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# Editorial

## Sagittal balance

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It has become increasingly clear in the past decade that local, regional, and global sagittal alignment of the spinal column is strongly correlated to both quality of life assessments and also the results of spinal surgical interventions. Traditional open spinal reconstructive procedures have emphasized these sagittal parameters recently, correlating to successful radiographic and clinical results. However, the quest for similar type of results when using less invasive surgical techniques has been more challenging. In their article, Manwaring and colleagues[1] performed a preliminary radiographic study examining the role that minimally invasive anterolateral lumbar interbody fusion plays in optimizing lumbar sagittal lordosis restoration, global sagittal alignment, and ultimately clinical outcomes.

In their retrospective review, data obtained in 36 patients in whom degenerative scoliosis had been diagnosed (coronal Cobb angle of > 10° or a sagittal vertebral axis of > 5 cm) were examined for various coronal and sagittal radiographic parameters. Of 36 patients, 27 had undergone standard anterolateral interbody fusion and 9 had undergone an anterior column release (ACR) with interbody fusion. In all patients a delayed second-stage surgery was performed and consisted of the placement of percutaneous transpedicular posterior instrumentation as well as an anterolateral lumbar interbody fusion or minimally invasive transforaminal lumbar interbody fusion at L5–S1 if that was included in the construct. The authors found, as others have shown, that a standard lateral interbody fusion really did not change segmental and regional lumbar lordosis, although it did improve the coronal Cobb angle. However, the ACR group had significant improvements in segmental and regional lumbar lordosis and sagittal realignment as well as improvement in the coronal Cobb angle. Unfortunately, there were no data provided on complications occurring during or after the procedure, and the mean follow-up for the small ACR group was admittedly short in the preliminary study (11 months).

So what can we learn from this preliminary radiographic analysis of these less invasive surgical techniques? In patients with relatively small degenerative lumbar scoliosis (mean coronal curves, 25°), the ACR technique can increase segmental and regional lordosis, which is certainly an important component to the surgical goals and ultimate clinical outcomes. The addition of posterior segmental percutaneous instrumentation did not seem to change the alignment or results, which is intuitive since correction was obtained with the anterior interbody procedure. This is certainly an important finding in the evolution of less invasive spinal surgical reconstructive techniques. However, it is important to note that there are things we did *not* learn from this radiographic review, including the following: the actual or potential complications from the ACR technique, durability of the radiographic results because the follow-up period was so short, ultimate fusion rates, and clinical outcomes at a minimum 2- to 5-year follow-up. Also, whether these results can be replicated at other centers is yet to be determined.

I congratulate the authors on this important manuscript and urge them to continue to pursue and publish additional data on complications and longer-term follow-up in the degenerative lumbar scoliosis population treated with these less invasive surgical techniques.

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# Response

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We appreciate Dr. Lenke's thoughtful commentary on our preliminary radiographic report. As noted by Dr. Lenke, the minimally invasive anterior column release (MI-ACR) shows promise in powerfully correcting not only local and regional abnormalities but also global sagittal imbalance, although durability is as yet unproven. We present the following case as an illustration of our results.

*History of Present Illness*

A 66-year-old retired dentist with a 15-year history of severe thoracolumbar back pain and 10-year history of radiating right leg pain was referred for treatment of his progressive degenerative scoliosis that was refractory to nonoperative treatment. His axial and radicular symptoms were exacerbated by prolonged ambulation. He reported experiencing mild relief when lying supine. Preoperative visual analog scale and Oswestry Disability Index scores were 4.7 and 50%, respectively.

*Physical Examination*

The patient had dextroconvex scoliosis of the lumbar spine and exhibited tenderness to palpation throughout the lower thoracic and the entire lumbar spine. Grade 5/5 strength was present at all motor levels of the lower extremities. The patient had intact sensation in all dermatomes of the lower extremities, 2+ Achilles and patellar reflexes with down-going toes on Babinski test, a negative Patrick's sign, and abnormal gait with walker.

*Imaging*

Preoperative images can be seen in Fig. 1 and postoperative images obtained at 11 months can be seen in Fig. 2.

*Operative Procedure*

The patient was taken to the operating room where he underwent T12–L5 MI lateral interbody fusion with ACR at L2–3 and L3–4. At the T12–L1, L1–2, and L4–5 levels, 10° lordotic, 55 × 22–mm cages were placed, whereas at the L2–3, and L3–4 levels hyperlordotic (30°, 55 × 22–mm, 14-mm anterior height and 4-mm posterior height) cages were placed. The lateral incision was then closed and the patient placed in the supine position. A mini-open anterior lumbar interbody fusion was performed with a 12° lordotic cage. Cellular bone matrix allograph (Osteocel) was used. On postoperative Day 2 we percutaneously placed instrumentation from T-10 to S-1 and performed a posterior T10–12 fusion with allograft through the percutaneous screw incisions.

**Fig. 1.** Preoperative radiographs showing scoliosis with the following parameters: coronal Cobb angle 54.1°; central sacral vertebral line 2.2 cm; sagittal vertical axis +11.6 cm; pelvic incidence 71.4°; pelvic tilt 40.2°; sacral slope 30.8°; lumbar lordosis 35.3°; and fractional curve 18°.

**Fig. 2.** Postoperative radiographs obtained at 11 months after correction. The improved parameters are as follows: coronal Cobb angle 15.2°; central sacral vertebral line 5.7 cm; sagittal vertical axis +4.8 cm; pelvic incidence 71.7°; pelvic tilt 25.7°; sacral slope 46.1°; lumbar lordosis 74.4°; and fractional curve 12°.

On postoperative Day 4 the patient was discharged to rehabilitation for a 2-week stay without complication.

*Follow-Up*

At the 12-month follow-up appointment, the patient had significant improvement in his axial and radicular symptoms. He reported improvement in his activities of daily living and exercise tolerance as well as a significant decrease in his narcotic need. His visual analog scale and Oswestry Disability Index scores were 2 and 2%, respectively. Standing scoliosis radiographs revealed improvement of the sagittal vertical axis from +11.6 cm to +4.8 cm with concomitant correction of his coronal Cobb angle from 54° to 15°, lumbar lordosis from 35° to 74°, and pelvic tilt from 40° to 26°.

*Discussion*

The MI-ACR technique is a spine-lengthening procedure that uses the minimally invasive anterolateral transpsoas approach and carries with it all the associated risks of the standard MI anterolateral approach described in the literature.[1,2] These include superficial nerve injury, lumbar plexus injury, sympathetic chain injury, visceral injury, ureter damage, and pneumothorax. The ACR portion of the procedure adds the additional risk of injury to the iliac or great vessels, as well as a higher risk of retractor injury due to the increased retraction time required to release the anterior longitudinal ligament. The MIS-ACR is the maximum expression of complexity for the MIS anterolateral approach and should be performed by surgeons who are well versed in the standard approach and are advanced on their learning curve. The only reportable injury from our MIS-ACR series is one case of transient lateral thigh numbness; no other complications were encountered.

The MIS-ACR has the ability to correct lordosis and sagittal vertical axis to a similar magnitude as the Smith-Petersen osteotomy (SPO) and can be performed at multiple levels to obtain a correction as powerful as the pedicle subtraction osteotomy (PSO). In opposition to the SPO and PSO, which are spine-shortening procedures, the MI-ACR is a spine-lengthening procedure that does not create foraminal stenosis. Other significant advantages are the complete avoidance of dural exposure and associated CSF leak risk as well as complete avoidance of posterior tension band disruption.

We acknowledge that our report is preliminary and has a limited follow-up of 11 months in the MI-ACR group. Final conclusions regarding the effectiveness and durability of the MI-ACR should therefore be postponed until fusion rates and clinical outcomes can be reviewed over the next several years. The case provided clearly emphasizes the power of the MI-ACR to correct segmental, regional, and global spinal disharmony, and the technique should be considered as an alternative to shortening osteotomy procedures.

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