Volume: 30, Issue: 2, April 2019 pp: 85-91 ORIGINAL ARTICLE

OPERATIVE TREATMENT OF SEVERE SCOLIOSIS WITH MODIFIED ARC ROTATION MANEUVER

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Received: 21th October, 2018.
Accepted: 17th February, 2019.

ABSTRACT

Objectives: Description of correction of severe scoliosis with modified Cantilever bending technique without anterior discectomy or osteotomy.

Summary of Background Data: Ponte, PSO and VCR type posterior osteotomies are often required for the treatment of rigid deformations above 55°. However, these procedures are monitored with high neurological deficit and bleeding risks, and according to the knowledge of some authors, complications can reach 80 % and can be experienced not only during the operation, but also 6 months after the post-operative period. The classic Cantilever maneuver was described by Kao-Wha Chang in 2003 and is said to have been implemented in 1998. In this study, we will discuss the correction of severe scoliosis with modified Cantilever bending technique without anterior discectomy or osteotomy.

Materials and Methods: The technique was performed in 24 patients. 2 of them were male and 22 were female. The age of the patients was between 12-32, the severity of deformity was 57°-120°. 1 or 1.5 years of outcomes are present.

Results: The degree of major curvature was 82.78° ± 19.89° (min. 57°, max. 120°). In order to measure the flexibility of the curves, bending graphs were determined and an average of 21,58° ± 14,46° (% 26.10 ± % 13.69; minimum 2.0°, maximum 40.1°) was detected. This means as the all curves were rigid and severe curves in the patients (t: 2.01; p> 0.05). On the other hand, mean postoperative correction of the major curves was 50,08° ± 13,23° (% 60.49 ± % 14.14; minimum 33.5°, maximum 82.3°) with statistically significance (t:14.85; p<0.01). Postoperative correction percentages were higher than the correction of the curves in the bending graphics with statistically significance (t: -15.42; p< 0.01) Operations were performed without neuromonitarization, none of the patients had neurological complications. One patient had lumbar decompensation, which was corrected by fixing the L4 vertebra. There was no dislocation during the operation, no infection was detected, there were no death issues, and blood loss was 200-250 ml. No clinical signs were observed in follow ups. Thoracoplasty was not performed in any patient and there was no patient complaint requiring thoracoplasty. During the operation, only facetectomies were used, and neither anterior release nor posterior vertebral osteotomies were performed.

Conclusion: We think that the technology does not thoroughly modify the principles of correction and require any special instruments and skills to be applied, so it can widely be used and outcomes observed.

Key words: Rigid scoliosis, surgical management, cantilever, complication.

Level of Evidence: Retrospective clinical study, Level III.

INTRODUCTION

Nowadays, despite the superior development of technology and medicine, treatment of severe scoliosis is a challenge of surgery. The operative correction of that kind of scoliosis remains a risky procedure. The operative correction of scoliosis at 50°-55° degree can be performed by means of derotation, compression distraction or rod replacement [5].

Surgeons often use special long-headed spondylolisthesis screws on all vertebras, which allows the rod adaptation when the curvature is greater than that. Ponte, PSO and VCR type posterior osteotomies

are often required for the treatment of rigid deformations above 55°. However, these procedures are monitored with high neurological deficit and bleeding risks, and according to the knowledge of some authors, complications can reach 80 % and can be experienced not only during the operation, but also 6 months after the post-operative period [1]. There is a lot of information in literature about the complexity of vertebra osteotomies and the risks of complications. In 2017, Prataly et al reported a high clinical effect of 60 % of the 3 colon resections despite neurological complications risks [13]. Trobisch et al performed PSO in 22 patients without neuromonitarization and an average of 2302 ml blood loss was reported. 2 patients had neurological deficits [17].

Two-stage correction is applied for over 70 degree curves: anterior discectomies followed by 2 to 3 weeks of halo traction and posterior surgery but there is a further complication risk [2,6-7,10,12,18].

The Cantilever maneuver was described by Chang in 2003 and is said to have been implemented in 1998 [4].

In this study, we will discuss the correction of severe scoliosis with modified Cantilever bending technique without anterior discectomy or osteotomy. Correction of advanced scoliosis will be evaluated radiologically and clinically and the effectiveness of the method will be indicated in the article.

MATERIALS AND METHODS

In 2014, when the first author started to apply polisegmental transpedicular systems in AzBÖTOE, severe scoliosis was the majority among the patients. Since neuromonitarization was not present in the clinic, vertebral osteotomy could be a high risk in these patients. For this purpose, the first author tried to create the modified Cantilever bending technique and was able to correct advanced scoliosis without anterior release and posterior vertebral osteotomies. This modification was called Arc Rotation because the correction began with the rotation of the cranial part of the curvature.

The technique was performed in 24 patients. 2 of them were male and 22 were female. The age of the patients was between 12-32, the severity of deformity was 57°-120°. 1 or 1.5 years of outcomes are present.

Standard preoperative and postoperative Scoliosis X-rays were obtained for all patients. Cobb angles and deformity flexibility were obtained. 3D CT and MRI of the spine were performed. Densitometry to determine bone density and heart echocardiography were also performed. In order to mobilize deformities before the operation, corset was used.

Posterior access was performed to all patients. Pedicle screws were driven hands free. Considering the damage of radiation to the personnel and the patient, screws were passed without O-arm. Neither neuromonitorisation nor wake up test was used. In the case of safety screws, mechanical multiple controls of the pedicle, rejection of screwing at this level when there is a suspicion of cortex failure, and the use of a small diameter is needed. Spine translation with passive correction by the assistant is applied and screws are compressed from caudal to the cranial order, as indicated (Figure-1).

Surgical technique

Neuroleptoanalgesia is performed. Posterior surgical exposure is performed. The patient is extended to the prone position on special parallel cylindrical devices which are based on the shoulders and pelvic corners on the surgical table, and the hip is extended in 30 degrees of flexion. Starting from the neck with antiseptic solutions, the surgical area and lower extremities are washed and covered with sterile drapes. The skin is cut linearly at the posterior projection of the C7- S1 vertebrae.

Dissection is performed from central to the lateral transverse projections. Three polisegmental polyaxial pedicle screws are driven to start from the cranial neutral vertebrae at the concave side of the deformity. On the concave and convex side spondylolisthesis screws are placed to all possible levels. For concave side; a rod with half the curvature of the scoliotic deformity is prepared. The rod is fixed inside the 3 screws located on the cranial site of the concave side. Assistant corrects the deformity by applying force against each other in the opposite direction; one hand from the rib convexity, one hand by the patient's crista iliaca.

The surgeon places the rod into the caudal screws by fixing the cranial screws by gently holding the caudal part of the rod and applying force, and fixing it with clamps. Rod is derotated as much as possible. Then, we place the rod on the convex side in the same way and place it into the screws. Derotation is done as much as possible carefully. If the derotation is overperformed, failure of the screws may be possible. It is natural that the rod on the concave side does not pass through the vertex screws. To do this, rod is removed from the concave side and curvature of the rod is reduced. By first fixing the rod to the cranial 3 screws, we can fix the screws by applying the modified cantilever bending maneuver. The clamps of spondylolisthesis screws in the vertical vertebrae are not tightened. Derotation maneuver is performed. In order to make the derotation on the concave side, the convex side screw clamps must be loosened. On the convex side, the rod is removed and the normal sagittal contours of the curvature is given. In the concave side, the spondylolisthesis screws of the vertex vertebrae are tightened in order and the risk of dislocation should be considered. The clamps are compressed

in half. The rod is placed on the convex side and the derotation is performed. If necessary, the curvature of the rod may be reduced on the concave side, when not required; the spondylolisthesis screws in the vertex are tightly compressed from the caudal to the cranial. The assistant must still correct by pressing hands to avoid dislocation during compression. One or 2 crosslinking and bone grafts are placed. The incision is sutured. No drain is needed.

The results of this study consist of minimum 2 years results of 24 patients (2 males and 22 females). The mean age of the patients was 19,043 (maximum 32.0, minimum 12.0). The etiology was idiopathic scoliosis in all patients.

The results were evaluated by SPSS statistical analysis. Probability value was taken as 0.05.

RESULTS

The degree of major curvature was 82.78° ± 19.89° (min. 57°, max. 120°). In order to measure the flexibility of the curves, bending graphs were determined and an average of 21,58° ± 14,46° (% 26.10 ± % 13.69; minimum 2.0°, maximum 40.1°) was detected. This means as the all curves were rigid and severe curves in the patients (t: 2.01; p> 0.05). On the other hand, mean postoperative correction of the major curves was 50,08° ± 13,23° (% 60.49 ± % 14.14; minimum 33.5°, maximum 82.3°) with statistically significance (t:14.85; p<0.01). Postoperative correction percentages were higher than the correction of the curves in the bending graphics with statistically significance (t: -15.42; p< 0.01) (Table-1). Operations were performed without neuromonitarization, none of the patients had neurological complications. One patient had lumbar decompensation, which was corrected by fixing the L4 vertebra. There was no dislocation during the operation, no infection was detected, there were no death issues, and blood loss was 200-250 ml. No clinical signs were observed in follow ups. Thoracoplasty was not performed in any patient and there was no patient complaint requiring thoracoplasty. During the operation, only facetectomies were used, and neither anterior release nor posterior vertebral osteotomies were performed.

Table-1. Indicative statistics

	Mean ± SD*	Range
Age	19,04 ± 5,62	12 - 32
Cobb Angle	82,78° ± 19,89°	57° - 120°
Flexibility (Degree)	21,58° ± 14,46°	2° - 40,1°
t	2,01	-
p	> 0,05	-
Correction (Degree)	50,08° ± 13,23°	33° - 82°
t	14,85	-
p	< 0,01	-
% FLEX, **	% 26,10 ± % 13,69	-
% COR,***	% 60,49 ± % 14,14	-
t	-15,42	-
p	< 0,01	-

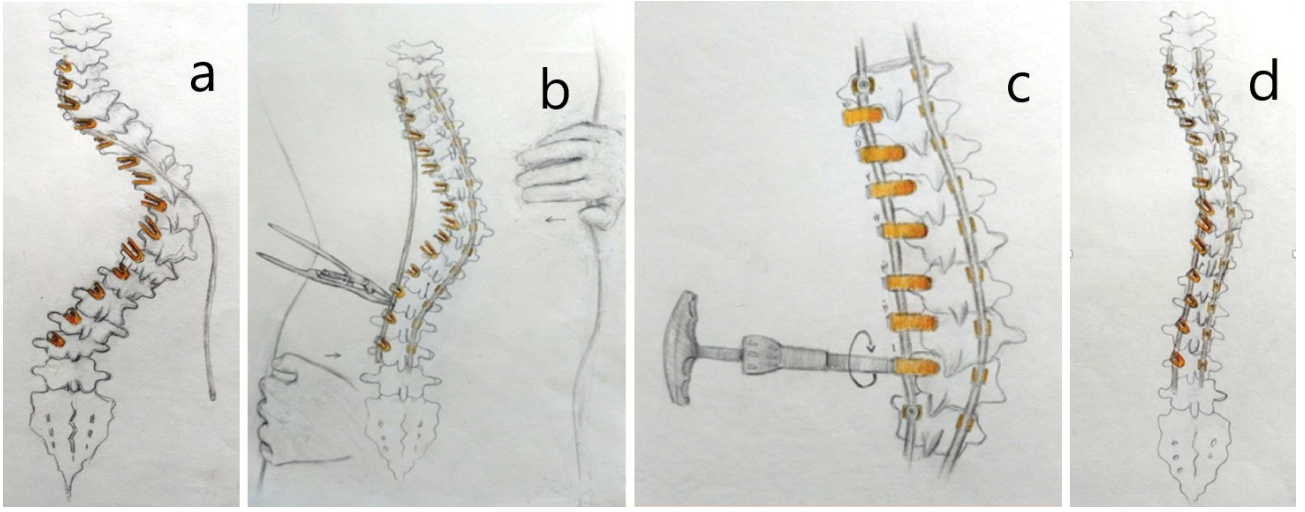

Figure-1. Arc rotation - Cantilever technique, **(a)** Drive the screws from the cranial neutral vertebra to the caudal neutral vertebra, Connect the rod to the 3 cranial neutral vertebra with the long-headed spondylolisthesis screws at the concave side, The rod will stay as shown in the figure, **(b)** Passive correction is performed with the help of the assistant's hand and the rod is inserted into the caudal screws by the operator, **(c)** The screws are placed on the convex side and the rod is placed in a similar way, Then the rod is taken out from the concave side and is put into place after straightening with the help of the rod bender, **(d)** As a result of the straightening and the derotation of the rod on the convex side, the rod reaches the spondylolisthesis screws on the concave side

Clinical example

19 year old boy admitted to the clinic with a large and rigid 123° right-sided thoracic idiopathic scoliosis with 1 cm body imbalance to the right. The main curvature was very rigid, with a total difference of 2 ° from bending radiographs. In postoperative radiographs the deformity was corrected by 57.7°, which means 47 %. The patient is very satisfied with the result (Figure-2).

The second patient, a 14-year-old female, was referred to our clinic with a rigid 110° right-sided chest type idiopathic scoliosis. Patient's body is balanced. The main curve was severely rigid bending radiographs differed by a total of 11.4°. In postoperative radiographs, deformity was corrected by 74.5° after the first operation, which means 68°. After 9 months, the patient was taken to the additional operation for correction and in addition we reduced the curvature of the rods by placing 2 more screws, and by derotation. We obtained an additional 10 ° correction, which means 77.2 %. The patient is very satisfied with the result (Figure-3).

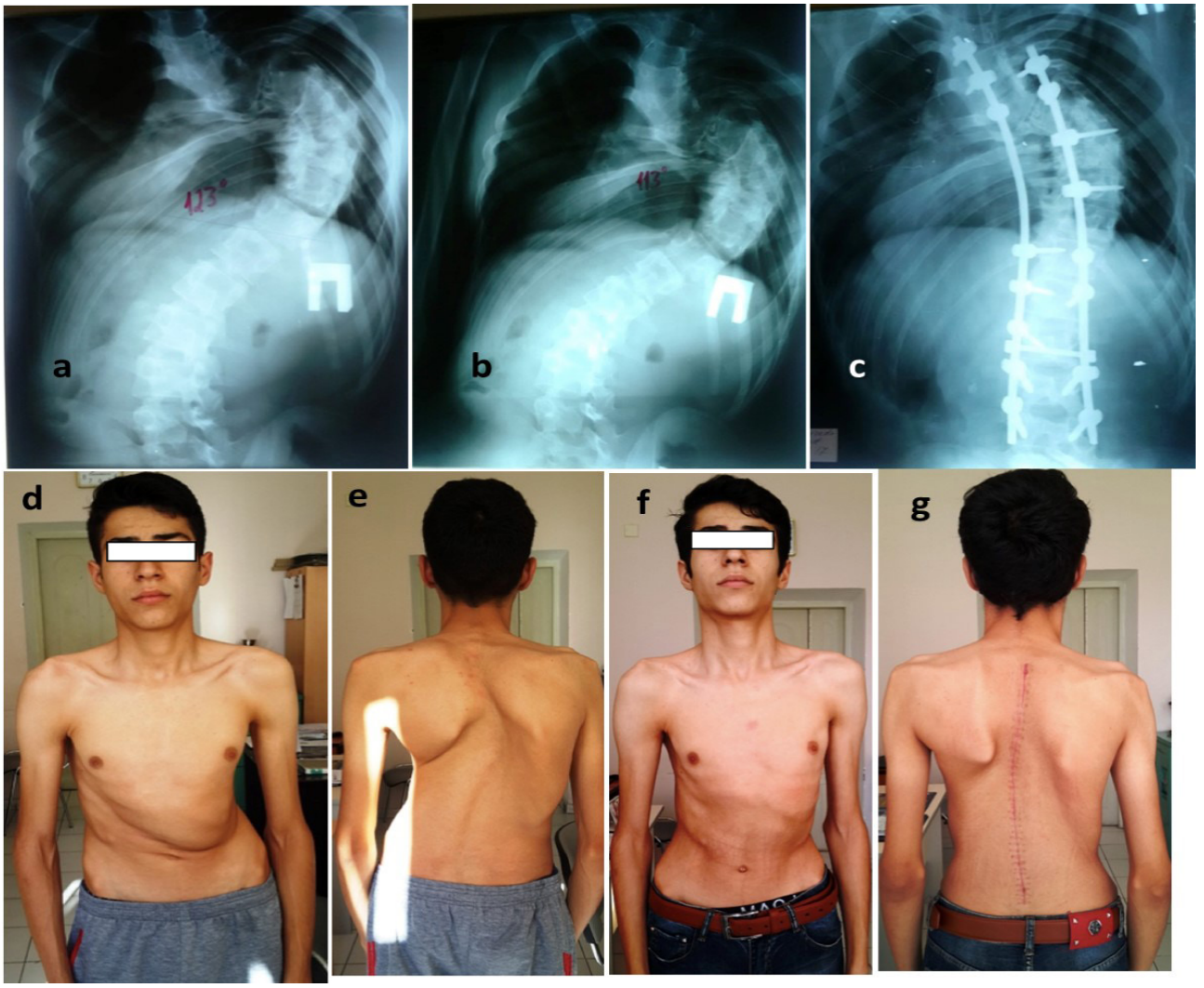

Figure-2. (a) Preoperative AP, **(b)** preoperative bending, **(c)** postoperative AP graphics, **(d)** preoperative clinical presentation from front, **(e)** preoperative clinical presentation from back, **(f)** postoperative clinical presentation from front, and **(g)** postoperative clinical presentation from back

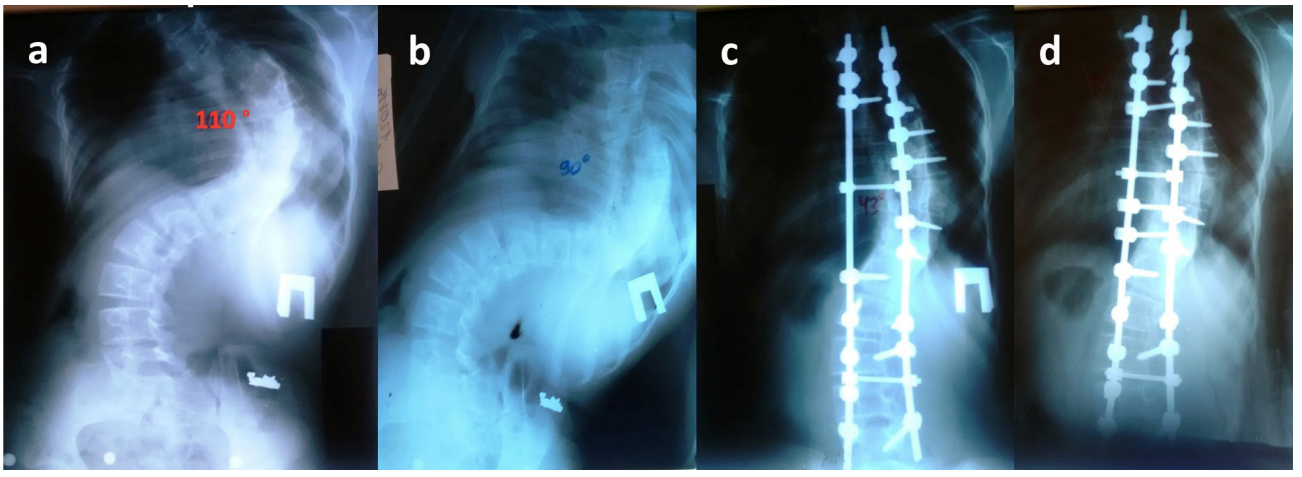

Figure-3. (a) Preoperative AP, **(b)** bending, **(c)** postoperative AP, and **(d)** postoperative AP graphics after the second surgery of the second patient

DISCUSSION

Generally, operative correction of scoliotic deformities by polisegmental transpedicular systems is done by simple rod derotation, 3 rod technique, direct vertebral body derotation, segmental derotation, and complete derotation and cantilever maneuvers [5].

In the maneuver mentioned in the illustrations; firstly; the bending of the rods with the rod bender on the convex side is defined. We think that this will not be effective enough in 90°-120° deformities. Obviously, the traditional cantilever maneuver in rigid scoliosis can eliminate severe operations such as anterior discectomies. We have given the modified maneuver the name Arc Rotation. Here; first movement corrects the deformity in frontal plane which starts from the 3 screws at cranial arc of the deformity and helps repetitive correction by derotation in the frontal plane. We do not use rod bender, we adapt the deformity to the rods as a result of tilting the rods slightly by selecting the correct abutment, by the cranial screws and lateral correction of the assistant. The degree of major curvature was 82.78° ± 19.89° (min. 57°, max. 120°). Major curves of the patients were rigid, the correction of the curves in the bending graphics (% 26.10 ± % 13.69) was not significant statistically ($p > 0.05$). Average correction of the major curves was % 60.49 ± % 14.14 with statistically significance ($p<0.01$). Meanwhile, postoperative correction percentages were higher than the correction of the curves in the bending graphics with statistically significance ($p< 0.01$).

It is possible to obtain sufficient radiological and cosmetic correction by performing this maneuver in concave and convex sides respectively. At this time, it is possible to obtain sufficient correction when passing the spondylolisthesis screws from the concave side vertex.

Correction of rigid scoliosis in the traditional method requires Ponte, PSO or VCR osteotomies, which increases bleeding, operation time and neurological complications risks [1]. According to Saifi, transient neurological complications can reach up to 13.8 % and permanent neurological complications can reach 6.3 % in order to obtain a 50-70 % correction in vertebral column resection in severe scoliosis [15]. In our study, similar correction values were obtained postoperatively and we did not observe any neurologic deficit in our patients.

According to Şenköylü, a number of long-headed new spondylolisthesis screws should be applied to reduce the risk of dislocation during conventional cantilever maneuver [15]. We have tried to show it as a separate maneuver and show the strength of it without osteotomy. It is easy to place the rod during the traction to obtain passive correction. However, at least 2 people are required - one must pull from the axillary region and the other from the legs. We accomplish passive correction by the effect of the assistant's force in the opposite directions (ribs and pelvis) in the frontal plane. We benefit from the help of 1 person successfully. We still apply the assistant's passive correction to reduce the risk of pull out of the screws.

Traction methods have been applied in advanced scoliosis [3,8-9,14,19]. Halo- pelvis traction is used in various modalities, as stage in vertebral osteotomies and as stage after anterior thoracotomy. The negative side of halo-pelvis trauma is long hospitalization. In 2018, Qiao et al proposed 3-phase operational correction for treatment of severe scoliosis [13].

1. Stage-1: instrumentation of vertebras with pedicle screws and Smith ve Petersen type osteotomies.

2. Stage-2: In the second stage, the humerus - thigh traction with large loads continuously
3. Stage-3: Posterior correction and fixation in 3rd stage. 63 patients participated in their research. The main curve's preoperative mean coronal Cobb angle was 118.7°, the postoperative degree of coronal correction was 55 %, and the postoperative mean coronal Cobb angle was 57.3°.

According to Qiao, in the first stage operation, the displacement of 17 screws in 12 patients had been observed, which were corrected during the last operation. In 2 patients, the pleura had been dissected and sutured during the last operation. Pleural discharge occurred in one of 2 patients whose pleura had been dissected and a thoracic closed drain was placed in it. Transient postoperative neurological disorder had been recorded in one patient. In general, postoperative complications were 19.0 % after the first operation and 4.8 % after the last operation. Two patients suffered from paralysis of the brachial plexus and one patient suffered from femoral nerve paralysis. However, complete recovery of nerve functions was achieved. Two patients had a short-term hematuria. One patient had gastrointestinal symptoms, and the symptoms were alleviated after the load for traction had decreased. Two patients had thrombosis of deep veins (DVT) and one patient had a vein filter. Two patients had pin tract infection. Traction related complications are 11.1 % [13]. We have not observed any displacement of screws in modified Cantilever Arc Rotation Technique. And no pleural complication was detected in modified Cantilever Arc Rotation Technique due to the lack of thoracoplasty. No postoperative neurological deficit was detected in the proposed method.

There is a lot of information in literature about the complexity of vertebra osteotomies and the risks of complications including neurological complication risks and blood loss [1,13]. Modi HN and authors have developed and reported results of PMVO for correction of severe idiopathic and neuromuscular scoliosis. Average number of osteotomy was 4.2 ± 0.8 (range 3-5). Average preoperative Cobb angle 99.2°± 29.6° wich improved after surgery to 44.7° ± 12.3°. A 54.3 % correction was achived in coronal plane. Average blood loss and operative time 3015 ± 1213ml and 6.01 ± 1.09 hours respectively. Three patients had postoperative respiratory complications 2 had hemothorax and 1 had atelectasis; none had follow-up consequences. Two patients had complication related with the implants; 1 screw brekage and other screw prominence. There was no neurology injury intraoperatively on motor evoked potentials or clinically after surgery [11]. The prolonged length of bed position gives a great deal of psychological stress in patients [14]. In our study, the arc rotation maneuver can thus be modified as a cantilever maneuver. Because it allows single-stage treatment of scoliosis without osteotomies, it can be considered effective because it provides enough strength to achieve adequate correction. Likewise, minimizing the operation trauma and reducing the risks of the major complications allow success.

The limitation of this study is the lack of psychological status of the patients undergoing the same complex examination and heterogeneity of the study group, insufficient of the patient's number and follow up period.

It is possible to obtain the results by other authors in severe scoliosis with this maneuver, no special training is required. Since there are no osteotomies, it can be applied without neuromonitarization and decreases the operational costs. According to our result, arc rotation technique was successful to correct for the rigid and severe scoliosis was concluded.

REFERENCES

1. Ayhan S, Aykac B, Yuksel S, Guler UO, Pellice F, Alanay A, Perez-Guerso FJ, Acaroglu E, ESSG European Spine Study Group. Safety and efficacy of spinal osteotomies in adult spinal deformity: what happens in the first year? *Eur Spine J* 2016; 25(8): 2471-2479.
2. Burd TA, Pawelek L, Lenke LG. Upper extremity functional assessment after anterior spinal fusion via thoracotomy for adolescent idiopathic scoliosis. *Spine* 2002; 27: 65–71.
3. Chan CY, Lim CY, Shahnaz Hasan M, Kwan MK. The use of pre-operative halo traction to minimize risk for correction of severe scoliosis in a patient with Fontan circulation: a case report and review of literature. *Eur Spine J* 2016; 25(Suppl.-1): 245–250.
4. Chang KW. Cantilever bending technique for treatment of large and rigid scoliosis. *Spine* 2003; 28(21): 2452–2458.
5. Cotrel Y, Dubousset J, Guillaumat M. New universal instrumentation in spine surgery. *Clin Orthop* 1988; 227: 10–23.
6. Fasciszewski T, Winter RB, Lonstein JE, Denis F, Johnson L. The surgical and medical perioperative complications of anterior spinal fusion surgery in the thoracic and lumbar spine in adults: a review of 1223 procedures. *Spine* 1995; 14: 1592–1599.
7. Hodge WA, DeWald RL. Splenic injury complicating the anterior thoracoabdominal surgical approach for scoliosis. *J Bone Joint Surg Am* 1983;65-A:396–7.
8. Koptan W, ElMiligui Y. Three-staged correction of severe rigid idiopathic scoliosis using limited halo-gravity traction. *Eur Spine J* 2012; 21(6): 1091–1098.
9. Kulkarni AG, Shah SP. Intraoperative skull-femoral (skeletal) traction in surgical correction of severe scoliosis (>80 degrees) in adult neglected scoliosis. *Spine* 2013; 38(8): 659–664.

10. McAfee PC. Complications of anterior approaches to the thoracolumbar spine: emphasis on Kaneda instrumentation. *Clin Orthop* 1994; 306: 110–119.
11. Modi HN, Suh SW, Hong JY, Yang JH. Posterior multilevel vertebral osteotomy for severe and rigid idiopathic and nonidiopathic kyphoscoliosis: a further experience with minimum two-year follow-up. *Spine* 2011; 36(14) : 1146-1153.
12. Nakai S, Zielke K. Chylothorax. A rare complication after anterior and posterior spinal correction: report on six cases. *Spine* 1986; 11: 830–833.
13. Pratali RR, Martins SM, Santos FPED, Barsotti CEG, Oliveira CEAS. The use of three-column osteotomy in the treatment of rigid deformities of the adult spine. *Rev Bras Ortop* 2018; 53(2): 213–220.
14. Qiao J, Xiao L, Xu L, Liu Z, Sun X, Qian B, Zhu Z, Qiu Y. Skull-femoral traction after posterior release for correction of adult severe scoliosis: efficacy and complications *BMC Musculoskeletal Disord* 2018; 19: 277.
15. Saifi C, Laratta JL, Petridis P, Shillingford JN, Lehman RA, Lenke LG. Vertebral coloumn resection for rigid spinal deformity. *Global Spine J* 2017; 7(3): 280-290.
16. Senkoylu A, Cetinkaya M. Correction maneuvers in the surgical treatment of spinal deformities. *EFORT Open Rev* 2017; 2 (5): 135-140.
17. Trobisch PD, Hwang SW, Drange S. PSO without neuromonitoring: analysis of peri-op complication rate after lumbar pedicle subtraction osteotomy in adults. *Eur Spine J* 2016; 25(3): 2629-2632.
18. Weis JC, Betz RR, Clements DH III. Prevalence of perioperative complications after anterior spinal fusion for patients with idiopathic scoliosis. *J Spinal Disord* 1997; 10: 371–375.
19. Zhang HQ, Gao QL, Ge L, Wu JH, Liu JY, Guo CF, Liu SH, Lu SJ, Li JS, Yin XH, Li F. Strong halo-femoral traction with wide posterior spinal release and three dimensional spinal correction for the treatment of severe adolescent idiopathic scoliosis. *Chin Med J* 2012; 125(7): 1297–1302.