

# Evaluation and Diagnosis of Back Pain in Children and Adolescents

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## Abstract

Although traditionally it has been accepted that back pain in young children and adolescents most often has an organic etiology, nonorganic back pain in this population is becoming more common. The most common identifiable clinical entities responsible for such pain are spondylolysis, spondylolisthesis, Scheuermann kyphosis, overuse syndromes, disk herniation, apophyseal ring fracture, spondylodiscitis, vertebral osteomyelitis, and neoplasm. Appropriate clinical workup leads to earlier diagnosis and management of back pain and avoids unnecessary cost. Knowledge of the most common diagnoses associated with back pain in children and adolescents and the use of a systematic method to select the appropriate diagnostic tests can help the clinician to minimize costs and maximize the likelihood of making the correct diagnosis and providing appropriate treatment.

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The prevalence of back pain in children and adolescents has increased and is responsible for a considerable portion of visits to providers of musculoskeletal health care. Here, we discuss the most common conditions associated with pediatric back pain, briefly highlight the clinical and radiographic findings, and describe the current options for formulating efficient strategies to diagnose and manage common sources of back pain in children and adolescents.

## Epidemiology

In a large, systematic review, the reported annual incidence of back pain in adolescents ranged from 11.8% to 33%.<sup>1</sup> The incidence of such pain increases with age, and the percentage of patients with a nonspecific or nonorganic etiology of back pain has increased substantially over the past decade. A retrospective review of 2,846 children aged 10 to 19 years

who had low back pain revealed that only 63% of patients had a specific diagnosis at their most recent follow-up visit, and 61% failed to appear for further follow-up after two visits.<sup>2</sup>

Proposed theories for the increase in nonorganic back pain in children and adolescents include sedentary lifestyle, obesity, and increased backpack use. Children with back, hip, knee, or ankle pain have been found to have a substantially higher body mass index than do those without pain.<sup>3</sup> A cross-sectional study of 9,346 adolescents in Denmark showed that those with high isometric endurance of the back extensor muscles had a lower risk of back pain. However, no associations were found with aerobic fitness, muscle strength, or flexibility.<sup>4</sup> Several investigators who have studied back pain associated with backpack use have suggested that backpacks that are heavy in relation to a child's body weight and longer duration of

use were associated with increased back pain, although the pain was not severe enough to warrant referral to an orthopaedic surgeon.<sup>5-7</sup>

## Clinical Evaluation

### History and Physical Examination

A detailed history and physical examination are critical to making an accurate diagnosis of the source of back pain in children and adolescents. Questions about the onset, duration, frequency, severity, and location of pain (including radiation to the extremities) are important. A history of trauma or illness should be documented. Potential warning signs, including night pain, constant pain, fever, weight loss, malaise, pain lasting more than several weeks, or back pain in children younger than 10 years, require further diagnostic investigation.

For a thorough physical examination, the practitioner should ask the patient to disrobe to the level of the undergarments and remove his or her socks to permit examination of the feet, then put on a gown. The patient's back should be examined for midline cutaneous lesions that may indicate intraspinal abnormalities. The back should be palpated for midline, paraspinal, and/or sacroiliac joint tenderness, palpable masses, or a step-off in the posterior elements. A forward bend test is helpful to evaluate the patient for deformities, such as kyphosis and scoliosis, and the patient should be assessed in the standing position for pelvic obliquity and truncal shift. The patient's gait should be assessed for any abnormalities and the active range of motion (ROM) of the lumbar spine should be measured. A complete neurologic examination is essential and should include assessment of motor and sensory function, deep tendon and abdominal reflexes, and upper motor neuron signs.

### Imaging

Radiographs of the entire spine with the patient in the erect, standing position are indicated when the history or physical examination reveals localized pain, a neurologic deficit, or a clinical deformity. Advanced imaging is recommended when radiography is inadequate to define the pathology (eg, neoplasm) that is causing pain or when a soft-tissue problem is suspected (eg, infection, tumor, dural compression, radiculopathy) on the basis of the patient's history, findings on examination, or laboratory values. Single photon emission computed tomography is helpful in identifying a suspected spondylolysis in younger children and has been shown to have a high specificity and sensitivity for this diagnosis.<sup>8</sup> Some authors recommend MRI when plain radiography yields negative results in patients with clinical findings that are suspicious for organic pathology. However, the decreased exposure to radiation associated with MRI must be weighed against the need for sedation in younger patients.<sup>8,9</sup> Furthermore, some authors have noted that MRI may fail to detect spondylolysis in adolescents with back pain.<sup>10</sup>

The use of advanced imaging studies such as bone scan, CT, and MRI has been controversial, and recommendations for their use have evolved in the past 10 years. Feldman et al<sup>9</sup> used an algorithm to evaluate 87 pediatric patients with back pain and found that it had a high diagnostic specificity and sensitivity for detecting an abnormality, making it a useful tool that can be used to guide treatment without unnecessary advanced imaging (Figure 1). No cause for symptoms was found in 64% of patients with a single report of low back pain; they were diagnosed with nonspecific back pain and were treated nonsurgically.<sup>9</sup>

## Differential Diagnoses

### Nonspecific Low Back Pain

Most patients (almost two thirds) with a report of low back pain have no demonstrable cause of organic pathology even after complete clinical evaluation and imaging.<sup>11</sup> Sources of this pain include musculoligamentous strain in the lower back, overuse syndromes, poor posture, and deconditioning. One approach to managing such pain is to discuss with the patient and his or her family the findings on examination and imaging and to reassure them that none of the "red flags" or warning signs of a specific diagnosis, such as radiculopathy or a neurologic deficit, exists. This approach can increase confidence in the provider and improve patient satisfaction. Physical therapy should be ordered for the patient, with recommendations for its frequency, duration, goals, precautions, and modalities. However, if the practitioner suspects that other factors (eg, depression, conversion disorder, amplified pain syndrome) may be contributing to the patient's pain, consultation with other specialists may be necessary.

### Spondylolysis and Spondylolisthesis

Spondylolysis is a defect in the pars interarticularis, typically in the lumbar spine. It typically results from bilateral defects at the same vertebral level, which allow the upper vertebral segment to slip forward on the lower segment. The prevalence of spondylolysis in children is 4.4% and ranges from 6% to 11.5% in adults.<sup>12</sup> In a long-term population study, 30 children aged approximately 6 years when they were diagnosed with spondylolysis were examined 45 years later, and the authors found that the patients had a clinical course similar to that of the general population.<sup>12</sup>

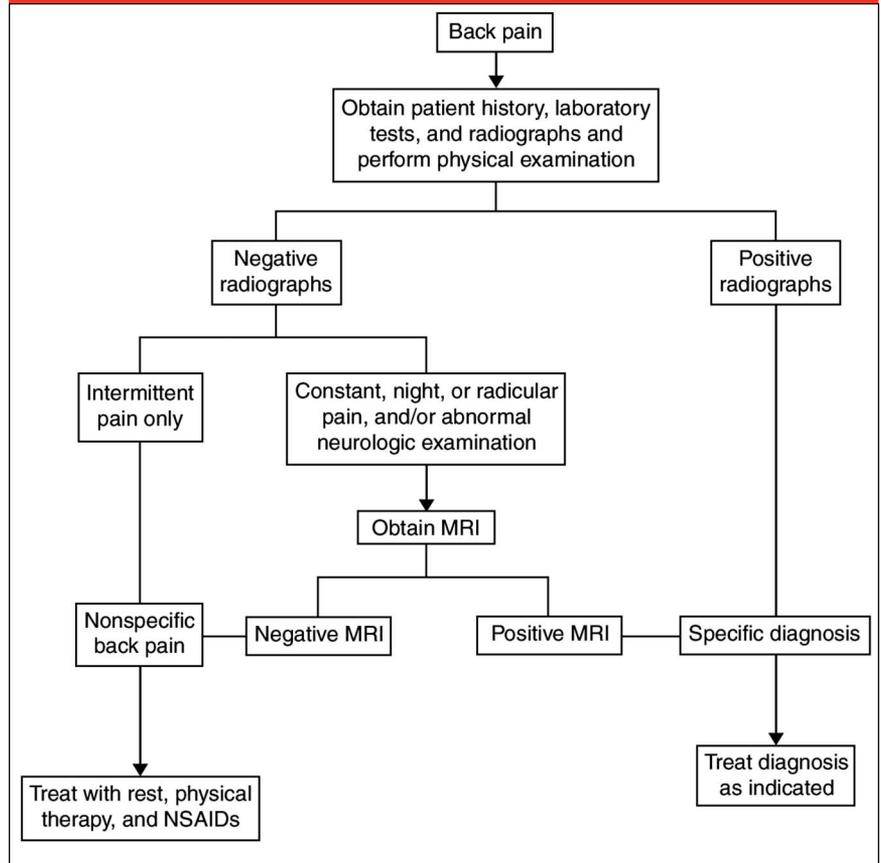
Symptomatic progression of vertebral slippage occurred in only 5% of the patients who initially had bilateral isthmic pars defects.<sup>12</sup>

The etiology of spondylolysis depends on the type of defect responsible for it. The isthmic type of the condition is the most common type in children and adolescents. It is caused by a stress fracture of the pars interarticularis that is thought to result from activities involving repetitive hyperextension of the lumbar spine. L5 is the most commonly affected vertebra, followed by L4 and then L3. Defects superior to L5 are more often symptomatic than those inferior to this level.<sup>12</sup> The dysplastic pars defect results from elongation of the pars as a consequence of a congenital defect of the inferior facets of the proximal vertebra and is a less common source of spondylolisthesis.

Back pain in spondylolysis ranges from mild to severe. It is exacerbated by extension of the lumbar spine and is relieved by rest. Patients may have tenderness to palpation over the spinous processes or paraspinal muscles. Patients with higher grade spondylolisthesis may have a palpable step-off resulting from the more prominent lower vertebra, tight hamstring muscles, and a stiff-legged gait with a short stride length.

Obtaining PA and lateral radiographs of the spine is the first step in the diagnosis of spondylolysis or spondylolisthesis. Oblique radiographs of the lumbar spine have not been shown to increase diagnostic accuracy, and they expose patients to additional radiation beyond that involved in lateral and PA views.<sup>11</sup> Single photon emission computed tomography was previously the standard of care for diagnosis of spondylolysis, but MRI is now preferred because of its lack of radiation and ability to detect soft-tissue and bony pathology. Lateral radiographs are diagnostic for spondylolisthesis.

Figure 1



Algorithm for detecting an abnormality resulting in back pain that can be used without unnecessary advanced imaging. (Adapted with permission from Feldman DS, Straight JJ, Badra MI, Mohaiden A, Madan S: Evaluation of an algorithmic approach to pediatric back pain. *J Pediatr Orthop* 2006;26[3]:353-357.)

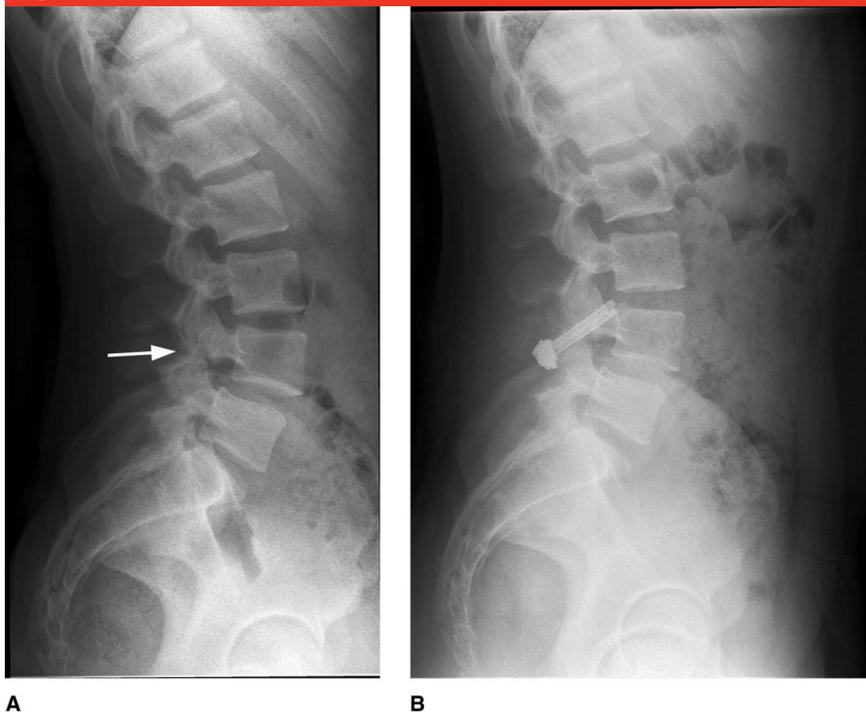
The Meyerding classification and slip angle are important sagittal measurements used to determine disease progression and severity and have been well described in the literature.<sup>13</sup>

Nonsurgical management of spondylolysis includes bracing, activity modification, NSAIDs, and physical therapy, but no evidence-based recommendations exist for establishing best practice guidelines. A meta-analysis of 15 observational studies with a total of 665 patients demonstrated that 558 patients (83.9%) with spondylolysis were successfully treated nonsurgically. The clinical outcome often did not correlate with radiographic union, especially in the

case of lesions that were chronic or bilateral. The authors also reported the lack of a significant difference in results for patients treated with a brace and those treated without a brace.<sup>14</sup>

Surgical treatment of spondylolysis or low-grade spondylolisthesis is reserved for patients with persistent symptoms after >6 months of nonsurgical treatment. Spondylolysis at L4 and above has been successfully treated using direct repair. This involves the débridement of bone surfaces involved in nonunion, autologous bone grafting, stabilization with a single screw, tension-band wiring, or a screw-hook construct<sup>15,16</sup> (Figure 2).

Figure 2



**A**, Preoperative lateral radiograph of the spine in an 18-year-old male with bilateral spondylolysis at L4 (arrow) and a 2-year history of low back pain for which nonsurgical management failed. **B**, Postoperative lateral radiograph of the spine obtained after bilateral débridement of defects of the pars interarticularis at L4, bone grafting, and internal fixation consisting of bilateral laminar screw compression fixation of the pars interarticularis with washers.

Lumbosacral fusion has also produced good results for lesions at L5 and grade I or II slips for which nonsurgical treatment has failed.<sup>17</sup> Grade III or IV spondylolisthesis is typically treated surgically to prevent further progression, although a delay in surgery until patients become symptomatic has not been shown to negatively affect outcomes.<sup>18</sup> Use of reduction and arthrodesis in spondylolisthesis continues to be controversial. Reduction and fusion have been associated with a higher risk of neurologic injury. However, a recent systematic review found that reduction was associated with a lower risk of pseudarthrosis and recurrent deformity; it restores spinal sagittal balance and achieves proper biomechanics for the healing of fusion without an increased risk of

neurologic injury<sup>19</sup> (Figure 3). This mirrors the authors' experience.

### Scheuermann Kyphosis

Scheuermann kyphosis (SK) can be a source of pain among older adolescents. It is a structural kyphotic deformity in the thoracic or thoracolumbar spine that may progress during the adolescent growth spurt until skeletal maturity. Patients with this kyphosis often report dull, aching pain at the apex of the deformity that is exacerbated by physical activity. This must be distinguished from postural kyphosis in which apical rigidity prevents SK from being corrected with hyperextension of the trunk. Other findings on examination of patients with SK include

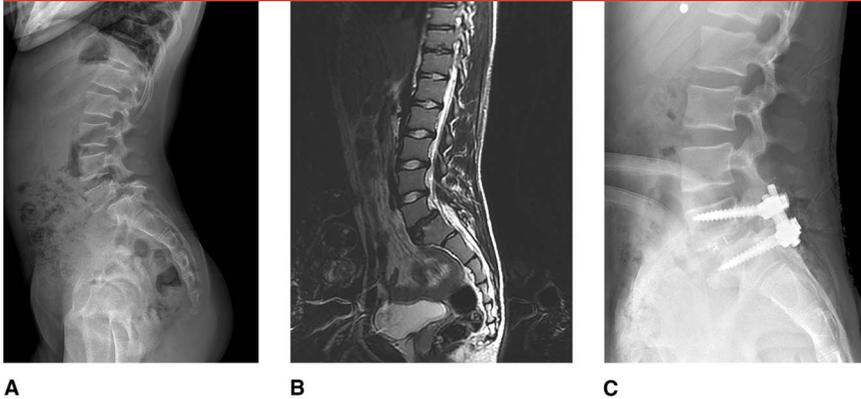
compensatory lumbar and cervical lordosis.

In a patient with SK, a lateral radiograph of the spine shows  $>5^\circ$  of anterior wedging of at least three adjacent vertebra and  $>45^\circ$  of regional kyphosis based on the Sorenson diagnostic criteria for the condition.<sup>20</sup> Other associated findings in patients with SK include Schmorl nodes, vertebral end plate irregularities, anterior-posterior elongation of apical vertebral bodies, and narrowing of intravertebral disk spaces. PA and lateral radiographs should be obtained to rule out spondylolysis or spondylolisthesis and associated scoliosis, the latter of which is present in one third of patients with SK.<sup>20</sup>

The natural history of SK has been the focus of several large retrospective cohort studies. In a long-term study of  $>30$  years, Murray et al<sup>20</sup> examined 67 patients with SK and an average kyphotic curvature of  $71^\circ$  and compared them with age-matched control subjects. Compared with the control group, the group with SK had more severe back pain but no greater analgesic requirements or more lost work days, activity restrictions, neurologic symptoms in the lower extremities, social limitations, or loss of self-esteem. Patients with curves  $<100^\circ$  were found to have normal pulmonary function, whereas those with curves  $>100^\circ$  that involved thoracic segments had restrictive lung disease.<sup>20</sup> In a more recent study in Finland, 59 adult patients with adolescent SK were compared with 31 age-matched control subjects.<sup>21</sup> At a mean follow-up of 37 years, the authors found that the patients with SK had a 2.5-fold greater risk for constant back pain than did the control subjects.

Curves  $<60^\circ$  should be managed with physical therapy, with a focus on exercises to improve trunk flexibility, hamstring and pectoral muscle stretching, and core strengthening. Patients with such curves should

**Figure 3**



**A**

**B**

**C**

**A**, Preoperative lateral radiograph of the spine in a 14-year-old boy with symptomatic grade III spondylolisthesis that failed to respond to nonsurgical treatment. Sagittal T2-weighted magnetic resonance image (**B**) and lateral radiograph (**C**) of the spine following treatment with a posterior lumbosacral approach with L5-S1 laminectomy, bilateral foraminotomies and nerve-root decompression, osteotomy of the sacral dome with resection of the inferior end plate of L5, partial reduction of slippage, and posterior instrumentation and fusion of L5-S1 with an interbody prosthetic cage and bone grafting.

have periodic clinical and radiographic follow-up to monitor for progression of the kyphosis. Full-time bracing (ie, 16 to 18 hours per day for at least 18 months) may be indicated for young patients with curves  $>60^\circ$  or documented curve progression despite an appropriate treatment regimen. If the apex of the SK deformity is superior to T7, a Milwaukee brace is recommended, whereas lower thoracic or lumbothoracic curves can be managed with an underarm brace with anterior infraclavicular outriggers. Patient factors related to successful brace treatment of SK include flexible curves  $<70^\circ$ , an apex at or inferior to T9, and compliance with treatment. Predictors of a poor outcome include rigid kyphosis  $>70^\circ$ , vertebral wedging  $>10^\circ$ , and limited or no remaining spinal growth. Patients considered for bracing should be advised that after it is discontinued, 30% of patients lose some of the correction they have gained.<sup>22</sup>

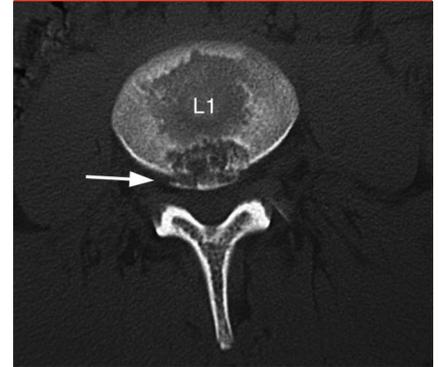
Surgical correction is typically reserved for patients with curves  $>75^\circ$  to  $80^\circ$  in whom brace treatment has

failed or who are poor candidates for it (ie, skeletally mature patients with rigid curves). Successful corrections of  $>50\%$  can usually be obtained with a posterior procedure using extensive segmental posterior closing wedge osteotomies (ie, Ponte osteotomies) across the apex of the deformity. For large, rigid kyphotic or acute angular deformities, a pedicle subtraction osteotomy combined with Ponte osteotomies may be required for correction. Historically, combined anterior and posterior procedures have been associated with a greater risk of complications, such as junctional kyphosis.<sup>23</sup> The risk of this complication can be reduced by limiting the correction to the upper end of the normal physiologic range of kyphosis (ie,  $40^\circ$  to  $50^\circ$ ), extending the fusion to T2 proximally, and including the first lordotic segment and sagittal stable vertebra distally.<sup>23</sup>

### Lumbar Disk Herniation

Lumbar disk herniation is less common in pediatric patients than in adults, and of children and adolescents

**Figure 4**

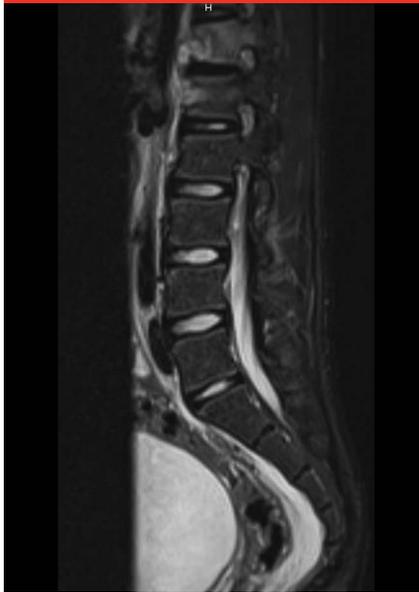


Axial CT of the spine demonstrating an apophyseal ring fracture (arrow).

with symptomatic lumbar disk herniation, 30% to 60% have a history of trauma before the onset of pain.<sup>24</sup> As with adult patients, pediatric patients with lumbar disk herniation often report pain with lumbar flexion or pain with Valsalva maneuvers. However, in the senior author's (S.A.S.) experience, pediatric and adolescent patients tend to have greater nerve-root tension and abnormalities of gait than do adults with lumbar disk herniation, although they less often report neurologic deficits, such as lower-extremity numbness or weakness. Signs of saddle paresthesia or bowel or bladder dysfunction should raise concern for cauda equina syndrome, and rectal muscle tone should be assessed in these patients.<sup>25</sup>

Standard radiographs of the spine should be ordered to rule out pathologies other than lumbar disk herniation. An MRI of the lumbar spine is the diagnostic imaging study of choice for this purpose.<sup>25</sup> Adolescent disk herniation is associated with separation of the apophyseal ring in 5.7% of patients. In these patients, CT will confirm the apophyseal ring separation on axial sections (Figure 4).

Most pediatric patients with lumbar disk herniation and neurologic symptoms are initially treated nonsurgically.

**Figure 5**

Sagittal magnetic resonance image of the lumbar spine in a 14-year-old boy with a 2-week history of flank pain. MRI confirmed spondylodiscitis involving the T12 vertebral body, T12-L1 disk, and L1 vertebral body.

This includes initial bed rest or activity modification, with a transition to limited physical activity in 1 to 2 weeks, analgesic and anti-inflammatory medication, the use of a soft supportive lumbar brace, and physical therapy. However, nonsurgical treatment is not as effective for lumbar disk herniation in pediatric patients as it is in adults.<sup>25</sup> In the authors' experience, some children with this condition have congenital spinal stenosis, and paracentral herniation becomes symptomatic at an early stage.

Indications for surgical management of pediatric lumbar disk herniation include pain refractory to nonsurgical management or progressive neurologic deficits. Surgical options include open discectomy with laminotomy or microdiscectomy. Short-term results (up to 12 months) have shown similar success rates (94% to 97.5%) for both open and microdiscectomies.<sup>26</sup> Complications of surgical management include infection, neurologic deficits,

and cerebrospinal fluid leaks; long-term relief and disease-free intervals have been found to diminish with time.<sup>25,26</sup>

Management of apophyseal ring separation is similar to that for disk herniation. In patients in whom nonsurgical treatment fails, the herniated disk is removed surgically. The decision to remove the fractured apophyseal fragment is controversial. Although many authors agree on excision of the fragment in patients who have preoperative neurologic deficits, Shirado et al<sup>27</sup> reported comparable results in patients who had discectomy with or without the removal of apophyseal fracture fragments.

### Spondylodiscitis

The term spondylodiscitis refers to an infection involving the intervertebral disk and/or its adjacent bony structures. Spondylodiscitis is most common among children aged 2 to 10 years. It has been shown to have a biphasic age distribution, primarily involving young toddlers, with a second peak in adolescence, and occurs most commonly in the lumbar spine.<sup>28</sup>

Clinical symptoms of spondylodiscitis are variable and often nonspecific, delaying the diagnosis. Back pain is the predominant symptom, but reports of abdominal pain, low-grade fever, and difficulty in sitting or walking are also common. In one study, the most commonly reported effect of spondylodiscitis in children younger than 28 months was gait abnormality noted by parents, and back pain was not reported.<sup>28</sup> Physical examination demonstrates a decreased ROM of the spine and loss of lumbar lordosis. If asked to pick up an object from the floor, a child with spondylodiscitis may squat down and avoid bending forward to prevent spinal motion. Neurologic abnormalities such as nerve root

compression and meningitis have been reported in up to 12% of patients.<sup>24</sup> Progressive weakness or paralysis may represent epidural abscess formation or kyphotic decompensation in the affected area of the spine.<sup>24</sup>

Laboratory markers of inflammation are elevated in most cases of spondylodiscitis but provide nonspecific information. Blood cultures, if positive, can serve as a useful guide for antibiotic therapy, but they have been reported to be negative in 50% to 88% of cases involving the disks and up to 57% of cases with vertebral involvement.<sup>29,30</sup> Tissue biopsies are rarely helpful because cultures often do not grow any organisms. Fungal and mycobacterial cultures should be obtained when bacterial blood cultures are negative and the patient's condition is worsening despite antibiotic therapy.<sup>31</sup>

Typically, plain radiographs are normal in the early stage of spondylodiscitis, with narrowing of the disk space usually the first abnormal radiographic finding (Figure 5). In late phases of the disease, further narrowing of the disk space, with vertebral end plate irregularities, is seen. Segmental collapse with loss of lordosis or development of kyphosis occurs in more severe cases.<sup>31</sup>

MRI is the most useful imaging modality for the early diagnosis of pyogenic spondylodiscitis. T1-weighted sequences show decreased signal in the bone marrow, and T2 sequences show increased signal in the bone marrow and/or intervertebral disks (Figure 5). MRI of the whole spine is recommended to avoid a delay in diagnosis in cases in which there is a high suspicion of spondylodiscitis. In patients with nonspecific symptoms in whom the diagnosis or location of pathology is unclear, bone scans can be used to identify areas of infection or inflammation within days of the onset of the condition.<sup>28,32</sup>

Nonsurgical management is indicated in most cases of pediatric spondylodiscitis and should include an accurate identification of the causative pathogen (when possible), management with appropriate antibiotics, and spinal immobilization. Recommendations regarding the duration and route of antibiotic administration vary, but most call for an initial period of parenterally administered antibiotics for 5 to 10 days followed by oral antibiotics for 2 to 4 weeks.<sup>24</sup> The senior author's (S.A.S.) preferred treatment includes oral pain medication and immobilization with a thoracolumbosacral orthotic brace to allow the child to return to activities of daily living and school. Cases involving only soft tissues are treated with 2 weeks of antibiotics. For vertebral osteomyelitis, antibiotics are administered for 4 weeks. The duration of treatment may vary based on clinical improvement and laboratory values (ie, erythrocyte sedimentation rate, C-reactive protein level).

Surgery is rarely indicated for spondylodiscitis in children with disk or vertebral body infections. Indications for surgery include failure of nonsurgical management, neurologic deficits caused by compression of the spinal cord or nerve roots by an epidural abscess, major destruction of vertebral bodies, or spinal instability.<sup>31</sup> After the resolution of an infection, patients should be followed for 1 to 2 years to assess for any late sequelae, such as a permanent decrease in intervertebral disk space, vertebra magna, or spontaneous fusion of vertebrae, all of which sometimes involve decreased mobility or chronic back pain.<sup>24,32</sup>

## Neoplasms

Approximately 20% of osteoid osteomas and 40% of osteoblastomas occur in the spine.<sup>33</sup> These neoplasms are typically found in the

posterior elements of the spine, commonly the lamina or pedicle. Patients with osteoid osteomas often report back pain that is worse at night and is relieved by NSAIDs. Neurologic symptoms of spinal neoplasms are rare. Scoliosis may occur with a lesion at the concavity of the apex of the curve. The lesion is often difficult to see on radiography and requires advanced imaging to make the diagnosis. Bone scintigraphy is the most sensitive modality for localizing a neoplastic lesion of the spine, and CT is best for visualizing the nidus of lesions within the vertebrae.<sup>31</sup> Treatment should begin with a trial of NSAIDs. For patients in whom medical treatment of a spinal neoplasm fails, surgical excision can provide rapid pain relief.<sup>33</sup> In patients with associated scoliosis present for <15 months, the deformity usually improves after the lesion is removed.<sup>31,34</sup>

Approximately 40% of osteoblastomas occur in the spine. They are typically found in the posterior elements but may extend into the vertebral body. Because of their larger size, osteoblastomas may cause neurologic symptoms. Scoliosis is seen in 40% of children with osteoblastomas.<sup>35</sup> Radiography typically shows an osteoblastoma, but CT is helpful in delineating the size and location of the lesion for surgical planning. Because of the benign, aggressive behavior of these lesions, management consists of surgical resection at time of diagnosis. Excision with an extended, intralesional curettage should be performed. If removing the lesion jeopardizes the stability of the spine, fusion and instrumentation should be done.<sup>34</sup>

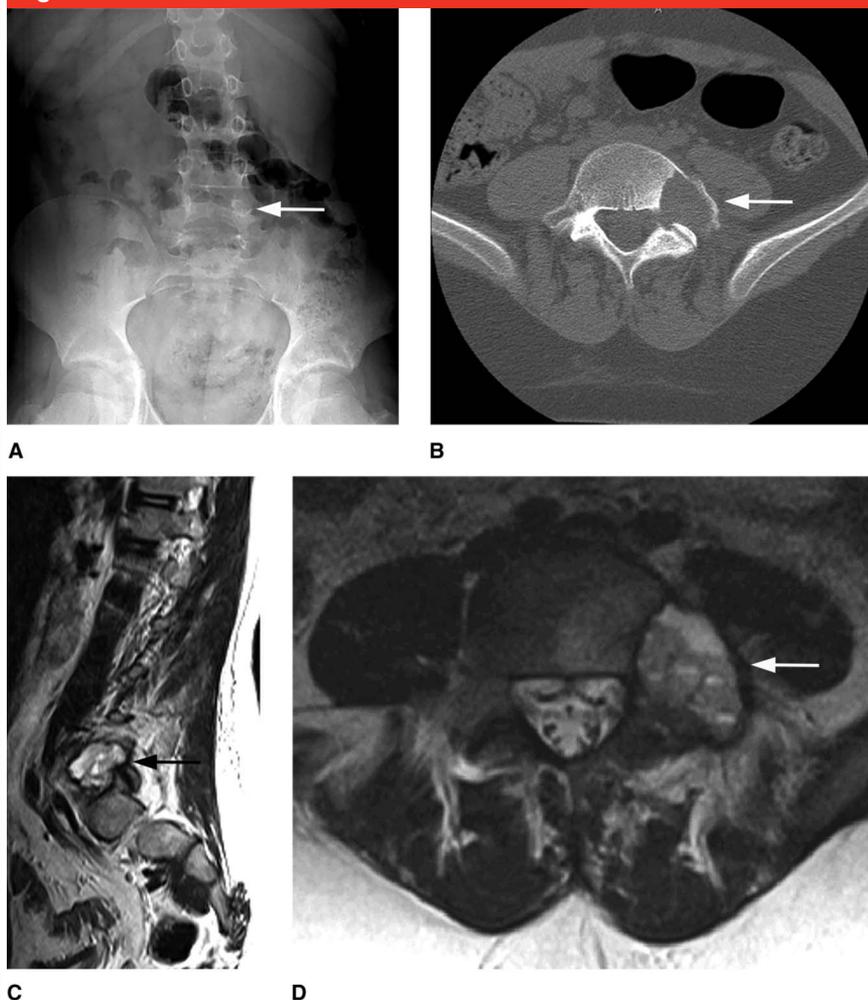
Langerhans cell histiocytosis, or eosinophilic granuloma (EG), involves the spine in 10% to 15% of those children with EG.<sup>36</sup> EG is most common in the cervical spine, followed by the thoracic and lumbar spine.<sup>36,37</sup> Back pain over the

affected vertebrae is most commonly reported. Radiography may show lytic lesions in the posterior elements or vertebral body as well as anterior vertebral wedging. Larger lesions can cause the collapse of an affected vertebral body, resulting in a vertebral plana deformity. A skeletal survey or bone scan is recommended for the detection of multifocal disease, which can be present in up to 50% of patients with EG.<sup>36</sup> MRI can be helpful in differentiating EG from malignant diseases or infections because EG does not typically involve the soft tissue. When MRI does not clarify the diagnosis, biopsy may be necessary.<sup>37</sup> Most EG lesions in children resolve with time and do not cause any long-term symptoms. Surgical management is rarely necessary but is indicated in the setting of considerable neurologic compromise or spinal instability.<sup>29</sup>

Up to 20% of aneurysmal bone cysts are located in the spine.<sup>31</sup> Most of these lesions involve the posterior elements; however, they can extend into the anterior vertebral body and can sometimes span two to three adjacent vertebrae. MRI shows multiloculated, expansile lesions with fluid-fluid levels and a low-intensity signal on T1-weighted images and a high-intensity signal on T2-weighted images (Figure 6). Because of the aggressive nature of aneurysmal bone cysts, surgical intralesional curettage and bone grafting are indicated. Biopsy with intraoperative histologic examination of frozen sections should be done before the curettage of a cyst.<sup>30</sup> Selective arterial embolization may be used preoperatively to minimize intraoperative bleeding.<sup>38</sup> Titanium instrumentation and fusion is sometimes necessary if spinal stability is compromised by the excision of an aneurysmal cyst.

Leukemia is the most common pain-producing malignancy of the spine and often produces constitutional

Figure 6



**A**, AP radiograph of the lumbar spine demonstrating a radiolucent lesion (arrow) involving the right pedicle in an 11-year-old boy with a 2-month history of low back pain with radicular leg pain and pain at night. A biopsy confirmed osteoblastoma with a secondary aneurysmal bone cyst within the lesion. **B**, Axial CT demonstrating an aggressive radiolucent lesion (arrow). **C**, Sagittal T1-weighted magnetic resonance image demonstrating a multilobulated lesion (arrow). **D**, Axial T2-weighted magnetic resonance image demonstrating fluid-fluid levels (arrow).

symptoms such as lethargy, fever, pallor, or unexplained bruising or bleeding. Laboratory findings in spinal leukemia include anemia with a decreased platelet count, increased peripheral leukocyte count, and increased erythrocyte sedimentation rate. Radiographic findings are nonspecific and include osteopenia, vertebral body compression, osteolysis, and sclerosis. Although a peripheral blood smear can lead to diagnosis in

some cases, most cases of spinal leukemia require bone marrow aspiration to confirm the diagnosis. Management consists of chemotherapy. Bracing may provide some relief from pain and protect the vertebrae, allowing time for collapsed vertebrae to heal.<sup>39</sup>

As many as 10% of cases of Ewing sarcoma originate in the spine.<sup>40</sup> These lesions most commonly involve the sacrum and/or pelvis, followed by the thoracic and lumbar spine. The

most common presenting symptoms are back pain and neurologic deficits. Radiography may show vertebral collapse with an associated soft-tissue mass. MRI is helpful for evaluating the extent of soft-tissue and spinal canal involvement. After appropriate staging and biopsy, management consists of neoadjuvant chemotherapy, local control with radiation and/or surgery, and postoperative chemotherapy. Metastasis is present in up to 25% of patients with Ewing sarcoma at the time of their initial presentation.<sup>33</sup>

Metastatic lesions of the spine can occur in children with a primary neuroblastoma, rhabdomyosarcoma, or Wilms tumor. Children with a spinal metastasis of any of these malignancies typically present initially with a pathologic fracture and less often with spinal cord compression resulting in neurologic symptoms. Biopsy is mandatory for a definitive diagnosis.<sup>33</sup>

### Summary

Back pain in children and adolescents is becoming more common, and nonspecific back pain in this population has become more prevalent, especially among adolescents. Radiography is indicated in most cases of such pain, and a careful history and physical examination can help the clinician identify signs that warrant advanced imaging for diagnosis of the source of pain. Knowing the clinical and radiographic features of the most common etiologies of pediatric back pain can help the clinician effectively identify and treat the conditions causing this pain.

### References

*Evidence-based Medicine:* Levels of evidence are described in the table of contents. In this article, references 1, 4, 12, 20, and 21 are level II studies.

References 2, 3, 5-9, 11, 14-19, 23, 26, 27, 29, and 37-40 are level III studies. References 25, 28, 32, and 36 are level IV studies.

References printed in **bold type** are those published within the past 5 years.

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