Segmental Derotation Using Alternate Pedicular Screws in Adolescent Idiopathic Scoliosis

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ABSTRACT

BACKGROUND: The use of pedicle screw implants for the treatment of Adolescent Idiopathic Scoliosis (AIS) has gained popularity over the past several years. Pedicle screws have been shown to be safe and effective in the treatment of AIS as well as having greater correction power in the coronal, sagittal, and axial planes over hybrid constructs

PURPOSE: To assess the effectiveness and safety of segmental derotation using alternate posterior segmental fixation in managing adolescent idiopathic scoliosis.

STUDY DESIGN/SETTING: A prospective clinical study enrolled 15 patients with adolescent idiopathic scoliosis who were treated by segmental derotation using alternate posterior segmental fixation. The study was performed between January 2005 and May 2007.

METHODS: This study enrolled 15 patients with an average age of 16 yrs. All patients had a preoperative assessment by physical examination and plain radiography (anteroposterior, lateral and dynamic views). The scoliotic curves had a mean preoperative value of 64.8o. All patients underwent segmental derotation using alternate posterior segmental fixation under general anesthesia. Average follow up was 24.3 months and was done on a regular basis; immediately postoperative, then at 4 weeks and regularly every 3 months with clinical and radiographic assessment by plain radiography (anteroposterior and lateral views). Measurement analysis was done using the Image Launcher 1.4.3.67 software. Statistical analysis was with SPSS13.0 for Windows software.

RESULTS: All patients showed marked postoperative improvement of their scoliotic deformities. Mean scoliotic curves improved from 64.8o to 8.4°. Radiographic assessment revealed 100% fusion with no loss of correction. Postoperative recovery was fast with weight bearing on the second postoperative day. No complications were found.

CONCLUSIONS: Segmental derotation using alternate pedicular fixation in managing adolescent idiopathic scoliosis provides an effective method of correcting scoliotic curves. This method provides excellent scoliotic curve correction with no loss of correction, better fusion rates, rapid postoperative recovery, and decreased complications.

KEY WORDS: Alternating levels, Derotation, Idiopathic scoliosis, Pedicle screws

INTRODUCTION

The ideal correction system for adolescent idiopathic scoliosis (AIS) should provide rigid fixation and maximal correction with minimal fusion levels. Moreover, it should correct all three dimensions of the scoliotic deformity. Using the hooks in the upper and lower stable vertebra, Harrington instrumentation applies distraction and/or compression forces for the correction and fixation of the curve. For many years, it was used throughout the world as a treatment of choice in scoliosis correction and fusion. Actually, Harrington instrumentation with compression-distraction did

make some coronal correction, but there was a major complication in the sagittal plane, such as flat back deformity. Other significant complications included loss of curve correction, long fusion levels and pseudarthroses.[5,18]

Since the advent of Harrington instrumentation, several new instrumentation systems and corrective methods have been developed with a goal of three-dimensional correction. In the early 1980s, Cotrel-Dubousset instrumentation with rod derotation was introduced to enable a three-dimensional correction in scoliosis surgery. Early papers of Cotrel-Dubousset upholders reported that the derotation maneuver could induce a three-dimensional correction.[3,4,5,18] However, recent reports question the rotational correction even though they generally find the corrections are satisfactory in both coronal and sagittal planes. [1, 8,17]

The use of pedicle screw implants for the treatment of AIS has gained popularity over the past several years. Pedicle screws have been shown to be safe and effective in the treatment of AIS as well as having greater correction power in the coronal, sagittal, and axial planes over hybrid constructs.[2,14,15,16,17] 10-16 Pedicle screws have shown superior biomechanical properties over other instrumentation techniques of the spine.[12] They allow for three-column fixation of the vertebral body, thereby allowing for improved correction over hook constructs.[2,3,4] Additionally, they allow for true derotation of the spine in all 3 planes, whereas other modern techniques provide only posterior medialization of the spinal column.[6,11]

This study was conducted to evaluate a technique of alternate pedicular screws as a new construct for segmental derotation in the treatment of AIS.

PATIENTS AND METHODS

This was a prospective clinical trial designed in the period between January 2005 and May 2007 and enrolled 15 patients with adolescent idiopathic scoliosis. All patients had a preoperative assessment by physical examination and plain radiography (antroposterior, both supine and erect, lateral, and dynamic right and left bending views). Estimation of scoliotic angle was done using Cobb's method. Estimation of apical vertebral rotation was done using Nash and Moe's method according to which the percentage displacement of the convex pedicle with respect to the vertebral body width is used to approximate the angle of vertebral rotation.[1,18] The caudalmost instrumented level was chosen using the stable end vertebra method. Thoracoscopic anterior release was performed for curves above 80° (4 cases) using the prone position (Figure 2).

The standard posterior mid line approach was used according to the levels planned to be instrumented. The upper construct consists of 2 pedicular screws at the uppermost vertebra and the lower construct consists of 2 screws at the lowermost vertebra. Alternate pedicular screws are inserted between these constructs such that each vertebra is instrumented with a single pedicle screw in alternative position with the above and below vertebrae. After insertion of all the pedicle screws, a lateral view is taken by image intensifier to be sure of screw position. Decortication of the laminae and facet joints is done on the concave side to prepare this bed for grafting and fusion. The pre-shaped rod is then inserted on the concave side with rod translation by the aid of specialized devices, such as a "persuader," to reduce the curve sequentially as vertebral segments are translated onto the rod. When the rod is secured inside the screw heads all nuts are applied without tightening and derotation of the curve is done sequentially until the rod is well rotated to produce the proper sagittal contours after which all the nuts are tightened to secure the rod properly inside the screw heads.

The convex side is then decorticated and the rod is applied to the screws. If needed, distraction and compression forces can be applied to gain more correction. After accomplishing the reduction of the curve, the Stagnara wake up test is done to assure the absence of cord injuries. We rarely needed an iliac bone graft and it was usually harvested from the local spinous processes. Closure was done as usual with suction drain for 48 hours.

Bracing with a thoracolumbosacral orthosis (TLSO) was performed in all patients after surgery. Patients were allowed to walk by the second postoperative day and were discharged from hospital by the fifth postoperative day. The first follow-up visit was done after 4 weeks and then at 3-month intervals till the end of follow-up.

RESULTS

Our study enrolled 11 female and 4 male patients with an average age of 16 years. There was no case of

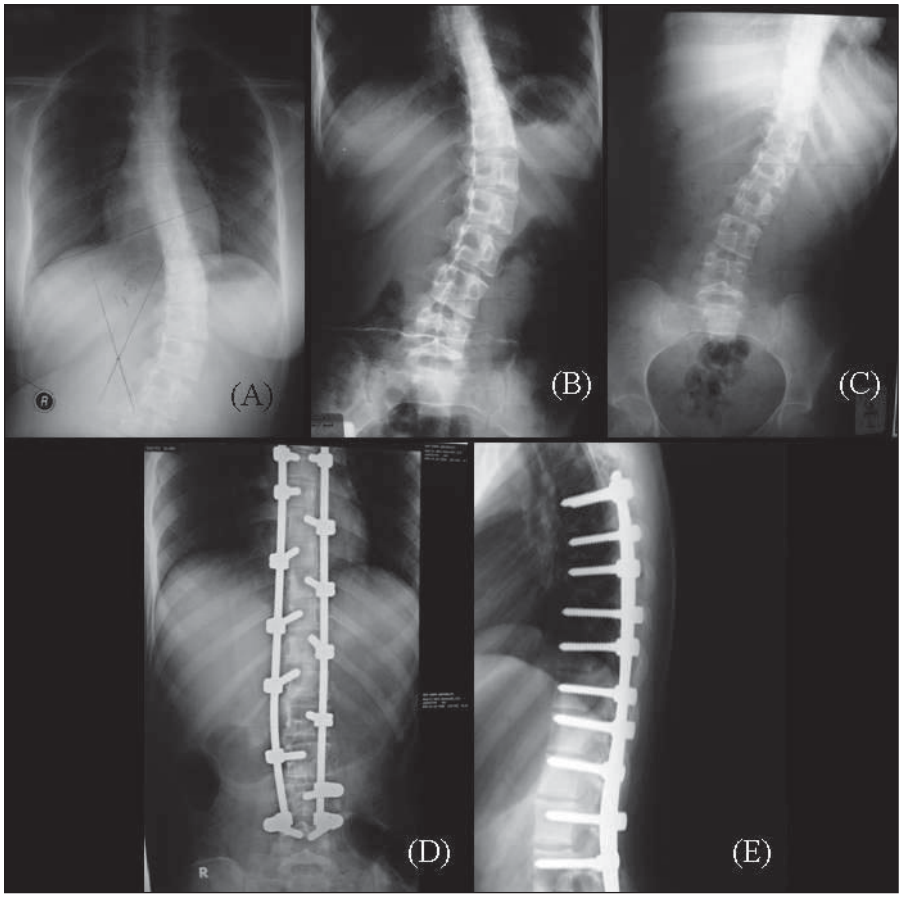

Figure 1: *Female patient,18 years old, with AIS with a curve of 45° has been corrected to 1.5° (nearly straight) with alternative pedicle screws technique with the Isola system. The erect Antero-posterior view with a regional Cobb angle of 45°. (C) Right and left bending views. AP view after correction.(Notice the alternative screw: one in each vertebra) Lateral view shows the screws in the pedicles. The top loading screws are monoaxial.*

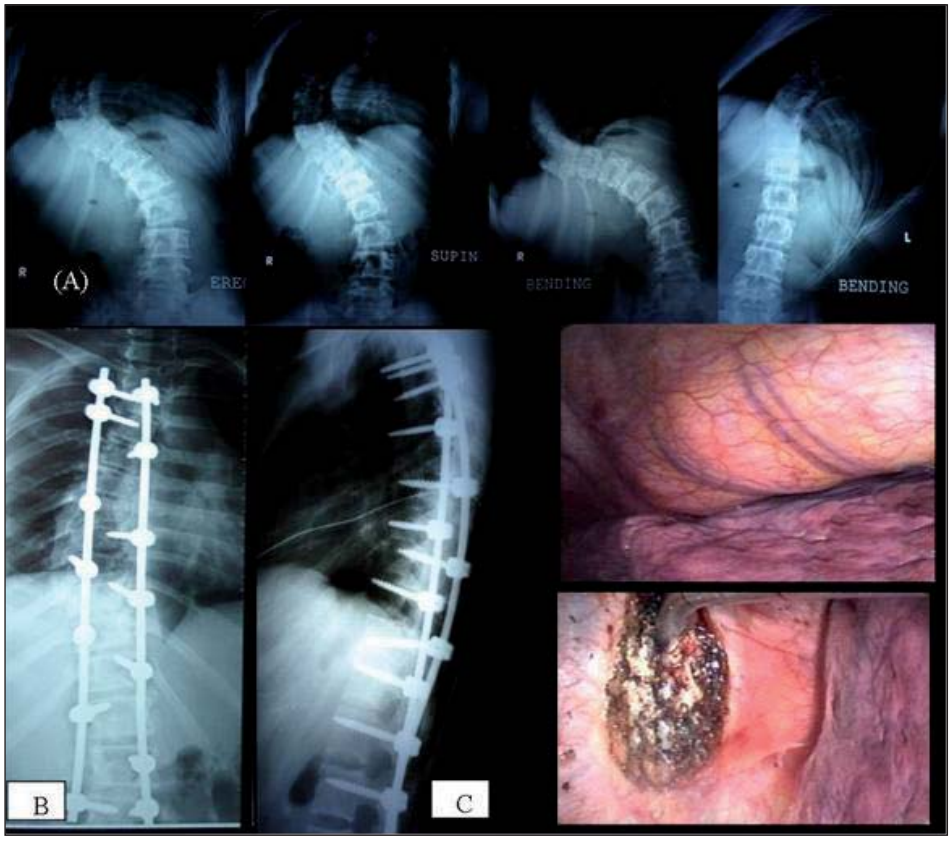

Figure 2: *Female patient, 14 years old, the curve magnitude was 92°. Thoracoscopic anterior release was performed, followed by posterior correction by alternative screw technique (Expeduim). The postoperative angle was 22°. Preoperative x-rays: AP erect and supine, Dynamic views.*
Postoperative AP view with good correction of the deformity by the alternative screws. Thoracoscopic view for the curve and another during anterior release

intra- or postoperative neurological deficit or infection. Postoperative recovery was fast with weight bearing on the second postoperative day. Scoliotic curves had a mean preoperative value of 64.8° .The largest curve was 92° and the smallest 45°. All patients showed marked immediate postoperative improvement of their scoliotic deformities. Mean scoliotic curves improved from 64.8° to 8.4°. Small curves were corrected up to 97%. Rod derotation improved apical vertebral rotational deformity (Table 1). At final follow up of a mean of 24.3 months, there was no loss of correction, pseudoarthrosis or nonunion. Delayed union (> 9 months) was observed in 2 patients but fusion occurred at the end of follow-up.

DISCUSSION

Treatment of adolescent idiopathic scoliosis remains a subject of ongoing development and still is a matter of debate with increasing consensus regarding segmental derotation maneuvers. Current surgical tools and techniques allow for an unprecedented ability to correct even the most severe scoliotic deformities.[6,7] The development of rigid segmental instrumentation devices (pedicle screws) has revolutionized the spine surgeon's capability to manipulate the spine and reduce its deformity. [5,18]

The concept of direct vertebral rotation (DVR) is simple: correction of vertebral rotation by application of a posterior force in the direction opposite to that of the deformity.[8] Derotation maneuvers include rod derotation, rod translation and direct vertebral derotation. Rod derotation involves placing a preshaped rod in one or both sides of a curve and rotating it to achieve curve reduction. Both maneuvers have become popular for obtaining triplanar correction using segmental instrumentation.[13]

All pedicle screws techniques, involving insertion of pedicle screws in all the pedicles of the curve, have gained marked popularity for correction of scoliotic curves with good results lately.[3,4] In our study, we introduce alternate pedicular screws as a variant of the all screws technique for correction of this coronal deformity. This alternate placement of screws provides a single pedicle and a facet joint untouched and uninjured by a screw in each vertebra involved in the curve. This allows controlled equal gaps between the screws on both the convex and concave sides alternatively without loosing the advantage of controlling each vertebra in the curve that is provided by the all screws technique.[13]

Therefore, a virgin, copious surface with preserved anatomy for impaction of bone graft and thereby more solid posterior fusion especially facetal fusion are ensured just by decortication of the nearby lamina and spinous process together with removal of the uninjured facetal joint cartilage.[9,10] These controlled gaps also allow easier application of the rods and more space for application of the bulky instruments needed for derotation and reduction of the curves. Another advantage of this technique is that it is much more economical than the traditional all screws correction. Finally, the surgeon still has an unmutilated pedicle in each vertebra in the curve with a preserved landmark for insertion of screw or even for an osteotomy that provides better chances for recorrection of the deformity if revision surgeries are needed for any reason.

CONCLUSION

Segmental derotation using alternate pedicular fixation in managing adolescent idiopathic scoliosis provides an effective method of correcting scoliotic curves. The construct of alternating pedicular fixation allows for a good bed for fusion on the contralateral side of the pedicular screw in each segment while enabling segmental fixation and good control of each vertebra in the curve for the rod derotation maneuver at the same time.

REFERENCES

1. Aaro S, Dahlborn M. Estimation of vertebral rotation and the spinal and rib cage deformity in scoliosis by computer tomography. Spine;6:460–7, 1981
2. Adjei OB, Girardi FP, Bansal M, and Rawlins BA. Safety and Efficacy of Pedicle Screw Placement for Adult Spinal Deformity with a Pedicle-Probing Conventional Anatomic Technique. Journal of Spinal Disorders 13, 496–500 .2000.
3. Belmont PJ, William KR. Aman D, David PW In Vivo Accuracy of Thoracic Pedicle Screws spine 26 ,2340-2346,2001
4. Beuerlein MJ, Raso VJ, Hill DL, Moreau MJ, Mahood JK: The relationship between axial rotation and lateral bending. Studies in Health Technology and Informatics: Research into Spinal Deformities 2, 59:105-108, 1999.
5. Cotrel Y, Dubousset J, Guillaumat M: New universal instrumentation in spinal surgery. Clin Orthop 227:10-13, 1988
6. Gardner-Morse M, Stokes IA. Three-dimensional simulations of the scoliosis derotation maneuver with Cotrel-Dubousset instrumentation. J Biomech;27:177–81,1994.
7. Ghanem IB, Hagnere F, Dubousset JF, et al. Intraoperative optoelectronic analysis of three-dimensional vertebral displacement after Cotrel-Dubousset rod rotation. A preliminary report. Spine;22:1913–21,1997

8. Gray JM, Smith BW, Ashley RK, et al. Derotational analysis of Cotrel- Dubousset instrumentation in idiopathic scoliosis. Spine;16: 391–3. 1991
9. Kim YJ, Lenke LG, Bridwell KH, et al. Free hand pedicle screw placement in the thoracic spine: is it safe? Spine;29:333–42 ,2004
10. Kim YJ, Lenke LG, Thoracic pedicle screw placement: Free-hand technique. Neurology India 53: 512-519,2005
11. Kuklo TR, Potter BK, PollyDWJr, et al. Monaxial versus multiaxial thoracic pedicle screws in the correction of adolescent idiopathic scoliosis. Spine;30: 2113–2120. 2005.
12. Lee SM, Suk SI, Chung ER. Direct vertebral rotation: a new technique of three-dimensional deformity correction with segmental pedicle screw fixationin adolescent idiopathic scoliosis. Spine;29: 343–9,2004.
13. Lehman RA, Lenke LG, Keeler KA, Kim YJ, Buchowski JM, Cheh G, Kuhns CA, and Bridwell KH Operative Treatment of Adolescent Idiopathic Scoliosis With Posterior Pedicle Screw-Only Constructs, Minimum Three-Year Follow-up of One Hundred Fourteen Cases Spine , 33; 1598–1604 ,2008.
14. Liljenqvist U, Hackenberg L, Link T, et al. Pullout strength of pedicle screws versus pedicle and laminar hooks in the thoracic spine. Acta Orthop Belg; 67:157–63. 2001
15. Liljenqvist UR, Halm HFH, Link TM. Pedicle screw instrumentation of the thoracic spine in idiopathic scoliosis. Spine; 22:2239–45. 1997
16. Muschik M, Schlenzka D, Robinson PN, et al. Dorsal instrumentation for idiopathic adolescent thoracic scoliosis: rod rotation versus translation. Eur Spine J Eur Spine J 8:93–99, 1999.
17. Suk SI, Lee CK, Chung SS. Comparison of Zielke ventral derotation system and Cotrel-Dubousset instrumentation in the treatment of idiopathic lumbar and thoracolumbar scoliosis. Spine 19:419–29,1994.
18. Suk SI, Lee CK, Kim WJ, et al. Segmental pedicle screw fixation in the treatment of thoracic idiopathic scoliosis. Spine 20: 1399–405, 1995.

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