallor,



A B

FIGURE 7–11 CT scans of aneurysmal bone cyst involving the sacrum. **A,** Scan delineates extent of the cyst and demonstrates the thin rim of surrounding bone. **B,** Scan shows improvement in the cyst after embolization.

bruising, bleeding, anemia, fever) that indicate the presence of a systemic condition.

Radiographic findings, when present, include osteopenia, vertebral body compression, and metaphyseal leukemic lines.[61,82] Vertebral compression fractures have been reported in 7 percent of patients with acute lymphocytic leukemia.[44]

Laboratory findings that help support the diagnosis include an elevated peripheral WBC count, decreased platelet count, anemia, and increased ESR. Counts may be normal, but inspection of the peripheral smear can pick up some cases. Laboratory abnormalities can be subtle,[61] so clinical suspicion must be high. Bone marrow aspiration is required for a definitive diagnosis.

Chemotherapy is used to treat the malignancy. Spinal bracing may provide symptomatic relief, permit repair of collapsed vertebrae, and deter future fractures from occurring.

SPINAL TUMORS. Primary tumors that originate in the spine include Ewing's sarcoma, osteogenic sarcoma, and chordoma. More than half of children with spinal tumors and canal compromise have back pain, with sarcomas most often associated with pain.[19]

Osteosarcoma is the second most common primary malignant bone tumor, but it rarely affects the spine.[85] When the spine is involved, the lesion usually is located at the thoracic or lumbar level. Radiographs may show osteolytic, osteoblastic, or mixed lesions. CT and MRI are required for staging the tumor. Because adjacent structures usually are involved, osteosarcomas are difficult to treat.

The sacrum is the most frequent site of Ewing's sarcoma of the spine. The most common symptom is relentless back pain, with 58 percent of patients having neurologic deficits.[40] Radiographs may reveal an expansile lesion and, as the disease progresses, vertebral collapse. MRI is helpful in delineating the entire lesion and any soft tissue involvement. Treatment of spinal sarcomas is discussed in Chapter 38, Malignant Bone Tumors.

SPINAL METASTASES. The spine is the most frequent site of skeletal metastases, with neuroblastoma the most common primary cancer responsible for skeletal metastases in children.[57] Neuroblastomas most often metastasize to the thoracic spine. Radiographs reveal diffuse vertebral involvement. Rhabdomyosarcoma frequently involves the spine, with radiographs revealing osteolytic lesions.[57] Another commonly occurring neoplasm giving rise to spinal metastases is Wilms' tumor.

SPINAL CORD TUMORS. The most common spinal cord tumors in children are astrocytomas and ependymomas. Children may have a history of incontinence even though they are toilet trained, abnormal gait, or delayed motor skills. The patients may also have back pain, scoliosis, and weakness of the lower extremities.[65,67,72,74] Physical examination may reveal asymmetry on forward bending and hamstring tightness. Radiographs may show thin or absent pedicles, widening of the intervertebral foramen, and scoliosis with rotation. Spinal cord tumors are best visualized on MRI.

MALIGNANT NEUROFIBROSARCOMA. Malignant degeneration of neurofibromas into neurofibrosarcoma can occur in children with neurofibromatosis.[36]

INTRA-ABDOMINAL AND INTRATHORACIC CAUSES OF BACK PAIN

A number of different intra-abdominal and intrathoracic conditions can cause referred back pain in children. These include inflammatory bowel disease, hydronephrosis, urinary tract infection, and ovarian cysts. Visceral referred pain usually is not affected by motion or alleviated by rest; it tends to be more constant and worse at night. Pain associated with the menstrual period is rarely due to orthopaedic causes. Pneumonia may cause thoracic back pain. It is imperative that the clinician rule out these possible causes during the history and physical examination.

PSYCHOSOMATIC BACK PAIN (CONVERSION REACTION)

In most children, a specific underlying medical condition usually can be found as the cause of back pain. There are

cases, though, in which a thorough evaluation will result in a negative diagnosis. Any type of back pain may be influenced by psychosocial problems and conflicts. These factors will alter the patient's perception, behavior, and relating of structurally mediated pain, as well as the resultant degree of dysfunction, disability, and response to treatment.

The diagnosis of psychosomatic pain is one of exclusion, though, and should only be made after all other possible causes of back pain have been excluded. Psychosomatic back pain is seen more often in older adolescents than in younger children. A detailed history often reveals social strife within the family, or other family members with similar complaints of back pain.[4,84] Successful treatment of psychosomatic back pain usually requires a multidisciplinary approach, with treatment and counseling provided by a team of physicians, psychologists, and physical therapists.

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