Chapter 7
Spondylolysis

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Introduction

Back pain in the female athlete is a common complaint. It may represent a simple muscular or ligamentous injury that will often resolve spontaneously. However, when pain is prolonged, a number of more significant considerations should be entertained, including disk pathology, stress fractures, and bone tumors. One common cause of back pain in the adolescent athlete that should be considered is spondylolysis.

Spondylolysis is an overuse injury to the posterior elements of the spine where a stress fracture occurs at the pars interarticularis (pars), between the facet joints. Repeated hyperextension and torsion of the spine are the main mechanisms for this injury. In this type of motion, the superior facet places an increased load on the pars [1]. Over time, there is enough stress across the pars that a stress fracture forms.

These stress fractures can occur unilaterally or bilaterally, and can take place at any level of the lumbar spine. The preponderance of cases, roughly 85–95 %, are seen at L5. The second most common site is L4, with 5–15 % of cases occurring at this location [2]. In 4 % of people experiencing spondylolysis, stress injuries occur at multiple levels [3]. Bilateral involvement occurs in 80 % of cases, and can result in spondylolisthesis, a slippage of one vertebra anteriorly over the level below it [1].

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C.J. Stein et al. (eds.), *The Young Female Athlete*, Contemporary Pediatric and Adolescent Sports Medicine, DOI 10.1007/978-3-319-21632-4_7

Definitions

Pars interarticularis: the area of the vertebrae located between the inferior and superior articular processes of the facet joints. The pars is situated in the posterior column of the spine, which is defined as the bony and ligamentous structures posterior to the vertebral body (Fig. 7.1).

Spondylolysis: a stress fracture in the pars interarticularis of the vertebral posterior elements (Fig. 7.2).

Spondylolisthesis: the slippage that occurs when a vertebra becomes displaced in relation to the vertebra below it (Fig. 7.3).

Facet joint: also known as zygapophyseal joint, the articulation between the superior articular process of one vertebra with the inferior articular process of the vertebra superior to it.

Stress fracture: also known as fatigue fracture, a fracture in the bone as a result of repetitive loading of a specific area over a period of time.

Lordosis: the normal sagittal inward curvature of the lumbar spine. When it is excessive it is referred to as hyperlordosis (sway back). Factors that contribute to hyperlordosis are anterior pelvic tilt and core imbalance of strength and flexibility.

Kyphosis: the normal thoracic outward curvature. At times it can be excessive and is referred to as round back. Excessive kyphosis may secondarily increase lumbar lordosis in order to maintain horizontal vision.

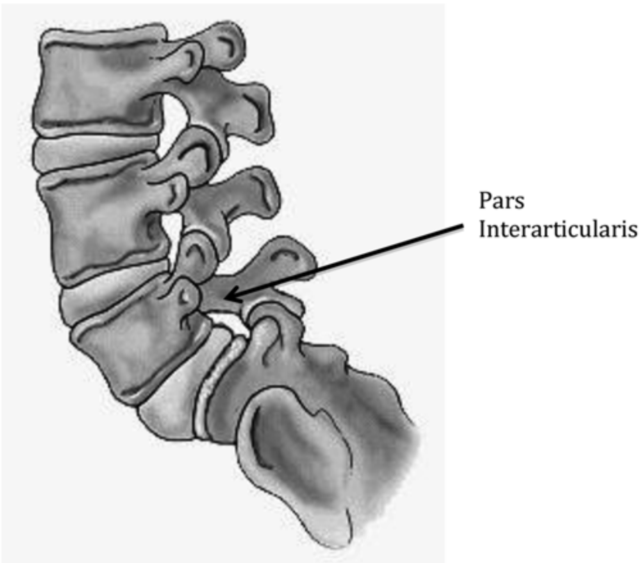

Fig. 7.1 Pars interarticularis

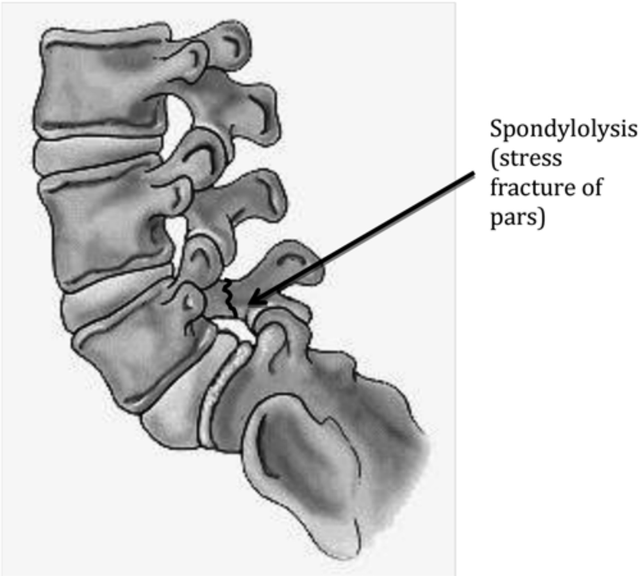

Fig. 7.2 Spondylolysis

Fig. 7.3 Spondylolisthesis

Epidemiology and Risk Factors

Spondylolysis and spondylolisthesis are the most common causes of back pain in young athletes. While the most common cause of back pain in adults is disk pathology, Micheli and Wood have reported the rate of spondylolysis to be as high as 47 % in the adolescent athletic population with back pain [4]. When looking at the adolescent population alone, the prevalence of back pain is 45 % in the athletic adolescent in comparison to 15 % in the sedentary adolescent [5]. Anyone who cares for young athletes should know how to diagnose, treat, and prevent this injury. The ability to identify risk factors for this condition is an important place to begin.

During growth acceleration, the female athlete experiences several anatomic changes that increase stress on the posterior elements of the spine. With the adolescent growth spurt, the anterior pelvic tilt increases. Lordosis of the spine progressively increases, which has been shown to result in back pain [14]. This pain may be due to increased compression of the posterior column and facet joints.

The rate of bony growth during this time exceeds that of musculotendinous growth. The subsequent muscular imbalance and tightness are seen particularly with the hip flexors and the thoracolumbar fascia. These changes, combined with weakness of the abdominal musculature and weakness of the gluteus maximus, have been shown to increase lumbar lordosis and are associated with back pain [6]. Athletic activity, particularly gymnastics, is an additional factor that has been shown to contribute to increased lordosis [7]. In female gymnasts participating in greater than 300 h per year, there was a noted increase in lordosis and kyphosis.

Rapid linear growth during the growth spurt occurs with a much slower acquisition of bone mineralization; therefore there is temporarily a lower bone density [8]. The combination of these factors follows an order of increased linear growth with decreased flexibility and temporary bone acquisition and increased anterior pelvic tilt. See Chapter 1 for additional details on normal growth.

Genetics also contribute to spondylolysis risk to a lesser extent. A study by Roche showed that in the prevalence of spondylolysis, the racial/ethnic breakdown includes 6.4 % of Caucasian men, 2.8 % of African American men, 2.3 % of Caucasian women, and 1.1 % of African American women [9]. Interestingly, Canadian Inuit Eskimos show the highest prevalence, with a reported rate as high as 50 % [11]. Spondylolysis has a familial association. One study reported spondylolysis in 19 % of first-degree relatives [10].

In the past, sex was thought to be a factor in the development of spondylolysis because the condition was seen two to three times more commonly in males than females; however, this is no longer the case [11]. As females have become more active in organized and competitive sports, the development of spondylolysis is now just as common in females as it is in males. In addition, sports and activities such as gymnastics, figure skating, ballet, and other forms of dance, have both a high level of female athlete participation and a higher incidence of spondylolysis than other sports [12].

Some spinal deformities have been found to be risk factors in the development of spondylolysis. The presence of Scheuermann's kyphosis, a fixed severe thoracic outward curvature, has been noted to increase the incidence of spondylolysis by 30–50 % [13, 14]. This is likely due to an increase in lordosis that occurs with Scheuermann's kyphosis. Spina bifida occulta has also been related to an increased incidence of spondylolysis by 3.7 % [15].

The biomechanics of specific sports are also predisposing factors for spondylolysis. Flexion, extension, rotation, and shear forces all play a role in the development of spondylolysis [16]. Sports that require a combination of repetitive extension and rotation of the spine place the greatest stress on the pars and have the highest incidence of spondylolysis [17]. The initiation of a pars fracture also involves a tensile force on the ventral aspect of the pars [18]. Sports and activities with the highest risk for the development of spondylolysis include dance, gymnastics, figure skating, wrestling, diving, and football, specifically the lineman position. All of these sports involve extremes of the motions mentioned above [19, 20]. The incidence of spondylolysis has been reported to be as high as 40 % in diving and 32 % in ballet dancing [21].

Spondylolisthesis

Bilateral spondylolysis occurs in 80 % of cases and can result in slippage of one vertebra over another, a condition known as spondylolisthesis [1]. The Wiltse Classification is used to classify the etiology of spondylolisthesis. There are five types described, with type II being the most common type seen with a sports-related mechanism. Type I is dysplastic, type II is isthmic (related to overuse of the pars seen most frequently in the female athlete), type III is degenerative (usually presenting during middle age at the L4-5 level), type IV is traumatic, and type V is a pathologic fracture. Thirty-two percent of type I fractures are likely to progress with increasing slippage. Conversely, only 4 % of type II are likely to progress [22].

The Myerding Classification is used to classify the actual degree of slippage that occurs in spondylolisthesis. It is based on the percentage of slippage of the involved vertebrae on the vertebrae below it. Grade I is less than or equal to 25 %, grade II is 26–50 %, grade III is 51–75 %, grade IV is 76–100 %, and grade V is greater than 100 %. Grade V is also referred to as spondyloptosis [23].

Clinical Presentation

In the adolescent athlete, back pain typically begins during sports activities, particularly those involving lumbar extension. The pain generally develops gradually with increased activity. Spondylolysis is an overuse injury that develops over time; however, patients often recall a particular injury or competition when the pain began. The location of pain is usually described as either central or off to one side with radiation to the buttocks or proximal extremity. In the early stages, the pain resolves after activity. However, as the spondylolysis progresses, it can persist after activity, even at rest. Neurologic signs are rare and are more often present in a high-grade

Fig. 7.4 Stork test

spondylolisthesis or disk herniation. However, sciatic symptoms occasionally occur, presumably secondary to the site of the fracture being one wall of the neuroforamina.

There are a number of common physical examination findings associated with spondylolysis. Patients typically do not have tenderness with palpation along the spine unless there is overlying spasm of the paraspinous musculature. Patients generally have no pain with flexion, but significant pain with hyperextension. Hyperextension of the spine with the patient standing on one leg (Stork test) helps to illicit information about the side of the spondylolysis (Fig. 7.4); pain on the weight-bearing side is indicative of a fracture [24]. In the athlete with spondylolisthesis, there may be a palpable step off with higher grades of slippage. Patients also commonly present with tight hamstrings. The strength and flexibility of the athlete should always be assessed in order to identify any abnormalities and to structure a regimented physical therapy program. A tight iliopsoas combined with weak gluteal and abdominal muscles can result in an anteriorly rotated pelvis with increased lordosis contributing to the progression of the spondylolysis [25].

Differential Diagnosis

There are several other diagnoses that the clinician must consider when seeing the female athlete with extension-based back pain. These include lumbar disk injuries, sacroiliac instability, lordotic low back pain, and segmentation abnormalities.

While lumbar disk-related pathology is uncommon in children and young adolescents, it may occur. Typically, patients present with worsened pain on flexion, such as during sitting. However, central disk protrusion may elicit pain on extension, causing some clinical confusion.

Another entity involving the disk in the young athlete is referred to as atypical Scheuermann's disease. Typical Scheuermann's disease is a kyphosis, which involves pathologic changes in the upper thoracic spine; this condition occurs when the disk compresses the soft growth plate of the vertebral endplate and causes wedging in the bone. When these changes occur in the upper lumbar and lower thoracic spine, they are often painful and result in a more flat back appearance, called atypical Scheuermann's.

Athletes with any type of lumbar injury may develop atrophy of the lumbar extensor musculature due to pain inhibition and disuse. This atrophy may result in some degree of sacroiliac instability, which typically presents with pain at the superior buttocks adjacent to the L5 region. Pain often increases with lumbar flexion as well as extension. A sacroiliac (SI) provocation maneuver, such as the thigh thrust or thigh compression test, can be helpful to distinguish between SI instability and spondylolysis. This maneuver involves having the supine patient flex both her hip and knee to 90°. The clinician then pushes the thigh posteriorly into the pelvis. Pain at the posterior superior iliac spine marks a positive test for SI instability.

Another possible diagnosis to consider is lordotic low back pain, which generally presents with diffuse, multilevel back pain and significant lordosis. Palpation may reveal tender posterior elements along the entire lumbar spine, including the facet joints and spinous processes. Apophysitis of the growth cartilage of the spinous processes can result in discomfort and tenderness to light palpation directly over the spinous processes, which would not be expected with simple spondylolysis. Most commonly, these diagnoses are made after spondylolysis has been ruled out.

Abnormalities of segmentation of the lower lumbar spine are common. These include lumbar super-segmentation with a lumbarized S1 (i.e., "L6" is not incorporated into the sacrum), which is not commonly associated with back pain. Conversely, incomplete segmentation of L5 is associated with a unilateral bony bridge from L5 that remains in continuity with the sacrum and creates a pseudoarthrosis. This pseudoarthrosis is a common cause of back pain in the athlete and often presents in a similar fashion to spondylolysis or SI pain with pain on hyperextension. It is identified by plain radiographs, and the pain often correlates with the area of pseudoarthrosis.

Diagnostic Testing

In order to confirm the diagnosis of spondylolysis, imaging is often needed if the pain is more than 3–4 weeks in duration. Plain radiographs may be the first line of imaging although they are not sensitive for picking up the disease process. The oblique view may yield the "collar on the scotty dog" but has been shown to be only 32 % sensitive and adds unnecessary radiation [26]. Many clinicians will now simply avoid the initial radiographs in cases of prolonged extension-based back pain in the young athlete and go straight to advanced imaging. However, plain radiographs with anteroposterior and lateral views are useful in detecting spondylolisthesis and transitional vertebrae (incomplete segmentation of vertebrae).

If suspicion is high, the most sensitive test is single-photon emission computed tomography (SPECT) [27]. SPECT scanning can also evaluate osseous healing as it is able to evaluate metabolic activity of bone [28]. In addition, it can be helpful in looking at other etiologies of pain such as SI pain, osteoid osteomas, and transitional vertebrae pseudoarthrosis [29]. However, there is a significant exposure to radiation with bone scans, which should be considered.

Magnetic resonance imaging (MRI) is commonly used for detecting spondylolysis. MRI can detect bone marrow edema in the pedicle and pars region to identify the disease process at an early stage [30]. The MRI techniques involve a sagittal STIR image that looks at pedicle edema, as well as axial T1 and T2 sequences. The STIR images demonstrate the acuity of the pars involvement much like the bone scan. Early detection of a stress reaction through MRI may prevent exacerbation of the condition and development of a pars defect [31]. MRI tends to be a preferred method of imaging in young athletes, as it does not involve radiation exposure. It can also help detect other pain generators, such as disk pathology or other lesions in the bone or soft tissue. At this time, many clinicians will use the MRI as the first line of imaging in athletes with persistent extension-based back pain.

Despite its many advantages, MRI is not as accurate as computed tomography (CT) in demonstrating bony detail. Once a fracture is detected, CT can classify lesions as early, progressive, or chronic. This characterization of the fracture can help to predict which fractures will heal. One study demonstrated healing in 73 % of early fractures, while only 39 % of progressive fractures healed, and none of the terminal or bilateral fractures healed [3]. Unfortunately, CT scanning involves radiation exposure. The amount of radiation is best minimized by scanning only the vertebral level of concern.

In the authors' experience, a limited CT of the affected level is used at times if the fracture is not responding in a clinically favorable manner. If the patient has persistent pain after 6–8 weeks of treatment, a CT may help provide more information for prognosis. An initial CT at the time of diagnosis is usually not needed.

Treatment

There is some controversy and variability in the treatment of spondylolysis. Treatment regimens vary in terms of brace utilization, activity modification, and physical therapy. Research does not support the superiority of one specific treatment over others; however, many studies have not adequately differentiated patients by age and fracture acuity. Furthermore, bony union is desirable, but fracture healing has not been correlated with successful outcomes [32]. Nonetheless, the clinician should attempt to gain a bony union when able. It is likely that the younger athlete with an early phase fracture will heal with a bony union. Those with a subacute or more chronic fracture may not attain a bony union, but usually do well with a stable fibrous union [33]. When considering treatment options, the principals remain the same, and each case should be evaluated and treated based on presentation.

Most treatment plans begin with activity modification. Some providers opt to restrict all sports and physical activities until the patient is pain-free, while others may choose to restrict only those activities that cause pain. Some providers suggest additional time out of sports even after the patient's pain has resolved. Most protocols utilizing only activity modification will recommend that the athlete remains out of sports for 3–4 months [34]. In one study on pediatric soccer players, those athletes who did not adhere to activity modification demonstrated diminished athletic performance [35]. When the Boston Overlap Brace (BOB) protocol is used as described below, the athlete will typically be out of sports for 4–6 weeks before returning to the athletic arena as tolerated.

The use of a brace in treating spondylolysis remains somewhat controversial. There has not been a definitive study demonstrating improved healing with or without bracing. Nonetheless, one retrospective study showed the utilization of the hard, customized BOB allowed early return to sports at 4–6 weeks while continuing brace use [36]. Bracing may consist of either a hard lumbosacral orthosis (LSO), the most common of which is the BOB, or a less rigid transitional brace.

There are three basic protocols for brace utilization. The first and one of the more commonly used regimens does not involve using a brace unless the patient has persistent symptoms after 3–4 months [37]. However, this approach often involves a more prolonged period of activity modification.

The second bracing protocol utilizes a smaller transitional brace along with activity modification for 6–8 weeks. At that time the athlete is assessed for continued pain and dysfunction. If pain persists, especially on lumbar hyperextension, the more rigid BOB is then utilized. This bracing would be combined with activity modification and maintained for an additional 6–8 weeks [2].

The third bracing protocol is the one the authors most often recommend. This utilizes the BOB after confirmation of the diagnosis. The patient is generally placed in the brace for 23 h/day, coming out only to shower and begin anti-lordotic physical therapy exercises. The athlete is reevaluated at 4–6 weeks [34]. If she is pain-free at that time and demonstrates no pain on lumbar extension, the brace is trimmed laterally and the athlete is allowed to return to sports in the brace. It is emphasized to the athlete that this return to activity is dependent on remaining pain-free, wearing the BOB brace, and continuing with a regular physical therapy program. At this point, some providers will allow the athlete to come out of the brace at night. Most athletes are able to participate in their sport and activities in the brace, but some sports such as gymnastics and dance will be significantly limited by brace wear. At this 4–6 week mark, the core stabilization is advanced to incorporate all of the lumbar extensors, while limiting hyperextension. With brace wear, it is crucial to avoid erector spinae and multifidi atrophy.

For most athletes using this protocol, the brace is continued for 3–4 months. However, in some circumstances, shorter treatment periods of 6–8 weeks may be considered; these shorter periods of brace use may be utilized in cases of stress reaction with no identified fracture, or subacute fracture with minimal edema on the T2 MRI signal. Early fractures may heal in as little as 3 months, whereas more chronic fractures can take up to 6 months to heal [38].

The athlete is reevaluated at 3–4 months from brace initiation to identify any residual pain as well as to assess strength and flexibility. If the athlete is pain-free and demonstrates good strength and flexibility, the brace is weaned off over the next 2–3 weeks. A smaller, less restrictive Velcro transitional brace for sports only may be considered. Most importantly, education regarding repetitive extension-based activity should be given in order to prevent recurrence.

Patients with persistent pain at this 3- to 4-month point should be evaluated for adherence to brace use and physical therapy. Providers should also consider persistent fracture and other pain generators, such as facet arthropathy or SI joint pain. Surgical consideration may be necessary at this stage. In patients with persistent pain and with non-union of the fracture, a bone stimulator may be considered to advance healing. While bone stimulators have not been shown to expedite healing in the acute phase of spondylolysis, there is evidence to suggest improved bony healing in chronic cases [39].

When considering other potential contributors to the pain, PT modifications and steroid injections can be utilized. PT can be directed at peri-pelvic strengthening as well as SI stabilization. Alternatively, SI or facet injections can be both diagnostic and therapeutic.

There are a few complications that can arise despite treatment. In general, the outcome of unilateral pars fractures is good [2]. However, up to 25 % of cases can develop a stress response or fracture in the contralateral side leading to bilateral fractures. In addition, patients with bilateral pars defects can also develop spondylolisthesis. These often do not progress after diagnosis.

Surgery is sometimes considered in cases of spondylolysis and spondylolisthesis. Surgery is reserved for truly refractory cases despite full conservative management of at least 6–12 months of treatment. Other considerations for surgery include progression of spondylolisthesis, a related neurologic deficit, or refractory radicular symptoms [40]. The surgical treatment may involve a fusion or in some cases a direct pars repair. Indications for a direct repair include minimal disk degeneration and less than 3 mm of spondylolisthesis [40]. Return to sports after surgery is often in the 6–12 month range.

Conclusion

Spondylolysis is an overuse injury to the posterior elements of the spine in which a stress fracture occurs at the pars interarticularis of the vertebra. Repeated hyperextension and torsion of the spine, which are common movements in many different types of sports, are the main mechanisms for this injury. The young female athlete is at particular risk for spondylolysis, especially during times of rapid growth with concurrent core weakness and muscle tightness.

When spondylolysis does occur, the best treatment starts with early detection to avoid prolongation of symptoms and progression of the injury. Treatment centers on limitation of extension and initiation of anti-lordotic and core stability exercises. Activity modification is usually a temporary but important element of treatment.

These stress injuries are best prevented with good core stabilization and limitation of hyperextension in the growing athlete. Therefore, it is necessary to recognize risk factors and treat the core instability, poor biomechanics, and muscular imbalances that can predispose young athletes to injury. Many of these risk factors can be identified through a thorough preparticipation exam.

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