Selection of Lowest Instrumented Vertebra in The Management of Lenke 5 Adolescent Idiopathic Scoliosis Using Pedicle Screw Instrumentation

Umair Nadeem,[1*] Waqar Alam,[2] Abdullah Shah,[1] Atiq-uz-Zaman,[1] Amer Aziz [1]

ABSTRACT

Objective *To determine the lowest instrumented vertebra (LIV) in the management of Lenke 5 adolescent idiopathic scoliosis (AIS) patients using pedicle screw instrumentation. (PSI)*

Study design *A retrospective review.*

Place & Duration of study *Department of Orthopedics and Spine Surgery, Ghurki Trust Teaching Hospital Lahore, from January 2014 to April 2016.*

Methodology *Analysis of radiographic parameters of 32 patients was done. The patients were grouped according to the LIV level; Group I (fusion to L3, n=25) and Group II (fusion to L4, n=7). The Group I was further subdivided into IA (L3 crossed the mid-sacral line with rotation of less than grade II on bending films - n=14) and IIB (L3 did not cross the mid-sacral line or rotation was grade II or more on bending films n=11). All the patients in the Group II had the same location and rotation of L3 in bending films as that of patients in the group IB. Patients with lowest instrumented vertebral tilt (LIVT) of more than 10° or coronal balance of more than 15 mm, were considered to have unsatisfactory results.*

Results *LIVT was reduced from 20.8±6.3 to 5.5±2.9° in group IA and from 24.1±8.2° to 10.8±5.1° in group IB and from 26.7±4.6 to 6.9±5.2° in group II. A significantly less reduction was obtained in group IB (49.7%) as compared to group IA (88.4%) and group II (81.8%). Unsatisfactory results were obtained in 1 (7.1%) patient of group IA, in 7 (63.3%) patients of the group IB, and in 1 (12.5%) patient of group II which was found to be statistically significant.*

Conclusions *For the correction of thoracolumbar / lumbar AIS with pedicle screw instrumentation, L3 can be selected as the LIV instead of L4, thus saving one distal motion segment, when preoperatively L3 crosses the midsacral line with a rotation of less than Nash-Moe grade II in both the active bending radiographs, otherwise fusion has to be extended to L4.*

Key words *Scoliosis, Adolescent, Lowest instrumented vertebra, Pedicle screw instrumentation.*

[1] Department of Orthopedics and Spine Surgery, Ghurki Trust Teaching Hospital Lahore.

[2] Department of Orthopedics Saidu Medical College, Saidu Sharif Swat

Correspondence:
Dr. Umair Nadeem [1*]
Department of Orthopedics and Spine Surgery
Ghurki Trust Teaching Hospital
Lahore
E mail: dr.umair.nadeem@gmail.com

INTRODUCTION:

Adolescent idiopathic scoliosis is a three-dimensional deformity of the growing spine, affecting 2%–3% of adolescents. Although benign in majority of patients, the natural course of the disease may result in significant disturbance of body morphology, reduced thoracic volume, impaired respiration, back pain, and serious aesthetic concerns.[1] Throacolumbar and lumbar AIS is rarer than the thoracic AIS and conversion of a C shaped coronal deformity into a S shaped sagittal balance and selection of the lowest instrumented vertebra at which fusion should be stopped, is a considerable surgical challenge.[2]

Anterior instrumentation of TL/L idiopathic scoliosis gives highly satisfactory morphological and functional results, as lumbar musculature are spared and the instrumentation placed at the apex of the curvature has selective effects.[3] However, it is associated with risk of mechanical failures, pseudarthrosis, loss of correction and kyphosis in the instrumented segment. Development of rigid instrumentation has reduced these risks but there is still a risk of major vessel or internal organ injury in anterior surgery and most spine surgeons are not well trained for this approach.[4]

Harrington instrumentation got popularized for the management of idiopathic scoliosis in 1950s. Posterior spinal arthrodesis with Harrington instrumentation and bone grafting was the first attempt to correct the coronal deformity with *in situ* fusion. This approach was associated with high pseudarthrosis rates, need for postoperative immobilization, and flat back syndrome.[5-6] For this instrumentation, stable vertebra was considered as LIV.

More recently, segmental pedicle screw instrumentation was introduced for correction of idiopathic scoliosis. A pedicle screw is a power nucleus which provides 3-column stability. PSI can provide enhanced three-dimensional deformity correction and preserves more motion segments by reducing the number of levels fused.[7-8] For performing this powerful instrumentation, either L3 or L4 has been commonly chosen as the LIV for TL/L AIS.

In patients with TL/L AIS managed with PSI, distal fusion level at either L3 or L4 is a subject of ongoing debate.[9-10] This retrospective study intended to compare the postoperative LIVT and coronal balance at follow-up after minimum of two years past surgery in patients with either L3 or L4 chosen as LIV. Aim was to determine the distal fusion level depending upon analysis of the surgical outcome of patients with Lenke 5 TL/L AIS treated with PSI. It was hypothesized that fusion could be stopped at L3 if powerful PSI could bring L3 in stable zone and hence we could preserve L4 motion segment and prevent adjacent segment degeneration.

METHODOLOGY:

This retrospective review was conducted in the Department of Orthopedics and Spine Surgery, Ghurki Trust Teaching Hospital Lahore, from January 2014 to April 2016. A total of 32 patients with Lenke 5 TL/L AIS (8 thoracolumbar and 24 lumbar) managed with posterior PSI were reviewed. There was a minimum follow-up of 2 years in all the patients. The mean age at the time of surgery was 15 year (range, 10.4–17.5 year). There were 5 males and 27 females and the male to female ratio was 1:5.4. Left convex curve was found in 29 patients, and atypical right convex curve in 3 with the end vertebra of L3 or L4.

After appropriate insertion of pedicle screws using image guidance, deformity correction was obtained by a combination of rod pre-contouring, rod de-rotation, translation and direct vertebral rotation (DVR). After locking the rod on the correction side, the opposite rod was bent to conform to the shape of the corrected curve and was placed on other side in situ. The two rods were connected by means of a transverse connector. Subsequently, posterior fusion was performed.

Postoperative standing anteroposterior and lateral radiographs were assessed to find out curve magnitude, sagittal profile, lowest instrumented vertebral tilt (LIVT) angle, and coronal balance. Cobb's method was used to determine curve magnitude. Sagittal alignment was checked by assessing thoracic kyphotic angle and lumbar lordosis. The LIVT was calculated as the angle between the inferior endplate of the LIV and a horizontal line. The coronal balance was measured as the distance between the C7 plumb line and the central sacral vertical line (CSVL). A LIVT of more than 10° or a coronal balance of more than 15 mm was considered unsatisfactory.

The preoperative right and left active bending radiographs were taken to evaluate the location and rotation of L3. Patients were grouped according to the LIV level; Group I (fusion to L3, n=25) and Group II (fusion to L4, n=7). The group I was further subdivided into group IA and group IB. In group IA L3 crossed the mid-sacral line with rotation of less than Nash-Moe grade II on active bending films (n=14), while in group IB L3 did not cross the mid-sacral line with rotation of Nash-Moe grade II or more on active bending films (n=11). All of the patients in the group II had the same location and rotation of L3 in bending films as that of patients in the group IB. Patients with lowest instrumented vertebral tilt (LIVT) of more than 10° or coronal balance of more than 15 mm were considered to have unsatisfactory results.

Statistical analysis was done by using SPSS version 19. Fisher's Exact test was applied to compare the percentages of unsatisfactory results in three groups. A p-value of less than 0.05 was considered statistically significant.

RESULTS:

LIVT was reduced from 20.8±6.3° to 5.5±2.9° in group IA and from 24.1±8.2° to 10.8±5.1° in group IB. In group II this reduction was from 26.7±4.6° to 6.9±5.2°. Considering p-value <0.05, there was significantly less reduction in group IB (49.7%) as compared to group IA (88.4%) and group II (81.8%) (table I)

The coronal balance improved from 13.9±6.6 mm to 6.1±5.4 mm in the group IA, from 17.8±9.4 mm to 13.1±6.8 mm in group IB, and from 15.4±10.4 mm to 9.2±3.8 mm in the group II (table II). Again, improvement in coronal balance was significantly better in group IA and II as compared to group IB.

Unsatisfactory results were obtained in 1 patient (7.1%) of the group IA, in 7 patients (63.3%) of the group IB, and in 1 patient (12.5%) of the group II which was found to be statistically significant. In group IB, preoperative active bending films revealed a relative stiffness of the TL/L curve: L3 did not cross the midsacral line and also showed rotation of more than Nash-More grade II.

DISCUSSION:

There is a consensus among spine surgeons for preserving as many lumbar motion segments and maintaining a physiologic sagittal profile of spine while surgically correcting the deformity of AIS.[11,12] By keeping the fusion mass as small as possible, risk of adjacent segment degeneration and back pain is also reduced.

After Harrington instrumentation, loss of lumbar lordosis (flat back syndrome) and abnormal transmission of loading forces led to adjacent segment degeneration and caused long term back pain. It had limited capacity for sagittal profile correction and could not adequately derotate the spine.[13] In previous generations of spinal instrumentation like Cotrel-Dubousset instrumentation (CDI) used for correcting AIS, distal fusion was extended up to stable vertebra and L4 was taken as LIV. Segmental PSI was introduced later on. Pedicle is the hardest part of a vertebra and provides the best possible 3-column anchorage at each vertebral level. Segmental PSI, by dispersing the stress at each spinal level, provides powerful three-dimensional correctional forces to the spine surgeon.[14,15]

Selection of LIV in Lenke 5 TL/L AIS with segmental PSI is controversial in literature.[8-10] Shufflelbarger et al reported excellent curve correction in Lenke 5 adolescent idiopathic scoliosis with PSI while using the same proximal and distal fusion levels as those in ventral instrumentation systems but they did not, however, establish any discrete criteria for stopping fusion at either L3 or L4 level.[8] Kim SS et al. concluded that the L4 motion segment could be preserved and fusion could be stopped at L3 if preoperatively the lumbar/thoracolumbar curve showed adequate structural flexibility.[2] Carreon LY et al cautioned, however, against stopping the instrumentation prematurely at a more proximal level in pursuit of saving a motion segment and rendering the spine unbalanced and undercorrected.[9]

We assumed that if powerful PSI could sufficiently derotate and translate the vertebra proximal to the stable vertebra (L3 in TL/L AIS) so as to bring it in the stable zone, fusion could be stopped proximally at L3 level. By bringing the fusion mass within the stable zone in a balanced spine adjacent segment degeneration could be prevented. For this, structural behavior of L3 on active bending radiographs was

Table I: Preoperative and Postoperative LIVT

LIVT (º)	Group IA	Group IB	Group II
Preoperative	20.8±6.3	24.1±8.2	26.7±4.6
Postoperative	5.5±2.9	10.8±5.1	6.9±5.2
Rate of Correction %	88.4%	49.7%	81.8%

Table II: Preoperative and Postoperative Coronal Balance

Coronal Balance (mm)	Group IA	Group IB	Group II
Preoperative	13.9±6.6	17.8±9.4	15.4±10.4
Postoperative	6.1±5.4	13.1±6.8	9.2±3.8

assessed to see if it crossed the midsacral line and showed rotation of less than Nash-Moe grade II. Results were largely unsatisfactory in Group IB patients where preoperatively L3 did not cross the midsacral line and had rotation of more than grade II. With this study, we can ascertain the LIV in patients with Lenke 5 AIS based on preoperative bending radiographs. However, a limitation of this study is its retrospective design and a relatively small number of patients in each group.

CONCLUSIONS:

For the correction of TL/L AIS with PSI, L3 can be selected as the LIV instead of L4; thus, saving one distal motion segment and diminishing the risk of adjacent segment degeneration, when preoperatively L3 crosses the midsacral line with a rotation of less than Nash-Moe grade II in both the active bending radiographs, otherwise, fusion has to be extended to L4.

REFERENCES:

1. Kotwicki T, Chowanska J, Kinel E, Czaprowski D, Tomaszewski M, Janusz P. Optimal management of idiopathic scoliosis in adolescence. Adolesc Health Med Ther. 2013;4: 59-73.

2. Cho S, Kim J, Ikram W, Cho K, Jeong YS, Um K, Sim S. Determination of the distal fusion level in the management of thoracolumbar and lumbar adolescent idiopathic scoliosis using pedicle screw instrumentation. Asian Spine J. 2014;8:804-12.

3. Kadoury S, Cheriet F, Beauséjour M, Stokes IA, Parent S, Labelle H. A three-dimensional retrospective analysis of the evolution of spinal instrumentation for the correction of adolescent idiopathic scoliosis. Eur Spine J. 2009;18:23-37.

4. Kaneda K, Shono Y, Satoh S, Abumi K. New anterior instrumentation for the management of thoracolumbar and lumbar scoliosis. Application of the Kaneda two-rod system. Spine. 1996;21:1250-61.

5. Sud A, Tsirikos AI. Current concepts and controversies on adolescent idiopathic scoliosis: Part I. Indian J Orthop. 2013;47:117-28.

6. Cochran T, Irstam L, Nachemson A. Long-term anatomic and functional changes in patients with adolescent idiopathic scoliosis treated by Harrington rod fusion. Spine. 1983;8:576-84.

7. Suk SI, Kim JH, Kim WJ, Kim DS, Lee SM, Kim JH. Pedicle screw instrumentation for adolescent idiopathic scoliosis: the insertion technique, the fusion levels and direct vertebral rotation. Clin Orthop Surg. 2011;3:89-100.

8. Shufflebarger HL, Geck MJ, Clark CE. The posterior approach for lumbar and thoracolumbar adolescent idiopathic scoliosis: posterior shortening and pedicle screws. Spine. 2004;29:269-76.

9. Leah Y. Carreon LY, Crawford CH, Lenke LG, Sucato DJ, Glassman SD. Optimal lowest instrumented vertebra selection for posterior instrumented fusion of lenke type 5 and 6 adolescent idiopathic scoliosis: is there a difference in outcome between L3 and L4? Spine J. 2013;13:S38.

10. Wang Y1, Bünger CE, Zhang Y, Wu C, Li H, Dahl B, Hansen ES. Lowest instrumented vertebra selection for Lenke 5C scoliosis: a minimum 2-year radiographical follow-up. Spine. 2013;38:894-900.

11. Reutlinger C, Hasler C, Scheffler K, Büchler P. Intraoperative determination of the load–displacement behavior of scoliotic spinal motion segments: preliminary clinical results. Eur Spine J. 2012;21S6:860-7.

12. Connolly PJ, Von Schroeder HP, Johnson GE, Kostuik JP. Adolescent idiopathic scoliosis. Long-term effect of instrumentation extending to the lumbar spine. J Bone Joint Surg Am. 1995;77:1210-6.

13. Renshaw TS. The role of Harrington instrumentation and posterior spine fusion in the management of adolescent idiopathic scoliosis. Orthop Clin North Am. 1988;19:257-67.

14. Suk SI, Lee CK, Kim WJ, Chung YJ, Park YB. Segmental pedicle screw fixation in the treatment of thoracic idiopathic scoliosis. Spine. 1995;20:1399-405.

15. Kim YJ, Lenke LG, Cho SK, Bridwell KH, Sides B, Blanke K. Comparative analysis of pedicle screw versus hook instrumentation in posterior spinal fusion of adolescent idiopathic scoliosis. Spine. 2004;29:2040-8.

Author's Contributions:
Umair Nadeem: Conception of idea, data collection and manuscript writing.
Waqar Alam: Collection of data and references.
Abdullah Shah: Study design and logistics.
Atiq-uz-Zaman: Statistical analysis and interpretation, discussion writing.
Amer Aziz: Critical revision and overall supervision of project.

Conflict of Interest:
The authors declare that they have no conflict of interest.

Source of Funding:
None

How to cite this article:
Nadeem U, Alam W, Shah A, Zaman A, Aziz A. Selection of lowest instrumented vertebra in the management of lenke 5 adolescent idiopathic scoliosis using pedicle screw instrumentation. J Surg Pakistan. 2016;21(3):92-6. Doi:http://-dx.doi.-org/10.21699/jsp.21.3.4.