

THREE DIMENSIONAL CORRECTION OF ADOLESCENT IDIOPATHIC SCOLIOSIS

By

**Osama Mohamed El Ghannam, Ahmed Mohamed Salem,
Yasser Mahmud El-Banna*, Ibrahim Gamiel Ewass,
and Mamoun Mohamed Abo Shosha**

Departments of Neurosurgery, Al Azhar and Alexandria* Faculties of Medicine.

ABSTRACT

Background: The fixation technique in treating idiopathic scoliosis ranged from either posterior fixation, anterior approach, or combined anterior and posterior approach.

Objective: Assessing the short-term outcome of pedicle-screw method in treating adolescent idiopathic scoliosis (AIS).

Patients and Methods: Twenty consecutive patients were prospectively included with minimum of 6-months follow-up. The average age of surgery ranged between 11 and 18 years, with a mean age of 15.25 ± 2.24 years. Radiographic and clinical measurements were assessed at preoperative (preop), postoperative (PO), and final follow-up (FFU) period for curve correction rate, correction loss rate, and complications.

Results: The average main thoracic curve was corrected from $69.80 \pm 21.0^\circ$ preop to $17.73 \pm 7.38^\circ$ postop. This revealed a rate of $74.56 \pm 7.32\%$ correction. The average thoracolumbar curve was corrected from $52.14 \pm 20^\circ$ preop to $15.36 \pm 10.53^\circ$ postop, with a rate of $66.87 \pm 24.81\%$ correction.

Conclusion: All-screw method was an efficient and safe method.

Key words: Scoliosis, three dimensional correction.

INTRODUCTION

Scoliosis is defined as a three-dimensional deformity of the spine, accompanied with vertebral rotation (**Boissiere et al., 2014**). Surgical treatment of adolescent idiopathic scoliosis entails instrumentation to provide correction and stability combined with sound principles of meticulous spinal arthrodesis with bone grafting (**Barrey et al., 2014**).

The main goals of surgical treatment of adolescent idiopathic scoliosis (AIS) is to achieve curve correction, obtain a balanced spine, and to improve cosmesis

(**Zheng et al., 2014**). This approach is either anteriorly, posteriorly, or combined (**Wang and Lenke, 2011**).

Pedicular screws still remain the main surgical technique for correction of adolescent idiopathic scoliosis (AIS), where the scoliotic deformity can be corrected in three dimensional plane, superior to the two previous methods, likethe all-hook method and hook/screw hybrid method (**Zhu et al., 2011**). The use of the pedicle-screw method achieves additionally, more motion segments which could be saved by reduction of the fusion length in thoracic scoliosis (**Lehman et**

al., 2008). However, the insertion of pedicle screws in the thoracic spine is always a safety concern, especially in the upper thoracic area because of small pedicle calibers, close anatomical relations to adjacent neural structures, and deformed anatomical structures (Davis and Dunn, 2013).

Skip pedicle screws, is the fixation technique in treating idiopathic scoliosis with the aim to decrease screw density and for financial causes, with comparable correction rate and minimal complications to all pedicle screws (Hicks et al., 2010).

The present work aimed to assess the short-term outcome of pedicle screw fixation method in treating of adolescent idiopathic scoliosis.

PATIENTS AND METHODS

The study was approved by the local ethics committee, and after fulfilling written consents from the patients and their relatives, on the procedure, anticipated results, and potential complications. Twenty AIS patients (12 females, 8 males) were prospectively evaluated. The patients were chosen with age from 10 years to below 18 years old. Congenital and all other acquired scoliosis will be excluded from the study. The initial evaluation of the patient included a thorough history, complete physical and neurological examination. All patients were operated on by the pedicle-screw method. The minimum follow-up was 6 months.

Procedures:

Pedicle screws were inserted on the concave side one by one from the lumbar up to the thoracic segments. Then the screws were inserted to the convex side,

ranging in every other segment from lower to the uppermost segment. We preferred inserting 2 screws each in the lower and uppermost adjacent 2 segments. The contoured rods were linked to the rods by vertical tapping on the rods into the heads of the screws on each side. Facetectomies were also performed in each segment. Derotation started on the concave side first after completion of connecting rod to the screws. This procedure finished after rotating the rod to the vertical position as seen from the top. Only mild distraction of the screws was necessary.

In the lower lumbar scoliotic ends, due to its convexity, compression between screws can be performed. Then, the same procedure was performed on the convex side. With proper decortication of the laminae, the bone chips were placed on them. Thoracoplasty was considered and carried out only when the rib protrusion was obvious and the angle of trunk rotation (ATR) was greater than 15°.

Statistical analysis: After fulfilling each patient sheet, the data is collected, and statistical analysed using a computer based software program (SPSS v 20, sing Wilcoxon signed ranks test, Kruskal Wallis test, and McNemar test).

RESULTS

The mean patient age at the time of the operation was 15.25 ± 2.24 years (range:11.0 – 18.0years). The period between deformity detection and surgery ranged between 0.5 - 3 years, with a mean of 12.6 months.

In our study, only five patients (25 %) have the shoulders leveled. All of them had a right thoracic curve. Seven patients (35%) had the right shoulder elevated. They also all had a right thoracic curve. The remaining eight patients (40 %) had

the left shoulder elevated: Five patients of them had a left thoracic curve, and the other three patients had a right thoracic curve.

Using the Lenke classification, the patient numbers were type 1 (n = 12), type 2 (n = 2), and type 3 (n = 6).

The main thoracic curves ranged from 40.0-110.0° with a median of 68.5°, and the bending angle ranged from 28.0 - 95.0°. The thoracolumbar curves ranged from 29.0 – 88.0° with a median of 50.0°, and the bending angle ranged from 19.0 - 75.0° (Table 1).

Table (1): Curve Cobb angle according to curve location.

Preoperative	Cobb angle	Bending angle
Mt (n=20)		
Min. – Max	40.0 – 110.0	28.0 – 95.0
Mean ± SD.	69.80 ± 21.0	53.0 ± 21.32
Median	68.50	53.50
TL(n=11)		
Min. – Max	29.0 – 88.0	19.0 – 75.0
Mean ± SD.	52.14 ± 20.26	39.14 ± 16.37
Median	50.0	35.0

Coronal plane correction: In the coronal plane, the preoperative Cobb angle of the major curve was 69.80 ± 21.0° (range, 40.0 – 110.0°), which was corrected by 74.56 ± 7.32% to 17.73 ± 7.38° (range, 7.0 – 33.0°). The preoperative Cobb angle of the thoracolu-

mbar curve was 52.14 ± 20.26° (range, 29.0 – 88.0°), which was corrected by 66.87 ± 24.81% to 15.36 ± 10.53° (range, 5.0 – 45.0°). The percentage of correction loss for major curve of all 20 patients at FFU was 3.25 % (Table 2).

Table (2): Distribution of the studied cases according to Cobb angle.

Cobb angle	Preoperative	Postoperative	Change	% of Change
Mt (n=20)				
Min. – Max	40.0 – 110.0	7.0 – 33.0	28.50 – 90.0	59.15 – 88.33
Mean ± SD.	69.80 ± 21.0	17.73 ± 7.38	52.08 ± 16.66	74.56 ± 7.32
Median	68.50	15.25	54.0	73.07
Z(p)	3.920 (<0.001)			
TL(n=11)				
Min. – Max	29.0 – 88.0	5.0 – 45.0	1.0 – 73.0	2.17 – 87.50
Mean ± SD.	52.14 ± 20.26	15.36 ± 10.53	36.77 ± 22.88	66.87 ± 24.81
Median	50.0	14.0	38.0	72.73
Z(p)	2.934 (0.003)			

Sagittal curve correction: The mean preoperative thoracic kyphosis (T4-T12) of $34.58 \pm 10.45^\circ$ (range:16.0 – 55.90°) changed to $36.13 \pm 4.94^\circ$ (range:20.0 – 40.50°) after surgery. The mean preoperative lumbar lordosis (L1-L5) decreased from $51.85 \pm 9.85^\circ$ (range: 63.00-12.00°) to $45.40 \pm 6.17^\circ$ (range: 34.0 – 55.50°) after surgery.

Axial plan alignment: The preoperative Nash and Moe grading of axial vertebral

rotation of the main structural curves was graded: 3 curves (15%) was grade 2, 11 curves (55%) was grade 3, 5 curves (25 %) was grade 4, and 1 curves (5 %) was grade 5. Post operatively the curves were graded: 10 curves (50 %) was grade 1, and 10 curves (50 %) was grade 2 (Table 3).

Table (3): Comparison between preoperative and postoperative Nash moe grading.

Nash moe grading	Preoperative		Postoperative		MH χ^2 p
	No.	%	No.	%	
I	0	0.0	10	50.0	<0.001
II	3	15.0	10	50.0	
III	11	55.0	0	0.0	
IV	5	25.0	0	0.0	
V	1	5.0	0	0.0	

Complications: Intraoperatively, one patient suffered from one screw pull out during correction. One of them was at the apex, and the other one at the upper anchor. This problem was managed by applying sublaminar wires around the screws under stress. One case had pleural opening during rib resection, managed by sutures and inserting chest tube intraoperatively, then removed 3 days post operatively.

Early postoperatively, there was one case that suffered of transient ileus, which was totally recovered at the third postoperative day with fluid and conservative treatment. Other two cases suffered from superficial wound infection that healed totally with daily dressing and antibiotic according to

culture results within 10 days, one of them had bad scare as experienced by the patient. Late post operatively, only one patient suffered from progression of the proximal curve and post operative coronal imbalance, managed in a second session surgery by fixation and including the proximal curve in instrumentation system.

DISCUSSION

Pedicle screw fixation for deformity surgery in thoracic spine became popular. It has been shown to be safe and accurate method and even in large curves can be used without pedicle screw related visceral or neurologic complications in experienced hands (Ersenetal., 2014).

Although some controversy does exist, the all-screw construct has gained worldwide popularity in treating idiopathic scoliosis in the last decade. **Ledonio et al. (2011)** concluded that pedicle screw constructs had a significantly larger percentage of Cobb angle correction compared with hooks and hybrid constructs.

There are limited studies investigating whether bilateral pedicle screw placement improves correction of deformity compared to alternate segmental fixation in AIS (**Obeid et al., 2014**). **Quan and Gibson (2010)** retrospectively reviewed Lenke Type 1, AIS who underwent one stage posterior only spinal fusion and found bilateral segmental fixation did not improve curve correction compared to unilateral or alternate segmental fixation. **Yang et al. (2011)** evaluated the relationship between implant density, Cobb angle correction, and cosmesis and found that increasing density did not improve Cobb angle, and did not change cosmesis parameters.

In the present study, we used alternate pedicle fixation, with a correction rate of 73.07%. This correction rate equals those of other studies on segmental pedicle screw fixation of idiopathic scoliosis. Correction loss of the major curve with various types of instrumentation has been given great attention in the literature. **Yu et al. (2012)** stated that the mean correction loss for major curve of all patients at final follow up was 2.4° (3.92%). In the present study, with minimum 6 month follow-up, the correction loss averaged 3.25 %.

In the present study, the thoracic hypokypnosis and lumbar lordosis were well-

maintained PO, and at the latest follow up. In addition, the thoracic hypokypnosis and hyperkypnosis improved. **Ersen (2014)** found that bilateral segmental fixation group's results were similar to alternate fixation group.

Therefore, we considered that placement of thoracic pedicle screws using free hand technique was a safe and reliable technique. However, the technique required experienced personal with better tactile feedback skills, and a thorough understanding of the deformed spine anatomy. The technique additionally benefited from the more user-friendly instrumentation tools developed in recent years (**Bianco et al., 2014**).

Limitations of this study included relatively small samplesizes and no comparative groups. We also did not use CT scan to assess the accuracy of screw placement. However, this study demonstrated the early experience and clinical results of using all-screw method.

CONCLUSIONS

The all-screw method was efficient and safe. The outcomes in three-dimensional correction were satisfactory and comparable. The curve maintenance was good with minimal loss of correction.

REFERENCES

1. **Barrey C, Perrin G, Michel F, Vital JM and Obeid I (2014):** Pedicle subtraction osteotomy in the lumbar spine: indications, technical aspects, results and complications. *Eur J Orthop Surg Traumatol.*, 24:21–30.
2. **Bianco K, Norton R, Schwab F, Smith JS, Klineberg E and Obeid I (2014):** Complications and intercenter variability of three column osteotomies for spinal deformity surgery: a retrospective review of 423 patients. *Neurosurg Focus*, 36:18-29.

3. **Boissiere L, Vital JM, Aunoble S, Fabre T, Gille O and Obeid I (2014):** Lumbo-pelvic related indexes: impact on adult spinal deformity surgery. *Eur Spine J.*,23: 203-214.
4. **Davis JH and Dunn RN (2013):** Limited pedicle screw constructs in adolescent idiopathic scoliosis surgery and clinical correlation. *Orthopaedic Journal*, 12:1-17.
5. **Ersen O, Bilgic S, Ozyurek S, Ekinici S, Koca K and Oguz E (2014):** Comparison of two treatment strategy for Lenke I adolescent idiopathic scoliosis. *Acta Orthop.*, 80: 487-492.
6. **Hicks JM, Singla A, Shen FH and Arlet V (2010):** Complications of pedicle screw fixation in scoliosis surgery: a systematic review. *Spine*, 35: 465–470.
7. **Ledonio T, Polly DW, Vitale MG, Wang Q and Richards BS (2011):** Pediatric Pedicle Screws: Comparative Effectiveness and Safety A Systematic Literature Review from the Scoliosis Research Society and the Pediatric Orthopaedic Society of North America Task Force Charles Gerald. *Bone Joint Surg Am.*, 93:1227-34.
8. **Lehman RA Jr, Lenke LG, Keeler KA, Kim YJ, Buchowski JM, Cheh G, Kuhns CA and Bridwell KH (2008):** 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.
9. **Obeid I, Bourghli A, Boissiere L, Vital JM and Barrey C (2014):** Complex osteotomies vertebral column resection and decancellation. *Eur J Orthop Surg Traumatol.*, 49–57.
10. **Quan GMY and Gibson MJ (2010):** Correction of main thoracic adolescent idiopathic scoliosis using pedicle screw instrumentation. Does higher implant density improve correction? *Spine*, 35: 562-567.
11. **Wang Y and Lenke LG (2011):** Vertebral column decancellation for the management of sharp angular spinal deformity. *Eur Spine J.*, 20:1703–1710.
12. **Yang S, Jones-Quaidoo SM, Eager M, Griffin JW, Defino H and Arletb V (2011):** Right adolescent idiopathic curve (Lenke 1 A and B) does cost of instrumentation and implant density improve radiographic and cosmetic parameters? *Eur Spine*, 20 : 1039-1047.
13. **Yu CH, Hen PC, Ma SC and Pan CH (2012):** Segmental correction of adolescent idiopathic scoliosis by all-screw fixation method in adolescents and young adults. minimum 5 years follow-up with SF-36 questionnaire. *Scoliosis*,7:5-12.
14. **Zheng GQ, Song K, Zhang YG, Wang Y, Huang P and Zhang XS (2014):** Two-level spinal osteotomy for severe thoracolumbar kyphosis in ankylosing spondylitis. Experience with 48 patients. *Spine*, 39:1055–1058.
15. **Zhu F, Chen WJ, Wang WJ, Wang B, Zhu ZZ, Zhu B and Qiu Y (2011):** Migration of thoracic aorta after the anterior correction of thoracic idiopathic scoliosis without parietal pleura closure. *J Spinal Disord Tech.*, 24: 390–396.

التصحيح ثلاثي الأبعاد للجنف الذاتي للمراهقين

أسامه محمد الغنام، أحمد محمد سالم، ياسر محمود البنا*، إبراهيم جميل عويس،
مأمون محمد أبو شوشة

قسمي المخ والأعصاب- كليتي الطب بجامعة الأزهر والإسكندرية*

خلفية البحث: تتراوح طرق التدخل الجراحي للجنف الذاتي في المراهقين بين التثبيت الخلفي لل فقرات، أو التثبيت الأمامي، أو التثبيت المشترك (الخلفي و الأمامي).

الهدف من البحث: تقييم التثبيت الخلفي لل فقرات باستخدام البراغي السويقية (مسمار عنق الفقرة)، في معالجة الجنف الذاتي للمراهقين.

المرضى وطرق البحث: تضمّن البحث عشرين مريضاً متتالياً من مرضى الجنف الذاتي في المراهقين، بالحد الأدنى من المتابعة و هو 6 شهور. العمر المتوسط للجراحة تراوح بين 11- 18 سنة، مع عمر متوسط $15,25 \pm 2,24$ سنوات. و تم تقييم المقاييس الإشعاعية والسريرية في ما قبل الجراحة، و ما بعد الجراحة، ومتابعة نهائية لنسبة تصحيح المنحنى، ونسبة خسارة تصحيح، ومضاعفات الجراحة.

النتائج: تم تصحيح متوسط المنحنى الصدري الرئيسي من $21,0 \pm 69,80$ درجة قبل الجراحة الي $7,38 \pm 17,73$ درجة بعد الجراحة. و هذا يظهر نسبة تصحيح $7,32 \pm 74,65$ % . و أما متوسط المنحنى الصدري القطني فقد صحح من $20,0 \pm 52,14$ درجة قبل الجراحة إلى $10,53 \pm 15,36$ درجة بعد الجراحة. وهذا يظهر نسبة تصحيح $24,81 \pm 66,87$ %.

الإستنتاج: طريقة التثبيت الخلفي لل فقرات باستخدام البراغي السويقية (مسمار عنق الفقرة) في التصحيح ثلاثي الأبعاد للجنف الذاتي للمراهقين هي طريقة ذات كفاءة وأمنة.