Back Pain in Children and Adolescents: Evaluation and Differential Diagnosis

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Abstract

Back pain in children and adolescents usually has a recognizable organic origin. The most common entities seen are spondylolysis, spondylolisthesis, Scheuermann's kyphosis, disk herniations, infections, and tumors. Early recognition and treatment can provide patients the best chance at relief of symptoms and eradication of the underlying disease process. The goals of this review are to (1) familiarize the clinician with the various diagnoses associated with back pain in the skeletally immature patient and (2) to assist the clinician in making the appropriate diagnosis by providing a rational method of selecting diagnostic tests that maximize specificity and minimize costs.

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Today's orthopaedist must have a basic understanding of the causes of back pain in children and adolescents in order to either evaluate and treat the problem or refer the patient appropriately. This review provides a detailed discussion of some of the more common conditions associated with back pain, with special attention to incidence, history, physical findings, and diagnostic tools, as well as a brief discussion of treatment modalities currently recommended. Armed with this information, the clinician should be able to construct an efficient and economical diagnostic and treatment approach. More important, the orthopaedist should also be able to avoid missed or delayed diagnoses of serious problems.

Epidemiology

Although the prevalence of low back pain in children and adolescents is far less than in the adult population, as many as 36% of school-age children report experiencing low back pain, and 7% seek medical attention.[1] It is important to evaluate all patients carefully, as in many cases an organic cause for their pain will be found.[2]

History

A thorough history is often hard to obtain in pediatric patients. The presence of the parents or guardian is important when patients are too young to give an accurate history. The physician should seek to determine the nature of the onset of pain. Was the pain acute, with a clear history of antecedent trauma, as seen in disk herniations and apophyseal ring fractures, or was it insidious, as in Scheuermann's kyphosis and malignant conditions? A history of pain radiating to the buttock or posterior aspect of the thigh is more characteristic of a lumbar herniated nucleus pulposus (HNP) than is radiation of pain below the knees, which is indicative of an epidural abscess or an intraspinal tumor.[3,4] Duration of pain greater than 4 weeks is often a sign of a potentially serious problem.

The presence of neurologic signs and symptoms is very unusual for benign conditions in children. The physician must ask about gait abnormalities (e.g., a stiff-legged gait may indicate spondylolisthesis), trunk list (a sign of HNP), or foot deformities (which may signify intraspinal anomalies or tethered cord). Bowel or bladder dysfunction should be noted. A history of unexplained fever, weight loss, or malaise should raise the suspicion of a systemic malignant condition, and recent bacterial or viral infections may suggest a diagnosis of diskitis.

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The physician should inquire about aggravating or alleviating factors. Is the pain exacerbated by certain activities (most typical of Scheuermann's kyphosis, HNP, spondylolysis, and spondylolisthesis)? Is the pain worse at night or when the patient is supine or it is unrelieved by rest (suggestive of malignant neoplasm)? Is the pain more intense when the patient is prone (possibly a sign of epidural abscess)? Is the pain relieved by nonsteroidal anti-inflammatory drugs (NSAIDs), as may occur with osteoid osteoma? Has the patient been involved in any activities, such as football (as a lineman), gymnastics, or swimming, that have been associated with an increased risk of spondylolysis? Has the patient been doing heavy farm work, shoveling, or weightlifting (which may suggest Scheuermann's kyphosis)? Has he or she recently started a new sport or activity or had to stop a previously enjoyed activity because of pain? Finally, has there been recent familial unrest, increasing school difficulty, or a history of litigation? The responses to these few questions, combined with a complete physical examination, should provide the interviewer with an accurate differential diagnosis.

Physical Examination

The physical examination should be conducted with the patient completely disrobed except for an examination gown and underwear. The socks should be removed to examine for foot abnormalities. The patient's general habitus and affect should be observed first. Is there appropriate eye contact between the patient and the examiner? Cachexia or pallor should be noted as a potential sign of an underlying malignant or nutritional disorder. The skin should be examined for the presence of hemangiomata, hair patches, or midline defects suggestive of an intraspinal disorder. Gait should be assessed, with notation of standing posture, balance, the Trendelenburg sign, and pelvic obliquity. The presence of a limp or ataxia may be the first sign of an intraspinal disorder.

The spine should be examined for scoliosis and kyphosis. An L5-S1 stepoff or heart-shaped buttocks may be the clue to underlying spondylolisthesis. The Adams forward-bending test should be used to document any reversal of spinal rhythm, trunk deviation, rib or lumbar prominence, or limitation of forward flexion, which is a sign of hamstring tightness. The back should be palpated for posterior-element, paraspinal-muscle, or costovertebral-angle tenderness. The straight-leg-raising test will reveal HNP and apophyseal fractures if present and can also be used to evaluate hamstring tightness. Also essential is a complete neurologic examination, including motor and sensory function, deep tendon and abdominal reflexes, and long-tract signs, such as the Babinski and clonus tests.

Diagnostic Studies

The diagnostic tests used to evaluate the causes of back pain are based on the level of severity of symptoms and physical findings. Effective and cost-efficient guidelines for the use of diagnostic studies have been proposed by Wenger[5] (Table 1).

Differential Diagnosis

Although no disease entity is absolutely specific to any one age group, some generalizations can be made to help arrive at the most likely diagnoses. Diskitis and vertebral osteomyelitis are more common in children under the age of 10 years. Neoplastic conditions in this age group include eosinophilic granuloma, leukemia, neuroblastoma, and astrocytoma. Idiopathic juvenile osteoporosis is also more common in this age group.

In patients over the age of 10, disorders involving repetitive loading or trauma, such as spondylolysis, spondylolisthesis, Scheuermann's kyphosis, herniated lumbar disk, and apophyseal ring fracture, occur more frequently. Tumors more common to this age group are osteoblastoma, osteosarcoma, and lymphoma. Other tumors, such as osteoid osteoma and aneurysmal bone cysts, are not age-specific. Psychogenic back pain, conversion reactions, and overuse syndromes may be seen in the preadolescent and teenager.

Spondylolysis and Spondylolisthesis

"Spondylolysis" is the term used to describe a defect in the pars interarticularis, usually affecting the lumbar spine. If defects are bilateral at the same level, the upper vertebral segment may slip forward on the lower segment, which is referred to as "spondylolisthesis." This is one of the most common causes of back pain in the adolescent (47% incidence in adolescent athletes complaining of back pain[6]). The overall prevalence has been reported to range from 4.4% in children aged 6 to 6% in adults.[7] Spondylolysis is rarely symptomatic before the adolescent growth spurt.

The etiology of spondylolysis depends on the type of defect seen. The isthmic defect, the most common in this age group, has been attributed to a stress fracture of the pars from repeated hyperextension,

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causing shear of the posterior elements. The fifth lumbar vertebra is affected most often, followed by the fourth and the third. There is an increased incidence in participants in sports associated with repetitive flexion-extension activity, such as gymnastics.[8] There is a strong association with thoracolumbar Scheuermann's disease, with up to a 50% coassociation with spondylolysis, thought to be secondary to the compensatory hyperlordosis of the lumbar spine.[9] The dysplastic type is much less common and is caused by a congenital deficiency of the inferior facets of L5 and/or the superior facets of S1 and elongation of the pars, allowing forward translation of L5 on S1.

The back pain in spondylolysis or spondylolisthesis is usually lumbar and mild to moderate in severity. The pain may radiate to the posterior aspect of the thighs and buttocks, is aggravated by repetitive flexion/extension maneuvers, and is relieved by rest. The classic gait in this condition is stiff-legged, with a short stride length due to tight hamstrings, often referred to as the "pelvic waddle." Hamstring tightness also limits forward bending. There may be pain on palpation of the paraspinal muscles. If the slip is severe, a stepoff can be felt at L5-S1. The buttocks have a heart-shaped configuration owing to the vertical position of the sacrum, and the abdomen is protruding, with transverse abdominal creases.

The anteroposterior and lateral radiographs will establish the diagnosis in most cases of spondylolysis when the defect is bilateral. Oblique films of the lumbosacral spine will usually demonstrate the pars abnormality, depicted as the collar of the "Scotty dog" sign in isthmic defects and the "greyhound sign" indicating an elongated pars in dysplastic spondylolysis. This pars defect is unilateral in 20% of cases and occurs at more than one level in 4%.[10]

If standard radiographs are nondiagnostic, a technetium bone scan will delineate an acute lesion within 5 to 7 days of the onset of symptoms. The bone scan can also be used to assess the healing activity of established lesions. In cases of unilateral defects, it may demonstrate increased uptake in the contralateral pars, indicative of a stress reaction.

Single-photon emission computed tomography (SPECT) has recently been useful in cases in which positive factors and symptoms (e.g., athletic patient, persistent back pain, tight hamstrings) exist in the absence of radiographic and scintigraphic findings. This study has been shown to be the most sensitive method of diagnosing stress reaction or spondylolysis, making possible early intervention to prevent a stress reaction from becoming established lysis.[11]

The treatment of spondylolysis and type I spondylolisthesis (<25% slip) associated with a history of recent injury and short duration of symptoms involves restriction of the aggravating activity and a muscle-strengthening regimen for the back and abdomen. Healing can be monitored by the resolution of back pain and hamstring tightness. If this does not occur and the bone scan shows increased uptake in the area of the fracture, a program of bed rest, NSAID therapy, and immobilization in a thoracolumbosacral orthosis or cast should relieve symptoms.

A 73% rate of healing of early defects has been shown with the use of lumbosacral support only.[10] With an established symptomatic spondylolysis without spondylolisthesis

and a "cold" bone scan, primary repair of small defects (<7 mm) with internal fixation across the pars defect and bone grafting has been successful in relieving back pain at levels proximal to the lumbosacral junction (Fig. 1).

Asymptomatic patients with slips ranging from 25% to 50% should be followed up with spot lateral radiographs until the end of growth[12] and cautioned that participation in contact sports may have to be restricted if progression occurs. Although Seitsalo et al[13] showed that 90% of slip progression had already occurred at the time of the first radiograph, mild slips in preadolescent patients may progress during the adolescent growth spurt and should be followed closely. These authors also showed that the only radiologic finding predictive of progression was a slip percentage of more than 20% at initial presentation.

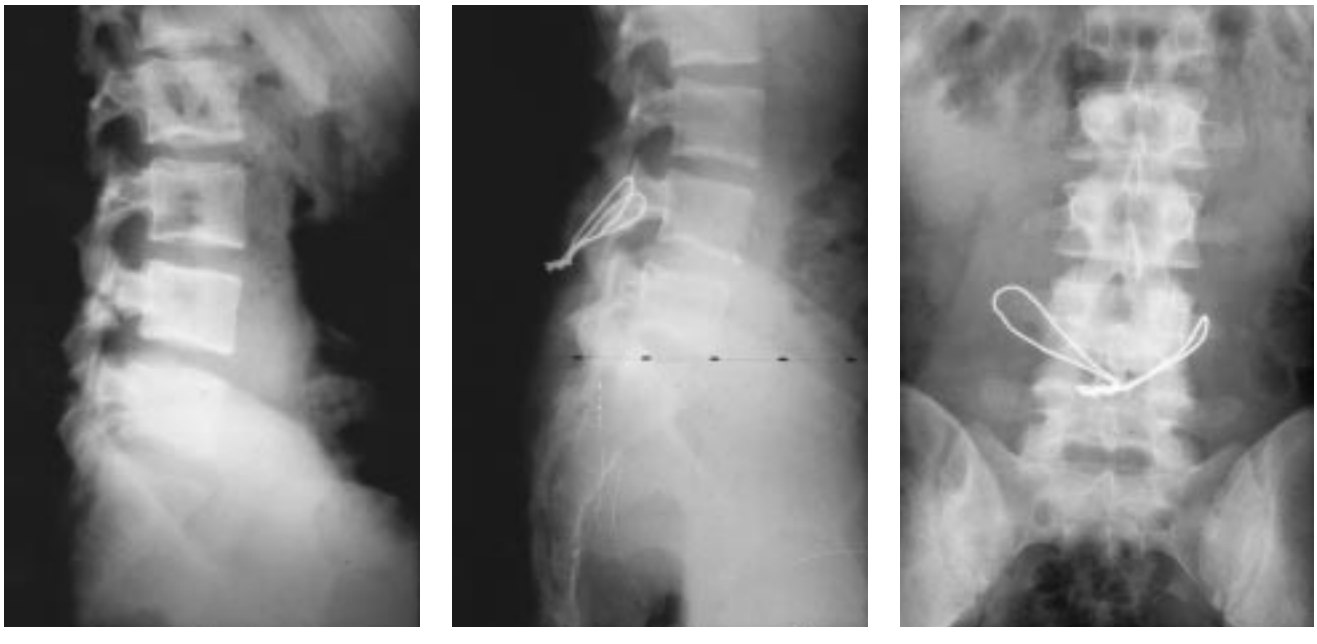
In situ posterolateral fusion without instrumentation is the procedure of choice for patients who have progressive slips, persistent back pain, neurologic deficits, or spondylolisthesis greater than 50%. Fusion from L5 to S1 is recommended for symptomatic slips less than 50%; fusion from L4 to S1, for slips greater than 50%. After successful arthrodesis, pain and hamstring spasm are reduced in 90% of patients.

Reduction of the slip remains a controversial topic. Currently, an indication for reduction and fusion would be a sagittal imbalance that is functionally debilitating, a high-grade slip that is cosmetically unacceptable, or a neurologic deficit necessitating laminectomy that would jeopardize the success of fusion by accelerating translation. Reduction can be achieved in a closed fashion by pelvic extension followed by spica pantaloon casting after in situ fusion. This method reduces the lumbosacral kyphosis and the risk of subsequent slip progression.[14]

Reduction with modern instrumentation techniques may be the frontier of spondylolisthesis surgery. Transpedicular fixation allows distraction, sacral rotation, and posterior translation of the lumbar spine, but has been associated with a higher frequency of lumbar nerve-root injuries than closed techniques. As experience with these techniques increases, complication rates should decline.

Scheuermann's Kyphosis

Scheuermann's kyphosis is a well-described disorder of endochondral ossification that affects the vertebral endplates and ring apophyses and results in intravertebral disk herniation, anterior wedging



A B C

Fig. 1 **A,** Preoperative lateral radiograph of patient with bilateral spondylolysis at L4. Defect measures 3 mm. **B,** Postoperative lateral radiograph after internal fixation of bilateral defect and bone grafting. **C,** Postoperative anteroposterior radiograph.

of consecutive vertebrae, and a fixed thoracolumbar kyphosis. This disorder may account for as many as a third of all instances of back pain as a presenting symptom in pediatric patients.[2] The prevalence has been estimated to be 0.4% to 8% of the general population. The condition mainly affects adolescents at puberty, with an equal male-female distribution.

A familial predilection has been theorized. Among the many causes that have been proposed are disordered endochondral ossification of the endplates, vertebral osteoporosis, and avascular necrosis of the ring apophysis. Increased height and repetitive loading may be inciting factors.

The pain in Scheuermann's kyphosis generally occurs at the apex of the curve and is usually aggravated by prolonged sitting, standing, and activity. Poor posture may be the reason for the initial presentation; this disorder must be differentiated from postural round back, which may also be associated with back pain. Patients with Scheuermann's kyphosis will have a sharp kyphotic deformity in the thoracic spine that is exacerbated by forward bending. The kyphos does not flatten when the patient lies supine or performs hyperextension maneuvers, as it does with postural round back. The patient with Scheuermann's kyphosis is often well muscled and may have hamstring contractures.

Pain at the thoracolumbar junction has been associated with lumbar Scheuermann's disease, which affects mainly young males who do heavy labor or are competitive athletes. The onset often occurs after lifting heavy weights from a flexed position. There may be no clinical deformity in lumbar Scheuermann's disease.

The diagnosis of Scheuermann's kyphosis is confirmed by radiographs (anteroposterior, lateral, and supine hyperextension lateral films) that show thoracic kyphosis greater than 45 degrees, 5 degrees of anterior wedging of the three adjacent vertebrae at the apex of the kyphos,[15] Schmorl's nodes, and endplate irregularities. In lumbar Scheuermann's disease involving the T10–L5 vertebrae, additional findings may include narrowing of the intervertebral disks, and anteroinferior or anterosuperior "scoop" defects of the vertebral bodies (Fig. 2). Bone scans are usually not needed to diagnose thoracic Scheuermann's disease, except to rule out spondylolysis or diskitis as the cause of pain. In lumbar Scheuermann's disease, a SPECT study may show increased uptake at one or two levels. This imaging modality has been shown to be more sensitive than bone scanning in evaluating lumbar disease.[16]

The treatment of postural round back and mild kyphosis (<50 degrees) involves thoracic-extension and abdominal-strengthening exercises. For a patient with true Scheuermann's kyphosis, an initial trial of exercise, stretching, and cessation of heavy lifting should be implemented. The back pain in Scheuermann's kyphosis usually resolves by the end of growth.

If the kyphotic curve measures more than 70 degrees and the patient is skeletally immature, a thoracolumbosacral orthosis for lumbar disease or a Milwaukee brace for thoracic disease should be prescribed. Improvement in wedging has been shown after 18 months of use. The orthosis is worn until skeletal maturity. According to a recent natural history study of Scheuermann's kyphosis, patients treated conservatively may have more pain at the apex of the curve as adults, but their quality of life should not be affected.[17]

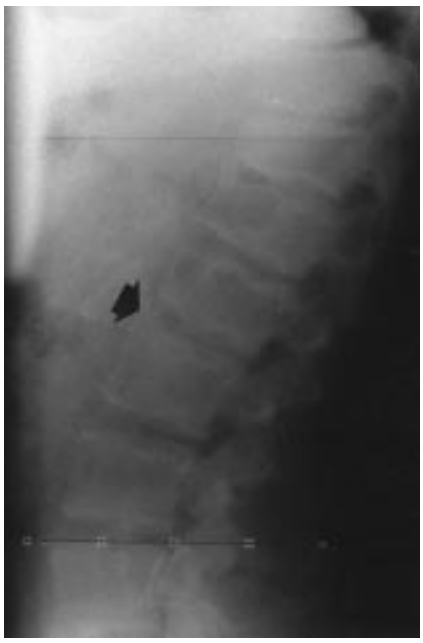


Fig. 2 Lateral radiograph of an adolescent boy shows typical findings associated with lumbar Scheuermann's kyphosis, including anterior wedging, disk-space narrowing, Schmorl's nodes, and anterior scoop defects (arrow).

Surgery may be indicated if the curve is greater than 75 degrees and the patient is symptomatic. Restrictive lung disease is usually not seen with kyphosis of less than 100 degrees. If the curve is rigid with marked anterior wedging, the treatment of choice is anterior diskectomy and arthrodesis of the apical segment, followed by posterior fusion of the entire kyphotic segment with instrumentation.

Diskitis or Vertebral Osteomyelitis

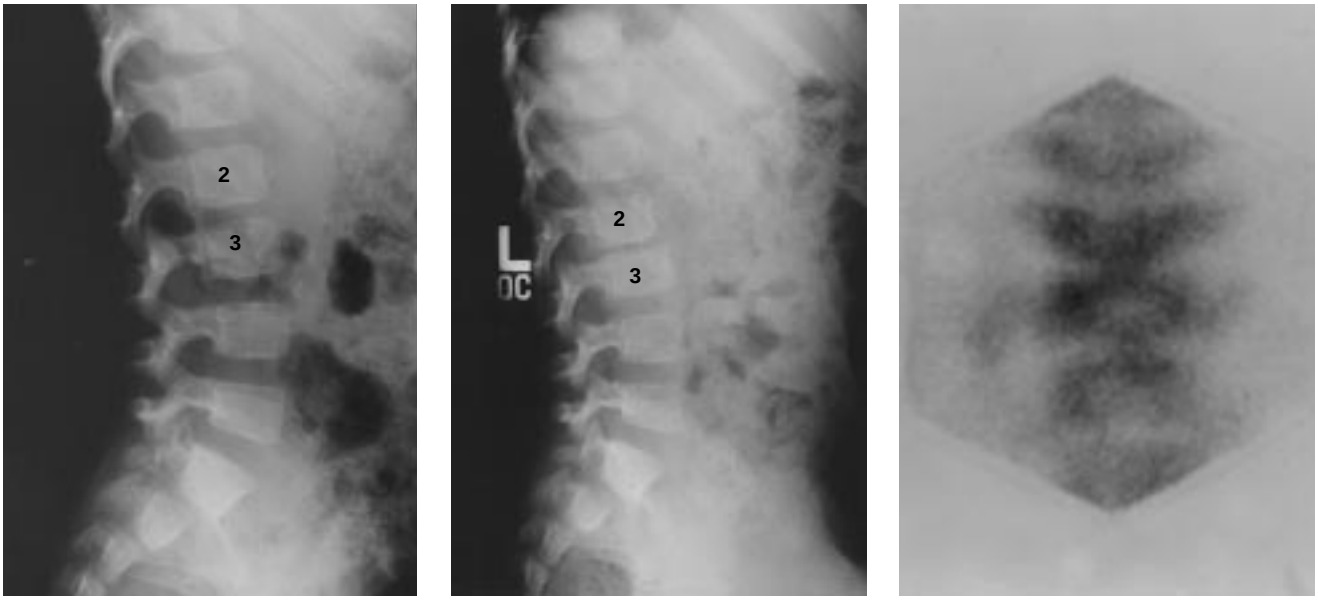
In the past, a distinction was made between these two entities that usually affect children under the age of 10 years. However, it may be more accurate to think of diskitis and vertebral osteomyelitis as representing a temporal progression of

the same disease process, that is, a bacterial or viral infection involving the vertebral body and spreading to the adjacent disk.[18] In the child, the blood supply traverses the vertebral endplate from body to disk, establishing a plausible route for the infection to travel. The cause of the infection is probably bacterial, but milder cases of diskitis may be viral.

Back pain is a common sign of spine infection in the child, along with fever, irritability, anorexia, and malaise. In the younger child (aged 1 to 3 years), there may be a sudden, unexplained failure to walk, which is seen in as many as a third of patients.[18] In the older child (aged 3 to 8 years), there may be associated abdominal pain if the infection involves the T8–L1 levels. In teenagers, localized back pain, which may radiate to the buttocks and legs, is more common. On physical examination, there may be generalized signs of irritability, loss of lumbar lordosis due to tight hamstrings, loss of spinal rhythm, a positive straight-leg-raising test, and tenderness over the lumbar spine.

Radiographs of the spine are often negative if the symptoms are of less than 3 weeks' duration. Changes most often seen on radiographs include decreased disk-space height at the involved levels and erosion or sclerosis of the endplate (Fig. 3, A and B). A complete blood cell count with differential and an erythrocyte sedimentation rate (ESR) should be obtained if diskitis or osteomyelitis is suspected. An elevated ESR has been noted in over 90% of patients with established pyogenic infection of the spine. The white blood cell count has been less reliable; in the study by Ring et al,[18] 40% of patients with spine infections had a high-normal count, and only 10% had an abnormal count. In a study by Wenger et al,[19] biopsy specimens and blood cultures taken from patients with suspected bacterial spine infections were positive in 67% and 41% of cases, respectively; *Staphylococcus aureus* was the most common isolate.

In the presence of nondiagnostic radiographs and an increased ESR, a bone scan should be obtained. Scintigraphic findings of increased uptake are seen in the adjacent vertebral endplates (Fig. 3, C). Magnetic resonance (MR) imaging is the radiologic modality of choice for differentiating diskitis or osteomyelitis from spinal epidural abscesses. Patients with epidural abscesses will have back pain and fever, but may also have marked root symptoms, muscle weakness, and decreased reflexes.[4] An MR imaging study can also be useful in distinguishing pyogenic osteomyelitis from tuberculosis, which will rarely cause signal changes in the disk.



A B C

Fig. 3 **A,** Lateral radiograph of the lumbar spine of a 2-year-old boy with low back pain for 1 week shows mild disk-space narrowing. **B,** Radiograph obtained 1 month later shows marked disk-space narrowing and endplate changes. **C,** Bone scan shows increased uptake in the adjacent endplates of L2 and L3.

The treatment of diskitis in young children is controversial. Good results have been reported with immobilization alone without antibiotic therapy. However, concurrent administration of parenteral antibiotics leads to more rapid resolution of symptoms and diminishes the risk of long-term sequelae. Ring et al[18] advocate the use of a parenteral antibiotic, such as nafcillin or cefazolin, for 6 days followed by 4 to 6 weeks of oral antibiotics on an outpatient basis. "Excellent" relief of symptoms was reported in 2 to 4 days by 73% of their patients and within 2 to 3 weeks by 82%. The ESR can be used to monitor the effectiveness of treatment; early termination of antibiotic therapy can be considered if the ESR returns to normal.

Lumbar Disk Herniation

Herniation of a lumbar disk is a rare occurrence in children and adolescents; only 0.5% of all diskectomies are performed in patients under the age of 16. The peak incidence in the pediatric population is at 10 to 18 years, with a slight male preponderance. Unlike lumbar disk herniations in the adult population, most of which are due to degenerative changes, herniations in adolescents are usually caused by trauma. In one report, the acute onset of symptoms was precipitated by a traumatic incident in 50% of adolescent patients.[20] When an acute traumatic event cannot be identified, repeated microtrauma from vigorous activity must be considered. The herniated disk fragment is usually composed of healthy, well-hydrated tissue and thus tends to be larger than a herniated fragment in an adult. A congenital transitional vertebra at L5 or S1 is also considered to jeopardize the disk.

Symptoms may be present for several months to a year before the patient seeks medical treatment. Back pain with sciatica is the most common complaint. Atypical presentations may include pain in the posterior aspect of the thigh or knee or a "pulled" hamstring. The onset may be acute or insidious. Coughing or sneezing will exacerbate the pain in a third of patients, and the pain will be worse with strenuous activity. The patient may demonstrate an abnormal gait because of lumbar spasm. The most common physical finding in patients with a herniated lumbar disk is the positive straight-leg-raising test (seen at <60 degrees), which will be present in 85% of patients. Paravertebral spasms are also common. Neurologic findings were seen in fewer than 40% of patients with HNP in a study by DeLuca et al[21]; these usually consisted of decreased reflexes and mild weakness, most commonly in the great toe extensor. Sensory changes and bowel and bladder dysfunction are rare.

Radiographs will be normal in about half of patients with HNP. In the study by Grobler et al,[22] the most common radiographic abnormality was nonstructural scoliosis, which was seen in 72% of cases. They found asymmetric facet orientation at the level of the herniation in 71% of their patients.

Magnetic resonance imaging is the study of choice for evaluating disk herniation. It provides excellent visualization of disk material and nerve roots and can differentiate epidural abscess, spinal cord tumors, and abnormalities of the conus or cauda. No myelographic contrast medium is needed. A disadvantage is that sedation may be required for the very young or claustrophobic patient.

Various nonoperative modalities have been used, including bed rest, NSAIDs, muscle relaxants, and physical therapy. Surgery is recommended if there are persistent symptoms or a progressive neurologic deficit or if repeated episodes have not responded to conservative care. In a report of surgical intervention for herniated disks, DeLuca et al[21] noted failure of conservative treatment in 75% of patients. In that series, excellent or good results were obtained in 91% of patients who underwent disk excision through laminotomy. The authors stressed that confirmation of the appropriate level is essential because of the common presence of a transitional or extra lumbar vertebra. Resolution of scoliosis and straight-leg-raising symptoms, as well as improvement in back pain and mobility, can be expected. Deep tendon reflex improvement usually lags behind.

Apophyseal Ring Fracture

Apophyseal ring fracture is the result of a fracture through the junction between the vertebral body and the cartilaginous ring apophysis that occurs before complete fusion at approximately 18 years. When a fracture occurs, the apophysis is displaced posteriorly with the disk, attached by Sharpey's fibers. The prevalence of this fracture is similar to that of disk herniation. Most patients are teenaged boys involved in sports or heavy lifting. Injury results from either acute trauma, such as hyperflexion of the loaded spine, or repetitive microtrauma. Takata et al[23] identified 31 patients in a 3-year period, half of whom could not recall an inciting event. Recognition of this condition appears to have increased commensurate with development of the technology of computed tomography (CT).

Back pain, usually bilateral, is the hallmark of this injury. The pain is associated with sciatica, but rarely radiates below the knee. The pain, described as constant and burning, is aggravated by the Valsalva maneuver. Patients usually complain of back stiffness. Neurologic symptoms and bowel or bladder involvement are rare. The physical findings are similar to those of herniated disk except that the contralateral straight-leg-raising test is usually positive and elicited at less than 40 degrees of flexion.[24]

Lateral radiographs may show a small triangular opacity posterior to the vertebral body. The inferior apophysis of L4 is most commonly involved.[23] A CT study with metrizamide myelography is the procedure of choice, providing excellent bone visualization and documentation of anterior epidural compression. An MR imaging study does not distinguish cortical bone as well as a CT study, making differentiation of bone from disk material difficult. Most associated herniated disks are central (Fig. 4).[24]

The treatment of a slipped vertebral apophysis without neurologic symptoms is similar to the nonoperative treatment of herniated disks. If there is neurologic compromise, excision of the bone fragment with attached cartilage and disk is the treatment of choice. A bilateral laminotomy is recommended to safely remove the entire central fragment. Complete laminectomy may destabilize the spine and is not recommended.

Tumors

Spinal tumors are rare in all age groups. Primary osseous neoplasms of the spine accounted for only 29 (1.5%) of 1,971 musculoskeletal neoplasms in a study by Delamarter et al.[25] Of these, only 8 (0.4%) were in children or adolescents. In 7 of 8 cases, back pain was the presenting symptom.

Most pediatric spinal neoplasms are benign; osteoid osteoma and osteoblastoma are the most common types.[25] Patients usually present with a history of back pain that is worse at night and is relieved by NSAIDs. Patients typically have a painful nonstructural scoliosis with asymmetric forward bending and tenderness to palpation over the paraspinal muscles. Although rare, neurologic symptoms due to compression can be seen with lesions in the cervical or thoracic spine.

The most common radiographic findings are sclerosis of the posterior elements with varying degrees of expansion. By definition, osteoblastomas are greater than 2 cm in diameter. A bone scan is frequently necessary for localization (Fig. 5, A); further localization of the nidus can be provided by CT scanning (Fig. 5, B).

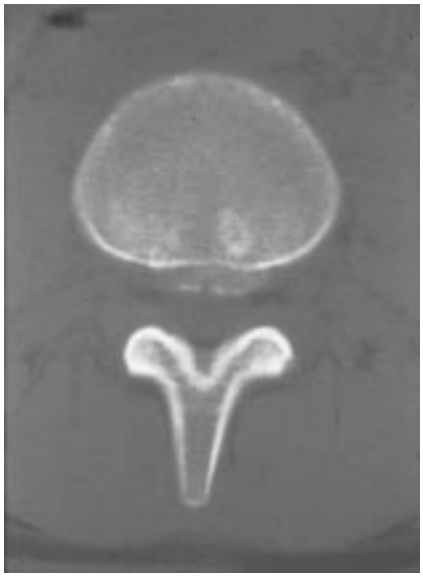
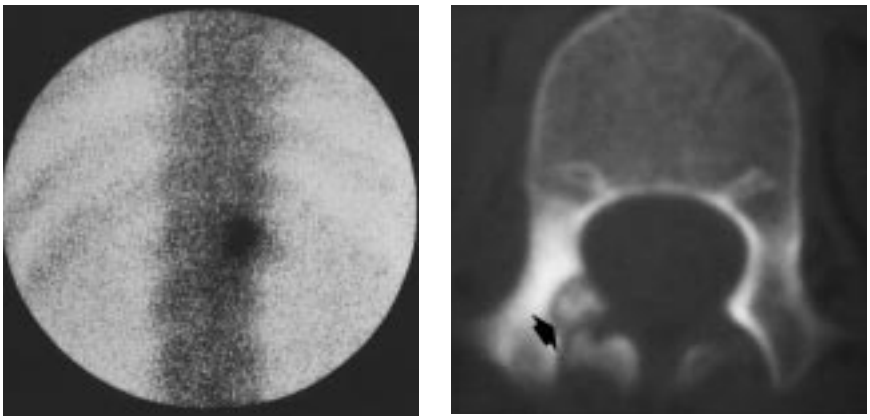


Fig. 4 Axial CT scan shows a slipped lumbar vertebral apophysis. Large central osseous lesion impinges on canal.

Although Kneisl and Simon[26] reported that relief of symptoms was achieved with an average of 33 months of NSAID therapy, the treatment of choice is excision of the nidus. Preoperative administration of radioactive tracer and intraoperative use of a radiosensitive bone probe can aid in localization and complete excision and diminish the amount of uninvolved bone excised. Drilling with CT guidance is another treatment option with proven success for lesions in the posterior elements of the spine in children.[27]

Eosinophilic granuloma (Langerhans cell histiocytosis) of the spine usually affects younger children, the average age being 4.5 years.[28] Boys and girls are affected equally. Nonspecific back pain is the usual presenting symptom. Nonstructural scoliosis or torticollis may be seen. On plain radiographs, the classic finding of vertebra plana marks vertebral collapse. If one suspects eosinophilic granuloma, a skeletal survey and a bone scan must be obtained to look for other osseous involvement. Iliac-crest marrow aspiration is usually indicated in new cases to rule out systemic forms of the disease. A needle biopsy of the lesion may be necessary to rule out a malignant neoplasm. Robert et al[28] recommend conservative treatment of these lesions, the majority of which show reconstitution of vertebral body height by endplate growth in the young child. The use of a spinal orthosis may be required to alleviate symptoms. Low-dose radiotherapy is recommended for patients who present with a neurologic deficit. If radiotherapy fails, surgical decompression may be required.



A B

Fig. 5 **A,** Bone scan shows increased uptake representing osteoid osteoma in pedicle of L1. **B,** Axial CT scan shows nidus (arrow) in pedicle and surrounding sclerosis.

Aneurysmal bone cysts constitute 10% of benign osseous lesions.[29] Most occur in persons under the age of 20 years. As many as 20% involve the spine, most commonly in the posterior elements. Symptoms of pain may develop as a consequence of the lesion itself or may be due to a pathologic fracture. Radiographs and CT scans show an expansile lesion with thinning of the surrounding cortex (Fig. 6). Intralesional resection and bone grafting is usually curative, with a recurrence rate of up to 25%.[29]

Malignant tumors are very rare in the pediatric population. Back pain is a common presenting symptom. Suspicion should be high if a child under age 4 has back pain at night when supine that is unresponsive to conservative therapy. Neurologic symptoms due to spinal cord compromise are common with malignant lesions of the spine, which were present in 70% of patients in the series of Shives et al.[30]

Although osteosarcoma is the second most common primary malignant neoplasm of bone, few osteosarcomas (5%) involve the spine.[30] Patients are usually in the second decade, and involvement of the lower vertebral bodies is most common. Osteolytic, osteoblastic, or mixed lesions may be noted radiographically. Both CT scans and MR images are necessary for staging. Osteosarcomas of the spine are difficult to treat because of the adjacent structures. Wide surgical resection is recommended, if possible. Adjuvant chemotherapy and local radiation therapy may increase long-term survival to 45%,[30] but the overall prognosis is poor.

Ewing's sarcoma occurs most frequently in the 5- to 15-year age group. Spinal lesions are seen in 3.5% of all cases of Ewing's sarcoma; the sacrum is the usual site.[31] Most patients will have back pain, but only 25% will have fever or a palpable mass. Radiographs show an expansile lesion and at later stages may show vertebral collapse, similar to what is seen in eosinophilic granuloma. An MR imaging study is recommended to visualize the entire lesion, including soft-tissue extension. Multiagent chemotherapy has improved the 5-year survival rate in these patients, and decompressive laminectomy has been shown to improve neurologic symptoms in two thirds of patients.[31] Resection of the lesion probably improves survival, but there are no long-term studies to date.

Acute leukemia is the most common malignant condition in the pediatric population, generally affecting children under the age of 10 years. Acute lymphoblastic leukemia is the most prevalent type of pediatric leukemia (80% of cases).[32] The systemic symptoms are fever, lethargy, and anemia. Back pain has been reported as the presenting symptom in 6% of patients with acute leukemia.[33] Laboratory findings include an elevated peripheral white blood cell count and an increased ESR. Vertebral compression fractures were reported in 7% of the

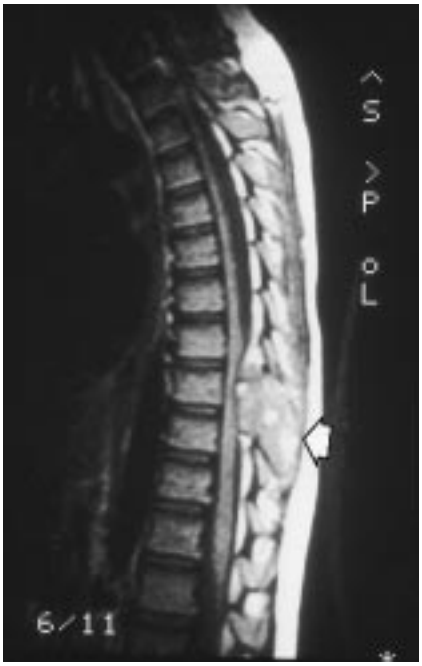


Fig. 6 Aneurysmal bone cyst involving the posterior elements of T11 (arrow).

patients with acute lymphoblastic leukemia in the series by Heinrich et al[32] (Fig. 7, A and B). More commonly, the vertebrae will show generalized osteopenia. Other common radiographic findings are metaphyseal banding (Fig. 7, C), periosteal reaction, permeative destruction, and osteolytic, osteosclerotic, and mixed lesions. The treatment involves type-specific chemotherapy. The 5-year survival rate is over 70% for acute lymphoblastic leukemia. Spinal bracing is used to ameliorate symptoms, allow reconstitution of collapsed vertebrae, and prevent future fractures due to osteopenia.

The spine is the most common site of skeletal metastasis (80%),[34] but metastatic tumors are rarely the cause of nonspecific back pain. Metastases generally affect children under the age of 10 years. Pain at the site of metastasis is the usual presentation, accompanied by systemic symptoms of fever, weight loss, and malaise.

Neuroblastoma is the most prevalent malignant condition that produces skeletal metastases. The incidence of neuroblastoma is 8 cases per 1,000,000 children. In as many as 80% of cases there will be spinal metastases, most commonly in the thoracic spine.[34] Radiographs show diffuse permeative destruction of the vertebrae.

Rhabdomyosarcoma, the most prevalent soft-tissue sarcoma in childhood, produces skeletal metastases in about one fifth of cases.[34] Spine involvement is usual. On radiographs, the lesions are osteolytic or radiolucent.

Spinal cord tumors in children usually appear in the first decade. Astrocytomas and ependymomas are the most common spinal cord tumors. Parents should be questioned about signs of enuresis in toilet-trained children, gait abnormalities, or delay in achieving motor milestones. Back pain, scoliosis, and lower-extremity weakness will be seen in about one third of patients with cord tumors. Physical examination may reveal asymmetric forward bending and hamstring tightness. Radiographic findings include pedicle thinning or absence, foraminal widening on oblique films, and scoliosis without rotation. Gadolinium-enhanced MR imaging is the procedure of choice for diagnosing cord lesions.

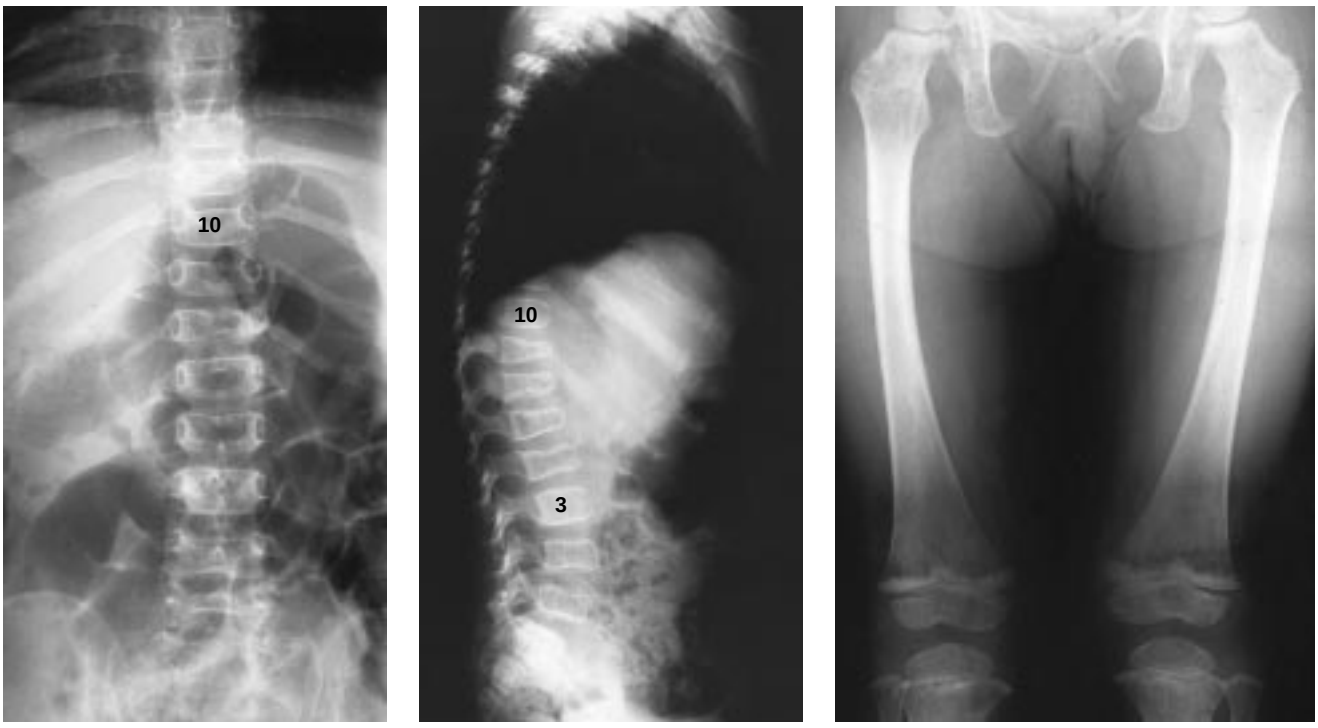


Fig. 7 Anteroposterior **(A)** and lateral **(B)** radiographs of the thoracolumbar spine of a 2-year-old child with new onset of back pain show multiple compression fractures at T11–L2 and generalized osteopenia. **C,** Metaphyseal bands in the distal femurs.

Spinal Cord Abnormalities

Syringomyelias are spinal cord cysts that may or may not communicate with the ventricles. Atypical painful scoliosis is seen in 25% of patients with syringomyelia. Other associated findings are headache, neck pain, cavus foot, and gait abnormalities. There may be a loss of abdominal reflexes, and loss of pain or temperature sensibility is common. Radiographs may show left thoracic scoliosis, which has been shown to have an association with intraspinal abnormality. The probability of there being an intraspinal lesion is increased if the patient is less than 11 years old and has any of the aforementioned signs or symptoms. An MR imaging study of the entire spine is recommended. In the series of Schwend et al,[35] 12 of 14 patients with MR abnormalities had a syrinx.

Children with a tethered cord may present with painful scoliosis, but this presentation is more common in adults. Bladder dysfunction is a frequent finding in the pediatric age group. The physician must check for a cavovarus foot, lumbosacral hair patch, hemangioma, or dermal sinus. A Babinski sign or motor abnormality may be present. Radiographs may show spina bifida occulta or diastematomyelia. An MR imaging study is necessary for evaluation and will typically demonstrate a thickened filum or low-lying conus (below L3 is always abnormal). Neurosurgical intervention is warranted for a documented tethered cord.

Idiopathic Juvenile Osteoporosis

This uncommon entity usually affects children under the age of 10 years. Back pain was the presenting symptom in 33% of 21 patients in a recent study; another 33% presented with long-bone pain due to metaphyseal compression fractures.[36] The vertebrae are always radiographically abnormal, with a progressive loss of height, multiple growth-arrest lines, and extreme symmetric biconcavity. The findings from a routine laboratory examination are normal. Radiodensity assays, such as dual-energy x-ray absorptiometry, show a marked decrease in spinal bone-mineral density.

The disease is usually self-limiting, and back pain should be treated symptomatically. The spinal changes are completely reversible. No benefit from hormonal or vitamin D therapy or administration of antiresorptive agents has been documented.

Diagnoses of Exclusion

Overuse syndromes are quite common in children. Patients may present with back pain radiating to the buttock, which is usually associated with vigorous play or work. This pain should resolve promptly with cessation of the aggravating activity. If it does not resolve within 2 to 3 weeks, another diagnosis should be sought.

Compensation must be considered in our litigious society if the right environment exists. A child with back pain and a history of an automobile accident must be questioned carefully. The accident need not be recent. The physician should be wary when the parents do not allow the child to answer questions. The parents should be asked whether litigation is pending. The physical examination may be equivocal for hard findings, and the radiographs are usually negative. The child's symptoms may not resolve until the litigation is settled.

Conversion reactions are expressions of internal conflict as physical symptoms, such as back pain. The physician should determine whether anyone else in the family is experiencing or being treated for back problems. Because back pain may be a sign of familial unrest, the child should be asked about a recent death or divorce in the family. If a thorough workup for an organic cause of back pain is negative and conversion reaction seems likely, evaluation by a mental health professional is warranted.

Summary

Back pain in children and adolescents, although rare compared with back pain in adults, is cause for concern because of the high association with serious organic causes. Trivializing a child's complaints as "growing pains" or "back strain" is a very dangerous practice. A careful history and physical examination, along with a working knowledge of the differential diagnosis of pediatric back pain, should allow the clinician to treat young patients with back pain safely and efficiently.

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