Clinical Evaluation of Pediatric Patient with Spondylolisthesis

4

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Introduction

The clinical presentation of pediatric patients with spondylolysis and spondylolisthesis is highly variable. Available literature on the physical features associated with this condition describes a wide range of symptoms and limited correlation of severity of spondylolisthesis with the physical manifestations [1–4]. As such, much of the information concerning the physical exam in pediatric patients with spondylolisthesis is based on commonly held beliefs and anecdotal experience.

Despite the limited documentation in the literature, the clinical evaluation of pediatric patients presenting with spondylolisthesis should follow general principles of examining pediatric patients with spinal deformities. The exam starts with a thorough history of the presenting symptoms, including onset and location with specific attention paid to complaints of back and leg pain, weakness, numbness, or tingling of the lower extremities. Other signs of subtle neurologic compromise should be inquired about including changes in gait, coordination, or stamina, and issues associated with the cauda equine such as bowel or bladder incontinence, urinary retention, and saddle or perineal anesthesia. The examining physician should inquire about aggravating or relieving postures or activities and times of onset, as well as prior therapies which have or have not been beneficial.

The basic elements of the physical exam of the pediatric spine consist of inspection of the back and trunk for overall coronal and sagittal alignment, rotational deformities, and skin abnormalities, such as creases, dimples, hairy patches, and pigment abnormalities. Palpation of the spine is performed to assess for step-offs, usually at the lumbosacral junction, and tenderness, followed by assessment of the overall range of motion of the spine in flexion and extension and rotation. Evaluation of the patient's gait is important, with particular attention paid to the fluidity of gait, abnormalities in the stride length, presence of a crouch posture or toe-walking. A complete neurologic exam is required to assess the strength and sensation of the lower extremities, the deep tendon and abdominal reflexes, and in some cases the rectal tone. Finally, there are some specific tests which are important in the evaluation of the pediatric patient with spondylolisthesis.

A thorough and complete physical exam in these patients is extremely important to assist the

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clinician in deciding on what type of advanced imaging might be appropriate. Additionally, in cases requiring operative management a baseline exam and documentation of the symptoms may guide surgical treatment and is important due to the possibility of complications or symptoms post operatively. In cases of significant deformity with a significant risk of post-operative complications, an independent pre-operative neurologic evaluation by a pediatric neurologist (who is available to evaluate the patient in the post-operative period) can be helpful to ensure all pre-operative symptoms are properly documented.

History

One of the most common complaints in patients with spondylolisthesis is back pain with or without concomitant radicular pain [1, 2, 5–12]. Pain may be insidious in onset and chronic in nature; however, some patients will have a specific event which they can recall which started the symptoms.

The nature of the pain is often dull and chronic with an area of pain identified in a band like pattern over the entire lumbar spine. Hyperextension activities may exacerbate the pain, which is usually activity related and improved with rest. Pain radiating into the posterior aspect of the legs is not uncommon, and usually limited to the upper posterior thigh and buttock region [6]. This can be unilateral or bilateral in nature. It is sometimes difficult to know if this is true radicular pain or an extension of the lumbar pain described above. True radicular pain which radiates past the knee in a specific nerve root distribution is rare, but can be seen in higher grade spondylolisthesis and requires more urgent evaluation.

The incidence of back pain in children with spondylolisthesis is unknown, as many children are asymptomatic. Due to the commonly held association of back pain in the pediatric population with spondylolisthesis, there have been a number of studies examining this link. The number of children presenting with anatomic findings for their back pain in these studies has decreased over the years, but the incidence of spondylolisthesis has remained relatively stable. Turner in 1989 and Bhatia et al. in 2008 demonstrated a decrease in the number of children with identifiable pathology causing back pain, from 50 % in 1989 to about 22 % in 2008; however, the percentage of subjects diagnosed with spondylolysis or spondylolisthesis remained relatively unchanged at 13 % in 1989 and 12 % in 2008 [13, 14]. This suggests a lowered threshold for orthopedic evaluation of back pain in more recent years, rather than a true change in the pathology of pediatric back pain.

In addition to isolated back pain, radicular type pain is reported by pediatric patients with spondylolysis and spondylolisthesis as well. As described above, this radicular pain is usually isolated to the upper buttock and thigh. The incidence of radicular pain, either isolated or in combination with back pain ranges in the literature from 20 to 80 % with the specific dermatomal patterns of radiating pain is usually difficult to determine on exam [1, 8, 9]. The etiology of this nerve root irritation is unknown, but suggested causes include disc herniation associated with the spondylolisthesis, sacral dome or L5 pedicle impingement, neuroforaminal stenosis, or nerve root compression between the sacral ala and the anterior lumbosacral ligaments [6].

Evaluation

The examination begins with an overall evaluation of the posture of the child. In patients with spondylolysis without any spondylolisthesis, there is typically little deviation in the coronal or sagittal alignment of the spine. As the deformity progresses and the spondylolisthesis worsens, the anatomic abnormalities of the spine will lead to distinct physical findings. Some authors have noted that this postural deformity may be the only finding which leads to the initial orthopedic referral [5]. As the spondylolisthesis progresses, the lower portion of the spine (typically the sacrum in an L5 spondylolisthesis) will rotate and become more vertical [15]; this sacral malalignment together with hamstring tightness which develops causes a distinct postural alignment [2, 16]. Children with this deformity are

Fig. 4.1 (**a**) Standing sagittal view of a patient with a high grade spondylolisthesis. Notice the flattened buttock (*black arrow*), flattened lumbar lordosis and the positive overall sagittal balance when standing with the knees straight. (**b**) A crouch stance and gait is used to improve the overall sagittal balance due to the spinal imbalance and tight hamstrings

often found to have a prominent and flattened buttock (due to the vertical alignment of the sacrum), flattening of the lumbar lordosis, and a crouched stance with flexion of the hips and knees to keep the overall sagittal alignment in a neutral position (Fig. 4.1a, b). Additionally, as the sacrum becomes more vertical and the lumbar lordosis is flattened, examination of the abdomen may reveal a horizontal abdominal crease above the umbilicus which is caused by the translation of the proximal portion of the spine on the vertical sacrum (Fig. 4.2).

In some cases, when an Adam's forward bend test is performed, scoliosis will be noted in the upper lumbar and thoracic region of the spine. McPhee and O'Brien have described three categories of scoliosis which are associated with spondylolisthesis [17]. The first is idiopathic scoliosis which is unrelated to the spondylolisthesis. The deformity has the typical appearance of thoracic or thoracolumbar idiopathic scoliosis, and is identified in about 5–10 % of patients with spondylolisthesis [2] (Fig. 4.3). The second type of scoliosis is a rotational deviation of the upper

Fig. 4.2 Coronal and sagittal view of an adolescent with a high grade spondylolisthesis. Notice the abdominal crease (*white closed arrow*) and flattening of the lumbar spine and buttock (*white open arrow*)

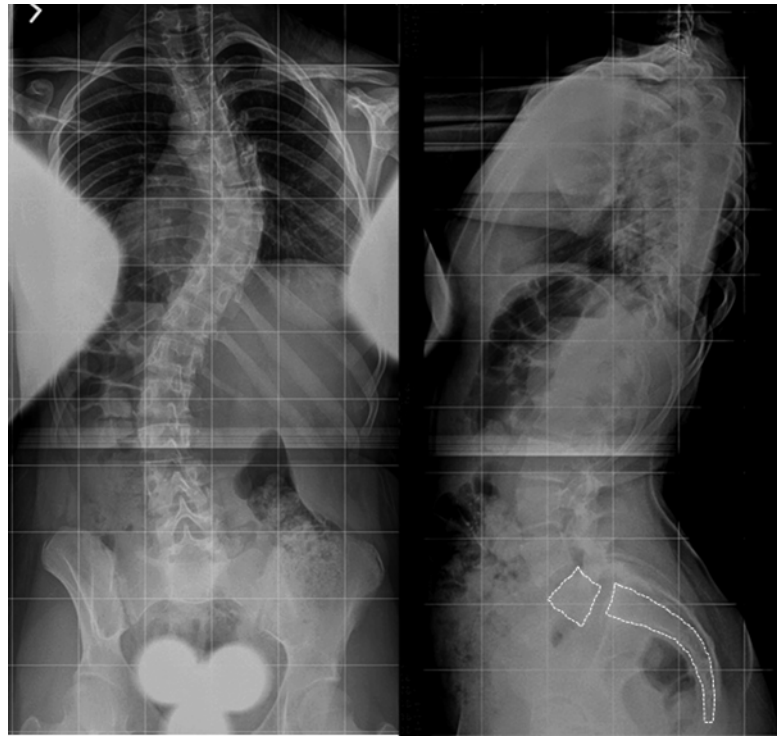

Fig. 4.3 AP and lateral radiograph showing a grade 1 L5–S1 spondylolisthesis and a 55° idiopathic scoliosis

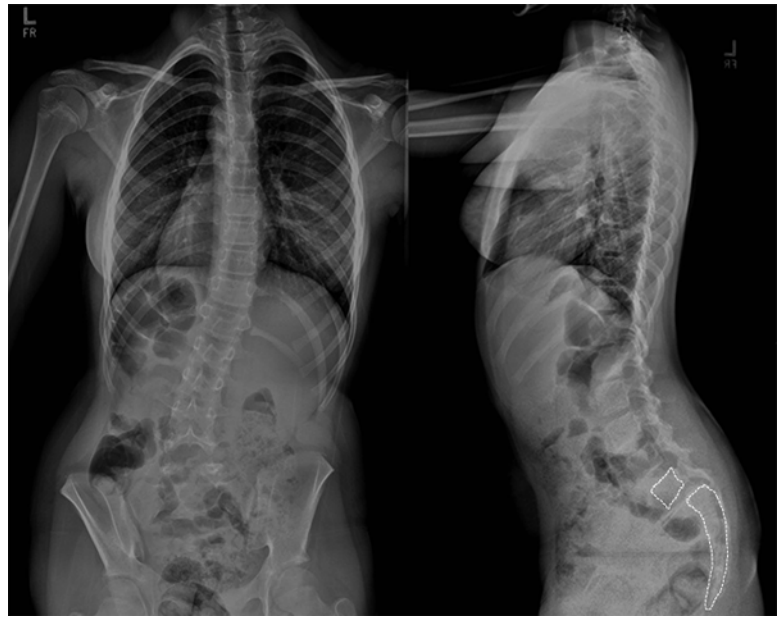

Fig. 4.4 AP and lateral radiograph showing a grade 3 L5–S1 spondylolisthesis and a 25° olisthetic scoliosis

spine due to an asymmetric slippage of the spondylolisthesis, more on one side than the other. In the third category the scoliosis is due to pain or muscle spasm caused by the spondylolisthesis and resultant nerve root irritation. This scoliosis, termed olisthetic scoliosis, has an atypical appearance and is non-structural (Fig. 4.4). Treatment of this third category of scoliosis is often aimed at the spondylolisthesis with subsequent expected resolution of the scoliosis [17].

Palpation

Palpation of the spine in children with spondylolisthesis is typically unremarkable. Pain is usually not exacerbated with palpation of the lumbar spine in these patients, even those reporting back pain. The pain is usually exacerbated with range of motion of the spine, specifically hyperextension. Occasionally in thin patients with high grade spondylolisthesis a step-off is appreciated at the lumbosacral junction, especially when assessed during Adams' forward bend test. This step-off correlates with the prominent posterior elements of the vertebral body immediately caudal to the level of the spondylolisthesis (Fig. 4.5).

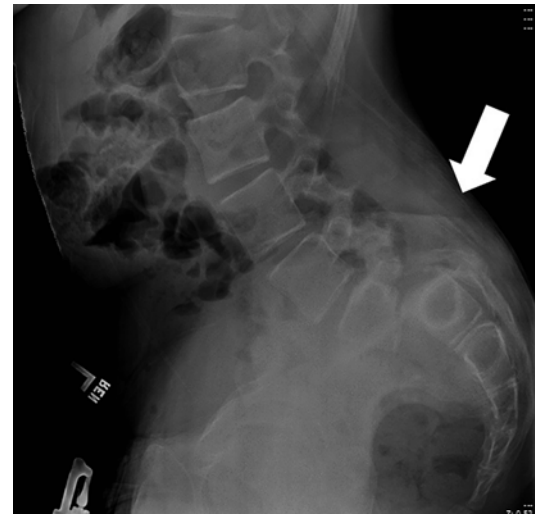

Fig. 4.5 Lateral lumbosacral radiograph demonstrating the prominence of the posterior elements of the sacrum (*white arrow*) caudal to the spondylolisthesis. This area is easily palpated on exam due to prominence

Range of Motion

As is the case with many of the physical findings in a child with spondylolysis or spondylolisthesis, the range of motion of the spine can range from full and unaffected to severely limited.

This motion is somewhat correlated to the degrees of displacement of the spondylolisthesis and the degrees of back pain and nerve root irritation. Flexion of the lumbar spine is typically unencumbered by the anatomic deformity of the spine, but may be limited by associated hamstring tightness. Extension is typically limited by pain in the lumbar spine. The rotation and lateral bending of the spine may also by limited by pain [7].

Tightness of the hamstrings is a classic physical finding associated with pediatric spondylolysis and spondylolisthesis. Originally described by Phalen and Dickson in association with spondylolisthesis, this is found in up to 80 % of symptomatic patients [4]. The etiology of this finding remains unclear. One leading theory is this tightness is due to irritation of the lower lumbar and upper sacral nerve roots which innervate the hamstring muscles and cause muscle spasticity. Some people believe this irritation is from stretching of the nerve roots due to the deformity while others believe it is caused by hypertrophic granulation tissue at the site of the pars defect which impinges on the traversing nerve roots. Others suspect the rotation of the pelvis leads to a mechanical tightness of the hamstrings. No one theory has been shown to be the definitive cause to this point [18, 19].

Gait

Evaluation of the gait of a patient with suspected spondylolisthesis is important. Many of the anatomic abnormalities found can lead to gait alterations. It is most helpful to have the child dressed in shorts, a bathing suit, or a small exam gown so the entire lower extremities and trunk can be evaluated. Shoes and socks are removed and the child is asked to walk back and forth down a long hallway. Often times it is helpful to have the child walk multiple times so different segments of the body can be watched, from the trunk to the pelvis and hip, to the knees and finally the feet. Additionally, in children with spondylolisthesis, it is helpful to evaluate the gait from the front and side of the child to assess both the coronal and sagittal plane.

As discussed above, severe spondylolisthesis typically results in a more vertically oriented sacrum, a forward displacement of the proximal spine and trunk, and tightness of the hamstrings. These deformities will lead to distinct gait abnormalities seen in these patients. In general, patients with significant spondylolisthesis will be found to have a shortened stride length due to the hamstring tightness. In extreme cases, this hamstring tightness and limited stride length can be so severe the child will need to walk sideways to move around effectively. As the spinal deformity, hamstring tightness and sacral malalignment worsen and a crouch alignment becomes more fixed, the child may begin to walk on their tiptoes to compensate for this flexed hip and knee deformity [20].

Neurologic Exam

A detailed neurologic exam is required when evaluating children with spondylolysis and spondylolisthesis. This exam should include documentation of a full lumbar root motor and sensory exam, evaluation of the deep tendon reflexes at the knee and ankle and the abdominal reflexes. Sacral root sensory testing and rectal exam are typically deferred to cases of severe deformity, pre-operative evaluation, and in those patients who complain of bowel or bladder dysfunction.

A complete evaluation of the lower extremity strength and sensation should be completed and documented in a systematic fashion. The typical root levels and exam findings are found in Table 4.1.

Deep tendon reflexes which are noted to be abnormal are often found to be depressed, with complete loss of the ankle jerk reflex in severe cases. This is due to the irritation of the lower motor nerve as it by-passes the deformity near the neural foramina, as opposed to an upper motor nerve irritation, which will more typically cause hyperreflexia. In patients complaining of even subtle bladder dysfunction, formal evaluation with urodynamic studies can identify neurologic issues associated with this finding.

Special Tests

The child being evaluated for spondylolysis or spondylolisthesis often will be found to have significant tightness of the hamstrings. While this is not pathognomonic for this issue, tightness of the hamstrings is often found to some degree in these patients. The most common method to evaluate this issue is to measure the popliteal angle (Fig. 4.6). This is performed with the patient lying supine on the exam table. One leg is gently held down on the table in an extended position by the examiner. The other leg is flexed at the hip and knee. When the hip is held at 90° of flexion, the knee is extended to the maximal amount. The angle subtended by the axis of the thigh and the anterior aspect of the leg is measured and recorded as the popliteal angle. As can be seen with significant tightness of the hamstrings, the leg is unable to be extended very much with the hip held at 90° and the popliteal angle is relatively large. In patients without hamstring tightness, the leg can be fully extended, even with the hip help at 90° of hip flexion.

Table 4.1 Neurologic examination findings in the lower extremities

Nerve root	Motor distribution	Sensatory distribution	Deep tendon reflex
L1	Iliopsoas (hip flexion)	Anterior hip	None
L2	Hip adductors (hip adduction)	Lateral thigh	None
L3	Quadriceps (knee extension)	Medial thigh and knee	Knee jerk
L4	Tibialis anterior (ankle dorsiflexion)	Medial leg	None
L5	Extension digitorum longus (great toe dorsiflexion)	Lateral leg and great toe	None
S1	Gastroc-soleus complex (ankle plantarflexion)	Lateral foot and toes	Ankle jerk

The Lasegue test, or the straight leg raise test, can also be helpful to distinguish back pain from radicular pain. In this test the child is positioned supine on the examining table (Fig. 4.7). With the contralateral leg gently held in extension on the exam table, the ipsilateral leg is extended at the hip with the knee held in extension. If this maneuver produces pain down the back of the leg to below the knee in a radicular pattern, this is an indication of nerve root irritation. Pain produced in the posterior thigh to the level of the knee is more indicative of irritation of tight hamstrings and does not necessarily due to nerve root irritation.

Finally, the so-called Stork test has been described to assess for pain associated with spondylolysis or spondylolisthesis. This test is performed by having the child balance on one leg, flex at the knee with the opposite leg held off the ground. The patient then hyperextends the lumbar spine (Fig. 4.8). A positive test is one which

Fig. 4.6 Measurement of the popliteal angle. Angle is measured as shown by the *dotted lines*, 50° in this patient

Fig. 4.7 Demonstration of the Lasegue test, or the straight leg raise test

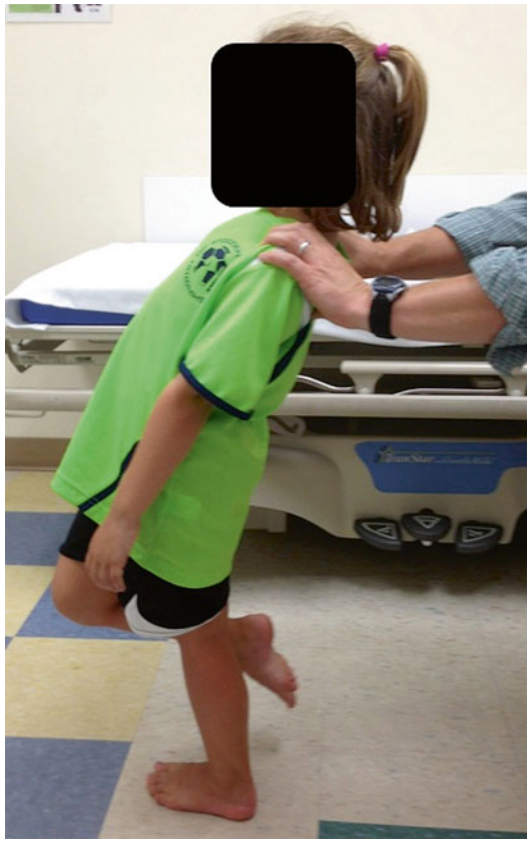

Fig. 4.8 Demonstration of the "Stork" test

exacerbates the back pain. Unilateral symptoms indicate a unilateral pars defect, while bilateral symptoms indicate bilateral defects. This test has been suggested to be quite useful to identify even subtle pars defects [21–23].

Conclusion

Pediatric patients are presenting to the orthopedic surgeons office for evaluation with increasing frequency, and approximately 12 % of those will be diagnosed with spondylolysis or spondylolisthesis. While back pain may be the presenting complaint, occasionally the initial finding is simply spinal deformity or abnormal gait. Reported symptoms may be minimal in the pediatric population with spondylolisthesis, and scoliosis of several types may also be present, so a careful and complete history and physical exam is essential. The exam begins by documenting a thorough history including presenting symptoms, duration, and aggravating or relieving factors. A thorough physical examination including gait assessment and neurologic evaluation is mandatory for the assessment of these children. Complaints or findings of motor weakness, sensory changes, or urologic abnormalities which are identified require further evaluation or imaging. A thorough initial history and physical exam will allow the treating physician to fully assess the impact of the spinal pathology and select appropriate treatment.

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