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CASE REPORT

Treatment for an Adult Patient with Slowly Progressive Idiopathic Scoliosis Using a Unique Anterior Scoliosis Correction Technique: A Case Report

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ABSTRACT

Adolescent idiopathic scoliosis (AIS) can continue to progress after skeletal maturity. Once the progression is severe, posterior spinal fusion (PSF) is the gold standard for surgical treatment. While effective in achieving curve correction, PSF is associated with many problems, including loss of spinal flexibility, uncorrected sagittal deformity, and adjacent segment disease. We present a case of a 50-year-old woman with a documented 38° thoracic curve as a late teen who experienced curve progression after skeletal maturity to > 70°. She underwent Anterior Scoliosis Correction (ASC), a "de-tethering" technique which allows for significant derotational correction of scoliosis and is a motion preserving correction surgery. Her progressive curve improved from 71° Lenke 1A main thoracic curve to 28°, with a 59% correction being maintained within 5° (33°) at 7 years. She also obtained a 50% correction of her compensatory lumbar curve and correction of 3-D calculated hypokyphosis from 2.4° to 29° at 7 years. Along with improvement of her thoracic kyphosis, her lumbar lordosis decreased to a normal range of 60° from 70°, giving her better overall alignment. This case report suggests that motion preserving Anterior Scoliosis Correction may be considered for some select adult patients with progressive scoliosis.

Key Words: Progressive Scoliosis, Anterior Scoliosis Correction

1. Introduction

It has been recognized that adolescent idiopathic scoliosis (AIS) can continue to evolve during adulthood after skeletal maturity.[1] The progression is precarious due to increased asymmetric load on the spine, which can lead to asymmetric degeneration.[2] The deformity affects both anatomic and functional aspects of the spine, which can demonstrate worsening disequilibrium, back pain, and radicular symptoms.[3] Regardless of the curve pattern, many AIS cases progress in curves measuring > 30° at skeletal maturity.[4,5] Once curve deformity progresses to > 50°, posterior spinal fusion (PSF) is usually recommended.[6] Long-term effects of extended posterior fusion constructs into the lumbar spine may include increased back pain, flatback syndrome, sagittal deformity, adding-on phenomenon, loss of spinal flexibility, and the development of adjacent segment disease into adulthood.[6-9] Therefore, slowly progressive residual scoliosis from adolescence in an active adult can present a treatment dilemma.

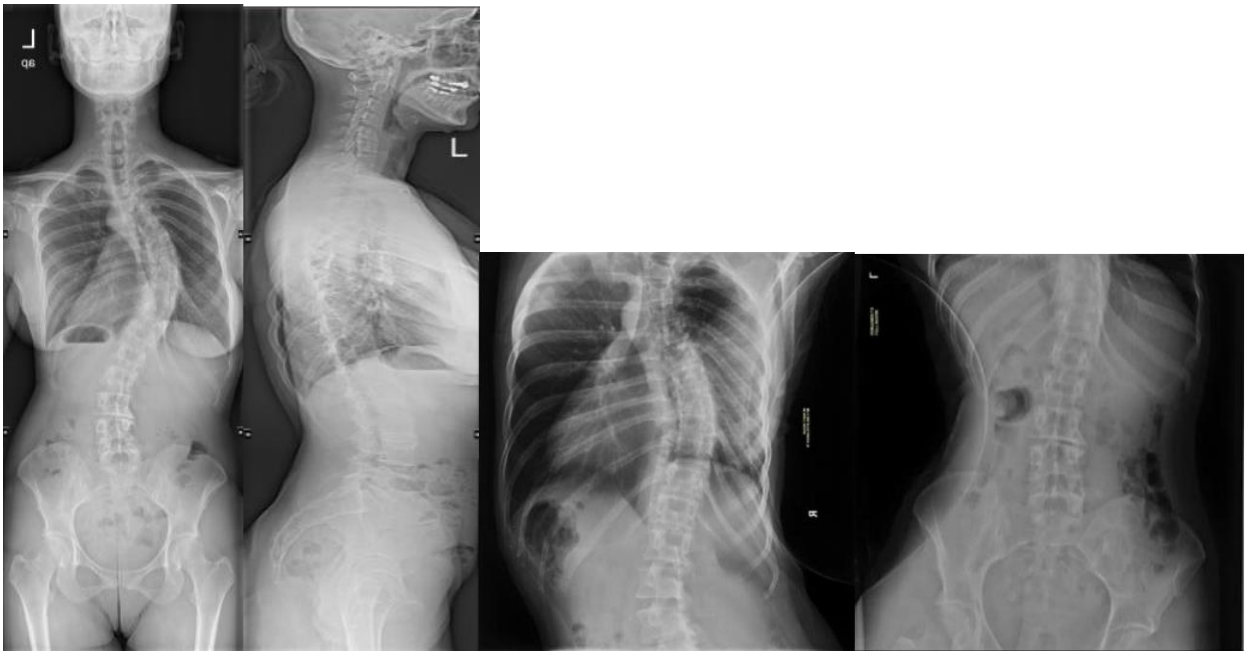
Developed by authors MDA, LC, and RRB, Anterior Scoliosis Correction (ASC) surgery is a spinal "de-tethering" technique using multiple flexible rod-cords and multiple screw-line constructs. It is performed with a modified anterior fusion approach that involves a muscle-sparing mini-thoracotomy. ASC is the authors' multi-year, multi-generational modification of the original anterior vertebral body tethering (VBT) technique but includes preservation of the segmental arteries and multi-level anterior longitudinal ligament and disc complex releasing techniques ("de-tethering") to obtain adequate derotation.[10-12] Unlike VBT, ASC has been shown to derotate the hypokyphotic scoliotic spine effectively towards normal thoracic kyphosis.[10-12] Because of this, ASC indications by the authors include the vast majority of thoracic, thoracolumbar, and lumbar curves in both immature and mature patients including stiff and severe curves. The aim of this case report is to present the long-term results of a 50-year-old woman with progressive scoliosis from adolescence utilizing our early generation ASC technique.

2. Case Presentation

A 50-year-old woman with history of AIS presented with thoracic back pain and concern over her curve progression. The patient was 5'1" and weighed 108 pounds. She had a documented untreated 38° right thoracic curve as a late teen. Over the years, she developed back pain associated with the progression of her curve and increasing right trunk shift, which she was able to manage with core strengthening until several years before presentation. However, her scoliosis had progressed to 71°. She did not have any difficulty with walking, nor was she taking any medications. She requested curve stabilization without spinal fusion to maintain her current level of physical activity (including yoga and swimming laps daily), decrease back pain, and stop curve progression.

On clinical examination, the patient's left shoulder was slightly lower than her right and she demonstrated a right truncal shift. Her significant trunk asymmetry was associated with rib deformity. The inclinometer showed an angle of trunk rotation (ATR) of 20° thoracic. She demonstrated no neurologic deficits on exam.

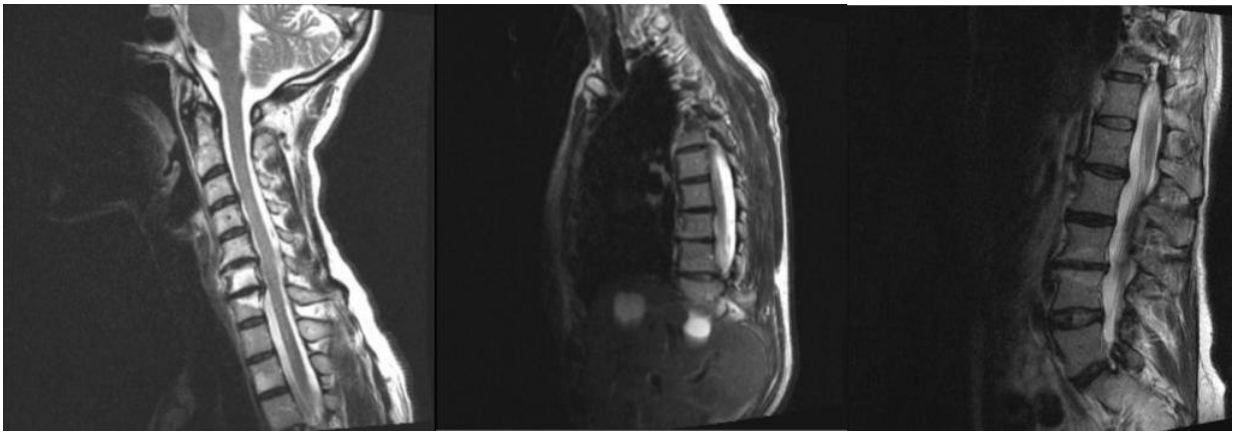
On the preoperative coronal imaging, the standing x-ray demonstrated a 71° Lenke 1A main coronal thoracic right curve at T5-T12 (Figure 1a). There was a compensatory 38° left coronal lumbar curve to L5 and a compensatory left proximal coronal thoracic curve of 32° (Figure 1a). On sagittal imaging, there was significant thoracic hypokyphosis, and calculated 3D kyphosis[13] was measured at 2.4° (Figure 1b). The formula to estimate 3D kyphosis was described by Parvaresh et al[13] and is the following: 3D T5-T12 kyphosis = 18.1 + (0.81*2D T5-T12 kyphosis) – (0.54*2D thoracic coronal curve) degrees. The lumbar sagittal curve angle was measured at 78°. Pelvic tilt was 0°, indicating a significantly posterior tilted pelvis. Fulcrum coronal bending of the main thoracic curve showed 30° over a bolster, with 57.7% flexibility of the thoracic curve (Figure 1c). The coronal lumbar curve T12-L5 bent to 12° (Figure 1d).



(a) (b) (c) (d)

Fig. 1a-d: Preoperative radiographs of a 50-year-old woman with progressive scoliosis.
(a) Coronal profile showed 71° Lenke 1A main thoracic curve with worsening trunk shift
(b) Sagittal profile showed a thoracic lordosis of calculated 3-D kyphosis of 2.4°
(c) Fulcrum bending of the main thoracic curve was 30° over a bolster
(d) Fulcrum bending of the compensatory lumbar curve was 12° over a bolster

Her preoperative MRI (Figures 2a-c) was significant for degenerative disc disease, most significant at L3-L4 including Modic changes. A posterior fusion approach would need to go distal to L2 as the last substantially touched vertebra (LSTV). There was concern that a PSF would put additional stress on the lumbar spine and change tolerable mid-lumbar spine pain to not being tolerable and might precipitate an extension of the fusion. Also, the option of a PSF to L4 to include the L3 -4 disc was discussed. CT scan and DEXA demonstrated mild osteopenia.Therefore she had injections of Forteo over 3 months pre-op to enhance bone mass.



(a) (b) (c)

Fig. 2a-c: Preoperative MRI imaging of a 50-year-old woman with progressive scoliosis
(a) MRI of the cervical spine showed degeneration of the intervertebral discs at C5-6 and C6-7
(b) MRI of the thoracic spine showed narrowing of the intervertebral discs at T7-8 and T8-9
(c) MRI of the lumbar spine showed degeneration of the lumbar intervertebral discs with Modic changes at L3-L4

In discussing options with the patient, it was important to her not to lose her mobility and flexibility. Thus, early generation Anterior Scoliosis Correction (ASC) was performed from T5 to L1 with anterior longitudinal ligament and anterior disc complex releases at T7-T11 through the mini-open incision and single screw line correction. She required 4 level de-tethering releases to get adequate correction of the curve in 3 dimensions (coronal, sagittal, and axial). The ASC and de-tethering release procedure is described in one of our previous publications.[14] A thoracoplasty was suggested but not performed as the patient's goal was not cosmesis but only curve stabilization. Estimated blood lost was 300cc. She had no perioperative or postoperative complications. At 6-week follow-up, the patient had returned to work and began swimming and treading water walking on an elliptical. On coronal x-ray (Figure 3a), her right main thoracic curve was reduced to 30° (58% coronal correction). The left lumbar curve was decreased to 18° (52% coronal correction). The proximal thoracic curve was corrected to 22° (31% coronal correction). 3D thoracic kyphosis improved to 27° (Fig. 3b), lumbar lordosis was 64°, and pelvic tilt was 8.7°.

Fig. 3a-b: 6-week postoperative radiographs demonstrated a 30° main thoracic curve. (b) 3-D thoracic kyphosis measured 27°.

At 3-year follow-up, the patient reported no back pain and had returned to a fully active lifestyle including daily lap swimming with rotational turns. She reported that she had, at minimum, the same motion that she had preoperatively and maybe more. [video link]

Her residual thoracic spine measurement by inclinometer remained reduced from 20 to 14°. Radiographs at that time demonstrated a right thoracic curve of 31°, left lumbar curve of 21°, and proximal thoracic curve of 22° (Figure 4a). 3D kyphosis measured 30° (Figure 4b) and lumbar lordosis was 63°. Pelvic tilt was 8.3°. All instrumentation appeared intact on radiographic analysis.

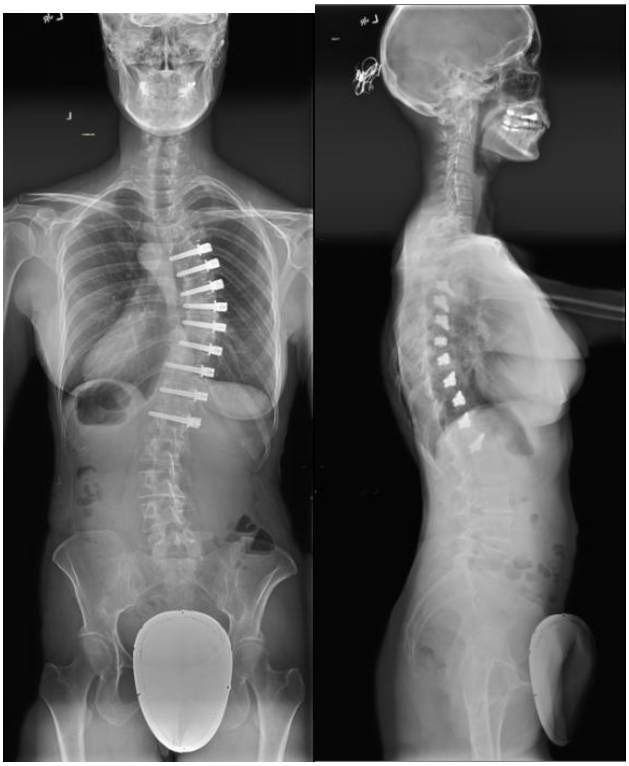


Fig. 4a-b: 3-year postoperative radiographs demonstrated (a) a 31° main thoracic curve with reduced trunk shift and (b) 3D thoracic kyphosis of 30°.

At 7-year follow-up, the right thoracic curve remained stable at 33°, the left lumbar curve measured 19°, the proximal thoracic curve was 22°, and 3D kyphosis was 29° (Figure 5a-b). Lumbar lordosis sagittal angle was 60° and pelvic tilt was 11°. All instrumentation appeared to be intact.

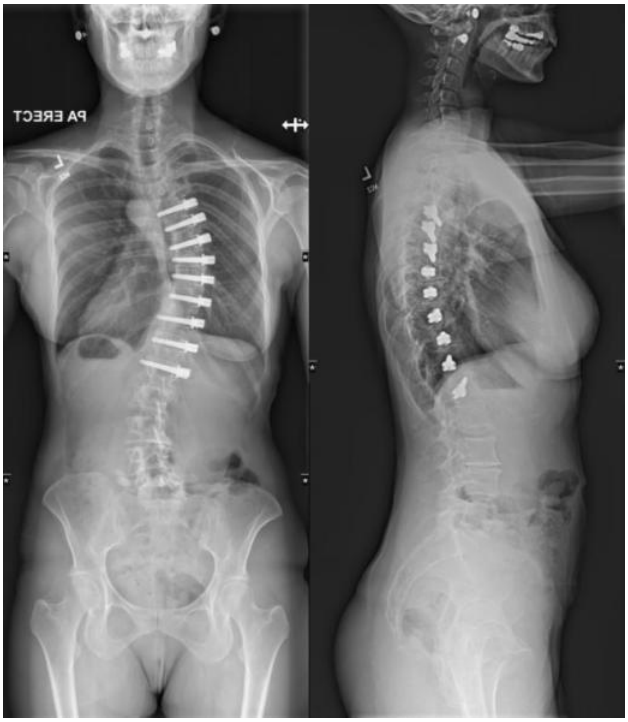


Figure 5. Radiographic analysis at 7-year follow-up revealed (a) 33° main thoracic curve with reduced trunk shift and (b) 3D thoracic kyphosis of 29°.

Radiographic findings for all time points are summarized in Table 1.

Table 1: Preoperative and Postoperative Radiographic Measurements.

	Pre-op	First Erect	6 weeks	3 years	7 years
Thoracic curve, degrees	71	28	30	31	33
Instrumented thoracic coronal curve, degrees		27	29	27	31
Lumbar curve, degrees	38	17	18	21	19
Proximal thoracic curve, degrees	39	23	22	22	22
T1 tilt, degrees	-5.2	0	0	0	0
Trunk shift, cm	0.989	0.955	0.926	0.517	1.06
2D kyphosis, degrees	31	32	30	34	33
3D kyphosis, degrees	2.4	29	27	30	29
Lumbar lordosis, degrees	71	64	64	63	60
Pelvic incidence, degrees	56	54	51	53	56
Pelvic tilt, degrees	0	9.8	8.7	8.3	11

3. Discussion

We present a case report detailing 7-year successful treatment of a 50-year-old woman with a large progressive scoliosis utilizing a motion preserving spine curvature correction technique. She had a documented 38° right thoracic curve as a late teen and, over the next 20 years, her scoliosis had progressed to 71°. This is consistent with the natural history of progression (about 1° per year) reported by Weinstein et al in 1981.[15] Our patient was fearful of an 80-90° curve developing over the next 20 years and eventually experiencing pulmonary compromise, which is common when curves reach that severity.[15] She also did not want to lose any of her mobility (which would have occurred with a posterior spinal fusion) as she was still very active athletically, doing yoga and swimming laps daily.

Another complicating factor for our patient was her degenerative disc with Modic changes at L3-4. She was controlling her lumbar pain with her exercise program. However, a posterior spine fusion with metal rods would have needed to go from T4 to L2. This would then have put additional stress on her remaining mobile lumbar segments and almost assuredly caused more severe pain at L3-4 from adjacent level disc disease.[7,8] The ASC which was performed is a "de-tethering" technique that allows almost normal segmental motion, thus minimizing the stress on the adjacent lumbar spine levels. As noted previously, she reported that she had, at minimum, the same motion that she had preoperatively and likely more [video link].

ASC is the multi-year, multi-generational surgical advancement of vertebral body tethering. However, the advanced concept of ASC is to "de-tether" the scoliotic spine to allow for an adequate three-dimensional correction, particularly derotation. This is obtained through multi-level and segmental anterior longitudinal and disc complex releases. Our current technique additionally allows for multiple and offset screw-line constructs to enhance derotation power through the derotational axis. Additionally, because this is a muscle preserving modified anterior fusion approach, many of the segmental arteries and vascular bundles are preserved, enhancing safety. The procedure is thereby applicable to nearly all scoliosis curves and sizes, thoracic and lumbar, and is not age-dependent. With nearly 10 years of experience developing ASC, and through staged surgeries, clinical and MRI data, it has been our observation that segmentally the de-tethered spine restores the disc and regenerates the nucleus, hence preserving motion. Importantly, ASC is not an intervertebral disc-destroying fusion as occurs in every metal rod fusion technique. Through the ASC modified fusion approach, the cartilaginous endplates are left intact . This allows maintenance and restoration of motion, and by the nature of the de-tethering, allows powerful correction of the scoliosis (the de-tethering aims to remove the internal torsional forces in the scoliotic spine, allowing for improved, stable correction after healing).

Besides allowing Dr. MDA to obtain the best correction of the spine, perhaps more important is maintenance of correction. Because the annulus and spinal ligaments heal after correction and do so in the newly corrected position, this helps maintain the correction obtained at surgery. Dr. MDA and his colleagues have performed over 750 cases, which

have included well over 3000 anterior spinal ligament and disc complex releases. We have yet to find a single case where a patient develops discogenic back pain. It is the authors' opinion that there is a remote possibility that a patient might develop back pain attributable to a discogenic disc; however, the alternative would have been a guaranteed destruction of multiple disc levels from a metal rod fusion for their scoliosis. If discogenic pain were to happen, with 2022 technology there are minimally invasive treatments for repair that do not involve surgery, or at worst, a single level fusion. In the authors' opinion, this possibility far offsets the guaranteed destruction of multiple disc levels, permanent flexibility loss caused by a multi-level metal rod fusion for scoliosis, and the risk of adjacent segment disease, which is reported to be as high as 25%.[16]

With respect to this case, postoperatively the patient obtained an initial thoracic curve improvement at 6 weeks from 71° to 30° (58% correction) and lumbar curve improvement from 38° to 18° (52% correction). This correction was maintained within a few degrees at 7-year follow-up. This is a clinical success and is comparable to the 96% clinical success of ASC treated thoracic curves we reported in an early cohort of patients age 11 to 22.[17] Further coronal analysis showed that her T1vertebra tilt angle improved to neutral from a decompensated position which may help her avoid cervical spine problems in the future.

The patient's thoracic 3D kyphosis using the formula to estimate 3D kyphosis as described by Parvaresh et al[13] improved from 2.4° preoperatively to 27° postoperatively and has been maintained at 7-year follow-up. Her cervical spine kyphosis did not improve like we have reported in adolescents and seen clinically for our adolescent patients with ASC.[18]
This inability to correct her cervical kyphosis spontaneously like we do in adolescents may be because of her degenerative disc disease in the cervical spine (Figure 2A).

Importantly, no complications occurred in the perioperative or postoperative follow-up periods. The procedure typically results in low blood loss (our patient had a typical 300mL loss), and the transfusion rate is extremely rare. On the contrary, blood loss during posterior spinal fusion in adults averages 1500 to 2000mL. Additionally, in our practice of ASC, we are not aware of any post-surgical infection complications.

Sagittal malalignments can affect a person's quality of life.[19,20] With our motion preserving surgical technique, we restored a more normal thoracic kyphosis to this patient and decreased her lumbar lordosis closer to normal of 60°, with a more normal pelvic tilt. Unfortunately her cervical kyphosis was minimally changed, possibly because of cervical disc degeneration. We did not have clinical or radiographic motion parameters in place preoperatively to then compare post-op. The patient subjectively reported that she has found no diminished motion compared to pre-op and is continuing with a very active lifestyle including daily lap swimming with flip turns.

4. Conclusion

This case illustrates proof of concept for an alternative treatment of adult patients with slowly progressive scoliosis residual from adolescence. Whereas the ultimate long-term outcome is not known, when adult scoliosis progresses it is possible to intervene with motion preserving surgical treatment. This reduction of the scoliotic curve presumably can decrease chronic asymmetric load on the spine and, in the long run, may reduce the risks of curve progression and lumbar decompensation.

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