

# Minimally Invasive Pedicle Subtraction Osteotomy



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## KEYWORDS

- Pedicle subtraction osteotomy • PSO • Minimally invasive surgery • MIS • Spinal deformity
- Scoliosis

## KEY POINTS

- The prevalence of symptomatic adult spinal deformity is expected to continue to increase along with our ever-aging population. Although traditional open surgical techniques are effective at correcting spinal deformity, they are associated with high morbidity.
- Advantages of pedicle subtraction osteotomy (PSO) include the ability to treat a rigid spine, little restriction on the level of surgery, and lack of need to reposition the patient during surgery.
- The minimally invasive surgery (MIS) PSO strives to fulfill the objectives of MIS spine surgery, which include reduced intraoperative blood loss, soft tissue destruction, postoperative pain, and narcotic use while facilitating early mobilization.
- MIS PSO involves an exposure just wide enough to directly decompress and protect vital neural structures, while using a rod-cantilever technique to maximize lordosis.
- Preliminary evidence suggests MIS PSO results in good clinical outcomes with significant improvements in patient-reported outcomes as well as deformity correction.

## INTRODUCTION

Adult spinal deformity (ASD) is a significant condition that affects the quality of life of thousands of people every year. With the substantially lengthened life span in the developed world, the prevalence of this condition is expected to increase markedly during the next few decades.<sup>1</sup> Many advances have been made and many new surgical techniques have been developed for the treatment of spinal deformity in both the sagittal and coronal planes. Open surgical techniques for the correction of kyphosis and/or scoliosis rely on osteotomies and/or restoration of anterior column height.<sup>2-5</sup> These open techniques, however, result in significant blood loss and a high rate of perioperative morbidity. The complication rate for such surgeries is at least 50% and can be as high as

90%, as shown in some large series.<sup>6-8</sup> The rate of major complications is significantly higher compared with that associated with their minimally invasive counterparts.<sup>9</sup> As such, there has been tremendous interest in the development, refinement, and study of less invasive techniques to achieve the same goals.

## MINIMALLY INVASIVE SPINE SURGERY

To improve outcomes and minimize complications in ASD patients undergoing surgical correction, various minimally invasive surgical techniques have been developed over the past decade.<sup>10</sup> Studies have demonstrated, however, that there are limitations to using such techniques compared with open surgery. For instance, various reports describe an upper limit in the degree of coronal

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curvature correction possible using MIS techniques without exposure of the dorsal spine that would allow for multilevel open osteotomies.<sup>9</sup> In addition, MIS faces certain limitations with regard to improvement of lumbar lordosis and sagittal balance.<sup>2,11</sup> Today, the most common spine MIS procedure for ASD correction is lateral lumbar interbody fusion.<sup>1</sup> This technique results in minimal improvement in overall lumbar lordosis; however, that amounts to only 5° to 10° of correction.<sup>11–13</sup>

The development of anterior longitudinal ligament release to add lumbar lordosis represents a significant advancement in lateral MIS surgery and is covered in detail in other sections of this publication.<sup>14</sup> Although a powerful alternative to open surgery, there are limits to anterior column reconstruction MIS surgery. These include (1) the inability to treat already fused levels of the spine (requires a flexible ligamentous anterior column at a minimum 1 level); (2) risks of injury to anterior hollow viscus structures, major vessels, and the lumbosacral plexus; (3) the need for 2 approaches, prolonging operative time and risk; (4) complications related to lengthening of the anterior column including stretching of the abdominal aorta; and (5) lack of evidence and familiarity with the procedure.<sup>14–18</sup> Nonetheless, this approach is growing in popularity due to the need for better treatment options.

The concept of MIS has been recently redefined to focus on preserving soft tissue rather than simply limiting skin incision length. Today, the clinical goals of MIS as related to spine surgery include reducing postoperative pain, narcotic consumption, and intraoperative blood loss while at the same time facilitating early mobilization, emphasizing the preservation of functional musculoligamentous structures.<sup>1</sup>

### **PEDICLE SUBTRACTION OSTEOTOMY**

The classic pedicle subtraction osteotomy (PSO) technique was first described by Thomasen in 1985 for the correction of kyphotic deformity.<sup>19</sup> It involves removal of the posterior elements and a wedge-shaped portion of the vertebral body to increase lordosis. PSO enables a correction of up to 30°, which may be required in severe cases of ASD.<sup>3,19</sup> It is ideal for patients with severe fixed angular kyphosis and positive sagittal imbalance greater than 10 cm.<sup>20</sup> Traditional PSO is nevertheless a large open procedure that is subject to all the aforementioned complications associated with open spinal surgery.<sup>21,22</sup> A minimally invasive form of the procedure is, therefore, an attractive alternative to open surgery for achieving a high

degree of spinal deformity correction while minimizing perioperative morbidity. PSO offers several advantages over other open and MIS deformity correction techniques, including (1) the ability to treat a completely fused and rigid spine (as with ankylosing spondylitis or in patients who have previously had spinal fusion surgery), (2) the ability to perform the PSO at virtually any level, (3) single position surgery, and (4) widespread spine surgeon familiarity with the technique.

### **MINI-OPEN PEDICLE SUBTRACTION OSTEOTOMY**

#### ***Technique***

The hybrid mini-open PSO technique was developed to combine the advantages of traditional MIS procedures with those of open surgical deformity correction using PSO.<sup>2</sup> Through this method, a 3-column osteotomy may be performed to correct sagittal plane malalignment. The approach was first explored in a cadaveric model by Voyadzis and colleagues,<sup>20</sup> in 2008, and was first described in vivo by Wang and Madhavan,<sup>1</sup> in 2014. This technique begins with a dorsal skin incision followed by lateral subcutaneous tissue dissection that exposes fascia. Bilateral subperiosteal dissection is then performed at the level of desired PSO, such that the transverse processes are completely exposed and such that the bony exposure extends from the pedicle above to the pedicle below. The spinous process, lamina, and facets of the desired PSO level are subsequently removed and the exiting nerve roots are exposed.

The annulus of the disk space immediately superior to the level of the PSO is cauterized and removed if an extended PSO is desired. The bilateral pedicles are then removed in their entirety. This approach makes the PSO segment an essentially open technique, but because the only subfascial opening is at this 1 level, the morbidity of the soft tissue dissection is similar to an open 1-level posterior fusion. This limited opening, which is much smaller than an open PSO, has 3 major advantages: (1) direct control and inspection of the neural elements at the PSO site, which is potentially at risk, thus enhancing safety; (2) the ability to assemble a construct at the area of greatest lordosis; and (3) the ability to maintain excellent hemostasis.

Next, percutaneous pedicle screws are placed through the fascia, 3 levels above and 3 levels below the PSO level. The extensions of the pedicle screws are used to prevent lateral translation of the vertebral bodies during the osteotomy. For this purpose, 4 lordotic rods are then passed

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