Mini-Open Pedicle Subtraction Osteotomy: Surgical Technique

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Key words
- BMP
- Interbody fusion
- Kyphosis Minimally invasive
- Osteotomy
- Pedicle screw
- Percutaneous
- Scoliosis
- Spinal deformity

Abbreviations and Acronyms
ASD: Adult spinal deformity
MISS: Minimally invasive spinal surgery
PSO: Pedicle subtraction osteotomy


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OBJECTIVE: **Minimally invasive spinal surgery (MISS) has many favorable attributes that would be of great benefit to patients with an adult spinal deformity. Decreased blood loss, lower infection rates, and faster mobilization may help to reduce the high rate of complications associated with these interventions. Although correction of coronal deformity has been well demonstrated with MISS, improvements in lordosis and sagittal balance have remained relatively elusive using the MISS approach. With open surgery, the most powerful techniques for improving sagittal balance include some form of a spinal osteotomy.**

METHODS: **In this report, we describe the evolution of a technique for treating thoracolumbar kyphoscoliosis using a mini-open pedicle subtraction osteotomy (PSO) combined with interbody fusion and percutaneous pedicle screws.**

RESULTS: **The patient underwent a T10 to S1 percutaneous posterior instrumented with an L3 PSO and right L4/5 minimally invasive transforaminal interbody fusion. Clinically, the patient had excellent improvement and regained the ability to ambulate independently for distances of up to one half mile. Imaging demonstrated good correction of coronal imbalance (1.8 to 9.5 cm) and sagittal imbalance (sagittal vertical axis of 22.5 to 7 cm).**

CONCLUSIONS: **The correction of sagittal plane deformities remains difficult using MISS approaches. In this report, we describe a new technique using a mini-open PSO technique to achieve significant improvement in thoracolumbar lordosis.**

INTRODUCTION

Advances in medical care, preventive measures, and standards of living in the developed world have resulted in substantially lengthened life spans. In the United States, the fastest growing population is projected to be persons >80 years old. Adult spinal deformities (ASDs), particularly deformities associated with kyphosis in the thoracolumbar spine, are associated with advancing age. It is anticipated that the number of patients experiencing problems with thoracolumbar kyphosis will increase significantly. Many contemporary surgical techniques have been developed to treat symptomatic kyphosis, and most of these rely on some form of anterior column height restoration or osteotomy to improve lordosis (3, 6, 10, 12, 13, 18, 22). However, these techniques often require multistaged operations, substantial soft tissue retraction, large subperiosteal exposures, and significant blood loss. In these aged patients, who often harbor multiple medical comorbidities, such surgeries pose a technical challenge associated with a high risk of intraoperative and postoperative complications. Smith et al. (16) analyzed data from the Spinal Deformity Study Group showing that 26.2% of 206 patients in the study experienced a minor complication and 15.5% experienced a major complication.

Numerous minimally invasive spinal surgery (MISS) techniques have been developed more recently to improve clinical outcomes of spinal surgery. Although many of the potential benefits of MISS have not yet been definitively proven, it is becoming apparent that reduced blood loss and infection rates are proven benefits of minimizing soft tissue injury. The application of MISS techniques for treating ASDs offers the potential to reduce the high complication rates associated with these surgeries. Several clinical series have already shown that MISS combining a lateral interbody fusion with percutaneous pedicle screws can be highly effective for correcting coronal deformities and instability (2, 4, 8, 20). However, a more powerful method for restoring sagittal alignment would involve a three-column osteotomy; this technique was explored in a cadaveric model by Voyadis et al. (19). In this report, we describe a new method for performing pedicle subtraction osteotomy (PSO) via a mini-open surgical approach.

SURGICAL TECHNIQUE

After intubation, the patient is positioned prone on a Jackson table. A dorsal midline skin incision is made from the lower thoracic area to the sacrum. A lateral subcutaneous dissection allows the muscle fascia to be exposed so that all subsequent steps are performed through the fascia. This is preferable to using multiple stab incisions, which are cosmetically unfavorable and result in more blood loss. After confirming the levels with fluoroscopy, a bilateral subperiosteal dissection is taken laterally at the level of the intended PSO at L3. The extent of the exposure should be such that the transverse processes of L3 are

fully exposed and the bony exposure occurs to the pedicle above and below. Typically, this amount of exposure would be needed for a single-level open laminectomy. In addition, if interbody fusion below the level of the PSO is desired, a unilateral subperiosteal exposure of the facet joints is undertaken at those levels to allow for minimally invasive thoracolumbar interbody fusions.

The L3 spinous process, lamina, and facets are removed with a rongeur. The exiting L3 nerve roots are fully exposed, and the anulus of the L2-3 disk is cauterized with a bipolar and incised with a number 15 blade scalpel to create an extended PSO. The L3 pedicles are removed entirely using rongeurs and the high-speed drill. A bilateral decancellation osteotomy is performed at L3 using a series of enlarging curets to remove two cones of cancellous bone from the vertebral body. Ventral bone is removed with a curved curet, and the decancellation is extended superiorly into the L2-3 disk space. Cottonoids are used to dissect and secure the lateral vertebral wall and its associated vasculature. A Leksell rongeur is used to remove the lateral vertebral body wall bilaterally in a wedge-shaped pattern to match the decancellation.

Control of the spine is achieved by placing percutaneous pedicle screws at least three levels above and below the PSO site. A primarily anterior-posterior–based fluoroscopic technique is used to compensate for axial rotation of the vertebral bodies. The pedicle screw extensions are used to prevent any catastrophic vertebral translation during completion of the osteotomy. The posterior vertebral body wall and posterior longitudinal ligament are removed by retracting the thecal sac medially on each side successively.

After ensuring there is no ventral bone or ligament that might impinge on the thecal sac, the osteotomy is closed. Four rods are bent to the same degree of lordotic curvature (approximately 35 degrees). Each rod is passed through each set of screw heads above and below the PSO; this is done because it is impossible to pass a lordotic rod below the fascia in a kyphotic region of the spine. A rod-to-rod connector is placed on the end of each rod at the PSO site where the tip is exposed. Set screws are used to attach each of the four rods loosely to its respective set of screws. By holding each of the four rod holders and forcing them toward each other, greenstick fracture is created at the osteotomy site, and the spine is placed into lordosis (Figures 1–3). At this point, the four rod-to-rod connectors are used to attach the cranial rod rigidly to the caudal rod on the same side. The set screws are fastened tightly, and all articulations are finally tightened.

The L3 nerve roots and thecal sac are inspected to ensure that there is no neural compression, and any bleeding is controlled with powdered collagen matrix. A small subperiosteal exposure is achieved on one side at the top of the construct, and an interlaminar fusion is created between the top three vertebral segments using autograft bone. The wound is closed over suction drainage in standard fashion.

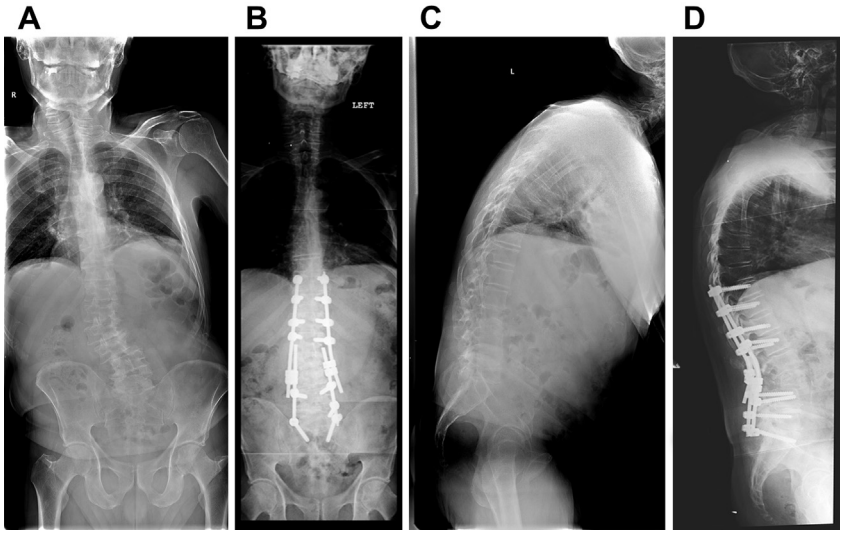

Figure 1. Preoperative (**A** and **B**) and postoperative (**C** and **D**) 36-inch standing x-rays.

CASE EXAMPLE

An 84-year-old white man presented to clinic with severe, progressive, and debilitating back pain and left gluteal pain of 1.5 years' duration. The pain had worsened to the point where he used a walker or wheelchair because of severe gait and postural imbalance as well as back pain. He was able to stand or walk for <2 minutes only and had fallen several times because of postural instability. The patient had tried multiple medications, therapies, epidural injections, and rhizotomies, which were not helpful. On examination, the patient was unable to stand erect. His station was forward, and he exhibited global weakness in both lower extremities. X-ray and computed tomography scan revealed severe degenerative kyphoscoliosis with a coronal plane imbalance of 9.5 cm and a sagittal vertical axis of 22.5 cm. There is an L3-4 lateral listhesis to the right of 2 cm. After several outside consultations, the patient was not offered surgery because of his advanced age and severe disability. After outlining the risks and benefits, the patient elected for surgical correction of his deformity.

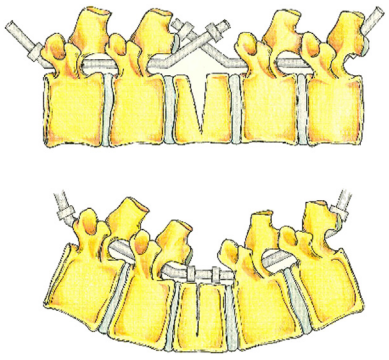

Figure 2. Pedicle subtraction osteotomy correction technique using percutaneous screws and four rods.