Abstract
The incidence of isthmic spondylolysis is approximately 3% to 6% in the general population. Spondylolytic defects involving multiple vertebral levels, on the other hand, are extremely rare. Only a handful of reports have examined the outcomes of surgical treatment of multi-level spondylolysis. Here, we present one case of bilateral pars defects at L3, L4, and L5. The patient, a 46-year-old female, presented with lower back pain radiating into the left lower extremity. Radiographs and CT scans of the lumbar spine revealed bilateral pars defects at L3-L5. The patient underwent lumbar discectomy and interbody fusion of L4-S1 as well as direct repair of the pars defect at L3. There were no postoperative complications, and by seven months the patient had improved clinically. While previous reports describe the use of either direct repair or fusion in the treatment of spondylolysis, we are unaware of reports describing the use of both techniques at adjacent levels.

Spondylolysis, a defect in the pars interarticularis of the vertebral arch, and spondylolisthesis, the anterior displacement of one vertebral body with reference to the one below it, were classified by Wiltse and colleagues into five types: dysplastic, isthmic, degenerative, traumatic, and pathologic. Isthmic spondylolysis, which refers to a stress fracture of the pars interarticularis, is the most common of the five types to present symptomatically, having a reported incidence of 3% to 6% in the general population. Of these cases, the majority of defects (85% to 95%) occur at L5, with much of the remainder occurring at L4. Spondylolytic defects involving multiple vertebral levels, on the other hand, are extremely rare. Only a handful of reports have examined the outcomes of surgical treatment of multi-level spondylolysis. This case report describes a unique approach to the treatment of a patient with bilateral pars defects at L3, L4, and L5.

Case Report
A 46-year-old female presented with lower back pain radiating into the left lower extremity. The patient’s pain began 2 years prior to her initial visit when she had reportedly fallen and sustained an injury to her lower back. Despite rest, medications, and physical therapy, her pain persisted. At the time of presentation, the patient’s pain was constant and worsened with activity.

Physical examination showed decreased range of lumbar spinal motion, especially with regard to extension of the lumbar spine, which caused pain. The straight leg test was positive on the left side, reproducing left lower back and leg pain. Furthermore, there was decreased sensation to light touch over the left L5 distribution. Motor strength was 5/5, reflexes were equal and symmetric, and the remainder of the exam was within normal limits.

Anteroposterior (AP), neutral lateral, flexion, and extension lateral views revealed grade 1 spondylolisthesis of L4-L5 and L5-S1. L4 and L5 pars defects were noted (Fig. 1). A computed tomography (CT) scan revealed bilateral pars defects involving the L3, L4, and L5 levels, and grade 1 spondylolisthesis at L4-5 and L5-S1 (Fig. 2). Magnetic resonance imaging (MRI) revealed degenerative disc disease at L4-5 and L5-S1, a central disc herniation at L4-L5, and a left paracentral disc herniation at L5-S1 (Fig. 3).

The patient underwent anterior lumbar discectomy and
interbody fusion of L4-5 and L5-S1 using a femoral ring structural allograft through a retroperitoneal approach. Posterior lumbar fusion and instrumentation of L4-S1 was then done using pedicle screw fixation and iliac crest bone grafting. Next, direct repair of the pars defect at L3 was done using pedicle screws bilaterally at the L3 pedicles. An up-going laminar hook was placed on each side of the lamina, and short rods were placed between the laminar hooks and the pedicle screws. The pars defects in L3 were decorticated, and the earlier harvested bone chips were impacted in place between the defects. Utilizing the rod and the screw hook construct, the defect was compressed. Posterior lumbar laminectomy was performed at L4-L5 and L5-S1. An EBI internal bone stimulator (EBI/Biomet, Parsippany, NJ) was placed along the pars repair of L3 on each side.

The patient had no postoperative complications. She wore a thoracolumbosacral orthosis (TLSO) brace for 4 months following the surgery. At 7 months postoperatively, her leg and back pain had improved, and the patient was instructed to increase activity as tolerated. Throughout her postoperative visits, root tension signs were negative and neurological examinations did not reveal any deficits. Flexion, extension lateral, and AP views showed good fusion with a well-fixed implant with no evidence of motion at the latest follow-up (Fig. 4).

**Discussion**

Spondylolytic defects involving multiple vertebral levels are very rare. Based on reported incidences at the time, Ravichandran calculated that only 1.48% of patients with back pain were diagnosed with multi-level spondylolysis. A higher rate of multi-level spondylolysis (as well as single-level spondylolysis) has been found in native Alaskans.

The causes of multi-level spondylolysis remain uncertain. Ogawa and associates hypothesized that multi-level spondylolysis results from fatigue fractures of the pars interarticularis, which underlie most cases of single-level spondylolysis as well. Ravichandran, however, reported six cases of multi-level spondylolysis, all but one of which involved symptoms that were precipitated by trauma. He concluded that trauma is an important factor in producing multiple pars defects in a single patient, but that genetics may play a role as well. It is possible that repetitive extension movements related to this patient’s employment...
as a housekeeper resulted in fatigue fractures at three levels. The patient’s fall 2 years prior to her initial presentation may have then aggravated her pars defects, sparking the onset of her symptoms.

Reports of patients with multi-level spondylolysis remain scarce. Privett and Middlemiss\(^1\) reported a 49-year-old male with bilateral three-level spondylolysis at L3, L4, and L5. The patient was employed as a coal merchant and presented with intermittent low backache of 5 years duration. The radiological findings in this patient were described, but the investigators did not describe any attempt at treatment. Similarly, Mathiesen and coworkers\(^2\) reported the case but not the treatment of a 53-year-old Eskimo female with multi-level spondylolysis. Following an episode of acute atraumatic lower back pain, the woman experienced intermittent (and ultimately chronic) lower back pain and right sided radicular pain. Radiological studies revealed spondylolysis at L3, L4, and L5 and spondylolisthesis at L4-5 and L5-S1. Beningfield and Heselson\(^3\) also reported on a 35-year-old male employed as a farm laborer who presented with lower back pain with radiation into the left leg of 7 years duration. Radiographs revealed bilateral spondylolyses at L3 and L5 and a unilateral spondylolysis at L4. Spondylolisthesis at L5-S1 was also present. The patient was treated conservatively, but a description of his long-term outcome was not provided.

The optimum treatment for multi-level spondylolysis remains controversial. It is widely accepted that most patients with single-level spondylolysis do well with conservative treatment.\(^7,14\) It is only when conservative treatment fails that surgical options are recommended. Ravichandran\(^1\) recommended a similar approach to patients with multi-level spondylolysis. Of the six cases of multi-level spondylolysis that he reported, four patients were treated surgically after conservative treatment failed, while the remaining two received conservative treatment alone. Half of the patients receiving surgery displayed “excellent” outcomes, while the other half were found to have “poor” outcomes. The two patients treated conservatively, on the other hand, had “good” clinical outcomes.

However, conservative treatment has generally been reported to be ineffective for patients with multiple pars defects. Eingorn and Pizzutillo\(^4\) reported the case of an 18-year-old female with pars defects at L2, L3, and L4. Conservative treatment, which involved the use of an underarm body jacket for 4 months, proved only partially
effective. The patient’s symptoms recurred upon the resumption of her daily activities, and surgery was required. Similarly, of the six patients with multi-level spondylolysis reported by Chang and colleagues,6 the five who were treated surgically had either “good” or “excellent” results based on the Henderson categories of functional capacity, while the one patient who was treated non-surgically only had “fair” results. At 16-month follow-up, the latter patient continued to complain of sports restriction. Furthermore, although the two patients reported by Ravichandran7 who received conservative treatment had “good” clinical outcomes, spontaneous fusion of the pars defects did not occur. Consequently, surgical treatment is typically recommended for patients with multi-level spondylolysis.6-7 The patient in our report presented with bilateral spondylolysis at L3, L4, and L5 and had already undergone 2 years of conservative treatment prior to presentation. Nevertheless, her back and leg pain persisted; therefore, it was decided that surgery was her best option.

A variety of procedures are used in the surgical treatment of spondylolysis. Such procedures may be grouped into two broad categories: fusion and direct repair of the pars defects. Of the six patients with multi-level spondylolysis reported by Ravichandran,7 four were treated with segmental fusion. One patient had spondylolyses at L3-L5 and underwent L3-S1 intertransverse fusion. A second patient had spondylolyses at L4-L5 and underwent L4-S1 intertransverse fusion. These patients both had “excellent” clinical outcomes. A third patient had spondylolyses at L3 and L5 and underwent L2-L4 intertransverse fusion. The final patient had spondylolyses at L2 and L4 and underwent Buck fusion at L2 and interspinous fusion using Attenborough springs at L4-S1. These patients had “poor” clinical outcomes. Ravichandran attributed the failure of the latter surgical procedures to the presence of an intervening unoperated segment between the two lytic vertebras. The intervening unoperated segment likely resulted in abnormal mobility at that segment. Ravichandran, therefore, concluded that when surgically treating patients with multi-level spondylolysis, a continuous fusion that encompasses all of the defects and the intervening vertebrae results in the best outcomes.

Direct repair of the pars defects represents an alternative to fusion. Unlike fusion, direct repair of the defects results in the preservation of motion at the involved vertebral segments. This becomes a significant factor when dealing with multi-level spondylolyses. The direct repair of pars defects involves a combination of bone grafting and fixation. Several options exist for fixation, including the use of a wire, pedicle screw, or hook.14-20

Eingorn and Pizzutillo14 reported that wire fixation, which involves the wiring of the transverse processes and spinous processes of the involved levels, was effective in treating a patient with bilateral pars defects at L3 and L4. Following the surgery, postoperative radiographs displayed complete fusion of the right pars defects at L3 and L4 and incomplete fusion of the left pars defects. The patient’s symptoms resolved and she was able to resume her previous activities.

Ogawa and associates7 confirmed the effectiveness of direct repair with segmental wire fixation. They reported the results of seven patients with multi-level spondylolysis; five patients had pars defects at two levels bilaterally, while two patients had pars defects at three levels bilaterally. All patients underwent direct repair with bone grafting and wire fixation at each of the involved levels. The patients wore a lumbar corset for 6 months postoperatively; during this period their activity was restricted. Five of the patients had “excellent” clinical outcomes, one patient had a “good” clinical outcome, and one patient had a “fair” clinical outcome. Radiographic and CT assessment revealed that 26 out of 32 of the pars defects were healed. The patients in whom healing of all pars defects did not take place had either attempted sports activities or had stopped wearing the lumbar corset within the 6-month postoperative period. In these patients, wire breakages occurred at the levels that did not heal. Furthermore, in the two cases in which “excellent” clinical outcomes were not achieved, wire breakages had occurred. Ogawa and associates, therefore, concluded that segmental wire fixation and bone grafting is an effective treatment for multi-level spondylolysis, but that the use of a lumbar corset in the post-operative period is critical for the healing of the pars defects.

Chang and coworkers,6 on the other hand, analyzed the use of direct repair with screw fixation. They reported on soldiers with multi-level spondylolysis, five of whom were treated surgically. Of these patients, two had spondylolysis at L4 and L5, one at L3-L5, one at L3 and L4, and one at L2 and L3. These patients underwent direct repair with autogenic bone graft from iliac crest and instrumentation with hook screws or translaminar screws. They wore a TLSO brace for 3 months postoperatively. Four of these patients had “good” clinical results, and one had “excellent” results.

Chung and colleagues8 also reported the effectiveness of direct repair with screw fixation and autogenous bone grafting. Specifically, pedicle screw laminar hooks were used. Six patients with bilateral pars defects at 2 levels were treated with this surgical technique. Four of the patients had bilateral defects at L3 and L4, while the remaining two patients had defects at L3 and L5. All of the patients had back pain that persisted despite 6 months of conservative treatment, and none of the patients were found to have degenerative disc disease at the affected or adjacent levels. Following the procedure, patients were instructed to wear lumbosacral braces for 3 months. CT scans revealed healing of 18 of the 24 pars defects. Furthermore, four patients had “excellent” clinical results, and two had “good” clinical results based on modified Macnab criteria.

Fusion and direct repair of the pars defects, therefore, represent the two basic choices for treating multi-level spondylolysis. Several investigators have noted, however, that the direct repair of pars defects in patients over 20 to 30 years old result in lower union rates and poorer clinical outcomes than in younger patients.16,21-26 Patients above
the age of 25 have been found to have a higher prevalence of degenerative disc disease, which has been cited as an important reason for both low union rates and poor clinical outcome.26,27 Consequently, Dai27 reported that the state of the intervertebral discs is an important factor in choosing between direct repair of the pars defect and segmental fusion. In the absence of disc pathology, direct repair is preferred as it is thought to preserve lumbar motion, have a lower rate of morbidity, and provide greater anatomic continuity.6,7 In the presence of disc disease, however, fusion is recommended.

As this patient’s MRI and CT scan had revealed significant disc degeneration with spondylolisthesis at the L4-L5 and L5-S1 levels, we chose to fuse these levels utilizing anterior and posterior approaches. In contrast, the L2-L3 and L3-4 disc spaces appeared relatively normal. Consequently, we chose to attempt a direct repair of the pars defects at the L3 level in spite of the patient’s age, in the hope of preserving lumbar motion. The alternative—a three-level fusion—would surely have resulted in significant functional compromise. Direct repair with bone grafting and pedicle screw hook fixation was chosen as the method of direct repair, as studies involving this technique demonstrated good clinical results.8,26

**Conclusion**

Our treatment approach proved successful for this patient. At the latest follow-up, her lower back and leg pain had resolved and plain radiographs showed a solid fusion. We therefore think that in treating multi-level spondylolisthesis, a combination of direct repair and fusion is a viable approach.

The technique to be used at each vertebral level should be assessed in relation to the degree of disc pathology at that level. Future studies should analyze this approach to treating multi-level spondylolisthesis in a larger sample of patients.

**Disclosure Statement**

None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

**References**


