Miniopen Pedicle Subtraction Osteotomy

Surgical Technique and Initial Results

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KEYWORDS

• Minimally invasive • Spinal deformity • Osteotomy • Scoliosis • Kyphosis • Pedicle screw • Percutaneous • Sagittal balance

KEY POINTS

- Adult spinal deformity surgery is becoming increasingly common, in part as a result of the aging of the population in the developed world as well as the increasing recognition that deformities can severely affect the quality of life of afflicted patients.
- The traditional open surgical procedures for adult spinal deformity are highly effective. However, they are associated with high morbidity and complication rates.
- Correction and maintenance of proper sagittal balance is a key determinant of success with spinal fusion surgeries.
- A new miniopen approach for using pedicle subtraction osteotomy to achieve sagittal realignment is a promising option for adult patients with deformity.

INTRODUCTION: NATURE OF THE PROBLEM

Throughout the developed world, the past century has seen phenomenal advances in medicine, safety, and sanitation. The result has been a substantially lengthened average life span, and it is now not uncommon for spinal surgery patients to be in their late 80s or 90s. In concert with this development has been the increasing expectation from patients that they will have not only a prolonged life span but also an associated full functional ability during most of that time. In the United States, the fastest growing population is between the ages of 80 and 100 years.[1] These forces are shaping the future for spinal surgeons and creating ever more challenges.

Adult spinal deformities (ASD), particularly those associated with kyphosis in the thoracolumbar spine, are commonly associated with advancing age. ASD is a common reason for presentation to the neurosurgeon or orthopedic surgeon, and the National Health and Nutrition Examination Survey database has identified that up to 8.3% of the adult population harbors a scoliosis of 10° or more.[2] Symptoms at presentation can include leg pain from radiculopathy, neurogenic claudication from spinal stenosis, back pain from degenerative arthritis, or postural complaints. Numerous modern spinal surgical techniques have been developed to treat symptomatic ASD, and most of these rely on some form of anterior column height restoration or osteotomy to improve lordosis and correct scoliosis.[3–9] However, these methods often require severe disruption of the soft tissue envelope through a subperiosteal to expose the spinal anatomy. This situation leads to substantial blood loss, prolonged

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hospitalizations, and higher risk for the patient. In many instances, the risks involved require a staged operation.

When coupled with the fact that patients with ASD are often aged with multiple medical comorbidities, such surgeries pose a challenge for surgeons managing their care. The major complication rate from these interventions is reported to vary between 25% and 60% in large reported series.[10–12] One of the future challenges for spinal deformity surgeons is to develop newer methods for minimizing the risks of the surgical intervention to improve the safety profile of these interventions.

Over the past decade, new minimally invasive surgical (MIS) techniques have been developed to improve the clinical outcomes of spinal surgery. It is becoming apparent that reduced blood loss and infection rates are benefits of minimizing soft tissue injury.[13–15] MIS techniques for treating ASD thus offer the potential for reducing complication rates and morbidity associated with these surgeries. Over the past 5 years, spinal surgeons have been using a combined approach with lateral MIS interbody fusion followed by percutaneous pedicle screws to correct ASD.[16–19] However, this approach has been proved to be limited for correcting regional or global lumbar lordosis or sagittal balance.[20] Traditionally, a 3-column osteotomy such as a pedicle subtraction osteotomy (PSO) has been necessary for correction of kyphosis or flat back syndrome. This approach has been previously described in a cadaveric model by Voyadis and colleagues.[21] More recently, the clinical feasibility of this approach in patients has been reported using a miniopen PSO and percutaneous spinal fixation.[22]

SURGICAL TECHNIQUE

The miniopen PSO that we have been using at the University of Miami incorporates 3 distinct elements. The osteotomy site is approached with a bilateral open subperiosteal dissection. Thus, it is achieved in a manner similar to an open PSO. This strategy overcomes the problem of control of bleeding and the management of neural structures intrinsic to 3-column osteotomies. However, the total soft tissue envelope disruption is similar to a 1-level posterolateral fusion or a 2-level open laminectomy. The surgery caudal to the PSO is performed with MIS transforaminal interbody fusions (TLIFs) with interbody cages, and potentially with percutaneous iliac screws.[23] Above the PSO site, the construct is achieved with percutaneous screws supplemented with facet or interlaminar fusions.

The difficulty with previous MIS sagittal deformity correction was the result of an inability to pass a lordotic rod through a kyphotic or flat spine. This procedure had been a geometric impossibility without further soft tissue elevation or placement of a rod above the fascia. With the mini-PSO, a technique was borrowed from the open surgical methods. Use of a 4-rod cantilever construct allowed for 2 rods to be passed from above and 2 from below (**Figs. 1** and **2**). The rod tips protruded through the central incision (at the mini-PSO site) and were connected after the osteotomy site was fractured to surgically introduce lumbar lordosis. The 4-rod technique provided 4 unique advantages. First, as mentioned earlier, the appropriate amount of lordosis can be introduced into the rod construct. Second, the spine can be mechanically controlled after the destabilizing osteotomy. In open surgery, this control is accomplished with a temporary rod. In the mini-PSO, the rod-screw articulations are used to break the wedge osteotomy and the final destabilizing maneuver (lateral or posterior cortical bone removal) is performed only after the rods have been affixed to the screws in a semirigid manner. Third, the use of 4 rods allows the spine to be managed as 2 distinct segments: cranial and caudal. The screws and rods above work as a single unit, and the screws and rods below work as another unit. This factor reduces the risk of screw pullout, which is more likely in segmental correction maneuvers. This situation is clearly beneficial when treating osteoporotic patients. The amount of rod bending before placement can be reduced on any part of its length. This goal is achieved by distributing half the total bend on the caudal rod and half on the cranial rod. The amount of lordosis is the same, but there is a reduction in the amount or metal fretting and etching as a result (**Fig. 3**). The result is simultaneous correction of the sagittal and coronal deformities, with the correction occurring through the PSO site (see **Fig. 3**).

Surgical procedure steps:

1. Minimally invasive interbody fusion at levels caudal to the planned mini-PSO
2. Exposure of the mini-PSO site (typically L2 or L3), with exposure to the transverse process at that level
3. Full laminectomy and bilateral full facetectomies at the mini-PSO level
4. Skeletonization of the roots above and below the mini-PSO pedicles
5. Disconnection of the transverse processes and removal of the pedicles bilaterally
6. Cancellous decandellation at the mini-PSO level