Minimally invasive image-guided direct repair of bilateral L-5 pars interarticularis defects

Technical note

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Lower back pain from spondylolysis historically has been treated with a variety of options ranging from conservative care to open fusion. The authors describe the novel technique of minimally invasive bilateral pars interarticularis screw placement by utilizing intraoperative 3D imaging and frameless navigation in a 17-year-old male athlete. This technique is a modification of the open technique first described in 1970 by Buck and has the advantages of minimal dissection requirements with improved screw trajectory visualization. The patient’s postoperative course is discussed, followed by a brief literature review of pars interarticularis defect treatment. (DOI: 10.3171/FOC/2008/25/8/E13)

Key Words • Buck screw • frameless navigation • internal pars interarticularis fixation • spondylolysis

Isthmic spondylolysis at L-5 is a common disorder that usually affects athletic adolescents.13 The cause of spondylolysis in these patients is repetitive stress on the pars interarticularis with subsequent microfracture, which in turn leads to a defect and can progress to spondylolisthesis in up to 25% of cases and lead to progressive back and radicular pain. Treatment for this disorder varies from conservative to surgical, depending on the stage of the fracture and the symptoms. We report the novel use of image guidance and 3D imaging in the surgical management of isthmic spondylolisthesis in a patient in whom conservative treatment had failed.

Case Report

History and Examination. This otherwise healthy 17-year-old boy presented with a 6-month history of chronic low-back pain that had begun during baseball season. He was very active in sports prior to symptom onset, and he could not recall an acute injury or incident that resulted in his current condition. A CT scan was obtained and demonstrated bilateral lysis of the pars interarticularis of L-5 (Fig. 1). The boy was treated with a rigid thoracolumbosacral orthosis for 6 months with no change in the back pain. A repeated CT scan showed no change in the degree of lysis, and a nuclear medicine bone scan showed increased uptake in both L-5 pars interarticularis defects. Given the failure of conservative treatment, the patient was referred for surgical evaluation. He admitted that he had not been strictly compliant regarding the brace and wore it only when his pain was severe. On physical examination he was neurologically intact, with slight give-away strength in the bilateral iliopsoas muscles due to back pain. He also had difficulty with lumbar flexion and extension because of the back pain. Given his refractory symptoms and the failure of conservative therapy, elective internal fixation was offered and he and his parents agreed that he would undergo surgical fixation.

Operation. The patient was placed prone on a radiolucent frame (Jackson table, Mizuhoji) in normal lumbar lordosis. A stereotactic reference arm was placed into the left iliac crest through a stab incision, and the O-arm (Medtronic) with navigational software was used to generate 3D images of the lower lumbar and upper sacral regions. These images were then imported into the image-guidance station (Stealth, Medtronic) for intraoperative planning and navigation. A small (2-cm) midline incision was made overlying the L-5 spinous process and through the lumbosacral fascia. The spinous process of L-5 was then dissected free of the paraspinous musculature, and image guidance was used to develop a trajectory for the right-sided L-5 pars interarticularis fixation. Using the universal spine system (USS, Medtronic), a pilot hole was drilled into the spinous process to allow subsequent placement of a K-wire, which was inserted using a high-speed drill with a drill guide referenced to the image-guidance system. The optimal screw length was determined using the image-guidance software based on the O-arm images, and a 50 × 4-mm-diameter, fully threaded cannulated screw was placed over the wire. The image-based navigation system was then utilized to develop the trajectory for left-sided screw placement, which allowed insertion of the staggered contralateral screw in a similar fashion. Because the fractures were not complete at the time of fixation, no
bone graft was applied and the fractures were not curetted. A 3D reconstructed image was then obtained with the O-arm while the patient was still in the operating room to confirm adequate screw placement. The operative and reference arm incisions were closed in layers using absorbable sutures, and the total blood loss was < 20 ml.

**Postoperative Course.** The patient had minimal postoperative pain that was easily controlled by oral narcotics, and he was released to home on postoperative Day 1. He was quickly weaned from the narcotics, and his incisional pain completely resolved by 1 month after surgery. A CT scan was obtained at 3 months postoperatively and demonstrated an attenuation of the pars fracture progression, adequate screw position, and no signs of lucency around the hardware. At 6 months after the operation, the patient had no back pain, his range of motion was normal, and he had resumed his athletic activities without restriction.

**Discussion**

Amid the multitude of surgical and nonsurgical techniques applied in the management of symptomatic spondylolysis, a review of the current and past literature revealed 3 basic interventional categories: conservative treatment, standard posterior or posterolateral fusion with instrumentation, and direct approaches to fixation. Although the definition of treatment success varies, most researchers typically assess the resolution of symptoms, return to work or athletics, or fusion/trabeculation across the defect as the primary outcome.3–6,12,19

The first intervention focuses on the use of conservative measures. This approach relies predominantly on the use of nonsteroidal antiinflammatory drugs, steroidal injections, physiotherapy with rigid braces, and avoidance of exacerbating activities.6,8,13 In a study performed to evaluate the efficacy of the conservative management of spondylolisthesis, 100 patients were followed-up for 11 years.10 Of these patients, 40 were forced to discontinue participation in sports because of persistent back pain. Among 40 patients in a subcategory undergoing conservative therapy for symptoms, 87.5% were able to return to athletics in < 6 months. In a long-term study by Beutler et al.,13 who analyzed the cause and progress of pars interarticularis defects in a group of 30 patients followed-up for a 45-year period, the authors demonstrated that the risk of progression to spondylolisthesis in patients with bilateral pars interarticularis defects is “equivalent to that of the general population.” It was also revealed that progression from spondylolysis to spondylolisthesis peaks in adolescence and diminishes with age. This phenomenon is believed to be the result of increased stability at the growth plate, leading to greater resistance to anterior shear forces.11,13 In Beutler and colleagues’ study, the reduction in slippage increased as age advanced, up to the 5th decade of life. Beyond this age, one must consider degeneration of the disc as a causal or contributing factor to the progression to spondylolisthesis.2,13 In deciding between treatment modalities, whether surgical or conservative, such studies have demonstrated the generally benign course of spondylolisthesis and offer support to proponents of a conservative nonsurgical management protocol. For the patient in whom a trial of conservative therapy has failed, several surgical approaches remain.3–5,8,10,12–18

Fusion techniques that immobilize the local joint were attempted earlier but were met with limited approval given the resulting immobility across an otherwise healthy motion segment. As spondylolysis is the most common cause of chronic low-back pain in adolescent athletes,12 subsequent direct repair techniques were developed to correct the...
defect while also allowing adjacent joint motion. In 1968 Kimura was the first to demonstrate an approach that offered pars interarticularis fixation that did not necessitate fusion of the adjacent joint.

Although many direct approaches offer a good outcome and improved mobility, researchers have concluded that overall success and fusion are highly dependent on the age of the patient. A retrospective analysis of 113 patients who had been treated with a screw-hook technique, first described by Morscher et al., and followed-up over 11 years demonstrated that the fusion across the defect was best in patients younger than 14 years of age and was decreased in patients older than 20 years of age. A study by Hefiti showed that 79% of the enrolled patients experienced improvement in symptoms following surgery, but this number increased to 88% among those younger than the age of 20 years. In discussing the rates of successful outcomes, the author advised against direct surgical intervention in patients older than 25 years of age, citing a degenerative disc rather than spondylolysis as the likely origin of discomfort in these patients.

In 1970 Buck described a technique for direct internal fixation. This technique directs a screw from the ipsilateral lamina directly through the pars interarticularis defect, gaining purchase and stabilization of the lamina. Using this method, Buck repaired the defect in 16 patients, noting only 1 failure and 2 complications. Despite excellent operative outcomes and a return to activity in 13 of 16 patients, this approach has been slow to gain in popularity because of the high degree of technical difficulty inherent in the procedure. However, a recent report has described a minimally invasive approach using an endoscope to place these types of screws. Additionally, some have argued that this technique traverses the pars interarticularis directly and ultimately reduces the amount of surface area available for new fusion to take place. Using image guidance, we were able to fixate the pars interarticularis without completely traversing it to allow the fracture to properly heal (Fig. 3).

Conclusions

We described a modified form of the Buck screw procedure with a minimally invasive, image-guided method of pars interarticularis fixation. The utilization of image guidance simplifies the otherwise difficult visualization required for pars interarticularis screw placement and allows minimal skin and muscle dissection, which may translate into a more rapid postoperative recovery. Future applications of frameless navigation in the spine may allow such uncommon hardware applications to be both successful and less invasive.

References

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Fig 3. Axial (right) and sagittal reconstruction (left) images obtained at 3 months postoperatively, showing no progression of the spondylolysis.


