Review

Adult Isthmic Spondylolisthesis

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Spondylolisthesis is defined as an anterior or posterior displacement or slipping of one vertebrae on another. Bilateral defects in the pars interarticularis of the superior vertebra with resultant anterior displacement of its body on the vertebrae below describes an isthmic spondylolisthesis. If there is no translation at the functional spinal unit, the defect in the pars interarticularis is described as a spondylosis (Figure 1). This spinal condition (spondylosis, spondylolisthesis) may, in rare situations, cause lower back pain in the adult patient. Fortunately, in the majority of cases, symptoms are not severe enough to warrant specific treatment, either nonoperative or operative. In rare situations, when symptoms related to an isthmic spondylolisthesis interfere with basic activities of daily living despite aggressive conservative treatment, surgical intervention may be warranted.

The goals of surgical intervention in an adult patient with an isthmic spondylolisthesis are to improve the symptoms of low back pain, neurological dysfunction (ie, weakness), and posture and gait by stabilizing the isthmic segment; and to relieve radiating discomfort. The results of surgical treatment for isthmic spondylolisthesis in children and adolescents have been well documented. Clinical success rates for in situ posterolateral fusion in this population ranges from 80%-100%.

Indications and surgical outcomes of adult disease vary in the literature. Haraldsson and Willner observed that in adults, instability is not the only pain generator as in children and adolescents. An adult also may have symptoms related to disk degeneration and nerve compression that cannot be resolved by fusion alone.

Several well-supported methods of surgical intervention in adults have been reported. These include a pars interarticularis repair, Gill laminectomy and adjunctive fusion, instrumented posterolateral fusion or interbody fusion with instrumented posterolateral fusion, anterior interbody fusion, or anteroposterior decompression and instrumented fusion procedure. The method chosen depends on the clinical scenario and the surgeon’s experience.

**CLASSIFICATION**

Wiltse et al classified isthmic spondylolisthesis into three subtypes based on the appearance of the pars interarticularis defect. Subtype A is the lytic type in which there is a fatigue fracture of the pars with complete bony separation. Subtype B describes an

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elation of the pars without separation. This is believed to occur due to repeated microfractures of the pars interarticularis leading to progressive elongation. This type may eventually progress to a nonunion, transforming a Subtype B into a subtype A lesion. Subtype C is an acute pars fracture. This lesion results in a spondylolysis, but over time may progress to an osteoarticular component. The prevalence of a pars defect is 4%-6% in the general population; however, a slippage component, if present, often is low grade and asymptomatic.

Spondylolisthesis also is graded by the Meyerding classification depending on the degree of displacement of the superior vertebra on the vertebra below. In grade I, the displacement is ≤25% of the anteroposterior diameter of the vertebrae below; grade II, between 25% and 50%; grade III, between 50% and 75%; and grade IV, >75% (Figure 2). A complete displacement or separation is termed a spondyloptosis.

SLIP PROGRESSION

Radiographically, there is well-documented evidence of slip progression in children and adolescents; however, adult progression of isthmic spondylolisthesis has rarely been described in the literature. Floman postulated that slip progression after skeletal maturity is almost always related to disk degeneration at the slip level. Therefore, slippage in the adult population is most likely to develop in the fourth or fifth decades of life. The capacity for the intervertebral disk to resist anterior shear forces is greatly diminished as the disk degenerates, thereby leading to the potential for slip progression in the setting of compromised posterior elements (ie, the pars interarticularis). Interestingly, in Floman’s study, slippage was uniformly accompanied by disk degeneration below the level of the pars defect. The presence of disk degeneration may explain how an asymptomatic lesion present for two to three decades may insidiously or suddenly, following a traumatic event, become symptomatic (Figure 3).

CLINICAL PRESENTATION

The majority of people with an isthmic spondylolisthesis are asymptomatic. If symptoms develop, they usually consist of back and leg pain. Back pain typically is intermittent, aggravated by strenuous activity and relieved with rest. Leg pain is a frequent complaint in adults and may be sciatic (ie, radicular), referred, or claudicant in nature. Radicular symptoms include pain, numbness, and paraesthesias in a dermatomal pattern. Symptoms of tight hamstrings, present frequently in children with isthmic spondylolisthesis, are not usually seen in adults.

Deep palpation of the spinous process above the level of the slip may elicit tenderness. A spinous process step-off may be felt immediately above a grade II or higher slip. Forward flexion of the trunk may be limited by paravertebral muscle spasms. Hamstring tightness, although uncommon, may be present in severe slips. At the lumbosacral junction, a palpable prominence may occur in high-grade slips as L5 translates and rotates anteroinferiorly over S1, producing a kyphotic deformity. This leads to a compensatory lumbar hyperlordosis and an appearance of trunk shortening. The nerve roots that exit adjacent to the pars defect may be compressed by either hypertrophied fibrocartilage that fills and occupies the defect, osteophytes adjacent to the defect, or degenerative hypertrophic facets caudal to the defect. The sacral roots also may be stretched in an L5-S1 spondylolisthesis. This may result in bladder and bowel dysfunction.
TREATMENT
Surgery is rarely required in adults patient with symptoms related to an isthmic spondylolisthesis. In fact, initial restriction of the patient’s activities, spinal and abdominal muscular rehabilitation, the judicious use of anti-inflammatory medications, and in some cases the use of epidural steroid injections may suffice.

Nonoperative Management
Nonoperative treatment therapies are aimed at reducing symptoms in the short term, as symptoms tend to run a course of acute exacerbation followed by remission. Treatment strategies usually are prescribed for a course of 4 weeks to 3 months to educate patients on the spinal disorder and appropriate back care techniques. The speed of symptom improvement often is correlated with the patient’s complicity with his or her therapy.

Common nonoperative treatment methods include the use of nonsteroidal anti-inflammatory drugs in combination with an exercise program that includes stretching, strengthening, and a flexibility program. Weight loss, if appropriate, should be an initial goal for an overweight patient with an isthmic spondylolisthesis. Some clinicians advocate using external bracing for evaluation of the potential effectiveness of future spinal fusion; however, the consensus on its predictive power is controversial. Spinal injection of corticosteroids into the epidural space or facet joint also may be of some temporary value. Narcotics, however, should only be used for acute exacerbations of symptoms and only for a brief time period. Chronic narcotic use in the setting of prolonged back pain will only contribute to the long-term disability of the patient’s spinal disorder due to the potential for drug addiction and the secondary effects of central nervous system depression.

Interestingly, a recent study by Moller and Hedlund has shown that the outcome of treatment for symptomatic adult isthmic spondylolisthesis unresponsive to conservative treatment is better with an in situ posteroatlateral fusion than with an exercise program.

Indications for Surgical Treatment
If the symptoms related to an isthmic spondylolisthesis do not improve with conservative management and significantly disrupt the lifestyle of the patient, surgical management may be considered. In general, the indications for surgical intervention in the setting of adult isthmic spondylolisthesis include:
- failure of an adequate trial of conservative therapy for disabling back and leg pain,
- symptomatic radiographic instability,
- documented slip progression greater than grade II,
- a symptomatic grade III or grade IV slip or a spondylolisthosis,
- a progressive neurological deficit, and
- bowel or bladder dysfunction related to the isthmic spondylolisthesis.

There are several documented predictors of outcomes following surgical intervention for symptomatic isthmic spondylolisthesis. In one study, patients involved in workers’ compensation or disability claims due to new onset low back pain in the setting of low-grade spondylolisthesis were found to be less likely to achieve significant pain relief or improvement of function after fusion with or without decompression. Cigarette smoking also portends a less than satisfactory result following surgical intervention. Schnee et al. found advanced patient age (up to 75 years) had no adverse effect on surgical outcome. Patients <55 years, however, were found to have significantly increased risks of poor employment and baseline pain profiles. Additionally, patients who have previously undergone two or three prior operations with or without the diagnosis of pseudarthrosis also have poor outcomes following surgical intervention.

SURGICAL OPTIONS
Once the decision for surgical intervention is made, the choice of surgical procedure is predicated on specific clinical diagnostic and radiographic parameters. The operative approach, the number of spinal levels involved, and whether to perform a decompression, a fusion, or to use adjunctive internal fixation are the major decision points. Surgical treatment options include: 1) pars interarticularis defect repair, 2) fusion with or without decompression, 3) instrumented posteroatlateral fusion with or without decompression, 4) interbody fusion alone or combined with posterior stabilization with or without decompression, and 5) a reduction of the isthmic deformity.

Pars Interarticularis Defect Repair
Direct repair of the pars interarticularis involves local bone grafting of the pars defect following adequate debridement and decortication followed by osteosynthesis across the graft site. This may be accomplished by pedicle screw fixation of the involved level attached to an ipsilateral hook-rod construct allowing compression, direct screw compression through the lamina into the pedicle, or through tension band wiring of the ipsilateral transverse process to the spinous process. This is considered an acceptable approach for patients <30 years in the absence of disk degeneration. This procedure assumes that the anatomic defect is the cause of the pain, preferably determined through presurgical selective pars injections. This procedure often is not used in adults with isthmic spondylolisthesis due to the frequent coexistence of symptomatic degenerative disk disease.

Decompression and In Situ Posterolateral Fusion
An in situ posterolateral fusion is the most widely selected means of surgically managing an isthmic spondylolisthesis (Figure 4). This involves placement of autologous bone graft...
along the decorticated posterolateral spinal elements (i.e., transverse processes, lateral aspect of superior articular facet, and sacral ala).

In the majority of cases, only a single motion segment involving the level of the pars defect is fused. In patients with evidence of supra or subadjacent advanced degenerative disk disease, an adjacent mobile retrolisthesis, a high grade slip (grade III or IV), or slip angle, extension of the fusion to the supra or subadjacent level often is recommended (Figure 5). This offers a better mechanical advantage in the sagittal plane for fusion healing. Additionally, in high grade slips, the L5 transverse processes are technically difficult to access for adequate bone graft application.12

The Gill procedure, first described in 1995,13 consists of removing the involved loose lamina and decompressing the exiting nerve roots by removing hypertrophic fibrocartilage in the pars defect. The risk of slip progression in these patients has been reported to be as high as 27% in one series,14 especially in patients <30 years. This has led to the recommendation of a concurrent fusion procedure in adults to prevent late symptomatic instability, especially in the setting of degenerative disk disease.

Although a decompressive procedure is recommended in a patient with radiculopathy or neurological deficit in the setting of radiographically documented neural compression, one study found an increased risk of fusion non-healing when a decompression was performed.15 Carragee15 recently studied the outcomes of patients (smokers or nonsmokers) who underwent fusion for symptomatic adult isthmic spondylolisthesis treated with or without decompression and instrumentation. He found that nonsmoking patients who underwent a decompression at the time of fusion without instrumentation were no better off symptomatically than patients who did not undergo decompression.15 However, the presence of a decompression was associated with an increased rate of pseudarthrosis and unsatisfactory clinical results. Patients who received adjunctive instrumentation to their fusion without a concomitant decompression had a better clinical outcome than those who were decompressed. The author found that the addition of a decompression at the time of arthrodesis for symptomatic low-grade spondylolisthesis in patients without a significant radiculopathy or neurological deficit does not improve outcomes and may significantly increase the rate of pseudarthrosis and clinical failure. He also recommended the use of instrumentation in any patient who smoked.15

Moller and Hedlund8,16 performed a prospective, randomized study that evaluated the efficacy of adjunctive pedicle fixation in the surgical management of adult isthmic spondylolisthesis. The study found that supplemental pedicle screw fixation prolonged the operative time and increased the total blood loss but did not affect the clinical outcome or fusion rate.

Other factors that affect the outcomes of posterolateral fusion include smoking, compensation claims, and NSAID use after surgery. Deguchi et al17 found a pseudarthrosis was most likely to develop in patients who continued to smoke postoperatively. They noted blood gas levels in smokers were significantly lower than nonsmokers because of increased carbon monoxide absorption, and that smoking led to arterial constriction. Inadequate oxygenation of blood flow to the neural tissues also may interfere with neurological recovery, leading to lower clinical success rates despite a solid fusion in patients who continue to smoke in the postoperative period. They also found the fusion rate was lower for patients who continued to take NSAIDs for the first 3 months postoperatively than those who did not.

Anterior Interbody Fusion

Many surgeons believe a significant amount of symptomatology noted in adults with an isthmic spondylolisthesis emanates from the degenerated anterior intervertebral disk. Therefore, to improve a patient’s clinical outcome, removal of the symptomatic disk, as guided by provocative diskography, followed by an interbody fusion is a necessary component of the surgical procedure. An interbody fusion can be performed either through an anterior or posterior approach. The approach should be predicated on the patient’s body habitus as well as localized and global sagittal balance. In a patient with poor sagittal alignment (i.e., neutral kyphosis with a positive vertical sagittal alignment), an anterior approach is preferential. The anterior approach to interbody reconstruction has the benefit of increased surface area available to a structural interbody device/graft as well as the ability to use a larger graft size (vertical height) as opposed to the posterior approach. Kim et al18 found that an anterior interbody fusion corrects malalignment of the lumbar spine, restores disk height, and resolves nerve compression by enlargement of the stenotic canal and foramens.

Following decortication of the intervertebral space, a structural autograft, allograft, or a variety of synthetic or metallic cages (cylindrical or trapezoidal) may be inserted through the
anterior or posterior approach. A transvertebral-disk-vertebral strut graft, preferably fibula allograft, also may be inserted through the involved levels of slippage (ie, L5 and S1) in high-grade slips following reaming under fluoroscopic guidance (Figure 6).

The placement of an interbody graft allows maintenance or elevation of disk space height with indirect opening of the neuroforamen. Placement of an interbody graft through the posterior lumbar interbody fusion technique requires significant neural retraction to access the disk space and has the inherent disadvantage of limited visualization with the potential for nerve root traction injury and increased perineural fibrosis. The need for significant nerve root retraction has been markedly decreased by the postero-lateral placement of an interbody device/graft through the transfornamental lumbar interbody fusion method (Figure 5).

**Combined Anteroposterior Fusion**

The fate of stand-alone anterior fusion for spondylolisthesis is uncertain, especially in light of the lack of posterior stability offered by the incompetent posterior elements. A recent study found no statistically significant difference in terms of deformity correction rate, fusion rate, and clinical results between an anterior interbody fusion and posterolateral fusion with transpedicular fixation in symptomatic adult patients with isthmic spondylolisthesis. If an anterior interbody fusion procedure is desired, many surgeons advocate a posterior instrumented stabilization procedure to confer additional stability (Figure 6).

**Conclusion**

Surgical intervention in symptomatic adult isthmic spondylolisthesis is rarely required. Appropriate patient selection is paramount to surgical success once a patient fails an attempted trial of conservative treatment. The surgical procedure selected is ultimately based on specific patient characteristics, such as body habitus, symptoms and radiographic findings, as well as the experience of the surgeon.

**References**

8. Moller H, Hedlund R. Surgery versus conservative management in adult isthmic spondylo-


**EDITORIAL COMMENT**

**ORTHOPEDICS:** The authors conclude the method of surgical intervention is patient specific and depends largely on the experience of the operating surgeon. In a scientific approach, one should use a variety of investigations (eg, electromyograms, magnetic resonance imaging, and diskograms) to determine the source of pain in these patients. The pain-specific surgery should be performed, not an operation with which the surgeon feels comfortable.

The authors also refer to lumbar instability. This specific entity has not been defined in the literature and remains a difficult question. As the source of pain can be from different origins, in treating adult isthmic spondylolisthesis, one should guard against performing a routine or standard operation, ending up with a dissatisfied patient in terms of pain, although the radiographs might be acceptable. It is crucial to visit the source of pain, and should it be from the disk, an anterior fusion would be more feasible than a posterior fusion. It has been proven that stand-alone decompression is one of the worst techniques in this situation, in which you are already facing a potential unstable situation. When this procedure is performed, the authors often comment that an anterior procedure is mandatory to ensure a positive fusion.