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Review Article

Spondylolysis and spondylolisthesis: A review of the literature

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A B S T R A C T

Spondylolysis is a common diagnosis with a high prevalence in children and adolescents complaining of low back pain. It may be caused by either a defect or fracture of the pars interarticularis due to mechanical stress. Depending on the severity of the spondylolysis and symptoms associated it may be treated either conservatively or surgically, both of which have shown significant success. Conservative treatments such as bracing and decreased activity have been shown to be most effective with patients who have early diagnosis and treatment. Low-intensity pulsed ultrasound (LIPUS) in addition to conservative treatment appears to be very promising for achieving a higher rate of bony union. LIPUS requires more supporting studies, but may prove to become a standard of care in the future. Surgery may be required if conservative treatment, for at least six months, failed to give sustained pain relief for the activities of daily living. Based on studies performed on each of the major surgical treatments we suggest the use of the pedicle screw hook technique and the pedicle screw rod technique due to low rates of hardware failure, increased maintenance of mobility, and lack of a postoperative bracing requirement.

1. Introduction

Spondylolysis is an anatomical defect or fracture of the pars interarticularis of the vertebral arch. It occurs at the L5 vertebrae between 85 and 95% of the time and occurs at the L4 vertebrae 5–15% of the time.[1] The defects can occur unilaterally or bilaterally. Spondylolysis is one of the most common causes of lower back pain in adolescents, although it remains asymptomatic in the majority of patients. Spondylolysis can progress to spondylolisthesis, which is defined as anterior displacement of the vertebral body in reference to the bordering vertebral bodies.

There are five categories of spondylolisthesis classified by Wiltse et al.[2] Type I is dysplastic and refers to a congenital dysplasia that results in the anterior and superior rounding of the S1 vertebrae. This rounding allows the L5 vertebrae to slip anteriorly on the S1 vertebrae. Type II is isthmic and is separated into Type IIA and Type IIB. Type IIA is caused by a stress fracture of the pars interarticularis (spondylolysis) that results in anterior slippage of the vertebrae. Type II B is caused by repetitive fractures and subsequent healing which results in lengthening of the pars interarticularis leading to anterior slippage of the vertebrae. Type III is degenerative and the root cause is commonly from arthritis. Arthritis of the facet joint prevents movement of the joint leading to stress and instability which ultimately leads to the weakening of the ligamentum flavum. Weakness of the ligamentum flavum leads to degenerative instability and permits anterior slippage of the vertebrae.[3] Type IV is traumatic and is caused by high energy trauma to the spine. Type V is pathologic and can be caused by lytic bone tumors, osteopetrosis, or osteoporosis. Type VI is iatrogenic spondylolisthesis and is a potential sequelae of spinal surgery. Frequently, these patients will have undergone prior laminectomy. If insufficient osseous structure is preserved during the procedure, the pars will be weakened and more likely to fracture.

The Myerding classification defines the amount of vertebral slippage on X-ray in reference to the caudal vertebrae.[4] There are five grades of spondylolisthesis in the Myerding classification. Grade I is less than 25 percent slippage, grade II is 26–50% slippage, grade III is 51–75% slippage, grade IV is 76–100% slippage, and grade V is over 100% slippage and is referred to as spondyloptosis.

2. Etiology

Spondylolysis has been shown to be absent at birth, and generally develops at a young age.[5] Fredrickson et al.[6] performed a prospective study on 500 first graders and found a prevalence of 4.4% at the age of 6 years which increased to 6% by the time adulthood was reached. The incidence of spondylolysis was present at a ratio of 2:1 male to female. Wynne-Davies[7] found that first-degree relatives of those affected by spondylolysis had a higher incidence (19%) of spondylolysis compared to the general population which signifies that a genetic component is likely contributory.

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3. Pathophysiology

Spondylolysis is generally caused by repetitive stress to the pars interarticularis, especially due to hyperextension.[8] This injury is commonly seen in football linemen, gymnasts,[9] and Olympic weight lifters due to repetitive hyperextension.[10] Dietrich and Kurowski[11] performed a study evaluating the load and stress that is placed on the lumbar vertebrae. They found that the highest amount of stress is placed on the pars interarticularis. The conclusion that spondylolysis is caused by mechanical stressors can be drawn from the fact that spondylolysis has been shown to be absent at birth and that the incidence of spondylolysis in a patient population of 143 adults who had never walked was 0%.[12]

Cyron and Hutton[13] examined the fatigue life on cadaveric lumbar vertebrae that were placed under forces comparable to those experienced during the activities of daily living. Repetitive forces will cause minute damage to the bone over time and when this rate of damage overcomes cellular repair of the bone, a fracture will result. They found that walking with a back pack and standing in flexion for prolonged periods of time put sufficient stress on the lumbar vertebrae to result in a fracture. They also found that the strength of the neural arch continues to increase up to the age of 50. Decreased strength of the neural arch at a young age predisposes children and adolescents to a higher risk of fracture. Adolescents and children also have more elastic intervertebral disks which causes increased stress to be placed on the pars interarticularis.[14]

4. Clinical presentation

Spondylolysis is usually asymptomatic and may be found incidentally on radiographic examination. If the patient is symptomatic with lower back pain present, the pain will generally be worse with back extension. Visual inspection of the child may reveal lumbar hyperlordosis. If severe spondylolysis is present, a drop-off from the lumbar spine to the sacral spine may be palpable and lumbosacral kyphosis may be present.[1] Contracture of the hamstrings can also be a common finding for which the mechanism has not yet been elicited.[15] Hirano et al.[16] evaluated 100 patients between the age of 8–18 years that played sports almost daily and had a chief complaint of lower back pain. Pain with normal physiologic lumbar extension was evaluated in all patients and was present in 69%. All patients were then evaluated with X-ray, followed by a CT scan if X-ray was not confirmatory for spondylolysis. 34 of the 42 (81%) patients that had spondylolysis on imaging had pain with back extension. 35 of the 58 patients (60.3%) without spondylolysis present on imaging had pain with back extension. These results give a sensitivity of 81% and specificity of 39.7% for pain with back extension in spondylolytic patients.

Spondylolisthesis may present with symptoms of a radiculopathy due to compression of the nerve roots. When spondylolisthesis occurs in the lumbar vertebrae, pain, numbness, tingling, or weakness will be present in the lower. Patients may also complain of sharp shooting pains down their legs with certain activities that involve extension of the back. The patient will generally have a kyphotic lumbar posture in order to relieve pressure off of the nerve roots, which will subsequently reduce their symptoms.

Spondylolisthesis has been shown to have a very high incidence rate (36.7%) in those with rheumatoid arthritis.[17] It is also very common in patients with scoliosis and has a reported incidence of 15–48% in these patients[18,19] Spondylolisthesis should be high on the differential in patients with rheumatoid arthritis or scoliosis presenting with low back pain or lower extremity neurological symptoms.

5. Clinical course

Beutler et al.[20] performed a 45 year follow up on the original subjects with spondylolysis in the study performed by Fredrickson et al.[6] Of those 500 original patients, 6% of them had spondylolysis in adulthood giving a patient population of 30. Eight of the subjects had unilateral pars defects and never developed spondylolisthesis. The other 22 subjects had bilateral pars defects with 18 (81.1%) of these patients developing spondylolisthesis. The only prognostic indicator found in this study for the development of spondylolisthesis was whether or not there is unilateral or bilateral spondylolysis. Beutler et al.[20] did not find any increased risk of slip progression as the patients aged into adulthood and this finding was further supported by other studies.[21,22] The strength of the growth plate has been shown to be the weakest portion of the lumbar vertebrae to resisting anterior shear forces. It is theorized that the growth plate plays an important role in the origin of spondylolisthesis.[23]

Progression of spondylolisthesis after the age of 20 years is much less common compared to progression during childhood and adolescence. This is likely due to ossification of the growth plate. McPhee et al.[22] followed 51 patients under the age of 30 with spondylolisthesis and evaluated the progression of slippage. The incidence of progression in the entire study population was 24%. It was found that the rate of progression was highest in adolescents with 38% of the adolescents progressing. Type I dysplastic spondylolisthesis was found to have the highest rate of progression with an incidence rate of 32%. Type II isthmic spondylolisthesis was found to have the lowest rate of progression with an incidence rate of 4%.

6. Treatment

There are few large clinical trials focused on the treatment of spondylolysis which makes it difficult to determine a proper treatment algorithm for conservative and surgical treatment. Young patients with spondylolysis generally receive conservative management as their initial treatment.[24] Conservative management generally consists of bracing, activity restriction, physical therapy and pain control.[25]

Morita et al.[26] defined the fractures of the pars interarticularis into three stages consisting of early, progressive, and terminal. The early stage was defined as a hairline defect of focal bony absorption. The progressive stage was defined as a wide defect with the presence of small fragments. The terminal change was defined as sclerotic change. The effects of conservative management on 185 adolescents with spondylolysis was studied. The adolescents were divided into early, progressive, and terminal stages of pars defects. Healing occurred in 73% of the early stage cases, 38.5% of the progressive stage cases, and 0% of the terminal cases. Sakai et al.[27] performed a very similar study on 60 pediatric patients and found 100% healing in the very early stage, 93.8% healing in the early stage, 80% healing in the progressive stage, and did not attempt conservative treatment in the terminal patients. Wiltse et al.[2] conservatively treated 17 adolescents and children with spondylolysis and had successful results in 12 (70%) of the patients. Blanda et al.[25] successfully treated 52 out 62 (84%) patients with spondylolysis in a conservative manner.

Arima et al.[28] evaluated the use of low-intensity pulsed ultrasound (LIPUS) versus conventional conservative treatment in patients with the progressive stage of spondylolysis. The experimental group consisted of 9 adolescent patients that received a combination of LIPUS for 20 min every day in addition to conventional conservative treatment. The control group consisted of 10 adolescent patients who received only conventional conservative treatment. The experimental group treated with LIPUS achieved a union rate of 66.7% with a mean treatment time of 3.8 months. In the control group treated with conventional conservative treatment, a union rate of 10% was achieved with a treatment time of 3.8 months. Busse et al.[29] performed a meta analysis of 3 trials with a total of 158 fractures of various bones that utilized LIPUS and found an average increase in healing time of 64 days between the LIPUS and control groups. Larger studies need to be undertaken regarding the effectiveness of LIPUS in treating spondylolysis conservatively, but the initial results seem very promising and may prove to become a standard of care in the future especially for patients diagnosed with the